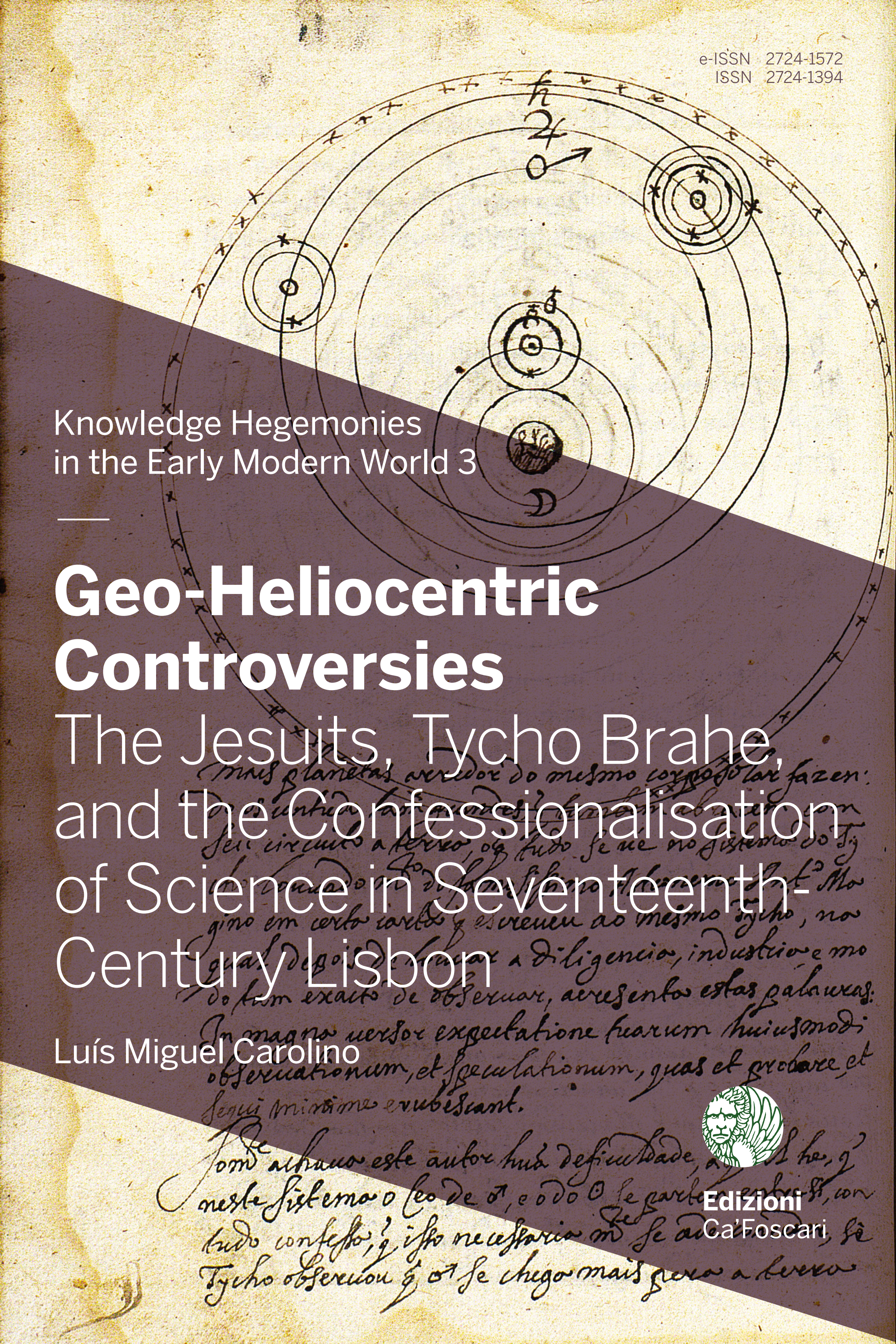

e-ISSN 2724-1572
ISSN 2724-1394

Knowledge Hegemonies
in the Early Modern World 3

Geo-Heliocentric Controversies

The Jesuits, Tycho Brahe, and the Confessionalisation of Science in Seventeenth-Century Lisbon

Luís Miguel Carolino

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e-ISSN 2724-1572
ISSN 2724-1394

URL https://edizionicafoscari.unive.it/en/edizioni4/collane/knowledge-hegemonies-in-the-early-modern-world/

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Venezia
Edizioni Ca' Foscari - Venice University Press
2023

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Edizioni Ca' Foscari
Fondazione Università Ca' Foscari
Dorsoduro 3246, 30123 Venezia
http://edizionicafoscari.unive.it | ecf@unive.it

1st edition March 2023
ISBN 978-886-969-661-9 [ebook]
ISBN 978-886-969-662-6 [print]

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme (GA nr. 725883 *Early Modern Cosmology*). The research for this book was partially supported by the Fundação para a Ciência e a Tecnologia (FCT) through the Strategic Financing of the R&D Unit UIDB/03126/2020.

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme (GA n. 725883 EarlyModernCosmology)

This volume is part of a series that results from a partnership between Edizioni Ca' Foscari, the Department of Philosophy and Cultural Heritage at Ca' Foscari University, and the Max Planck Institute for the History of Science, Berlin, in connection with the Edition Open Access endeavor.

Scientific certification of the works published by Edizioni Ca' Foscari: this essay has received a favourable evaluation by subject-matter experts, through a double-blind peer review process under the responsibility of the Advisory Board of the series. The evaluations were conducted in adherence to the scientific and editorial criteria established by Edizioni Ca' Foscari, using a dedicated platform.

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Geo-Heliocentric Controversies. The Jesuits, Tycho Brahe, and the Confessionalisation of Science in Seventeenth-Century Lisbon / Luís Miguel Carolino— 1. ed. — Venice: Edizioni Ca' Foscari, 2023. — x + 158 p.; 25,5 cm. — (Knowledge Hegemonies in the Early Modern World; 3). — ISBN 978-886-969-662-6.

URL http://edizionicafoscari.unive.it/it/edizioni/libri/978-886-969-662-6
DOI http://doi.org/10.30687/978-886-969-661-9

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Abstract

This is a book about the confessionalisation of science in the early modern period. The constitution of homogeneous religious communities in early modern Europe did not affect only the political and religious system, but also the entire cultural life and particularly science. It shaped educational institutions, intellectual communities and scientific debates and activities. This book addressed this issue by focusing on the cosmological controversies raised by the appropriation of Tycho Brahe's astronomical theories. Although aiming at providing a comprehensive and original view of the Jesuit scientific ideas in the framework of the European Republic of Letters, it will focus particularly on the international community of Jesuit mathematicians who taught astronomy at the College of Saint Antão, Lisbon, between 1615 and 1652.
This book argues that the cultural politics of the Counter-Reformation Church curbed the reception of Tycho Brahe within the Jesuit milieu. Despite supporting the Tychonic geo-heliocentric system, which they explicitly conceived of as a 'compromise' between the ancient Ptolemy and the modern Copernicus, and making recourse to some of the cosmological ideas produced in Tycho's Protestant milieu, the Jesuits active in Lisbon strove to confine the authority of the Lutheran astronomer to the domain of mathematics. Philosophy was expected to remain the realm of Catholic orthodoxy. Thus, while Tycho Brahe entered the pantheon of 'Jesuit' authorities, he nonetheless was not granted the absolute status of intellectual authority. This case demonstrates how the impact of confessionalisation reached well beyond the formal processes of science censorship.

Keywords Confessionalisation of science. Astronomy. Cosmology. Tycho Brahe. Copernicanism. Martianus Capella. Giovanni Paolo Lembo. Johann Chrysostomus Gall. Cristoforo Borri. Ignace Stafford. Simon Fallon. John Rishton. College of Saint Anthony. Colégio de Santo Antão. Portugal.

Acknowledgments

This book stems from the *Provas de Agregação* held at ISCTE – Instituto Universitário de Lisboa in November 2020. I would like to thank Professors Helena Carvalho, Luís Nuno Rodrigues, João Arriscado Nunes and particularly Víctor Navarro Brotóns, Ana Simões and Nuno Luís Madureira for their comments and insightful suggestions.

I am especially grateful to Augusto Fitas and Carlos Ziller Camenietzki, with whom I have discussed several topics related to this book over the years. Their comments stimulated my research in such a deep way that it would be difficult to summarise here. I am also deeply indebted to the late William G.L. Randles for his support and criticism of my early research on Cristoforo Borri. Randles was a model of scholarship and academic generosity.

This book has also benefited greatly from comments and suggestions made by scholars who read early drafts of parts of it. I would therefore like to thank Ivana Gambaro, Víctor Navarro Brotóns, Pietro Daniel Omodeo, Miguel Ángel Granada, Rodolfo Garau, Tayra Lanuza Navarro and Darrel Rutkin. Furthermore, I am indebted to the anonymous referees for their comments and precious suggestions.

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To the memory of my mother,
Maria Clementina Nunes

1 Introduction

Tycho Brahe did cosmology a great wrong.[1] Such was the opinion of Mendo Pacheco de Brito, who, in the middle of an impassioned controversy over the nature and location of the exceptionally bright comets that appeared above Portugal in late 1618, accused his opponent – the astronomer and physician Manuel Bocarro Francês – of seizing the ideas of the Lutheran astronomer Tycho Brahe.[2] According to Brito, these Tychonic theories were particularly pernicious as they risked jeopardising the long-established worldview born out of the consensus between Aristotelian philosophy and orthodox theology:

> We announce that the originator of these new ideas is Tycho Brahe, who was a heretic (*herege*) and intended, on every matter, to weaken Aristotle's doctrine so that his mistakes could be corroborated.[3]

Although not unusual, these religious arraignments have passed largely unnoticed by historians concerned with the so-called relationship between science and religion. While discussing the impact of ecclesiastic agency on science and scientific activity in early modern Europe, historians have focused mainly on formal processes of censorship. Accordingly, the inquisi-

1 This book develops the argument made in Carolino, "How Did a Lutheran Astronomer Get Converted into a Catholic Authority?".

2 On this controversy, see Carolino, "Disputando Pedro Nunes" and Camenietzki, Carolino, Leite, "A Disputa do Cometa".

3 de Brito, *Discurso em os Dous Phaenominos Aereos*, ff. 18*v*-19*r*: "Aduertimos tambem, que destas opiniões nouas, he inuentor Tycho Abrahe, o qual foy Herege, e em tudo pretende enfraquecer a doctrina de Aristoteles, pera com isso ficar mais em seus erros confirmado".

DOI 10.30687/978-886-969-661-9/001

torial trials of prominent individuals, such as Galileo Galilei, Giordano Bruno and Giambattista della Porta, have regularly been scrutinised, with the lists of prohibited books being increasingly dissected.[4] Undoubtedly, the direct effects that ecclesiastic censorship had on scientific activity in early modern Europe are hardly to be ignored. Nevertheless, statements such as that made by Brito, linking confessional identity to philosophical orthodoxy, suggest the existence of a more complex, indirect and subtle influence. In the aftermath of the Western Christian schism, the Catholic Church, with the support of increasingly centralised states, struggled to promote the religious conformity of doctrine and practices through censorship, religious propaganda and education. In this context, as the Counter-Reformation gained momentum, the confessional agenda exerted an increasing influence over the ongoing philosophical debates and science. Indeed, Brito's statement epitomises the cultural politics of the early Counter-Reformation Church. Striving to ensure their intellectual hegemony, the Catholic authorities established a close link between Aristotelian natural philosophy and metaphysics and orthodox theology. The interpretation of the doctrine of transubstantiation in Aristotelian-Thomist philosophical terms handed down by the Council of Trent represents a case in point. The conversion of the substance of bread and wine into the body and blood of Christ, while maintaining the constitution of the former substances, required an Aristotelian-Thomist understanding of the metaphysics of substance.[5] In this context, any attempt to put forward a theory that conflicted with the Aristotelian-Thomist theoretical framework was easily converted into an implicit attack on Catholicism and its truths of faith (the Eucharist) and science (geocentrism). Science became a confessional matter, as Brito was well aware.

What Brito ignored was how, even as he wrote those lines against Tycho Brahe, the Danish astronomer was in the process of being assimilated by the Society of Jesus authorities. The astronomical novelties revealed by the brand-new telescope rendered the traditional Ptolemaic system untenable. The geo-heliocentric system elaborated by Tycho Brahe stood out as a likely candidate for replacing it. After a distressing process of censorship, Giuseppe Biancani's *Sphaera Mundi* was finally published in 1620. Although Biancani's book was to a large extent just a traditional treatise on cosmography, it was nevertheless the first printed work by a Jesuit author to endorse the Tychonic planetary system.[6] For such a reason, it is regarded as a turning point in the science politics of the Jesuits, when the Jesuit authorities officially accepted Tychonic geo-heliocentrism. Soon after this foundational moment, Tycho Brahe emerged as an authority among Jesuit astronomers and philosophers.[7]

4 The production in this field of historical research has been abundant. Some of the most influential and recently published works are Baldini, Spruit, *Catholic Church and Modern Science*. Vol. 1, *Sixteenth-Century Documents*; Finocchiaro, *On Trial for Reason*; Gingras, *Science and Religion*.

5 Redondi, *Galileo Heretic*, 209-26; Dear, "The Church and the New Philosophy", 124.

6 Prior to this, the Tychonic system had already been taught in the Jesuit milieu by at least Otto Cattenius at the University of Mainz, in 1610-11, and Cristoforo Borri at the College of Brera (Milan), in 1612. Krayer, *Mathematik im Studienplan der Jesuiten*, 135-7; Carolino, "The Making of a Tychonic Cosmology".

7 On the Jesuit reception of Tycho Brahe's astronomical system, see Lerner, "L'entrée de Tycho Brahe"; Schofield, *Tychonic and Semi-Tychonic*, 277-89; Lattis, *Between Copernicus and Gal-*

However, the incorporation of Tycho Brahe into the pantheon of Jesuit authorities was anything but a straightforward process. The Tychonic astronomical system conflicted with several astronomical tenets long since taught at Jesuit colleges and universities, such as the existence of celestial spheres. It also contradicted the theories generally maintained by Jesuit natural philosophers in the cosmological domain. Furthermore, Tycho Brahe was publicly Lutheran. A quick reading of his *Epistolarum astronomicarum libri* (Uraniborg, 1596) would have left no Jesuit in any doubt about Tycho's confessional identity. This most likely explains why Jesuits seemed to be so cautious about explicitly crediting Tycho with *his* new astronomical system around 1620. As Christine Jones Schofield has already pointed out, in her pivotal book on the diffusion of the Tychonic system in early modern Europe, the Swiss Jesuit Johann Baptist Cysat, Professor of Astronomy at the University of Ingolstadt, despite using a diagram representing the Tychonic world system in his famous book on the comet of 1618 and praising Tycho's ability to determine the motions of the comets,[8] did not identify Tycho as the author of the new world system.[9] Needless to say, Cysat was most likely aware of Tycho's authorship of the geo-heliocentric system of which he availed himself. A couple of years earlier, in the academic year 1613-14, his Jesuit confrère, collaborator and predecessor in the teaching of astronomy at Ingolstadt, Christoph Scheiner, had already disclosed the Tychonic system to his students of cosmology at the University of Ingolstadt.[10] The same strategy of praising the astronomical abilities of Tycho Brahe in print while explicitly avoiding crediting the Danish astronomer with the 'Tychonic' system was followed by Giuseppe Biancani himself. In his *Sphaera Mundi* (mentioned above), while delving into *De Mundi Fabrica*, Biancani exposed the geo-heliocentrism of Tycho Brahe, but not a single word was said about its author.

By the time Cysat and Biancani published their books, a process of censorship of Tycho Brahe's *Astronomiae instauratae progymnasmata* was underway in Rome under the surveillance of Roberto Bellarmino. As one learns from the censure issued by the Roman Congregation of the Holy Office, it was not Brahe's scientific ideas that were at stake but his religious identity. Accordingly, it urged the Catholic reader to suppress the praises that Tycho Brahe addressed to Luther and his prominent worshippers from his book. The question was not about the (in)ability of Protestants to access the truth in science and philosophy[11] but was about establishing the intellectual hegemony of the Catholics over the Protestant scholars. Tycho Brahe's religious belief remained an issue for a few Jesuit astronomers until the mid-seventeenth century. As Michel-Pierre Lerner revealed, in his *Almagestum novum* (1651), Giambattista Riccioli addressed severe words to the "impi-

ileo, 205-16; Strano, Truffa, "Tycho Brahe Cosmologist", 89-93; Marcacci, *Cieli in contraddizione*; Carolino, "Astronomy, Cosmology, and Jesuit Discipline", 678-81.

8 Cysat, *Mathemata astronomica*, 57.

9 Schofield, *Tychonic and Semi-Tychonic*, 170-1. Schofield also referred to the case of the Jesuit theses of the College of Pont-à-Mousson (1622).

10 Scheiner, *Disquisitiones mathematicae*, 52-3. Scheiner taught mathematics (including astronomy) and Hebrew at the University of Ingolstadt between 1610 and 1616-17. Daxecker, *The Physicist and Astronomer*, 9-10. The *Disquisitiones mathematicae* stemmed from these mathematical classes at Ingolstadt.

11 On the question of establishing and making sense of truth among early modern Catholics, see Badea et al., *Making Truth*.

ous" Tycho Brahe,[12] accusing him of following Luther, Melanchthon and David Chytraeus, the "plague of the human race" (*humani generis pestes*) according to the Italian Jesuit.[13]

This book explores the complex process of integrating Tycho Brahe's astronomical theories into the Jesuit intellectual framework by focusing on a specific community of Jesuit scholars, the group of professors who taught mathematics at the College of Santo Antão, Lisbon, during the first half of the seventeenth century. Recent scholarship has emphasised the role that the Jesuit polyvalent information network played in the circulation of knowledge in the early modern period.[14] An analysis of the appropriation of Tycho Brahe's astronomical theories by the international community of Jesuit mathematicians active in Lisbon may also offer an appropriate occasion to investigate how the Jesuit network affected the production of knowledge process itself. Between 1615 and 1652, a series of foreign Jesuits, trained in different academic traditions from across Europe, taught the Tychonic system in the College of Santo Antão's Class on the Sphere (*Aula da Esfera*). The respective professors were (according to the order in which they taught) the Italian Giovanni Paolo Lembo (1570-1618, who taught in Lisbon from 1615 to 1617), who studied mathematics at the Collegio Romano under Christoph Clavius; the German Johann Chrysostomus Gall (1586-1643, t. 1620-27), who trained in astronomy at Ingolstadt University under Johann Lanz, Christoph Scheiner and Johann Baptist Cysat; the Italian Cristoforo Borri (1583-1632, t. 1627-28), who learned and taught mathematics at the College of Brera, in Milan, before departing to East Asia as a missionary; the English Ignace Stafford (1599-1642, t. 1630-36), a former student of the Royal English College of Valladolid, Spain; the Irish Simon Fallon (1604-1642, t. 1638-41), who studied at the College of Arts, Coimbra, and the University of Évora, Portugal;[15] and, finally, the English John Rishton (1615-56, t. 1651-52), a Jesuit who trained in Ghent and Liège before departing for Lisbon in the late 1640s.[16]

At the College of Santo Antão, these Jesuits of different European origins reflected on the astronomical and philosophical challenges raised by adopting Tycho Brahe. Since they were supposed to provide an introduction to astronomy (to the Sphere), Santo Antão's professors usually did not discuss the technical aspects involved in the astronomical debate. Even John Rishton, who examined the Copernican system in greater detail, did not consider technical details. The English Jesuit tackled the crucial arguments of the controversy, such as the parallax issue, but did not focus, for example, on the theory of the Sun or the movement of Mars.

The confessional issue nevertheless remained at the forefront of all concerns. The situation was especially tense because, as those professors unanimously realised, the celestial novelties of the late sixteenth and early

12 Lerner, "Tycho Brahe Censured", 95.

13 Riccioli, *Almagestum novum*, Pars prior, XLVI, col. b. Cf. Pars posterior, 74, col. b.

14 See, among many others, Findlen, "How Information Travels"; Romano, *Impressions de Chine*; Harris, "Mapping Jesuit Science".

15 Biographical details of these Jesuits can be found in Baldini, "L'insegnamento della matematica", 129-67, 142-4.

16 Baldini, "The Teaching of Mathematics", 386-7. To this list, we should add the English Jesuit Thomas Barton (c. 1615-?), who taught mathematics at the College of Santo Antão in 1648-49. However, I was unable to examine his lecture notes (*Tractado da Sphera*), which are in the possession of a private owner. On Barton and his lecture notes, see Bernardo, "O Tractado da Sphera".

seventeenth centuries had forced Jesuit mathematicians to work out an astronomical solution that enabled the replacement of the Ptolemaic traditional planetary system without yielding to the temptation of advocating the Copernican heliocentric system, which was rigorously forbidden in 1616.[17] The prohibition of endorsing the Copernican theory was regularly reinforced. In 1651, for example, the *Ordinatio Pro Studiis Superioribus*, issued during the short generalate of Francesco Piccolomini, excluded the teaching of any theses that, among many others, proclaimed the diurnal motion of the Earth.[18] It was against this complex background that this Jesuit community devised the Tychonic system as a solution and explicitly conceived it as a 'compromise' system. In doing so, they paved the way for the entrance of Tycho Brahe into the restricted selection of Jesuit authorities. Nevertheless, the Lutheran astronomer remained strictly confined to the realm of astronomy. The Jesuits soon recognised that Brahe's accurate observations and precise instruments made him an astronomical *auctoritas*. Nevertheless, they seemed much more cautious regarding the cosmological ideas that Tycho discussed in his works. As this book will demonstrate, they assimilated Tycho's and his correspondents' ideas on celestial matter and fluidity while avoiding any recognition of their authorship. Inspired by the Tridentine instructions, Jesuits instead endeavoured to attribute the source of those cosmological ideas to the early Church Fathers. Thus, while Tycho Brahe entered the pantheon of 'Jesuit' luminaries, he nonetheless was not granted the full status of an authority. This complex and intricate process through which Tycho Brahe was integrated into the Jesuit intellectual framework thus demonstrates that the impact of confessionalisation reached well beyond the formal censorship of science. Confessionalisation correspondingly shaped the very formation of early modern scientific culture.

I develop this argument in a dozen short chapters. The book starts with a brief introduction to the College of Santo Antão's Class on the Sphere, the institutional setting in which the geo-heliocentric controversies took place (chapter 2). There was a strong link between the Lisbon mathematics class and the Collegio Romano, the Jesuit key institution of mathematical teaching at the turn of the seventeenth century. Alongside several professors who, having been trained in Rome, travelled to Lisbon, an Aristotelian-Ptolemaic orthodox cosmological view inspired by the work of the influential mathematics professor of the Roman college Christoph Clavius made its way into the Lisbon institution. This cosmological view was based on a few conventional cornerstones, such as the notions of the incorruptibility and the solidity of the celestial region. Nevertheless, the appearance of comets and new stars in the late sixteenth and early seventeenth centuries radically challenged these cornerstones. Chapter 3 analyses the telescope observations of these celestial novelties carried out by the Lisbon community of Jesuit astronomers. This analysis corroborates the existence of a close interconnection between the Collegio Romano's and the Santo Antão College's astronomical agenda at the beginning of the seventeenth century.

17 On the 1616 ban on Copernicus, see particularly Frajese, "Il decreto anticopernicano" and Fabbri, Favino, *Copernicus Banned*. For a seminal insight into the complex reception of and reaction against Copernicus in the sixteenth and seventeenth centuries, see Omodeo, *Copernicus in the Cultural Debates*.

18 "Ordinatio Pro Studiis Superioribus", 92. On the complex process that would result in the publication of this Ordination, see in particular Hellyer, "The Construction of the *Ordinatio*".

Since the astronomical novelties revealed by the brand-new telescope rendered the traditional Ptolemaic system untenable, the Jesuit astronomers struggled to devise astronomical solutions. In the following chapters, I discuss the Jesuit refutation of Copernicus based on astronomical, physical and biblical arguments (chapter 4), the development of an alternative geo-heliocentric model of Capellan inspiration, which came to terms with the celestial novelties while simultaneously retaining intact the foundations of traditional cosmology (chapter 5), and finally the reception of Tycho Brahe's geo-heliocentric system (chapter 7). However, a complex process of censorship preceded the reception of the Tychonic astronomical system and ideas, focusing not so much on scientific questions but above all on confessional issues. This is the theme of chapter 6.

Chapters 7 and 8 focus on the intricate process of integrating Tycho Brahe into the framework of the Jesuit authorities. In the early stage of this process, Jesuits strove to confine Tycho Brahe's influence to the realm of mathematics (chapter 7), but, as the seventeenth century progressed and Jesuit mathematicians became increasingly involved in the physical discussion of the structure and composition of the cosmos, they started to make use of Tychonic ideas on topics such as the celestial matter and fluidity. Nevertheless, as chapter 8 shows, they still explicitly avoided crediting Tycho Brahe and his correspondents with these new notions. Aligned with the Catholic Church's guidelines, issued by the Council of Trent, Jesuits strove to credit the early Church Fathers as the source of their theories.

Although deeply influenced by Tychonic cosmology and astronomy, chapter 9 shows nevertheless that Jesuit astronomers worked out a coherent cosmological view that, on the one hand, was fully consistent with the Catholic theology and, on the other hand, addressed some topics left unsolved by the Danish astronomer. This cosmological view proved quite influential not only among the mathematician community but also among the Jesuit philosophers. While historians have tended to emphasise the existence of strict disciplinary distinctions and different scholarly practices within the Jesuit Order, chapter 10 proves that, despite operating in different institutional settings, there was no divide between mathematicians and philosophers at the Lisbon College of Santo Antão.

The book finishes with a brief discussion of the impact that the ecclesiastic ban on Copernicanism had on Jesuit cosmological teaching (chapter 11). While Santo Antão's mathematics professors initially insisted that the Copernican system was mathematically sophisticated and useful but physically incongruent and potentially heretical in religious terms, by the middle of the seventeenth century, they did not avoid stating that "the system of Copernicus is not physically impossible".[19] Nevertheless, the ban on Copernicanism by the authorities of the Catholic Church remained an obstacle to elaborating further on heliocentric cosmologies as models that described the world.

Except for chapter 6, each chapter is followed by the transcription and translation of a relevant primary source discussed in the chapter. In part because these sources were written in Portuguese (for reasons discussed in chapter 2, the College of Santo Antão's mathematical class had the peculiarity of being taught in the Portuguese language), they have passed large-

19 Rishton, Curso de Mathematica, BNP, PBA. 54, f. 140*v*.

ly unnoticed in the mainstream historiography of early modern science. All the translations from Portuguese and Latin are my own.

2 Clavius's Astronomical Legacy in Lisbon

The Class on the Sphere

The Jesuit mathematician Christoph Grienberger (1561-1636), who was sent to Portugal at the close of the sixteenth century, was utterly disappointed with the Lisbon intellectual milieu.[1] Writing in 1601, a couple of years after his arrival, to the Jesuit leading mathematical authority, Christoph Clavius, whom he would eventually succeed in the Collegio Romano's mathematical chair roughly a decade later, he reported:

> There is no shortage of people in Lisbon, but studious men are lacking as well as schools. It would be astonishing indeed that mathematics could persist, wherein no other studies exist. Sailors are easily satisfied: not even a year-long course is needed. The noble's freedom is greater than their obligation to attend school. If [you consider] those who are more diligent and more devoted, they would hardly fill up the students' due number. Finally, you would scarcely persuade the Portuguese people unless you use the Portuguese language. Mathematics is regularly lectured neither in our college in Coimbra nor in that of Évora, and I believe, this is one reason, among others, why so few are attracted to mathematics.[2]

1 On Grienberger's scientific culture and practices, see Gorman, *The Scientific Counter-Revolution*, particularly 41-83.

2 "Non desunt Ulyssipone homines, sed desunt studiosi, sed desunt studia. et sane mirum foret continuari posse Mathematicam, ubi non sint alia studia. Nautis satisfit per paucis: nec opus est curriculo annuo. Nobilium maior est libertas quam ut ad scholas cogi possit. Si qui sunt diligentiores et curiosiores, ii vix debitum studiosorum numerum expleverint. Denique Lusitanis nisi Lusitane non facile persuaseris. Nostris ordinarie nec Conimbricae nec Eborae praelegitur Mathematica, et hanc puto esse unam causam inter alias quod pauciores appetunt

DOI 10.30687/978-886-969-661-9/002

Grienberger's account could hardly be more negative: a poor institutional framework, a lack of intellectual and social interest in mathematics and the absence of mathematical training at the University of Coimbra's College of Arts (*Colégio das Artes*) and the University of Évora, the Jesuit university institutions in Portugal.

This desolate scenario explained to a large extent why the ingenious Austrian Jesuit found himself in Lisbon. In 1574, King Sebastião, whose religious zeal, crusade fervour and political ambitions would drive him to wage war in Morocco and eventually to die in the so-called 'Battle of the Three Kings' (Battle of Alcácer Quibir, 1578), asked the Lisbon Jesuits to teach a class of mathematics at the College of Santo Antão.[3] It was a pressing matter. As the Counter-Reformation gained momentum in Portugal,[4] the ties between the political authority and the Society of Jesus were becoming increasingly strong. King João III (1502-57) authorised the College of Arts to be handed over to the Jesuits in 1555, and, four years later, in 1559, his brother, Cardinal Henrique (1512-80), backed the establishment of the University of Évora, granting the Jesuits the monopoly of university teaching on natural philosophy in Portugal. The launching of a mathematical class at the College of Santo Antão, where the offspring of the noble elite and Lisbon urban classes had been educated since the early 1550s,[5] was crucial in their quest for cultural hegemony over Portuguese society.

The Lisbon mathematical class was initially devoted to the teaching of nautical science. This subject was a critical issue for a country where the royal finances increasingly depended on colonial revenues. The chief cosmographer traditionally provided nautical training at the Armazéns da Guiné, Mina e Índia (Stores of Guinea, Mina and India), close to the Tagus River and the Casa da Índia (House of India), the cornerstone of the network of colonial trade institutions. At the Armazéns, he introduced the would-be nautical personnel to the foundations of the sphere and the use of nautical instruments and charts. The chief cosmographer was also responsible for assessing prospective pilots and validating instruments' and charts' accuracy before boarding.[6] Nevertheless, despite being taught for decades by the celebrated mathematician Pedro Nunes, who served as chief cosmographer between 1544 and 1578, the nautical course was reputedly defective and most likely not attended by most of the pilots.[7] This fact explains, in part, why Grienberger complained, in his correspondence to Clavius, that pilots would not even require a one-year course. Thus, when King Sebastião asked the Jesuits to establish a 'class on the sphere' in Lisbon, in 1574, they most

Mathematicam". Christoph Grienberger to Clavius, 24 March 1601, in Clavius, *Corrispondenza*, 4, 1: 138.

3 Lima, *História dos Mosteiros*, 397; Carvalho, *História do Ensino*, 378.

4 The reign of João III marked a strengthening of the Counter-Reformation movement in Portugal, with the establishment, for example, of the Inquisition (1536) and the Society of Jesus (1542). A sound and comprehensive account of the history of Portugal, in English, can be found in Disney, *A History of Portugal*; Marques, *History of Portugal*; Newitt, *Portugal*.

5 The College of Santo Antão was the first educational institution that Jesuits established in Portugal, in 1553, with the support of Cardinal Henrique. The grammar and humanistic studies started in the early 1550s. Later, theological and philosophical courses were included. Rodrigues, *História da Companhia de Jesus*, 1, 2: 290-1.

6 Luz, "Dois organismos de administração ultramarina"; Xavier, "The Casa da Índia".

7 Albuquerque, *Curso de História da Náutica*, 251-71.

likely perceived it as an opportunity to strengthen their influence over Portuguese politics and society.

Nevertheless, the Jesuit authorities had to circumvent a major difficulty. As Grienberger reminded us, there was no proper training in mathematics at the Jesuit university institutions in Portugal. Being a transnational institution, the Society of Jesus found the solution elsewhere in its network of European colleges. As a result, foreign Jesuit mathematicians were sent to Lisbon to teach the Class on the Sphere. For several decades, most of these professors indeed came from other European colleges. Christoph Grienberger was the first and one of the foremost foreign professors to teach mathematics in Lisbon. The selection criteria of these teachers changed over the last decade of the sixteenth century and the first half of the seventeenth century, the time interval under analysis in this book. In the beginning, the mathematics professors of Santo Antão College were selected preferably amongst the closest collaborators of Clavius at the Roman College. When this was not possible, a Portuguese substitute was temporarily assigned. By the 1620s, the professors appointed to teach mathematics in Lisbon were Jesuit missionaries moving to or from Asia. Finally, preference was given to British exiles, who, upon graduating from continental colleges, moved to Lisbon to teach the Class on the Sphere.

Even though these foreign mathematicians probably did not cross paths at the College of Santo Antão, they were most likely aware of the scientific content of their predecessors' teaching. Cristoforo Borri, for example, in a letter sent to the General of the Jesuits, Mutio Vitelleschi, revealed that, once he had landed in Lisbon, he learned that Gall, who was then the Professor of Astronomy in Lisbon, was already teaching the theory of celestial fluidity, which he had defended at the College of Brera in 1612.[8] From this point of view, they constituted a scholarly community.

As the historian of science Luís de Albuquerque pointed out in his seminal article on this institution, the first professors of Santo Antão College closely followed the syllabus delineated by the chief cosmographer, albeit in further detail. They tackled the issues included in the nautical regiments, such as cosmography, nautical astronomy, navigation, construction and the applications of nautical and astronomical instruments. Nevertheless, as the seventeenth century progressed, Santo Antão's mathematics professors increasingly delved into more theoretical subjects, like cosmology.[9] They taught the course in Portuguese. Lembo justified the use of this language with the Portuguese audience's lack of motivation. Nevertheless, the fact that the lectures were intended for seamen, who did not know Latin, explains the preference for Portuguese as the teaching language.[10]

The first mathematical course to be delivered at the College of Santo Antão most likely started in the autumn of 1590. The professor was the Portuguese João Delgado (c. 1553-1612), whom Ugo Baldini considered "the true

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8 Cf. Borri, *Al molto Reu. Pre. Generale*, ANTT, Armário dos Jesuítas, XIX, f. 315*r*.

9 Albuquerque, "A 'Aula da Esfera'", 537-8.

10 An introductory study of the Class on the Sphere can be found in Leitão, *A Ciência na "Aula da Esfera"*. For further details, see Albuquerque, "A 'Aula da Esfera'"; Baldini, "L'insegnamento della matematica"; "The Teaching of Mathematics". An analysis in English of the context in which mathematics was taught in early modern Portugal is provided by Leitão, "Jesuit Mathematical Practice".

initiator of a mathematical tradition amongst the Portuguese Jesuits".[11] Born in Lagos, in Southern Portugal, he joined the Society of Jesus around 1574. A few years later, Delgado moved to Rome, where he studied theology and, more importantly, attended the mathematics academy directed by Clavius at the Collegio Romano. Back in Portugal, he taught mathematics in Coimbra before heading for Lisbon and being engaged in the Class on the Sphere.[12]

The attendance at Clavius's academy proved to be quite influential for Delgado and the newly established Jesuit "mathematical tradition" in Portugal. When Delgado arrived in Rome, Clavius was preparing the second edition of his influential *Commentarius in sphaeram Ioannis de Sacro Bosco* (1581), in which he exposed the foundations of his cosmology.[13]

Clavius was a committed advocate of the idea of celestial solidity. This was – he maintained – the only notion that could account for the Aristotelian principle according to which celestial bodies perform a sort of unidirectional, uniform and regular motion. In fact, following the Ptolemaic astronomical tradition, Clavius argued that the unidirectionality of celestial bodies required the existence of a complex system of solid celestial orbs comprising several epicycles and eccentric circles. This notion shaped Clavius's understanding of the celestial architecture and the dynamics of celestial bodies.

First, the astronomical evidence pointed unequivocally to the existence of such a complex architecture of eccentric circles and epicycles. Thus, for example, the fact that planets were observed nearer and farther away from the Earth demonstrated that they moved with eccentric circles. The same held true with regard to observations not only of how the Sun moved irregularly over the centre of the Earth and the universe but also of the changes in the dimensions of the Moon, Mercury and Venus, which were deemed to occur in accordance with the variations in the distances that they reached from the Earth's centre. The variation in altitude, the distance from the Earth and the velocity of all the planets, except for the Sun, together pointed to the existence of epicycles. The differences in solar and lunar eclipses were also put forward as evidence that the planets moved in epicycles and eccentric circles.[14]

Additionally, this system of solid epicycles and eccentric circles not only accounted for the apparent changes in velocity, direction and distances of the planets but also, according to Clavius, constituted the only possible means of fully respecting Aristotle's dictum that celestial bodies performed one single, circular and Earth-centred motion without simultaneously violating the astronomical evidence.[15] This argument was crucial at that time.

11 "Il vero iniziatore di una tradizione matematica tra i gesuiti portoghesi" (Baldini, "L'insegnamento della matematica", 281).

12 Delgado alternated the teaching of mathematics with his students Francisco da Costa and Christoph Grienberger (and occasionally António Leitão). For biographical details of Delgado, see Baldini, "L'insegnamento della matematica", 281-2.

13 Comparing it with the first edition dated 1570, in the second edition of his *Commentarius*, Clavius went into much further detail on cosmology. For a broad view on Clavius's astronomical ideas, see, above all, Lattis, *Between Copernicus and Galileo*. A very detailed and insightful analysis of the intellectual environment of the Collegio Romano during the period in which Clavius produced his *Commentarius* is presented in Corrado Dollo, "Le ragioni de geocentrismo".

14 Clavius, *In sphaeram* (1581), 418-31.

15 Furthermore, as Lattis has already stressed, Clavius's argument was also probably meant to address the sceptical views of his colleague at the Collegio Romano, Benedito Pereira, according to which astronomy was incapable of dealing with celestial phenomena. Pereira argued

In the sixteenth century, a group of astronomers, which included Girolamo Fracastoro and Giovanni Battista Amico, had invoked the Aristotelian dictum to put forward alternative homocentric cosmological models. These authors claimed that only these homocentric models could respect the principle according to which the heavens experienced one single circular motion around a unique cosmic centre.[16] From an Aristotelian-Ptolemaic point of view, the proponents of homocentric cosmology were probably the most severe contenders whom Clavius had to face as he began preparing his *Commentarius in sphaeram Ioannis de Sacro Bosco*, the first edition of which was published in 1570.[17]

Clavius recognised that "no physical body can be moved simultaneously with opposite and contrary motions".[18] Nevertheless, he refused to accept the view supported by the champions of homocentric theories according to which planets moving in eccentric circles and epicycles necessarily resulted in a set of contrary and non-uniform motions. According to Clavius, a contrary motion "should be judged by reference to one and the same fixed point so that it is clear that, through a certain motion, one approaches that point and, through another motion, one moves away from it".[19] This experience does not occur by any means with celestial bodies as the two basic motions displayed by the planets, a daily movement from East to West and a proper motion from West to East, at different velocities, featured different reference points while moving around a different axis. Whereas the *Primum mobile* (prime mover) drove the sphere of fixed stars, and subsequently the celestial orbs below it, to move westwards through the poles of the world, each orb was attributed a particular motion running from West to East through the poles of the zodiac.[20] As the references as well as the axis of these two motions were different, Clavius argued, they should not therefore be understood, properly speaking, as contrary motions.

The solid spheres played a crucial role in this entire argument. They accounted for the apparently contrary and diverse motions of the planets. Their own spheres pushed a certain celestial body in one direction even while this celestial body was simultaneously influenced by the motion of another sphere that also comprised it. From this point of view, each orb was responsible for a singular motion displayed by the celestial bodies. Since the fixed stars additionally displayed two sorts of celestial orb movements, the trepidation or oscillation movement and the precession of the equinoxes, Clavius added two spheres to this compound system of orbs, below the *Primum mobile*, to account for those movements.

The Aristotelian dictum on the unidirectional, uniform and regular motion of the celestial bodies thus led Clavius to argue in favour of the exist-

that since astronomers had no proper knowledge of the nature of celestial matter, they could not discuss the causes of celestial movements and therefore put forward notions such as epicycles and eccentrics. See Lattis, *Between Copernicus and Galileo*, 109.

16 See, among others, Peruzzi, *La Nave di Ermete* and Di Bono, *Le Sfere Omocentriche*.

17 From his perspective, the homocentric systems did not account for the astronomical evidence. See Lattis, *Between Copernicus and Galileo*, 91-4.

18 Clavius, *In sphaeram* (1581), 42: "Nullum enim corpus potest simul eodem tempore moueri oppositis, et contrariis motibus".

19 Clavius, *In sphaeram* (1581), 54: "Contrarij namque motus referri debent ad vnum idemque punctum fixum, vt videlicet vno motu ad illud punctum accedatur, et alio ab eodem recedatur".

20 Clavius, *In sphaeram* (1581), 52.

ence of a complex system of solid orbs. Furthermore, this moulded Clavius's understanding of celestial dynamics. The need to explain the apparently contradictory motion of celestial bodies was indeed the ultimate reason for Clavius refuting the notion that heavenly bodies moved on their own account, like birds in the air or fishes in the water. If such were the case, the planets would not move with two apparent motions; they would merely move in one direction.[21] Celestial bodies must therefore be correspondingly imbedded within the celestial spheres responsible for their complex movements.[22]

Clavius's reasoning in favour of celestial solidity would probably not have appeared particularly convincing to the advocates of homocentric cosmology. Clavius's endorsement of the notion of eccentric planetary motion presupposed that the Earth was not, properly speaking, the centre of planetary motion. Thus, from the theoretical point of view, the planetary bodies moved uniformly in a circle around some point other than the centre of the universe. Nevertheless, from the perspective of an observer placed on the Earth's surface, they would seem to perform a non-uniform motion, with cyclical changes occurring in the distances, speed and directions of the planets.

Clavius dealt with this criticism by putting forward the notion of the *sphaera tota*, a single complete celestial sphere that was deemed to comprise all the existing partial spheres. Each of these partial orbs accounted for individual motions. He thus stated:

> Since it is actually impossible, according to the decrees of Aristotle and the philosophers, that several motions be contained in the very same celestial orb, as it is a simple body, [astronomers] are constrained to attribute several partial orbs to every singular sphere, from which the complete sphere is composed. The root of the irregularity of those appearances can hence be explained by the multitude of the motions of those orbs. The more diverse movement of a planet is observed, the higher number of movements and orbs should be attributed to its place.[23]

By introducing this notion of the *sphaera tota*, Clavius succeeded in respecting the Aristotelian dictum according to which celestial bodies performed a single, circular and Earth-centred motion and, simultaneously, maintaining consistency with the traditional astronomical evidence. Celestial solidity was nevertheless a physical requirement.

According to the last version presented by Clavius, the universe comprised thirty-three partial orbs, twenty-seven moving around the Earth plus six epicycles.[24] These partial spheres were then encompassed within twelve complete spheres, the inner and outer surfaces of which were actually con-

21 Clavius, *In sphaeram* (1581), 46-7.

22 Clavius, *In sphaeram* (1581), 73-4.

23 Clavius, *In sphaeram* (1581), 419: "Quoniam vero impossibile est, secundum decreta Aristotelis, et philosophorum, vni et eidem orbi caelesti, cum sit corpus simplex, plures inesse motus; coacti sunt singulis planetarum sphaeris plures assignare orbes partiales, ex quibus tota sphaera componatur, vt ex multitudine motuum horum orbium causas apparentis illius irregularitatis possent explicare. Vnde quo motus alicuius planetae magis varius apparebat, eo etiam plures illi motus, atque orbes tribuendi erant".

24 Clavius, *Opera mathematica*. Vol. 3, *In sphaeram* (1611), 300.

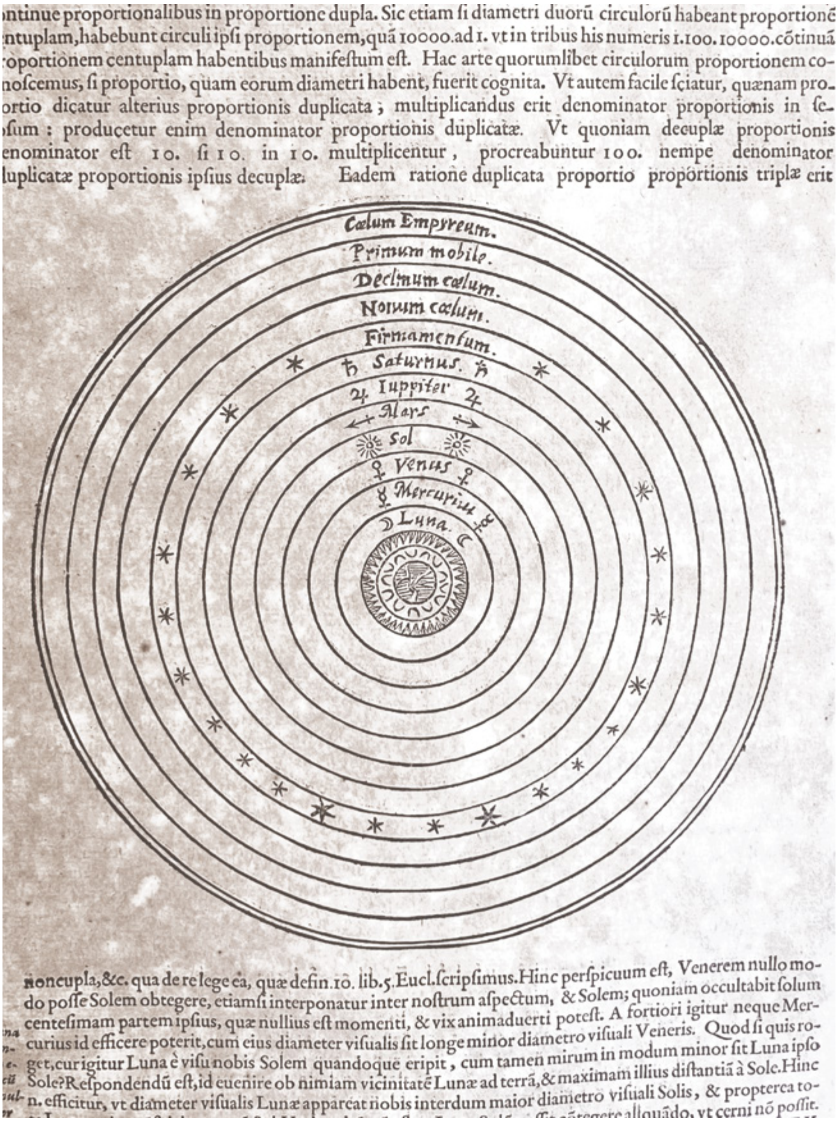

Figure 1 The geocentric system according to Clavius (*Opera mathematica*. Vol. 3, *In sphaeram* [1611], 46, BNP, Res. 3152 A)

centric with the universe.[25] Clavius attributed one sphere to each planet (in the following order: the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn), with one sphere for the Firmament, the heaven of fixed stars. Nevertheless, as already mentioned, the German Jesuit recognised the existence of further orbs that accounted for the motions of trepidation or oscillation and precession of the equinoxes exhibited by the fixed stars. In the 1593 edition of his *Commentarius*, due to the influence of the astronomer Giovanni Antonio Magini (1555-1617),[26] Clavius recognised, in keeping with Copernicus, that the Firmament displayed four motions.[27] Apart from the daily movement, it performed two librational motions and one precessional motion. This assumption led Clavius to recognise that the precessional motion was due to the Firmament. He included two extra spheres above it to account for the two oscillatory movements.[28] Beyond these spheres was placed the eleventh sphere, the *Primum mobile* (First mover), responsible for the diurnal westward motion of the fixed stars over each twenty-four-hour period. The Empyrean heaven sealed the universe by making up twelve complete solid orbs **[fig. 1]**.

Upon returning from Rome, João Delgado introduced his Portuguese students to these cosmological tenets. Although not an uncritical reader of Clavius,[29] Delgado shared his ideas on celestial architecture and the dynamics of heavenly bodies. Before entering into details on the *theorica planetarum*, Delgado addressed the issue in his lectures on the sphere. In a chapter entitled "Whether There Are only One or Several Heavens", he recognised that the complexity of celestial motions required the celestial region to be fractionated into several heavens or spheres.[30] As planets dis-

25 While preparing the second edition of his *Commentarius*, Clavius adopted the Alfonsine system of ten orbs (eleven with the Empyrean heaven). This was the certainly the view with which Delgado was acquainted in Rome. Nevertheless, as already mentioned, in the 1593 edition of the *Commentarius*, Clavius introduced one more sphere, corresponding to the eleven spheres which Magini included in his *Novae coelestium orbium theoricae congruentes cum observationibus Nicolai Copernici* (Venetia: ex officina Damiani Zenarii, 1589).

26 Magini's influence on Clavius has already been pointed out by Lerner, "L'entrée de Tycho Brahe", 150-1.

27 Clavius, *In sphaeram* (1593), 77.

28 Clavius, *In sphaeram* (1593), 76-7.

29 For example, while approaching the celebrated *Quaestio de certitudine mathematicarum*, in the mathematical course that he taught at the College of Santo Antão in 1605-6, Delgado did not follow the line of reasoning established by Clavius to argue in favour of the scientific nature of mathematical sciences. Inspired by a Platonic-oriented outlook, while approaching the classification of sciences in the prologue to his *Euclidis Elementorum Libri* (Cologne: expensis Joh. Baptistae Ciotti, 1591, 5), Clavius held that mathematics should be placed above natural science, because the former takes quantities abstracted from the physical sensible realm into account. Thus, he considered the superior character of mathematics to reside in the excellence of mathematical entities. This Platonic-oriented position was also shared by his pupil, Grienberger; see Gorman, "Mathematics and Modesty", 33-8, 50-1. Delgado's approach to the scientific character of mathematics was instead carried out within the Aristotelian framework. According to Delgado, mathematics should be considered as an Aristotelian science as it was successful in establishing knowledge based upon the proper and true causes of its subject matter. From his point of view, these causes included not only physical causes, but also "causes with no physical motion and existence" (Delgado, Esphera do Mundo, BPMP 664, ff. 42*r*-43*r*). Hence, mathematicians made use of formal, material, efficient and, in a certain way, final causes in their demonstrations. On Delgado's Aristotelian defence of the scientific nature of mathematics, see Carolino, "João Delgado SJ".

30 Delgado, *Esphera do Mundo*, BPMP, MS 664, f. 52*v*; Delgado, *Sphera do Mundo*, BACL, MS SV 491, ff. 22*v*-23*r*.

played contrary motions and stars always kept the same distances among themselves, it should not be conceded – according to the Portuguese Jesuit – that celestial bodies moved "by themselves as fishes in water and birds in the air". Thus, as Delgado argued, along the lines of Clavius, the celestial bodies should "move embedded in the skies as their denser parts in the way of the knots in a wooden table".[31] As his master did previously in Rome, the Portuguese Jesuit laid the foundations of his cosmology on the principle of celestial solidity.

Unsurprisingly, Delgado introduced his students to the same worldview that Clavius exposed from the 1593 edition of his *Commentarius* onwards, a universe that comprised twelve spheres concentric with the universe.[32] As the Portuguese Jesuit explained:

> There are twelve [heavens], the highest and immobile is the Empyrean heaven; below it, in the direction of the centre of the world, [comes] the first mobile; then, the tenth sphere, with the movement of the solstices; after it, the ninth heaven, with the movement of the equinoxes; below the ninth [sphere], there is the eighth, the so-called Firmament or heaven of the fixed stars. The seven planets, each one with its heaven, follow according to this order: Saturn in the seventh, Jupiter in the sixth, Mars in the fifth, the Sun in the fourth, Venus in the third, Mercury in the second, and finally, the first heaven, closest to the Earth, [there is] the Moon.[33]

Differently from the terrestrial region, where interminable processes of coming to be and passing away occur ceaselessly, the celestial region was described by Delgado as being perfect, provided only with quintessential qualities: "variations in the heavens are all perfect, like being illuminated, coloured, etc.: no destructive changes take place [there]".[34]

31 Delgado, *Esphera do Mundo*, BPMP, MS 664, f. 53*v*: "[as estrelas e os planetas] se mouem fixas no[s] Ceos como partes suas mais densas à maneira dos nós das taboas".

32 Delgado explicitly mentioned this edition in *Esphera do Mundo*, BPMP, MS 664, f. 65*r*.

33 Delgado, *Esphera do Mundo*, BPMP, MS 664, f. 35*r*: "São 12 [céus], ho mais alto e immouel he o ceo impirio, apos elle pera o centro do mundo o primeiro mouel, logo a decima esphera com o mouimento dos solstitios, apos este o nono ceo com o mouimento dos esquinoctios, abaixo do 9 esta o 8 chamado firmamento ou ceo das estrellas fixas: seguem se por esta ordem os 7 Planetas cada hum com seu ceo, Saturno no 7, Jupiter no 6, Marte no 5, Sol no 4, Venus no 3, Mercurio no 2, e no ultimo lugar o 1 ceo a lua mais vezinha da terra".

34 Delgado, *Esphera do Mundo*, BPMP, MS 664, f. 35*v*: "As alteraçoens do ceo todas são perfeitiuas, como ser alumiado, colorado et caetera: destrutiuas não tem nenhumas alterações".

Document I

Questão 3a, Se o Ceo he hum só, ou são muitos Ceos. João Delgado, *Esphera do Mundo*, BPMP, MS 664, ff. 50*v*-53*v*

Ainda que aos Astrologos pertença diretamente tratar sómente dos Ceos que se mouem: contudo não deixa de ser de sua profissão saberem se sobre estes há algum outro Ceo immouel, e se influe per uentura nas cousas inferiores sua uertude ou não. He opinião commua dos Theologos escolasticos com os mestres das sentenças Niculao de Lyra, Tostado, Chaterino, e antes destes mais de 900 annos Deberda [de Beda], e depois Alcinou Rabano, Estrabão, Basilio, que sobre todos os ceos mouentes no numero [f. 50*v*] em que concordarem os Astrologos, ha hum ceo immouel, do qual falou Moyses quando ao principio do mundo disse, que criara Deos o ceo e a terra, e desse dizem que fala a sagrada escriptura, quando lhe chama ceos dos ceos, como no psalmo 113 e 148 ao qual quer Sam João Damasceno que fosse arrebatado Sam Paulo, quando na epistola segunda ad Corinthios diz, que foi [a]té o terceiro ceo, entendendo pelo primeiro quanto ha da superficie da terra [a]té ao concauo da Lua que chamão ceo Aerio, e pelo segundo todos os ceos mouentes [a]té o concauo do mesmo ceo impyrio e immouel, que a todos uençe em grandura e excellencia da qualidade, como lugar que Deos fez ao modo de seus paços reaes e corte dos Anjos e bemauenturados, pera nelle se lhes mostrar manifestamente e ser sua morada pera todo sempre: e o nome Empyrio não denota nelle natureza de fogo, senão uehemencia de resplandor e claridade, posto que dos olhos mortaes não se ueia, como tambem não se ue o elemento do fogo muito mais somenos que os philosophos poem no concauo da Lua, Alberto Magno na sua philosophia pequena proua que o ha, porem mais theologi[c]a que philosophicamente Francisco Titelmano diz que he fé catholica auelo no seu compedio natural, e que o criou Deus no principio do mundo logo com milhares de Anjos, cuio lugar elle fosse, como o Ar he das aues, e o mar dos peixes, e a terra dos corpos mixtos: e pelo menos seria grande temeridade negualo. Aiunta Titelmano que he plano, deuemos de entender de superficies planas pela parte de cima e pela concaua redondo, na qual como em lugar se reuolue a conuexa do ultimo ceo mouel. Alguns pretenderão mostrar philosophicamente que auia esse ceo immouel, porque segundo Plinio diz no livro 8º, capítulo 16, em Europa entre o rio Achelso e neste se crião huns lynces mais fortes [f. 51*r*] que os de Aphrica e de Syria, a que não podendo causarse dos ceos mouentes, porque assi em toda aquella corda ou parallelo se geraria he sinal que por influencia particular do ceo immouel, que alli se comonica: e o mesmo argumento dos caualos ligeirissimos e fortissimos, que nascem em Umgria em altura de 47 graos de polo, e em nenhuma outra parte da mesma altura, item, outras aues e animaes, plantas e fruitas, que se dão em lugares particulares e outras não, mas desta uirtude o ceo empyreo, com que o fazem: a causa de certos effeitos ueremos ao principio da Astrologia pratica. Concluamos por hora com dizer que Agostinho Eugobinho na sua cosmopeia teue pera si ser esse ceo Empyrio eterno e incriado e luz ou claridade, que mana da essencia do mesmo Deos, como refere e confuta asperamente no primeiro liuro Bento Pereira sobre os Genesis.

Falando dos ceos mouentes a primeira openião he dos que dizem não auer mais que hum só ceo, e podese prouar deste modo. Primeiramente Aristoteles no liuro 1 dos centauros [*sic*, Meteoros] capítulo 2 diz que pera os ceos terem acão e influencia nas cousas inferiores, he necessario que seião todas huma causa continua, logo etc [é um só céu].

Segundo, se nos ceos ha distincão seguirsehia, que quando hum se moue, não leuaria os outros consigo, como acontece entre quaisquer corpos distintos em sustancia e em uirtude motiua: e todauia nos uemos que quando os ceos se mouem tudo uai iunto desda Lua [a]té o firmamento nem temos outro sentido, com que possamos philosophar dos ceos senão o da uista, logo etc [é um só céu]. [f. 51*v*]

Terceiro argumento, se ha mais de hum só ceo, ou a superficia que aparta quaisquer dous, he huma só, ou são diuersas superficias: se huma só, serão hum continuo e hum ceo só (como quer esta opinião) porque os continuos são aquelles cuia superficia he huma só. Se sam superficias diuersas em cada huma sua: pregunto ou ellas são entre si iguaes ou desiguaes: iguaes não podem ser, porque sendo o ceo deçimo maior que o debaixo, necessariamente terá maior a sua superficia pela primeira definição do liuro 3º de Euclides, assi como tem maior o diametro: nem tão pouco podem ser desiguais, porque sendo hum lugar do outro necessariamente hai aonde se aiuntão hão de ser o locante e o locado iguaes, como querem os philosophos no liuro 4º dos physicos, logo etc [é um só céu].

Desta opinião, que foy de alguns antiguos e de alguns modernos, que sem aiuda do discurso creem simplesmente, o que lhes representão os sentidos, não se admite: e para satisfasermos as suas rezões, disemos à primeira [razão] com Scoto que nos ceos podemos considerar duas causas, huma he o lume, outra he a sustancia, segundo o lume são todos hum continuo: porque o lume assi se diffunde per todos os ceos, como uemos diffundirse pelo Ar e pella Agoa. E deste modo se ha de entender Aristoteles no lugar citado, ou que conuem serem hum continuo ou de modo que entre elles não haia uacuo ou algum outro corpo de naturesa contraria. Segundo as sustancias são os ceos diuersos ou tambem hum não per continuidade [f. 52*r*] senão per contiguidade, que he serem muitos e não hum só.

Ao segundo argumento se responde da mesma maneira que o sentido da uista iunto com alguma consideracão, uendo que os ceos tem diuersos mouimentos: e a nosso modo de iulgar para partes contrarias, como mostrão manifestamente os Planetas, e sendo o inconueniente (como depois diremos) moueremse como aues no Ar per si sós, ou como peixes nagoa necessariamente hão de auer tais mouimentos, hauemos de dar distincão de ceos, de modo que de tal maneira uai tudo iunto que tambem cada hum tem seu mouimento per si diuerso.

Ao terceiro [argumento] dissemos que as superficias de quaisquer dous ceos são contiguas e diuersas: e a pregunta he se são iguaes ou desiguaes. Respondo que são desiguaes porque não he necessario que o lugar e o locado seião iguaes, senão quanto a continencia conuem a saber que as partes do que esta no lugar respondão proporcionalmente as partes do mesmo lugar, não considerando as corpulencias ou grossuras, nem quaisquer outros accidentes assi do locante, como do locado: e se fizerem instancia deste modo imaginemos que uai huma linha do meio do mundo [a]té o concauo de algum orbe superior. Pregunto o ponto que toca este concauo he o mesmo com o ponto ultimo da superficie conuexa do inferior ou são diuersos: se he o mesmo farão hum corpo continuo e não muitos, se são diuersos como não possão ser immediatos, auerá entre elles distancia ou distinsão, entre o qual pello primeiro postulado se pode lançar huma linha, e porque a linha não esta naturalmente sem superficie, nem está sem corpo, auerá entre hum ceo e outro algum corpo, que ou seia celeste, ou elemental, ou se adimitirá uacuo, o que tudo parece inconueniente, logo não ha mais que hum só ceo. [f. 52*v*] Respondo que as superficias e pontos dos dous ceos são immediatos, nem he absurdo que o seião superficias e pontos terminatiuos de dous corpos distinctos, o absurdo fora, como se proua no 6º [livro] dos physicos dous pontos como se pusera continuatiuos, ou duas superficias immediatas no mesmo corpo. Respondo segundo com Scoto, que Euclides entende poderse lançar huma linha entre dous pontos, quando os tais pontos estão no tal corpo, como no Ar ou na agoa ambos, porem em diuersos corpos não, porque aqui podem ser os pontos immediatos e não deixarem lugar pera se lançar linha. A rezão he porque do aiuntamento de dous pontos no mesmo corpo logo nasce união e continuidade e não do aiuntamento de dous pontos em diuersos corpos, e assi dois pontos de diuersos corpos podem estar iuntos, ficando todauia dois se[m] se unirem hum com outro.

A segunda openião seia dos que poem mais de hum ceo em que ha muita uariedade e porque quasi todos se fundão pera porem huns mais e outros menos no numero dos mouimentos que no[s] ceos considerão: comprenderemos nesta questão para não repetirmos o mesmo iuntamente com o numero do ceo a espiculação do[s] seus mouimentos. Auertindo primeiro que os que admitem hum só ceo quasi todos lhe negão o mouimento disendo huns que sempre perseruerão no mesmo [f. 53*r*] lugar mas que nos parece a nos mouerse de Oriente pera Occidente per amor do mouimento da terra, que consigo nos leua de Oriente para Occidente [*sic*, de Ocidente para Oriente] com muita uelocidade dando em espaco de 24 horas huma uolta enteira como acontece aos que uão ao longo do rio no barco e cuidão mouersemse as aruores e sinais da terra pera a parte contraria donde o barco os leua: mas claramente se enganão porque [além] de outros inconuenientes, que contra este e contra os tres mouimentos da terra de Copernico no capítulo 11 do primeiro liuro, aponta Ptolemeu no 7º capítulo da primeira [edição ?] do Almagesto, diuirão os Planetas guardar entre si sempre as mesmas distancias e nos experimentamos o contrario manifestamente, pelo menos nas coniuncões, quadraturas e opposicões do Sol e da Lua: outros dizem que os ceos e a terra estão immoues, porem que as estrellas com os planetas se mouem per si, como peixes na agoa e aues no ar. Estes ainda que não tam grossamente como os primeiros tambem se enganão porque deste modo contra a opinião dos mais Astrologos não poderião se mouerse as estrellas e Planetas ao mesmo tempo com dous mouimentos diuersos pera Oriente e [para] Occidente, como uemos que se mouem alem das rezões que ha para disermos que se mouem fixas no[s] ceos como partes suas mais densas à maneira de nós das taboas e não como no mar os peixes. [f. 53*v*]

Document I

English translation. Third question: whether there are only one or several heavens. João Delgado, *Esphera do Mundo*, BPMP, MS 664, ff. 50*v*-53*v*

Although astrologers are directly concerned with the study of the heavens that move, it is still their business to know whether there is some other immobile heaven above them and whether it exerts some influence over the inferior bodies through its virtue. It is the common opinion of the scholastic theologians, such as the masters of sentences Nicholas of Lyra, Tostado, Chaterino, and over 900 years before them, Beda, and then Alcinou Rabano, Strabo and Basil, that above all the moving heavens, in the number [f. 50*v*] ascribed to them by the astrologers, there is one immobile heaven, about which Moses spoke when he said that God created the Heaven and the Earth at the beginning of the world. The Holy Scripture is said to mean this immobile heaven when it refers to the Heaven of heavens, in Psalms 113 and 148. In the second epistle ad Corinthians, Damascene argues that Saint Paul was carried up to this heaven, when he asserts that this saint was raised to the third heaven, understanding the first heaven as the space from the surface of the Earth to the concave of the heaven of the moon, which is named the airy heaven (*céu aéreo*), and the second heaven as the space that comprised the mobile heavens up to the concave of the Empyrean and immobile heaven. This heaven – the Empyrean – is the place that God created as His royal palace and the court of the angels and blessed, where He constantly shows Himself to them, to be their dwelling place forever and ever, surpassing everything in dimension and excellence. The name Empyrean does not indicate in it the nature of fire but its extreme brightness and clarity. Even though one sees it neither through our mortal eyes nor the element of fire that philosophers put below the concave of the moon, in his short philosophy, Albert the Great proves that this heaven exists. Francis Titelmans argues, in his natural philosophical compendium, more theologically than philosophically, that it is a principle of the Catholic faith to maintain the existence of this heaven and its creation by God at the beginning of the world, together with thousands of angels, whose natural place is this heaven, as the air is to the birds, the sea to the fishes and the Earth to the mixed bodies. It would be, at least, a great temerity to deny it. Titelmans also adds that this heaven is flat, meaning that it has flat surfaces on the top and round surfaces on the concave part, under which the convex of the upper mobile heaven revolves. Some authors strove to show, from a philosophical standpoint, the existence of this immobile heaven, because, according to Pliny, in book 8, chapter 16, some lynxes stronger than those of Africa and Syria are created in Europe between the river Achelso [?] and the river Neste [?]. [f. 51*r*] Since it could not be caused by the mobile heavens because, if it were the case, those animals would be generated in all places with the same latitude. The creation of those lynxes is due to the particular influence of this immobile heaven, whose influx is operative there. The same kind of argument applies to the fast and strong horses that are born only in Hungary at 47 degrees of latitude of the pole, and not in other places with the same latitude; the same holds true for other birds and animals, plants, and fruits, which occur in some specific places and not in others. They are produced by the Empyrean heaven through its virtue. We shall analyse the cause of certain effects at the beginning of practical Astrology. Let us conclude now by saying that Augustine Eugubinus, in his *Cosmopeia*, holds the idea that the Empyrean heaven is eternal, uncreated and itself is a light or clarity that emanates from the essence of the very same God, as Benedito Pereira refers and roughly contends in the first book on *Genesis*.

As far as the mobile heavens are concerned, the first opinion holds that there is but one heaven. It can be proved as follows. First, in book 1 of the centaurs [*sic*, Meteors] chapter 2, Aristotle argues that for the heavens to have action and influence over the terrestrial bodies, it is necessary that they constitute one single and continuous cause, therefore etc. [there is one heaven only].

Second, if some distinction were to be found in the heavens, it would follow that when one sphere moved, it would not take the other spheres with it, as happens between bodies different in substance and movement virtue (*virtude motiva*). Yet, we observe that when the heavens move, everything moves together from the Moon to the Firmament. We have no other way to philosophise about the heavens than that of the sight, therefore etc. [there is one heaven only]. [f. 51*v*]

The third argument claims that if there is more than one heaven, the surface area separating the two heavens is either one or several. If it is one surface area, there will be only one continuous heaven (as this opinion holds) because continuous bodies are those whose surface area is one. If there are several surfaces, each heaven has its own. In this case, I question whether those surface areas are equal or unequal. They cannot be equal because, being the tenth heaven larger than everything that is underneath it, its surface area will necessarily be larger as – according to the first definition of Book 3 of Euclid – it has a larger diameter. Nevertheless, they cannot be unequal either, because being one, the place of the other, they must be equal at the point where they touch, as the philosophers maintained in the fourth book of *Physics*, therefore, etc. [there is one heaven only].

This opinion advocated by some ancient and modern authors, who without good arguments simply believe in what their senses show them, cannot be accepted. As far as the arguments are concerned, we answer to the first reason [presented by those authors], claiming, with Scotus, that we can attribute two causes to the heavens: one is light (*lume*, i.e. 'fire'), the other is substance. According to light, everything is a continuum, for light diffuses through the whole heavens just as we see it diffusing through air and water. This is the right way Aristotle should be understood when he mentioned – in the place mentioned above – that there must be a continuum [in the celestial region] so that there will be neither vacuum nor any other body of a contrary nature between the spheres. According to the substances, the heavens are diverse and not one body, not through continuity [f. 52*r*] but through contiguity, meaning several and not one heaven.

The second argument is answered likewise with recourse to the sense of sight. We see that the heavens have distinct movements and – according to our judgement – in opposite directions, as the planets clearly show. The planetary movements must necessarily occur because it is inconvenient (for reasons we will discuss later) that the planets move on their own, like birds in the air or fishes in the water. [Therefore] we shall distinguish the heavens so that they can all move simultaneously, keeping each one [at the same time] its proper movement, which is different from the movement displayed by the other planets.

To the third [argument], we answer that the surface area of any two heavens is contiguous and diverse. The question is whether they are equal or unequal. I answer that they are unequal because both surfaces do not have to be alike. As far as the point of contact is concerned, the parts of one surface area must correspond proportionally to the sections of the same place on the opposite surface area, ignoring the bodies, dimensions, or any other accidents. If you want a demonstration of this argument [see the following reasoning]: let us imagine that a line is drawn from the centre of the world up to the concave surface of some superior orb. I wonder if the point wherein the line touches this concave surface is the same as that of the convex surface of the inferior sphere or is different. If it is the same, these heavens shall be not several but one continuous body. If the points of the concave and convex surfaces differ, as they cannot be contiguous, there will be space distance or distinction between them, through which – according to the first postulate – a line can be drawn. Nevertheless, since this line can be drawn with neither a surface area nor a body, there must be some physical body (celestial or elemental) between the heavens. Otherwise, one would have to admit the existence of a vacuum, which seems highly inconvenient. Therefore, there is but one single heaven. [f. 52*v*] I answer [to this argument] that the surface area and points of two heavens are contiguous. It is not absurd that these coexist as the surface areas and ending points of two distinct bodies, as proved in the 6th [book] of *Physics*. Nevertheless, it would require that two continuous points or two contiguous surface areas were found in the very same body. I answer secondly, with Scotus, that according to Euclid, a line can be drawn between two points when such points are both in the same body, as in the air or water. Yet, it is not possible if those points are found in different bodies because, in this case, they could be contiguous and, therefore, there would be no room to cast a line. The reason is that the union and continuity stem from the connection of two points of the same body and not from the link of two points of different bodies. Thus, two points belonging to different bodies can actually be together, yet, without being united with each other in the same body.

The second opinion holds that there is more than one heaven with great variety. Since almost everyone establishes a connection between the number of heavenly movements and the number of heavens, we shall address this question to avoid mingling the discussion on the number of heavens with the speculation of their motions. First, it should be emphasised that almost all who admit the existence of one single heaven deny that it moves. Some maintained that the heavens always keep the same [f. 53*r*] place. Nevertheless, it seems that they move from East to West because of the movement of the Earth, which takes us with its motion from East to West [*sic*, West to East] with great speed, producing an entire revolution in 24 hours. Something similar is experienced by those who go down the river in a boat and believe that the trees and landmarks move in the opposite direction. But they are clearly mistaken because, [besides] other difficulties, which Ptolemy (in chapter 7 of the first lection [?] of his *Almagest*) raises against this and the other three movements attributed to the Earth by Copernicus (in chapter 11 of the first book [of *On the Revolutions*]), the planets should always keep the same distance between them. Nevertheless, we clearly observe the opposite, at least during the conjunctions, squares, and oppositions of the Sun and the Moon. Other authors argue that the heavens and the Earth stand still and the stars with the planets move by themselves, like fishes in the water and birds in the air. These authors are also wrong, though not as roughly as the former, because, apart from the reasons that exist to claim that planets and stars move incrusted [*fixas*, i.e. 'fixed'] in the heavens as their densest parts in the manner of wooden knots and not as fishes in the sea, according to this view (and against the opinion of the majority of the astrologers) the stars and planets could not move simultaneously with two different movements to the East and [to] the West, as we observe. [f. 53*v*]

3 The Celestial Novelties

João Delgado taught his students in the Class on the Sphere that the heavens were perfect bodies and, therefore, devoid of any process of generation and corruption. Nevertheless, several celestial novelties seemingly indicated otherwise. In the period that spanned from 1572 to late 1618, a series of bright *novae* (namely those of 1572, 1600 and 1604) and great comets (particularly those of 1577 and 1618) appeared in the skies around the world, drawing the attention and curiosity of astronomers, scholars, *virtuosi* and countless readers of the popular booklets and astrological almanacs that overstocked the European markets and piazzas at the time. These celestial novelties tore down the traditional worldview. They showed that the process of coming to be and passing away also took place in the heavens, demolishing the ontological divide between the celestial and the terrestrial region that structured the Aristotelian worldview. In addition, the movement of comets proved that celestial spheres could not exist, challenging the principle of celestial solidity that Clavius, Delgado and the Jesuit mathematical community keenly advocated at the turn of the seventeenth century.[1]

The astronomical observations carried out by Galileo around 1610 using a brand-new instrument – the telescope – not only corroborated these events but also posed new challenges. As astronomers quickly realised, the observations of Venus's phases, the four satellites of Jupiter and the apparent three-bodied Saturn denied celestial solidity. They suggested furthermore that celestial bodies could revolve around centres other than the

1 On the overwhelming impact of the celestial novelties on the astronomical and cosmological debate, see, among many others, Granada, *Novas y Cometas* and Tessicini, Boner, *Celestial Novelties*.

DOI 10.30687/978-886-969-661-9/003

Earth. This being the case, Christoph Clavius urged his fellow mathematicians to work out a solution. As he mentioned in the last edition of his celebrated *Commentarius in sphaeram Ioannis de Sacro Bosco*, published in Mainz in 1611, shortly before his death:

> Quae cum ita sint, videant Astronomi, quo pacto orbes coelestes constituendi sint, ut haec phaenomena possint salvari.
>
> As this is so, astronomers ought to see how the celestial orbs may be arranged in order to save the phenomena.[2]

The professors who taught astronomy at the College of Santo Antão in the 1610s and the 1620s were in an excellent position to respond to Clavius's plea. This was particularly the case with Giovanni Paolo Lembo, who taught in the Class on the Sphere between 1615 and 1617. Born in Benevento, in Campania, Southern Italy, Lembo, upon completing his philosophical studies at the Jesuit College of Naples moved to Rome in 1607, probably on the suggestion of his Naples mathematics professor, Giovanni Giacomo Staserio (1565-1635), to study theology and mathematics with Clavius.[3] At that time, the 'Academy of Mathematics' run by Clavius at the Collegio Romano gathered a group of advanced students, which included Christoph Grienberger, Odon van Maelcote (1572-1615), Paul Guldin (1577-1643) and a few others.

At the Collegio Romano, Lembo became one of Clavius's closest collaborators.[4] He was indeed the first to attempt to produce a telescope for the use of the Roman Jesuit mathematicians between 1610 and 1611. As Christoph Grienberger revealed in his well-known letter addressed to Galileo on 22 January 1611, in which he made a case for the independence of the early Jesuit telescopic observations from those of Galileo, Lembo had produced the first rudimentary telescope by the spring or summer of 1610, even though this first effort did not enable him to observe Jupiter's moons. As Grienberger informed Galileo:

> before hearing anything about [your instrument], [Lembo] had made some spyglasses himself; not by imitation of others, but rather by the power of inference. He observed both the lunar irregularities and the multitude of stars in the Pleiades, Orion, and other [constellations], but he did not see the new planets.[5]

A few months later, by late October or early November of 1610, Lembo, with the help of Grienberger, managed to produce a superior instrument that did enable them to observe the satellites of Jupiter whenever optimal viewing conditions prevailed. Nevertheless, in late November, the Jesuits in Rome received a much better telescope, sent to them by Antonio Santini, a mer-

2 Clavius, *Opera mathematica*. Vol. 3, *In sphaeram* (1611), 75.

3 A biography of Lembo, with detailed description lecture notes for the course that he gave at the College of Santo Antão, features in Baldini, "Giovanni Paolo Lembo's Lessons in Lisbon", 126-45.

4 On Lembo's involvement in the astronomical observations carried out in Rome, see also Bucciantini, Camerota, Giudice, *Galileo's Telescope*, 208, 210-11. See also Reeves, van Helden, "Verifying Galileo's Discoveries".

5 Galilei, *Le Opere*, 11: 33-4, translation by Lattis, *Between Copernicus and Galileo*, 185.

chant in Venice. Apart from allowing better observations of the satellites of Jupiter, this instrument enabled the Collegio Romano Jesuit mathematicians to start studying Venus.[6]

On the night of 17 January 1611, after a systematic series of observations, Lembo and the Collegio Romano Jesuits observed Venus in conjunction with the Moon. As Grienberger mentioned, the observation conditions were particularly favourable as Venus seen through the telescope appeared quite similar to the Moon viewed with the naked eye.[7] In Lisbon, Lembo's College of Santo Antão lecture notes would provide additional details on the Jesuit Venus observation programme. In reference to this specific observation, Lembo reported that "the masters of theology, philosophy and mathematics of the Collegio Romano, who were almost all there, did ingenuously confess to seeing two Moons".[8]

In April 1611, Clavius would himself acknowledge the central role played by Lembo in the Collegio Romano telescopic saga. On 19 April, Cardinal Roberto Bellarmino sent a letter to the Collegio Romano mathematicians asking for their opinion on the new celestial phenomena observed through the telescope, some of which Bellarmino had already seen for himself. Aware of the different views on the physical reality of these appearances (*perché ne sento parlare variamente*),[9] Bellarmino wanted specifically to know whether they agreed on the existence of a multitude of fixed stars invisible to the naked eye and, particularly, whether the Milky Way and nebulas were made up of very dim stars; whether Saturn was not a single star but rather a unit of three stars; whether Venus waxed and waned like the Moon; whether the Moon had a rough and uneven surface; and, finally, whether there were actually four stars moving differently around Jupiter.[10]

In conjunction with Grienberger and Maelcote, who would deliver the famous oration *Nuntius Sidereus Collegii Romani* when Galileo paid a visit to the Roman Jesuit College in May, Clavius made Lembo sign the letter of response to Bellarmino, dated 24 April. In this missive, the four Jesuit astronomers responded affirmatively to each of the five queries. They thereby recognised how telescope observations had revealed that there were indeed a great number of stars in the nebulas of Cancer and Pleiades, though it remained not entirely clear whether the Milky Way was made up of minute stars; that Saturn was not round like Jupiter and Mars, although they were unable to see three distinct stars clearly; that Venus did actually wax and wane, although they said nothing about its potential cosmological implications; that the Moon's surface did appear to be uneven, even though Clavius attributed this appearance to variations in the density of the Moon's body; and, finally, that there were four stars moving quickly and almost in a straight line around Jupiter.[11]

Thus, apart from being the Collegio Romano's principal telescope maker, Lembo was one of the *Clavisti* who first observed the celestial novelties re-

6 Galilei, *Le Opere*, 11: 34.

7 Galilei, *Le Opere*, 11: 34

8 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 33*v*.

9 Galilei, *Le Opere*, 11: 88.

10 Galilei, *Le Opere*, 11: 87.

11 Galilei, *Le Opere*, 11: 92-3.

vealed by Galileo. Having started these astronomical observations in Rome, in October 1610, with recourse to two telescopes – as he informed the Portuguese audience[12] – he continued his astronomical programme while in Lisbon in 1615.[13] In the Portuguese capital city, the Campanian Jesuit replicated some of these observations, particularly those of the phases of Venus and, to a lesser extent, Mercury. There, according to him, he "showed [the phases of Venus] not only to my students (*ouvintes*), but also to several other *virtuosi* (*pessoas curiosas*)".[14] Lembo also wished to continue his observational programme by studying Mars in greater detail. In 1615, he had already started observing Mars but wished to carry out further observations later that year. As he informed his students, "we will see later [the orbit of Mars with regard to the Sun] after a few observations of this very same planet [Mars] that we aim to carry out with a greater diligence this year if God wishes".[15] No documentary evidence exists of these later telescopic observations of Mars. In 1617, Lembo became seriously ill and, upon finishing his lessons in Lisbon, he returned to Italy. He died in Naples in May 1618, most likely from tuberculosis.[16]

In the Class on the Sphere, Giovanni Paolo Lembo was succeeded by a couple of professors who were also particularly suited to approaching Clavius's plea to work out an astronomical solution to the Galilean challenging discoveries of 1610: Johann Chrysostomus Gall and Cristoforo Borri. Although there is no concrete evidence that these Jesuits performed astronomical observations while living in Lisbon, they were both experienced astronomical observers.[17] Apart from presenting exhaustive descriptions of the observational account of the celestial novelties, they described their own astronomical experience. Thus, for example, Gall reported to his 1621 students of the Class on the Sphere, that

> we sighted and observed a comet in 1618, which our father Baptist Cysat, public professor of mathematics at the University of Ingolstadt, demonstrated, with great erudition, that stood above Venus.[18]

Before coming to Lisbon to teach mathematics at the College of Santo Antão and then embarking to India as a missionary in late 1629, Gall studied at the

12 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 33*r*.

13 In Lisbon, Lembo also provided his students with very brief and practical instruction on how to build a telescope. Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 135*r*-136*r*. See Leitão, "Galileo's Telescopic Observations", 910-11.

14 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 33*v*.

15 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 36*r*: "Veremos depois de algumas obseruacoins que com mais deligençia este anno querendo Deos faremos açerca do mesmo planeta".

16 Baldini, "Giovanni Paolo Lembo's Lessons in Lisbon", 145.

17 Nevertheless, the fact that Gall complained of not having an adequate telescope to observe Saturn's "satellites", in 1625, might suggest that he had at his disposal some other instrument of inferior quality. In his words: "I cannot solve this question through my observations because no ordinary telescope is adequate to reach the distance and [to observe] the constitution of the mentioned two companions [of Saturn]" ("Eu não acabo de resoluer por minhas obseruacoes porque não qualquer ocolo basta para alcancar a distancia ou constituição dos dittos dois companheiros [de Saturno]"); Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 63*r*.

18 Gall, *In Sphaeram*, BGUC, MS 192, f. 17*v*: "Nos uimos, e obseruamos no anno de 1618 outro que o nosso padre Bautista Sizado publico profesor da mathematica na uniuersidade de Ingolstadio, com grande erudição demonstrou que ficaua sobre Venus".

University of Ingolstadt. There, he collaborated with Cysat, Scheiner and probably Johann Lanz (1564-1638) in the astronomical observations carried out at this university, the bastion of Catholic education in Southern Germany.[19] In Lisbon, the German Jesuit followed the astronomical activity of his confrères, not only in Europe but also in the East. As he stated:

> The fact that comets display movements that differ from those of the planets constrains us to attribute them distinct orbs from those of the planets. This last comet [of 1618] and the works of the above-mentioned mathematicians and those of Tycho, showed it to us. Letters addressed by our priests from Ethiopia, China and India also established it. Letters from Ethiopia reported that one of those two comets, which appeared less than a couple of years ago, moved southwards while the other northwards. But from China, news came that only one moved to the south. We observed the other comet moving to the north. This kind of movement has been observed neither in the planets nor in the fixed stars. A letter addressed from Cochin, which we received this year, corroborated this view as – apart from many other particular things – [it showed that] the movements either of trepidation or libration are not so fast, nor so great, nor are they made simultaneously to the south and the north.[20]

Gall did not identify the missionaries to whom he was referring. He might be alluding to Antonio Rubino (1578-1643), who observed the comet in Cochin while serving as rector of the city's college before departing for Japan,[21] or even to the Milanese Jesuit Cristoforo Borri, who would eventually replace him in the mathematical chair of the College of Santo Antão. Before coming to Portugal, Borri had carried out missionary work in Asia, having lived in Goa, Macao and Cochinchina (now Laos and Vietnam), where he observed the first of the 1618 comets. Additionally, he managed to establish a correspondence network across Asia that allowed him to conclude that the comets of 1618 moved in the celestial region. As he put it in his *Collecta astronomica*, a book destined to exert a profound influence on the Portuguese intellectual milieu:

> I carefully observed [the first comet of 1618] in the kingdom of Annam, generally called Cochinchina by the Portuguese. Father Jan Wremann, a Dalmatian, of the Society of Jesus, formerly professor of mathematics in

19 On Gall's biography, see Baldini, "L'insegnamento della matematica", 286-7.

20 Gall, *In Sphaeram*, BGUC, MS 192, ff. 18*r*-*v*: "Auermos de dar à estes cometas distintos orbes dos orbes dos planetas nos constrangem a isso seos mouimentos desimilhantes a todos os mouimentos dos planetas como uimos neste ultimo cometa [de 1618] e se pode uer assi nos mathematicos alegados, como tambem nas obras de Tycho o que confirmam cartas de nossos padres escriptas da Etiopia, China e India porque de Etiopa se escreue que hum daquelles dous cometas que a menos de dous annos aparecerão se mouia para o Sul, o outro para o Norte: porem da China só se fas menção do mouimento de hum delles, a saber daquelle que se mouia para o Sul, o outro nos o uimos mouerse para o norte. Os quais mouimentos nunqua forão obseruados, nem nos planetas, nem nas estrellas fixas, como bem se nota em huma carta, que este anno nos escreuerão de Cochim, porque os mouimentos ou de tripidação ou de libração, não sam tam aprecados, nem tam grandes, nem se fazem iuntamente para o sul e para o norte alem doutras muitas couzas em que differem".

21 Kirwitzer, *Observationes Cometarum*.

Coimbra[22] and expert in that science, and companion on my journey from Portugal to China, also observed it in China. He collaborated with me not only in the observations concerning this comet, but also in other observations and always agreed with me. Father Manuel Dias, a Portuguese theologian and a very clever professor of philosophy from the Society of Jesus, observed the same comet in India, in the city of Cochin, and wrote a treatise against those who still considered, according to the outdated view, that comets are sub-lunar and elemental bodies.

I, let me say, together with Father Jan Wremann, separated by a great distance, having compared together the data through letters, both unanimously concluded that that comet (whatever the Peripatetics' suppositions) was a celestial body and far above the Moon.[23]

Upon returning to Europe, Borri continued his astronomical observations. On the night of 6 July 1627, for example, he observed, in Coimbra, the Moon's surface using a telescope that probably belonged to André de Almada, a nobleman and Professor of Theology at the University of Coimbra.[24] His students in the Class on the Sphere were properly informed about these astronomical observations and their results.[25]

In short, the professors who taught mathematics at the College of Santo Antão were utterly familiar with the celestial novelties that deeply challenged the traditional worldview at the turn of the seventeenth century. As skilled astronomers, they knew what was at stake. From this point of view, they had the full credentials to follow Clavius's appeal to work out an astronomical solution, but what sort of solution did Clavius have in mind when he urged the astronomers "to see how the celestial orbs may be arranged in order to save the phenomena?"

22 Although Borri mentioned that Wremann had taught mathematics in Coimbra, according to Baldini, he was responsible for a private course on mathematics at the Lisbon College, in 1614-15, just before he went to China. See Baldini, "L'insegnamento della matematica", 285-6.

23 Borri, *Collecta astronomica*, 117[115]-6: "Ita egomet non negligenter observavi in Regno Annam vulgo a Lusitanis Cocincina dicto. Observavit etiam in regno sinarum Pater Ioannes Vremanus Dalmata e Societate Iesu, Conimbricae olim Mathematicarum professor, et in hac scientia versatissimus, et mearum peregrinationum a Lusitania ad Sinas usque comes, et socius. Is autem non solum in ijs, quae ad hunc cometam pertinent, sed et in plerisque alijs astronomicis observationibus mecum collaboravit, et consentaneum semper observationibus meis fuit. Item P. Emmanuel Diaz lusitanus theologus, et philosophiae professor acutissimus e Societate item Iesu observavit eundem cometam in India in civitate Cocin; qui quidem tractatum scripsit contra eos, qui etiam num iuxta antiquam opinionem cometas putarent esse sublunares, et elementares.

Ego, inquam, et P. Ioannes Vremanus longissimo terrarum tractu dissiti, cum per litteras simul contullissemus, unanimi consensu ambo conclusimus comentam hunc, quidquid Peripatetici sentiant, caelestem fuisse, et Luna multo superiorem".

24 Borri, *Collecta astronomica*, 137.

25 See, for example, Borri, *Nova Astronomia*, BGUC, MS 44, ff. 94*v*-5*r*.

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Lembo's telescopic observations of Venus and Mercury in Rome (1610-11) and Lisbon (1615). Giovanni Paolo Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 33*r*-34*r*

Nestas ultimas pallauras em que o Padre Clauio se remette à obseruação dos Astronomos no modo com que se deuem saluar as Phenomenas que nestes nossos tempos se descobrirão e virão com o occulo nouamente inuentado pareçe que nos dá licença de por os orbes caelestes em hordem algum tanto diuersa do que elle com os demais Astronomos ordenou.

E ainda que eu me não tenha na conta daquelles a quem o Padre Clauio remeteo a obseruação disto contudo não deixarei de referir aquellas cousas que ha annos obseruei nos planetas por meo do mesmo occulo e as mostrei ao padre Clauio para que as visse das quoaes podera cada hum colher se por uentura os orbes caelestes se deuem ordenar de outro modo para saluar as Phaenomenas.

No anno pois de 610 tomando o occulo grande no mez de Outubro no principio da noute e vendo a Venus aduerti que na parte mais oriental e que mais ficca apartada do Sol, tinha algum deffeito da luz, o que eu no principio atribuia ao mesmo occulo porque não me podia persuadir que venus tiuesse a tal falta de luz, ou não fosse perfectamente redonda, mas fazendo a mesma experiença muitas vezes hora com hum occulo hora com outro e vendo que sempre lhe ficcaua o mesmo deffeito na mesma parte detreminei de lhe buscar a causa com mais dilligencia dalli por diante repetindo as obseruaçoins o que fiz e achei que não somente o tal deffeito perseruaua na mesma parte mas que tambem se fazia maior cada vez mais e que iuntamente a mesma estrella appareçia maior no seu diametro visual de modo que indo os dias e a experienças por diante à vespora de Santo Antonio Abbade 17 dias de Janeiro estando Venus junto da lua e estaua então a lua no quarto dia depois [f. 33*r*] de conjunção com o Sol pouco mais ou menos vista pello occulo pareçia de tanta grandesa em seu diametro visual, de quanta a lua sem occulo se mostraua; e com pontas do mesmo modo que a lua: de maneira que os mestres de Theologia, Philosophia e Mathematica do Colegio Romano que quasi todos alli se acharão ingenuamente confessauão que uião duas luas. A mesma obseruação fiz os meses passados estando iá aqui em Lixboa e a mostrei não somente a meus ouuintes; mas tambem a outras pessoas curiosas (muitas) que a virão com pontas do mesmo modo que a lua ao prinçipio menores depois maiores cada vez mais, falo com testemunhas de vista.

Depois da Coniunção com o Sol, estando Venus no seu perigeo do Epiçiculo conforme à comum oppenião que se explica nas Theoricas dos Planetas logo que se pode ver liure dos Rayos do Sol, vi o que dantes aduinhaua que áquelle deffeito da luz ficcaua para à parte occidental do mesmo modo que o deffeito da lua antes de se juntar com o Sol, no tempo da madrugada e depois correndo o tempo obseruei que o mesmo deffeito se fazia cada vez menor e que juntamente o semediametro visual de Venus se hia deminuindo atee que finalmente appareçia redonda mas em diametro visual muito pequeno, tanto que este diametro visual não tinha nem a baixa [?] parte daquelle com que Venus appareçia quando tinha maiores pontas. E depois da conjunção de Venus com o Sol no Appogeo, obseruei que aquelle deffeito successiuamente outra vez hia sobindo pouco e pouco, atee tornar as mesmas apparencias, que de primeiro e assim aduerti que fasia todos os annos mostrandosse hora chea hora meia chea, hora com pontas com as mesmas mudanças que a lua comforme e uariedade e tempo do seu periodo; Isto que em Venus se obseruou senão pode obseruar em Mercurio com a mesma dilligencia com que se obseruou em Venus [e] a lua porque o Sol nolo tira quasi sempre de vista, por se não apartar delle hum signo enteiro, e outra por ser muito pequeno, de modo que escassamente se podem aduertir os defeitos que padeçe, quoando se pode ver, mas quoando pude coniecturar assi em Roma aonde algumas vezes o obseruei vespertino e o mostrei a outros para o obseruarem como a Venus como tambem muito mais aqui em Lixboa o mez passado de Março quoando semelhantemente desçia para baxo, vespertino ao Perigeo do Epiciclo desde os 24, 26 dias atee o ffim do mez obseruei dilligentissimamente quasi todos os dias appareçia não de outro modo do que en Venus, nelle algum deffeito na parte contraria ao Sol, donde se pode conjecturar estar sogeito aos mesmos deffeitos que Venus. Sendo isto assim, e nem Venus nem mercurio se afastem tanto do Sol; que se possão oppor por diamentro, ou pella quarta parte do ceu, como a lua se oppoem ao Sol pera nelles se poderem ver as variedades que cada mez vemos e experimentamos na Lua; necessario he que pera saluar as apparençias que referimos tão semelhantes as da lua: confessemos que Venus e mercurio se mouem ao redor do Sol e que hora abaixo [ora] assima delle: hora antes, hora depois delle fasem seu curso como tambem se pode collegir das uarias oppenioens dos antigos dos quoaes huns poserão estes dois planetas assima outros abaixo do Sol, e na verdade huma e outra cousa podia constar das apparençias porque [f. 33*v*] pode mui bem aconteçer que no tempo das obseruaçoins se achassem humas vezes em çima outras abaixo do Sol e assim os que os poserão em çima do Sol disserão verdade conforme as obseruaçoins em que assim appareçeo e os que os poserão abaixo tambem fallarão verdade conforme as suas obseruaçoins em que os virão abaixo do Sol. [f. 34*r*]

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English translation. Lembo's telescopic observations of Venus and Mercury in Rome (1610-11) and Lisbon (1615). Giovanni Paolo Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 33*r*-34*r*

In these last words, in which father Clavius refers to the need for astronomical observations to save the phenomena that have been discovered and seen in our time through the newly invented telescope [*occulo*, i.e. 'eyeglass' or 'monocle'], he seems to permit us to organise the celestial orbs in a different order from that that he and other astronomers had conceived.

And even though I do not consider myself among those to whom father Clavius recommended this observation, I cannot ignore what I observed on the planets some years ago through the same telescope [*occulo*] and showed to father Clavius. From these [observations], each one can conclude whether we should rearrange the heavenly orbs differently to save the phenomena.

In October 1610, at the beginning of the night, while observing Venus with the large telescope, I noticed that there was some imperfection in the light at the easternmost part of its body, which was the farthest from the Sun. I first attributed it to the telescope because I could not persuade myself that Venus had such a lack of light or was not perfectly round. But, having repeated the same observation on several occasions, sometimes with one and sometimes with another telescope, and seeing that the same imperfection always remained in the same part of Venus, I decided to seek its cause more carefully by repeating the observations from then on.

I did so, and I realised that this imperfection not only persisted on the same part but also increased. The visual diameter of this imperfection and the star appeared to get bigger. Days and experiences [i.e. observations] progressed and on the eve of St. Anthony Abbot's day, 17 January, being Venus close to the Moon, which was then on the fourth day after [f. 33*r*] the conjunction with the Sun, while observing through the telescope, [I realised that] its visual diameter seemed to be as large as that of the Moon viewed through the naked eye, with its edges in the same way as the Moon, so that the masters of theology, philosophy and mathematics of the Collegio Romano, who were almost all there, did ingenuously confess to seeing two Moons. I repeated the same observation when I was already here in Lisbon, and I showed it not only to my students (*ouvintes*) but also to several other *virtuosi* (*pessoas curiosas*), who saw it with the same edges as the Moon, first smaller and then bigger – I declare this with support of sight witnesses.

After the conjunction with the Sun, being Venus at the perigee of the epicycle, upon getting rid of Sun's rays – according to the common opinion explained in the Theories of the Planets – I observed that that imperfection of light stood in the western part of its body, similar to what the Moon experiences before joining with the Sun at dawn, as I had previously foreseen. Later I observed that the same imperfection of light, together with the visual semidiameter of Venus, was diminishing up to the point where Venus finally appeared with a round shape but with a tiny visual diameter. This visual diameter was so small that it was not even comparable to that that Venus exhibits when it appears provided with larger edges. After the conjunction of Venus with the Sun at the apogee, I observed that this imperfection increased again little by little until it reached the same appearance it had initially. And so, I concluded that this phenomenon happens every year, with Venus sometimes appearing full, sometimes half-full, sometimes with edges, with the same changes displayed by the Moon according to the passage of time and its cycle. This phenomenon, which was seen on Venus, cannot be observed with the same diligence on Mercury because the Sun almost always takes Mercury out of our sight as it does not move away from it one entire sign, and also because Mercury is tiny. So even when you can see Mercury, you hardly observe the phenomena it suffers. I came to this conclusion while in Rome, where I observed this planet sometimes in the evening and showed it to others so that they could see it like Venus. I repeated the observation of Mercury here in Lisbon, where I observed it more often during last March, when Mercury moved during the evening downwards in the epicycle's perigee. I observed it diligently almost every day from the 24th and 26th until the end of the month, and it appeared no different from Venus, with some imperfection on the opposite side of that of the Sun. One can conjecture from this observation that Mercury is subjected to the same phenomena as Venus. Despite the fact that we cannot see and observe [in Venus and Mercury] the same variations displayed by the Moon because neither Venus nor Mercury are so far from the Sun that, while in opposition, they are a diameter or a fourth part of the sky away from it, as the Moon does regarding the Sun, to save their appearances, which are so similar to those of the Moon, we must confess that Venus and Mercury move around the Sun and that sometimes they are below it and sometimes above, sometimes they move before it and sometimes after. The same conclusion follows from the various opinions of the Ancients, among whom some authors placed these two planets above the Sun and others below it. In fact, both views are consistent with the phenomena because [f. 33*v*] Venus and Mercury sometimes stand above the Sun and sometimes below it. Accordingly, those who put them above the Sun were right, according to their observations, because these revealed that the planets were in such positions. The other authors who claimed that Venus and Mercury are below the Sun were also right because they had observed the planets moving below the Sun. [f. 34*r*]

4 The Jesuit Rejection of Copernicanism

The College of Santo Antão's mathematics professors obviously knew that the heliocentric model put forward by Copernicus was not the sort of solution that Clavius had in mind. In his *Commentarius de Sphaera Ioannis de Sacro Bosco*, Clavius presented a somewhat concise refutation of Copernicus based on astronomical, physical and biblical arguments, which would become quite influential among Jesuit mathematicians.[1] In addition, in March 1616, the cardinals belonging to the Congregation of the Index, among whom Bellarmino was a leading character, deemed heliocentrism to be false and contrary to the *Bible*.[2] Copernicanism was, henceforth, considered a quasi-heretic theory.

As such, it nevertheless remained an issue for teaching and criticism at Jesuit colleges and universities.[3] Just like their confrères in Rome and throughout Europe, the professors of Santo Antão delved into the Copernican theory. While Lembo set out the Copernican planetary system but refrained from discussing its cosmological consequences in depth,[4] his successor in the mathematics chair at Lisbon, Johann Chrysostomus Gall, however,

1 On Clavius's critique of Copernicus, see particularly Lattis, *Between Copernicus and Galileo*, 106-44. Cf. also Volker R. Remmert, who argued that the rebuttal of Copernicanism within the Society of Jesus was due not only to the theologians but also to the mathematicians, and particularly to Clavius, who played a key role in building up a consensus to reject Copernicanism in the late sixteenth and early seventeenth centuries. Remmert, "Our Mathematicians Have Learned".

2 See, among the extensive bibliography on this issue, Fabbri, Favino, *Copernicus Banned*.

3 Renée J. Raphael has convincingly argued that the need to refute Copernicanism led the Jesuits to teach it rather than simply suppress it. Raphael, "Copernicanism in the Classroom".

4 Lembo included a drawing of the heliocentric system; Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 24*v*.

DOI 10.30687/978-886-969-661-9/004

did not avoid discussing the topic in greater detail. He approached it firstly when introducing his students to the main planetary rearrangement hypotheses as well as subsequently when making his point in favour of geocentrism and geostaticism.[5]

Gall, who taught in Lisbon from 1620 until 1627, when he departed for Goa, India, presented to his Portuguese audience the key features of the Copernican system. As he described it:

> The second system is that of Nicholas Copernicus and [f. 14*r*] Aristarchus, and other ancient authors. These authors, contradicting the common understanding, claim that the Sun stands still at the centre of the entire universe, and the Earth, together with all the other planets and elements, moves around it. They order the parts of the universe as follows: to the Sun they give the centre of the universe, to which follows Mercury, then Venus, and, in the third place, the great orb wherein the Moon's heaven moves, as an epicycle, in the centre of which is the Earth surrounded by the elements. The heaven of Mars follows the great orb, then that of Jupiter, then that of Saturn, and finally, the immobile Firmament. [f. 14*v*][6]

A diagram of the Copernican planetary system was added **[fig. 2]** to support his discussion of Copernicanism.

Nevertheless, rather than merely discussing the technical issues of heliocentrism, Gall's emphasis was placed on refuting this system. In Lisbon, he presented the standard criticism of Copernicanism. Like Clavius before him, his disapproval of heliocentrism relied on three sorts of arguments. In the realm of mathematical astronomy, Gall pointed out that the Earth's revolution motion would require the apparent position of the fixed stars to shift over the course of a year (the so-called parallax argument) or alternatively the celestial region, and particularly the space between Saturn and the fixed stars, to be much more extensive than astronomers had traditionally conceived – which clashed with the authority of Brahe and Christoph Scheiner.[7] As Gall put it:

> If the Earth moved, it would follow that the Firmament, the planetary heavens and the heaven of the fixed stars would be an immense space. There would also be a massive distance between Saturn and the heaven of fixed stars, with no reason or purpose for such a spatial immensity.[8]

5 The Portuguese public libraries and archives preserved two copies of Gall's lecture notes, respectively at the Biblioteca Geral da Universidade de Coimbra and the Biblioteca Nacional de Portugal. Copernicanism is discussed in Gall, *In Sphaeram*, BGUC, MS 192, ff. 14*r*-14*v*, 56*r*-58*v* and Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, ff. 43*r*-45*v*, 64*v*-65.

6 Gall, *In Sphaeram*, BGUC, MS 192, ff. 14*r*-*v*: "O segundo sistema he de Nicolao Copernico, e de Aristarco, e doutros antigos. Estes contradizendo ao comum sentir dos homens, afirmão estar o Sol immouel no meo de todo o uniuerso, e a terra com todos os mais planetas e elementos mouerse ao redor delle. Pelo que ordenão as partes do uniuerso desta maneira: ao Sol dão o centro, a este segue Mercúrio, logo Vénus, no terceiro lugar o orbe grande, no qual se moue o ceo da Lua, como epiciclo, no centro do qual esta a terra rodeada dos mais elementos. Ao orbe grande socede o ceo de Marte, logo o de Júpiter, depois o de Saturno, e finalmente o firmamento immouel".

7 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, ff. 43*v*-44*v*.

8 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 43*v*: "porque este mouimento da terra se seguiria primeiramente huma huma imensidade do firmamento e dos mais caeos, e estrellas fixas e necessariamente ouuera entre o Saturno e estrellas fixas huma distancia imensa sem se saber o proueito nem fim destas grandes".

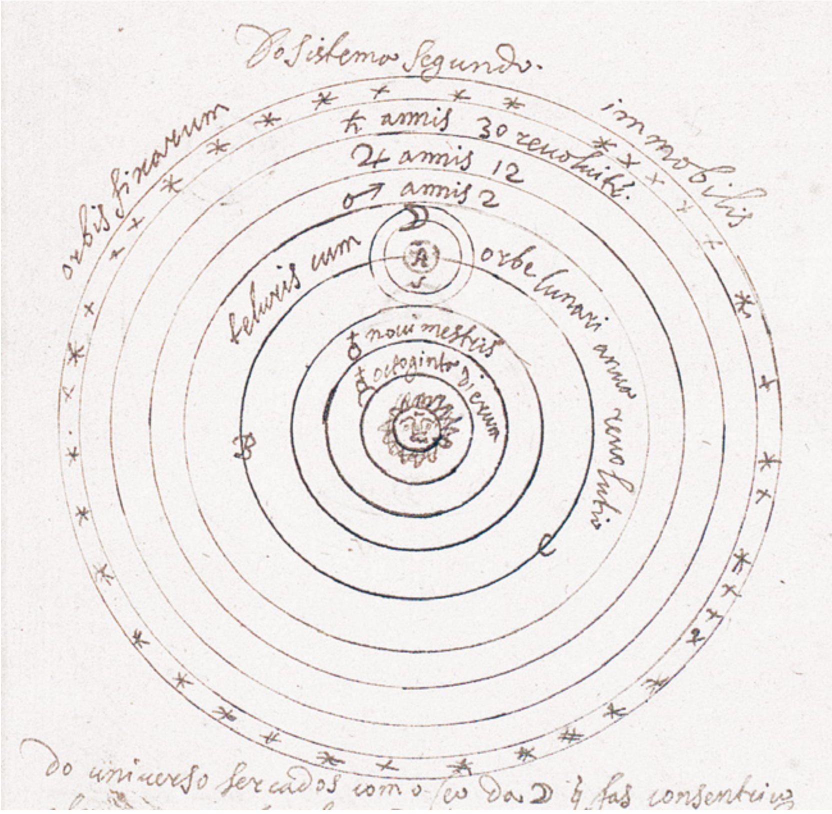

Figure 2 The Copernican system according to J.C. Gall (*In Sphaeram*, BGUC, MS 192, f. 15*r*)

Additionally, the German Jesuit proposed the typical set of physical evidence that he maintained contradicted the notion of the Earth's rotational motion, namely the fact that a small rock, when thrown directly upwards, falls back in exactly the same place and not at some distance eastwards; were the Earth to be moving very fast in an eastward direction, a bird flying eastwards would neither ever reach its destination nor fly at the same speed in both the easterly and the westerly direction.[9] The Copernican theory also violated the basic cornerstone of Aristotelian physics; that is to say, a simple body cannot move with more than one simple motion. If this was the case – Gall argued along the lines of the Aristotelian natural philosophy – the Earth's motion would necessarily be downwards. Furthermore, the Earth could not be subject to any violent movement because no extrinsic cause could impel it to move, not even the Sun, as Gall pointed out, alluding to Kepler. Thus, the Earth could not be provided with the three motions attributed to it by Copernicus.[10]

Finally, Copernicus's heliocentric theory conflicted with the many biblical passages that state that the Earth stands still at the centre of the universe.

9 Gall, *In Sphaeram*, BGUC, MS 192, ff. 56*v*-57*v*; Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, ff. 44*v*-45*r*.

10 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 43*v*.

Gall invoked some of the usual passages deployed in this debate: *Psalm* 75:4, 93:1, 103:5, *Ecclesiastics* 1:5 and *Jos*. 10:13.[11] In this context, the Jesuit added a subtle reference to the Protestant Copernicans (whom he did not name), who recommended "understanding these passages in a non-literal sense".[12] After Gall, this became a leitmotif in the Jesuit criticism of Copernicanism. Borri, who discussed the *Copernici hypothesi repugnat Physicae* very cursorily,[13] explicitly refuted any attempt to understand the *Bible* critically in a historical context.[14] Approximately a decade later, the Irish Jesuit Simon Fallon would address the point more directly in his criticism of the recourse to the theory of accommodation by Copernican astronomers:

> Neither is it worth what Kepler and others answer by claiming that the Scripture speaks, in those passages, in the common and ordinary sense of men, nor is it worth the fact that this hypothesis has pleased, in the past, some learned men in the Scripture, nor the fact that the same Copernicus dedicated this work to [the Pope] Paul III, as one can conclude from the Prolegomena to this book, because as regards the interpretation of the Holy Scripture, there is a very well received rule that advises not to deviate from the real meaning of the words when the proper sense of their meaning can be verified. It should also be added that there is already a statement produced by the Cardinals against this opinion as well as the fact that this book is prohibited by the Index until amended.[15]

Fallon here epitomised the essential attitude that Jesuit intellectuals were required to adopt in the Copernican dispute: to interpret biblical passages in the literal sense.[16] As this book shall demonstrate in its final section, this literalist approach conditioned the Jesuits' cosmological discussion and correspondingly their own ongoing relationship with Tycho Brahe's heliocentric system. Furthermore, the Irish Jesuit recalled the critical events of 1616 deriving from the Galileo affair, specifically the statement produced by the cardinals of the Congregation of the Index that banned Copernicanism, condemned Foscarini's book and censured Copernicus's *De Revolutionibus* and similar books. The authority of the *Bible* and the Church thus emerged as undisputable in cosmological matters.[17]

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11 Gall, *In Sphaeram*, BGUC, MS 192, f. 58*r*.

12 Gall, *In Sphaeram*, BGUC, MS 192, f. 14*v*: "ainda que seos defensores, sem necesidade, pretendam auerse de tomar estes lugares no sentido menos proprio".

13 Borri, *Collecta astronomica*, 42-3.

14 Borri, *Collecta astronomica*, 43: "Neque admittenda est Kepleri, et aliorum circa terrae stabilitatem intepretatio, qui dicunt scripturam ad Vulgi sensum se accomodasse".

15 Fallon, *Compendio Spiculativo*, BNP, cod. 2258, f. 97*v*: "Nem vale o que responde Keplero e outros dizendo, que a Scritura falla aly no sentido comum e ordinario dos homens, como também não nem vale o parecer bem algum dia esta hypothesi a alguns varões doctos na Scritura, nem o ter dedicado o mesmo Copérnico esta obra a Paulo III, como tudo se vê nos Prologuomenos deste mesmo liuro, porque no explicar da Sagrada Scritura he mui bem recebida a regra, que senão há de desuiar do que as palauras soão, quando no sentido proprio se pode verificar o que dizem. Acrescentasse auer iá contra esta opinião huma declaração dos Cardeaes e também ser este liuro prohibido pello expugatorio até se emendar". Another copy of this manuscript can be found at BNP, cod. 2125 (Fallon, *Sphera Arteficial e Natural*).

16 On the Jesuit bond to biblical literalism, see in particular Kelter, "The Refusal to Accommodate". See also Blackwell, *Galileo, Bellarmine, and the Bible*.

17 This led Gall to conclude that, "if its author (Copernicus) lived today, he would not support those things because he was a good Christian and dedicated [the book] to Pope Paul III"

Document III

Capítulo IV

Do mouimento, e quietasões do globo da terra e augoa [1625]. Johann Chrysostomus Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, ff. 43*r*-45*v*

Não tartaremos nestes capítulos do mouimento de cada hum destes elementos em particular com que apartados de seus lugares proprios se tornão a elles por meio de sua grauidade mas se explicarmos primeiramente se toda a bolla composta de ambos iuntos tem algum mouimento proprio. Item se pode dizer que a dita Bolla esta quieta em que centido e donde naçe a dita quietação.

1ª Conclusão

O globo da terra e augoa não se moue ao redor do Sol. Esta conclusão vai contra alguns philozophos antigos e principalmente contra os outros modernos, os quais com Nicualo [sic. Nicolau] Copernico afirmão que o Sol fica no meio do mundo e a terra iuntamente com os mais elementos e a lua se moue ao redor della [*sic*, dele] entre o ceo de venus e marte con espacio de hum anno.

Os principais fundamentos desta openião acho que são estes dois. O primeiro he que dizem estes autores que por se escusarem muitas dificuldades, mais facilmente se pode explicar por operacões e mouimentos dos corpos caelestiais. O segundo porque lhe pareçe muito grande encoueniente que corpos tão grandes e perfeitos como são os caelestiais se moue[m] com o mouimento tam aprezado por respeito de huma bolla da terra tão piquena e imperfeita.

Porem nossa conclusão he mais conforme a rezão e sentimento comum de todas as gentes e dos milhores philozophos he [*sic*, e] Astronomos e sobre tudo a Sagrada escritura fala tão claramente nesta maneira que senão pode dizer o contrario pos os Eclesiasticos no 1º capítulo disem terra autem inter medium stat[18] e no salmo 92 se dis firmauit orbem terrae numero commouebitur[19] e no salmo 74 falando da terra diz Ego confirmavit colunas eius[20] como se disera eu estabelesi a terra, a qual se a pusera [f. 43*r*] com colunas firmes. Em o 1º dos palelipomenos [i.e. Paralipomenon] capítulo 16 ipse fundauit orbem imobilem,[21] a ressão Philozophica he porque o mouimento da terra nem he natural nem violento, não he natural porque a terra como corpo simples não tem mais que hum mouimento natural como disem os philosophos com Aristoteles, no 2º capítulo do 1º livro dos Ceos o qual mouimento ha de ser para baixo, e nunqua auemos de comceder que a terra he animada com dis

(“e seu autor mesmo se ainda hoie uiuera não ouuera de aproueitar taus coissas pois era bom christão e dedicou [o livro] a[o] Santo Padre Paulo 3º”) (Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 64*v*).

18 *Terra autem in aeternum stat. Oritur sol, et occidit sol. Eccle.* 1:4-5.

19 *Etenim firmavit orbem terrae, qui non commovebitur. Ps.* 93 (92):1.

20 *Ego confirmavi columnas eius. Ps.* 75 (74):4.

21 *Ipse enim fundavit orbem immobilem. I Par.* 16:30.

hum destes modernos: nem he violento porque não se acha [causa] extrinsica deste mouimento pois diser que o Sol o he como dis o dito moderno fazendo o Sol dispencario de todos os mouimentos he fingimento, toda a resão e o comum parecer de todos confirma nossa sentença porque este mouimento da terra se seguiria primeiramente huma huma imensidade do firmamento e dos mais caeos, e estrellas fixas e necessariamente ouuera entre o Saturno e estrellas fixas huma distancia imensa sem se saber o proueito nem fim destas grandes e para milhor se entender o argumento se ha de notar primeiramente que cousa he paralaxis que he o dia[metro] [i.e. ângulo] entre o lugar proprio, e aparente, lugar proprio da estrella se chama o em que cae huma linha direita que saindo do centro do mundo passa pello centro da estrella. O lugar apparente he o em que cae huma linha direita ou raiovisual que saindo da superficie da terra ou do olho daquelle que obserua a estrella que passa pello dito centro da estrella como se ue nesta figura que se segue **[fig. 3]**, e por exemplo seia o centro do mundo A, e o olho do obseruador fique na superficie da terra no ponto B, e seia qualquer estrella e pello centro da qual paca a linha direita ACD e outra linha direita BCE que sae do olho G [*sic*, B] e passa pello mesmo centro C o lugar proprio desta estrella fica na linha AD, o lugar apparente fica na linha BE o angulo ECD com diferenca do lugar proprio, e apparente se chama paralaxis, cuio effeito he fazer que a estrella C pareça mais baixa e menos leuantada sobre o orizonte do que he pois a propria altura da altura he o arco GC (ou que he o mesmo) FD mas quem obseruar no lugar B uera que a altura da estrella he o arco FE **[fig. 3]**.

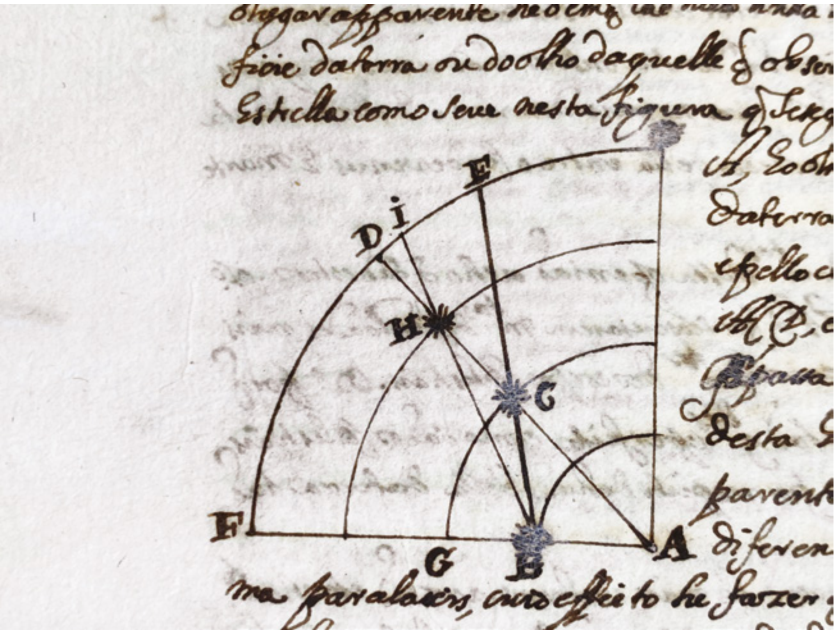


Figure 3 Stellar parallax according to J.C. Gall

Notesse no 2º lugar que o paralaxis das estrellas que distão mais do centro do mundo tem menor paralaxis do que tem as que ficão mais perto, pois fica a estrella H mais apartada do centro [f. 43*v*] que a estrella C e lancesse a linha BI pello centro da dita estrella H, e sera o lugar apparente o ponto I e o paralaxis IHD, o qual prouo que he menor que o paralaxis ECD da estrella C pois o angulo DHI he igual ao angulo CHB polla [preposição] 15 do livro de Euclides, e o angulo ECD he igual ao angulo ACB polla dita proposisão, e o angulo exterior ACB he maior que o angulo interior oposto CHB polla [preposição] 16 do dito livro logo tambem he maior o angulo ECD, he igual o paralaxis da estrella C IHD que he o paralaxis da estrella H maior logo he o paralaxis da estrella inferior ou mais chegado ao centro do mundo do que he o paralaxis da estrella mais afastada do dito centro, e asim pode a distancia ser tão grande que desapareça o paralaxis, enão seia sensiuel quando a distancia da estrella for tão grande que a distancia da largura da obseruacão B, e do centro do mundo A não tenha proporcão sensiuel com a distancia da estrella.

Notesse no 3º lugar que os Astronomos não achão paralaxis sensiuel nas estrellas do firmamento, donde se colhe que a distancia do lugar donde obseruão do centro do mundo não tem proporcão notauel com a distancia ou semidiametro do firmamento, a qual contudo tem como maior distancia do altissimo Planeta Saturno, o qual segundo Copernico dista da terra mais de 9 vesses do que o Sol dista da mesma terra, e a distancia do Sol contem segundo o mesmo Autor 1208 semediametros da terra. Desta doutrina de Copernico, e destas anotacões colige Tyco bray a imencidade do firmamento deste modo a mais alta distancia de Saturno contem na doutrina de Copernico o semediametro da terra 12900 vesses, a qual distancia necessariamente se ha declarar 700 ou 800 vesses para alcançar tanta distancia do firmamento que não aia paralaxis notauel nas estrellas fixas donde sairão 10320000 semediametros da terra e tantos tera o semediametro do firmamento na sentenca de Copernico, e chegara todo o ceo do Sol a ter aquella proporcão com o firmamento qual tem o centro da esphera com a mesma esphera.

O Padre Christhopho Scaneiro [i.e. Scheiner] nas desquiticões [i.e. *Disquisitiones mathematicae de controversiis et novitatibus* (1614)] colige desta imencidade do firmamento que o diametro do semediametro do firmamento, que o diametro das estrellas de primeira grandeza, conforme [?] esta openião tem mais que três vesses o diametro do ceo do Sol ou do orbe grande, e o diametro das estrellas da terceira grandeza, mais que huma ves o diametro das estrellas da sexta grandeza pouquo mais ou menos, de modo que huma estrella minima que se ue [f. 44*r*] se parece seu centro no centro do mundo enchera quasi todo o que fica debaixo da superficie conuexa do ceo do Sol, e as outras maiores tomarião inda o ceo de Marte e de Iupiter, e por uentura algumas o proprio ceo de Saturno pois serião mais de trinta e três vesses maiores que o ceo do Sol. O mesmo Auctor colige tambem [que] entre o Saturno [no] Apogeo e entre o firmamento ha huma distancia inserta de 700 ou 800 vesses maior do que he a distancia do dito planeta Apogeo da terra, que senão pode entender nem conceder, nem resões urgentissimas quais não são as que os aduersarios trazem.

Pois a facelidade de explicar os mouimentos caelestiais não he tão grande nesta openião como elles imaginão, e ainda que forão não era bastante resão para concederemos tantos inconuenientes quantos se seguem do mouimento da terra, como se uera mais claramente na 2ª conclusão quanto a outro fundamento que parece ter algum geito. Respondo primeiramente que não he coussa seria a nobreza dos ceos e estrellas moueremse para comonicarem suas virtudes, e enrequiserem a terra e gouernar os mais elementos, antes ficão em esse fundamento mais illustres e grandiosos. Respondo no segundo lugar que o mouimento tão apresado nos corpos caelestiais não mostra menos a omnipotencia do Criador do que o pudera mostrar aquella imensidade fabulosa que elles poem. Respondo no terceiro lugar que os ditos elementos não se fazem particularmente por amor do elemento da terra e dos mais [elementos] senão por amor do homem a quem elles seruem o que he infenitas vesses mais nobre que quaisquer corpos caelestiais.

2ª Conclusão

A terra não se moue com o mouimento circular ao redor de seu proprio centro e eixo. Esta conclusão he tambem [falsa] segundo os ditos Autores que dizem que a terra não somente se moue ao redor do Sol senão tambem ao redor do seu proprio eixo, dando huma volta em espacio de 24 horas e mostrando humas e outras [faces] ao Sol fazendo deste modo dias e noites mas este mouimento he tambem [falso] segundo a comua openião de todos os milhores Philozophos e sabios. Nem se pode afirmar sem fazer força a alguns pacos da Sagrada escritura pois o Eclesiaste 1 no alegado capítulo [5] dis oritur Sol e[t] occidit et ad locum suum revertitur ibique renascens girat per meridiem et flectitur ad aquilonem lustras uniuersam in circuitu. Pergit spirito, et in circulos suos reuertit.[22] E no capitulo de Iosue, se dis que mandou Iosue ao [f. 44*v*] Sol e a lua que paracem e dis a escriptura steteruntque Sol et Luna stetit itaque Sol in medio Caeli et infestinauit occumbere spatio unius diei, non fuit ante, et tam postea longa dies[23] nos quais paços se declara não somente o orto e o ocasso e mouimento do Sol, que fas de Oriente para Occidente, senão tambem o mouimento que fas norte e sul andando pellos doze signos, que os aduersarios explicão pellos mouimentos da terra que refutamos nesta e na 1ª conclusão, e querem que entendamos estes e outros paços da Escriptura as auesas, disendo que a terra nas partes da terra nacem, e se poem, e dão suas voltas pello norte e tornão pello meio dia, e vão lustrando tudo ao redor, e tornão em seus circulos, e tambem querem que digamos que Iosue mandou a terra que paraçe, e a terra parou.

Alem disso he o dito mouimento contrario a muitas experiencias pois vemos que quando huma bolla, pelouro ou se he pedra se lança direitamente para sima torna a cahir no mesmo lugar donde se lancou, o que não podera ser se a terra tiuera o dito mouimento, porque emquanto a dita pedra ou se [?] sobe e dese mouesse o dito lugar da terra para oriente e tanto mais tempo gasta a pedra no subir e no decer se o lugar estiuer debaixo do equinocial mouerseha em hum dia natural 5400 legoas geometricas e em huma hora 225, e em hum menuto da hora legoas e 4 e em hum segundo huma 16ª parte da legoa que he a 4ª parte de huma milha.

22 *Oritur sol et, occidit sol et ad locum suum anhelat ibique renascitur. Gyrat per meridiem et flectitur ad aquilonem, lustrans universa in circuitu pergit spiritus et in circulos suos revertitur. Eccle.* 1:5-6.

23 *Steterunt sol et luna, donec ulcisceretur se gens de inimicis suius. Nonne scriptum est hoc in libro Iusti? Stetit itaque sol in medio caeli et non festinavit occumbere spatio unius fere die. Non fuit antea et postea sicut dies illa. Ios.* 10:13.

Notasse no segundo lugar que as aues, nuues, fumos etc as vesses parão em sima de hum lugar não pouquo tempo sem se apartarem delle, o que tambem não pudera ser se o lugar se mouera com tanta presa. No terceiro lugar as aues voão com a mesma pressa para oriente e occidente, o que tambem não puderão fazer se a terra tiuera o dito mouimento. Pois a aue que voa para Occidente voa contra o mouimento [?] da terra, e asim encontra grande parte della: e a outra que voa para oriente voa com o dito mouimento da terra, o qual so não pode alcansar necessario he que fique atras, e ao contrario a outra parecera ser voada para oriente sendo asim que voa para occidente de modo que se ambas voarem huma hora inteira debaixo do equinocial ficara a primeira adiantada mais de 225 legoas pois tanto espacio da terra lhe encontrou, e ainda o que responde o que o proprio mouimento, e a segunda ficara trazeira ou mais occidental do que estaua quando comesou a voar porque não pode alcancar o mouimento da parte donde se alcansou. O mesmo se dira de huma pessa de artelharia que tanto espacio alcança para oriente quanto para occidente, o que tambem não podera estar com dito mouimento da terra. [f. 45*r*]

3ª Conclusão

A terra não tem outro mouimento circular pois se o tiuera fora o terceiro de copernico a que chamão mouimento de inclinacão, com que explicão como o eixo da terra em qualquer parte do orbe grande fiqua na mesma postura emdireitada para a mesma parte do Ceo mas como não ha aquelle mouimento no orbe grande não ha resão para afirmarmos o terceiro mouimento.

4ª Conclusão

A terra não se moue com o mouimento direito, a rezão notauel he porque se se mouera, mouerasse para sima, o que he contra sua natural: nem ha cousa [*sic*, causa] motiua extrincica que lhe faça tanta violencia. Dise notauel porque he prouauel mouersse a terra quasi continuamente (como tocamos na 1ª conclusão do capítulo 2º) por resão do Centro grauitatis, que continuamente se muda e acresentandose qualquer pesso em huma parte da terra se tira da outra parte, e pareçe dificultoso diser que qualquer destes pezos sempre se poem outro pezo. Porem como todos estes pezos que se acrescentão, e se tirão não tem proporcão com o pezo de toda esta terra não pode ser notauel o mouimento que por elle se causa, e este mouimento não se dis aos passos Sagrada Escriptura, que alegamos na 1ª conclusão, a qual não se mede nestas miudessas philozophicas, que tem pouquo proueito, e não sentem.

Corolario

Destas conclusões se colige qual he a quietação desta bolla da terra pois [carece ?] todos os mouimentos circulares e todos os direitos notaueis.

5ª Conclusão

A dita quietação desta bolla em que fica sentada no meio do mundo elemental não tem outra coussa [i.e. causa] senão a grauidade com que ve que todas as suas partes se enclinão e chegão quanto podem ao centro do mundo, e se conseruão no meio delle; pois não se pode dar outra resão natural; enão devemos de imaginar milagres nestas cousas ordinarias, e naturais, as quais o criador deu seus instrumentos e meios naturais para alcancarem o que lhes conuem; e esta grauidade se significa por aquella estabelidade sogre [*sic*, sobre] a qual Nosso Senhor fundou a terra Salmo 103 como tambem por aquellas colunas do Salmo 74 de que dissemos na 1ª conclusão. [f. 45*v*]

Document III

Chapter IV

English translation. On the motion and rest of the Earth's and water's globe [1625]. Johann Chrysostomus Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, ff. 43*r*-45*v*

In these chapters, we shall not deal with the motion of each of these elements in particular, with which, once removed from their natural places, they return to them through their gravity, but explain first whether this whole globe composed of both elements has some motion of its own or whether it stands still, in what sense and from where does it stem.

1st Conclusion

The Earth's and water's globe does not move around the Sun. This conclusion goes against some ancient philosophers and especially some modern authors who claim, with Nicholas Copernicus, that the Sun stands in the middle of the world and the Earth, together with the other elements, and the Moon moves around it in a year, between the heaven of Venus and that of Mars.

I believe that the main foundations of this opinion are the following two. In the first argument, these authors claim that it is easier to explain [the appearances] through the operations and movements of the celestial bodies because this solution cut many difficulties out. In the second place, those authors consider it highly inconvenient that such large and perfect bodies, like the celestial bodies, move with such a fast movement because of such a small and imperfect globe as the Earth.

Nevertheless, our assumption is more in keeping with the common reason and the understanding of all the people and the best philosophers and astronomers. Furthermore, the Sacred Scripture speaks so clearly in this way that one cannot say the opposite, for the *Ecclesiastics*, in the first chapter, state *Terra autem inter medium stat*[24] and, in *Psalm* 92, it is mentioned *firmauit orbem Terrae numero commovebitur*[25] and, in *Psalm* 74, referring to the Earth, it is said *Ego confirmavit columns eius*,[26] meaning 'I establish the Earth, which had been laid [f. 43*r*] upon firm columns'. In the first [book] of the *Paralipomenon*, chapter 16, [it states] *ipse fundauit orbem imobilem*.[27] The philosophical reason is that the movement of the Earth is neither natural nor violent. It is not natural because the Earth, which as a simple body, has but one natural movement, which, as the philosophers say with Aristotle, in the second chapter of the first book *On the Heaven*, must be downwards. Furthermore, we shall never recognise that the Earth is animated, as one of these modern argues. Nor is it a violent movement because there is no extrinsic cause to this movement. It is a trick to make the Sun responsible for all the celestial motions, as the above-mentioned modern [author] does.

24 *Terra autem in aeternum stat. Oritur sol, et occidit sol. Eccle.* 1:4-5.

25 *Etenim firmavit orbem Terrae, qui non commovebitur. Ps.* 93 (92):1.

26 *Ego confirmavi columnas eius. Ps.* 75 (74):4.

27 *Ipse enim fundavit orbem immobilem. I Par.* 16:30.

All the arguments and the common opinion of scholars confirm our sentence because, if the Earth moved, it would follow that the Firmament, the planetary heavens and the heaven of the fixed stars would be an immense space. There would also be a massive distance between Saturn and the heaven of fixed stars, with no reason or purpose for such a spatial immensity. To better understand this point, let us see what the parallax is. It is the dia[meter] [i.e. the angle] between the celestial body's true position and its apparent position. The star's true position is the point in which a straight line drawn from the centre of the world and passing through the centre of the star falls. The apparent position is the point in which a right line or visual radius drawn from the Earth's surface or the observer's eye, passing through the centre of that star, falls – as one can see in the figure **[fig. 3]**. For example, be it A the centre of the world; B the eye of the observer on the Earth's surface; the right line ACD a line [drawn from the centre of the world] through the centre of a certain star; and the right line BCE that is originated in the eye G [*sic*, B] and passes through the centre of that same star C. Thus, the true position of this star is in line AD while the apparent position is in line BE. The angle ECD with the difference between the true position and the apparent position is called parallax. Because of the parallax, the star C appears to be in a lower position and not so much raised from the horizon as it really is. Thus, although the star's true height corresponds to the arc GC (which is the same as FD), whoever observes it from place B will perceive the star's height as corresponding to the arch FE **[fig. 3]**.

In the second place, note that stars that are farther away have a smaller parallax than the closer stars. Thus, the star H is further away from the centre of the world [f. 43*v*] than the star C. Let the line BI be drawn through the centre of the star H, so the point I will correspond to its apparent position and its parallax to [the angle] IHD. This angle is smaller than that of the parallax ECD corresponding to the star C because the angle DHI is equal to the angle CHB by [preposition] 15 of Euclid's book, the angle ECD is equal to the angle ACB by the same preposition, and the external angle ACB is larger than the opposite internal angle CHB by [preposition] 16 of the same book. Therefore, the angle ECD, which corresponds to the parallax of star C, is also greater than the angle IHD, which corresponds to the parallax of star H. Therefore, the parallax of the lower star or those nearer to the centre of the world is greater than the parallax of the star that is farthest away from the centre of the world. And so, the distance may be so great that the star parallax disappears, or it is no longer perceptible because the interval between the observer's place B and the centre of the world A is not proportional to the great distance of the star.

In third place, note that astronomers do not find a sensible parallax in the stars of the Firmament, which means that there is no remarkable proportion between the distance of the observer to the centre of the world and the space or the semidiameter of the Firmament. There is, however, a great distance with respect to the very high planet Saturn, which is, in the opinion of Copernicus, more than nine times distant from the Earth than the Earth is from the Sun. According to the same author, the Sun is 1,208 terrestrial semidiameters away from the Earth. Based on this doctrine of Copernicus and these figures, Tycho Brahe establishes the immensity of the Firmament. Thus, the distance between Saturn, when it is further away from the Earth, and the Earth's surface, corresponds, according to Copernicus's doctrine, to 12,900 times the semidiameter of the Earth. We must multiply 700 or 800 times that figure to reach the large interval that exists between the Firmament and the Earth's surface. Accordingly, there is no sensible parallax in the fixed stars that are 10,320,000 semidiameters away from the Earth. This distance corresponds to the semidiameter of the Firmament according to Copernicus's doctrine. And the proportion between the whole heaven of the Sun and the Firmament would be the same as that between the centre of the sphere and the same sphere.

In *Disquisitiones* [*mathematicae de controversiis et novitatibus* (1614)], father Christoph Scheiner estimated from the Firmament's immensity that the diameter of the semidiameter of the Firmament, the diameter of the first magnitude stars, according to this opinion, would be over three times bigger the size of the Sun's heaven's diameter or that of the big orb; third magnitude stars' diameter would be over one time bigger than the size of [Sun's heaven's diameter]; and the sixth magnitude stars would be more or less the size of [the diameter of the Sun's heaven]. If this were the case, a minimum star, whose centre was observed from the centre of the world [f. 44*r*], would fill almost the entire space under the convex surface of the Sun's heaven, and the larger ones would even occupy the heavens of Mars and Jupiter, and perhaps that of Saturn, for they would be over thirty-three times larger than the heaven of the Sun. The same author also estimates [that] the space lying between Saturn [at the] apogee and the Firmament is some 700 or 800 times greater than the distance between that planet [at the] apogee and the Earth, which can be neither understood nor conceded, nor even are there any imperative reasons for that, as those adversaries claim.

The ease of explaining the celestial movements following this opinion is not as great as those authors envisage. And, even if it were the case, there would be not enough reason to accept it because of the several inconveniences that result from admitting the Earth's movement, as shall be discussed in more detail in the second conclusion. As for the other argument, which seems to make some sense, in the first place, I reply that the fact that they move to communicate their virtues, enrich the Earth and govern the other elements does not affect the nobility of the heavens and stars. On the contrary, by doing that, they are provided with a more illustrious and superb function. In the second place, I answer that the heavenly bodies' fast motion shows no less the omnipotence of the Creator than that incredible immensity that they put forward. In the third place, I reply that those elements [i.e. the celestial bodies] are not made particularly for the love of the Earth and the other elements but for the love of man whom they serve and who is infinitely nobler than any heavenly body.

2nd Conclusion

The Earth does not move with a circular motion around its own centre and axis. This theory is also false in the opinion of those authors who claim that the Earth not only moves around the Sun but also shifts around its axis, turning around within 24 hours and showing its different faces to the Sun, thus producing the days and nights. But this theory is also false, according to the common opinion of all the best philosophers and wise men. Nor can it be affirmed without forcing the interpretation of some parts of the Sacred Scripture such as when *Ecclesiastes* 1 in the above-mentioned chapter [5] affirms *oritur Sol e*[*t*] *occidit et ad locum suum revertitur ibique renascens girat per meridiem et flectitur ad aquilonem lustras uniuersam in circuitu. Pergit spir-*

ito, et in circulos suos reuertit,[28] or when it is refereed in Joshua's chapter that Joshua ordered [f. 44*v*] the Sun and Moon to stop, and the Scripture says *steteruntque stetit itaque Sol in medio Caeli et infestinauit occumbere spatio unius diei, non fuit ante, et tam postea longa dies.* [29] This excerpt refers not only to sunrise and sunset and the Sun's movement from the East to the West but also to its northwards and southwards motion through the twelve signs of the Zodiac. The adversaries explain these phenomena by attributing the movements to the Earth, which we refute in these conclusions. Furthermore, they want us to understand these and other parts of the Scripture in the wrong way, meaning that the Earth and its parts rise and set, revolving around the North pole, providing every part of it with light. They also want us to recognise that Joshua ordered the Earth to stop, and the Earth did stop.

Furthermore, the said movement [i.e. Earth's rotation] is contrary to many experiences, for we see that when a ball or stone is thrown straight up, it falls back in the same place. This effect could not occur if the Earth moved with a [rotation] movement because as the stone went up and down, the position on the Earth would move eastwards. And if the place were under the equinox, the stone would spend more time going up and down. It would move 5,400 geometric leagues in a natural day; 225 [leagues] in an hour; 4 leagues in a minute; and a 16th part of the league in a second which corresponds to the fourth part of a mile.

In the second place, birds, clouds, fumes, etc., are seen to occasionally stop for long above a specific location without moving away from it. This effect likewise could not occur if the place moved quickly. In the third place, the birds fly with the same speed Eastwards and Westwards, which they could not do if the Earth moved with such motion. If it were the case, the bird flying to the West would fly against the Earth's movement, thus having to cross a greater distance, while the other bird that flies Eastwards would fly following the Earth's fast motion. Since this second bird cannot reach the same velocity as the Earth, it would remain necessarily behind. Thus, this bird would appear to have flown eastward, even if it actually flew westward. Therefore, if both birds flew an entire hour under the equinox, the first would be over 225 leagues ahead while the second, incapable of reaching the same velocity as the Earth's motion, would be back or in a more western position than it initially was when it began flying. The same holds true for an artillery piece that reaches the same distance eastwards and westwards, which could not occur if such Earth's movement occurred. [f. 45*r*]

3rd Conclusion

The Earth has no other circular movement because if it had it, it would be the Copernicus' third [movement], which they call inclination movement (*movimento de inclinação*). They use this motion to explain why the axis of the Earth always points to the same part of heaven. Nevertheless, since that movement does not occur in the big orb, there is no reason to admit the third movement.

28 *Oritur sol et, occidit sol et ad locum suum anhelat ibique renascitur. Gyrat per meridiem et flectitur ad aquilonem, lustrans universa in circuitu pergit spiritus et in circulos suos revertitur. Eccle.* 1:5-6.

29 *Steterunt sol et luna, donec ulcisceretur se gens de inimicis suius. Nonne scriptum est hoc in libro Iusti? Stetit itaque sol in medio caeli et non festinavit occumbere spatio unius fere die. Non fuit antea et postea sicut dies illa. Ios.* 10:13.

4th Conclusion

The Earth does not move with a straight movement. The notable reason is that if it moved this way, it would move upwards, which is against its nature. Furthermore, there is no extrinsic cause to push it with such violence. I said notable [reason] because it is probable that the Earth moves almost continuously (as we shall discuss in the first conclusion of chapter 2) because of its centre of gravity (*centro gravitatis*). By adding some weight to one part of the Earth and pulling another from the other part, the Earth's centre of gravity moves continually, for it seems difficult to admit that there is always a balance between these weights. However, this motion is not perceptible because no relationship exists between all these weights (which are constantly added and removed) and that of the whole Earth. Furthermore, this motion is not discussed in the mentioned excerpts of the Sacred Scripture, whose aim is not to analyse these philosophical details with such a small use.

Corollary

Based on these reasons, one can conclude that the Earth sphere stands still because it lacks [?] all the circular and straight movements.

5th Conclusion

The so-called stillness of this sphere, with which it stands in the middle of the elemental world, has no other cause than the gravity that makes [sees, in Portuguese] all its parts tend, as much as they can, towards the centre and kept in the middle of it. Since there is no other natural reason, we must not imagine miracles to explain these ordinary phenomena. The Creator has provided them with the tools and natural means to reach the goals that are convenient to them. This gravity is meant, in *Psalm* 103, by that stability upon which our Lord established the Earth, as well as by those pillars of *Psalm* 74, which we have discussed in the first conclusion. [f. 45*v*]

5 The Geo-Heliocentric Model of Capellan Inspiration

As we have already seen, the Jesuit Christoph Clavius acknowledged the ground-breaking nature of the Galilean telescopic observations of 1610 in the final edition of his celebrated *Commentarius in sphaeram Ioannis de Sacro Bosco*, published in Mainz in 1611, shortly before his death.[1] After including a striking reference to Galileo's discoveries – the Moon's uneven surface, Venus's phases, the four satellites of Jupiter and the apparent three-bodied Saturn –, the mathematics professor at the Collegio Romano stated "as this is so, astronomers ought to see how the celestial orbs may be arranged in order to save the phenomena".[2]

Enigmatic as this sentence undoubtedly sounds, it has nevertheless been interpreted as an unofficial and, in some cases, indirect encouragement for Jesuit astronomers to adopt the cosmological path set out by Tycho Brahe.[3] In fact, as Clavius admitted, acknowledging the Galilean novelties meant recognising that the traditional Ptolemaic 10 or 11-orbs planetary arrangement was simply no longer tenable. The 1610-11 astronomical observations had hence paved the way for the cosmological discussion that eventually led to the Jesuits officially adopting the Tychonic geo-heliocentrism.

1 This chapter relies on Carolino, "Between Galileo's Celestial Novelties and Clavius's Astronomical Legacy".

2 Clavius, *Opera mathematica*. Vol. 3, *In sphaeram* (1611), 75.

3 For example, Bucciantini, Camerota, Giudice, *Galileo's Telescope*, 210; Donahue, *The Dissolution of the Celestial Spheres*, 108; Schofield, *Tychonic and Semi-Tychonic*, 277 ff.; Omodeo, *Copernicus in the Cultural Debates*, 56; Westman, "The Copernicans and the Churches", 95. Westman provides a more nuanced interpretation in Westman, *The Copernican Question*, 483-4.

DOI 10.30687/978-886-969-661-9/005

But what did Clavius really mean with his enigmatic sentence? Did he intend astronomers to search for a new astronomical system or, instead, accommodate the new telescopic observations within received astronomical theory? What answer might he have given to Paul Guldin when he asked the old Jesuit, on the suggestion of Johann Lanz, "if, in order to save the motions of these new satellites of Jupiter, Saturn, and Mars, one needs merely place epicycles with centres coincident with the centres of Jupiter, Saturn, and Mars; or if a new theory must be devised?".[4]

Clavius did not live long enough to elaborate a solution to this astronomical dilemma. Nevertheless, I believe that there are sound pieces of evidence indicating he would have opted for the first path suggested by Guldin, hence working out a means of incorporating the new telescopic evidence within the conventional Aristotelian-Ptolemaic cosmology. If this was the case, Tycho Brahe's geo-heliocentrism, which took celestial fluidity for granted, was not the kind of solution Clavius had in mind. In fact, Grienberger, one of the closest collaborators of Clavius, reported that the old Collegio Romano mathematics professor deeply opposed the notion of the fluidity of the heavens, an idea which was proving instrumental to the alternative planetary rearrangements that accounted for the new telescopic evidence.

> I am aware, as were those who also worked intimately with him, that Clavius abhorred the fluidity of the heavens until the end of his life and, accordingly, he searched for arguments through which he could save the phenomena in the ordinary way. He was less apprehensive concerning the incorruptibility of the heavens. Thus, when he recommended considering other Spheres, it seems that he wished for the new observations to be accommodated within the old hypothesis rather than changing it completely.[5]

The planetary system that Clavius was contemplating before his death might well be the kind of system later put forward by his pupil Giovanni Paolo Lembo at the College of Santo Antão.[6] Lembo was the only member of Clavius' close collaborators in the 1610-11 telescopic observations at the Collegio Romano, who signed the letter to Bellarmine corroborating the Galilean observations to actually follow Clavius's plea to rearrange the celestial orbs in such a way that these new phenomena might be saved. Clavius himself died in February 1612; Odon van Maelcote, who delivered the celebrated *Nuncius Sidereus Collegii Romani* in May 1611, died shortly after, in May 1615. In turn, Grienberger renounced participation in any public astronomical debates in the wake of the Catholic Church's condemnation of heliocentrism in 1616, although he most likely still played a crucial role behind the scenes in

4 Cited in Bucciantini, Camerota, Giudice, *Galileo's Telescope*, 210.

5 Undated letter from Grienberger to Biancani, cited in Baldini, *'Legem impone subactis'*, 237-8: "Scio enim Clavium, et sciunt qui cum ipso familiariter egerunt, ad finem usque vitae a liquiditate caelomm abhorruisse, et subinde inquisivisse rationes, quibus via ordinaria phaenomena defenderet. de incorruptibilitate tantum caelorum minus fuit sollicitus. Itaque cum de alia sphaera cogitandum monuit, optasse videtur, ut aliquis observationes novas, hypothesi veteri accommodaret potius, quam ut penitus immutaret".

6 Some historians indeed argue that this was the very meaning Clavius advocated for his words. See, for example, Ariew, *Descartes among the Scholastics*, 184; Lattis, *Between Copernicus and Galileo*, 202; Westman, *The Copernican Question*, 483.

the Society of Jesus through continuing to advocate for the Tychonic system.[7]

In Lisbon, in the 1615-16 academic year, [8] Lembo set forth a geo-heliocentric system of Capellan inspiration that came to terms with the Galilean novelties (and particularly with the phases of Venus and Mercury) while simultaneously retaining intact the foundations of Clavius's astronomical and cosmological ideas. While discussing the impact of Galileo's telescopic observations, Lembo recognised that the Ptolemaic traditional system of eleven solid orbs as once endorsed by Clavius was no longer tenable. Furthermore, in making this statement, the Italian Jesuit relied upon the authority of Clavius himself:

> Father Clavius held this view on the order and number of the celestial orbs [i.e. the Ptolemaic system of eleven orbs], on which, there is no doubt that, had he lived longer, he would have certainly changed his opinion (at least on some issues), as some of the words he included in the final edition of his works, published in the last year of his life in Mainz in the year of 1610 [*sic*, 1611], show.[9]

According to Lembo's interpretation, the words of Clavius "seem to provide us with permission to arrange the celestial orbs in a somewhat different way to how he and the other astronomers had done".[10]

To a certain extent, Lembo was just the right person to respond to Clavius's plea that featured in the 1611 edition of his complete works. In fact, not only had he been trained by Clavius but Lembo above all shared the same cosmological principles of the leading mathematical authority at the Collegio Romano. The Italian astronomer argued in favour of a cosmos organised into solid and impenetrable orbs, concentric to the Earth, but also comprising a complex system of epicycles and eccentric circles.[11] Similar to Clavius, Lembo built his argument upon the belief that only this sort of astronomical model might account for the diversity of motions presented by celestial bodies without questioning the cosmological principle according to which celestial bodies performed one single circular and earth-centred motion. In this respect, Lembo relied on Clavius's instrumental definition of contrary movement. Thus, just as did his mathematics professor, Lembo maintained that contrary motions "should be considered by reference to the same fixed point".[12] Accordingly,

7 Baldini, *'Legem impone subactis'*, 225-6.

8 The lecture-notes containing the astronomical and cosmographical contents finish by referring to how the contents were taught from 1615 to October 1616: "o que se leo atee [a]qui, foi do anno de 615 atee o primeiro de Outubro de 616", Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 53*v*.

9 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 32*v*: "Esta oppenião teue o padre Clauio acerca da ordem e numero dos orbes coelestes, na qual sem duuida pello menos em algumas cousas mudara o pareçer se viuera mais tempo como mostrão algumas pallauras que elle fez imprimir no derradeiro anno de sua idade na ultima edição de suas obras do anno de 610, em moguntia".

10 The complete account reads as follows: "Nestas ultimas pallauras em que o Padre Clauio se remette à obseruação dos Astronomos no modo, com que se deuem saluar as Phenomenas, que nestes nossos tempos se descobrirão e virão, com o occulo nouamente inuentado, pareçe que nos dá licença de por os orbes caelestes em hordem algum tanto diuersa do que elle com os demais Astronomos ordenou". Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 33*r*.

11 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 7*r* and 11*r*.

12 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 19*v*: "os mouimentos contrarios se hão de referir ao mesmo ponto fixo".

he argued that planets and stars did not perform opposite movements as the diurnal motion westwards took place around the poles of the world whereas the proper planetary motion eastwards was performed around the poles of the zodiac.[13] Thus, for Lembo, again like Clavius before him, the solidity of the heavens constituted an astronomical requirement stemming directly from the Aristotelian dictum on the unidirectional nature of celestial motion.

This Aristotelian principle also required the celestial bodies to move according to their spheres, and neither by themselves nor by an angelical agency. If the celestial bodies moved by themselves or were pushed by angels, they would forcibly move in one direction only, argued Lembo.[14]

The celestial bodies thus displayed two basic motions which originated differently in the celestial spheres. Whereas the *Primum mobile* (First mover) would push the celestial spheres below it to move westwards every twenty-four hours (*per accidens* motion), each planet would move eastwards at a different velocity due to the motion imposed on it by its particular celestial sphere (*per se* motion). As he explained to his Lisbon students:

> [The heavenly bodies] have two primary and well-known movements, as we have stated earlier. The first motion is that from East to West with which the First mover, or 10th heaven, transport with it, without resistance, all the other inferior orbs around the Earth every day in 24 hours. This movement is *per accidens* to the inferior orbs and not *per se* because it was due to an extrinsic principle. […] The second [movement], as we have already stated, is proper of the nine inferior orbs from West to East. This movement is in no way due to the First mover, but it is a *per se* and not a *per accidens* movement to them […] because [the planets] progress *per se*, with a proper motion which we also attribute to the celestial orbs.[15]

Alongside these two basic motions, celestial bodies also underwent two other additional movements perceptible in the long term, the trepidation and the precession of the equinox motions.[16] In the same manner as Clavius argued in his *Commentarius in sphaeram de Sacro Bosco*, Lembo thereby acknowledged that each particular movement required its own specific orb.

Lembo was a correspondingly committed disciple of Clavius. He stood up for Clavius's major cosmological synthesis even while reaching beyond

13 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 15*v*, 20*v*-21*r*.

14 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 18*r*-18*v*.

15 The complete account: "Por estas rasoens os maes doctos Astronomos disem que se notão 2 mouimentos prinçipais e mui conheçidos, como disse no principio. O primeiro do Oriente para o Occidente com o quoal o primeiro mouel ou o décimo leua consiguo sem resistençia alguma todos os outros orbes inferiores ao redor da terra todos os dias em vinte e quatro horas, o qual mouimento he per accidens, aos orbes inferiores e não per si porque lhe nasçe de principio extrinseco, como aquelles que vão na nao, ou no coche, os quoaes se a nao, ou coche não se mouerão estiuerão immoueis. O segundo [movimento] como tambem ja dissemos he proprio dos nove orbes inferiores do Occidente para ho Oriente o quoal de nenhum modo conuem ao primeiro mouel e lhe conuem per se e não per accidens de modo que se alguem indo com huma nao do Oriente para o Occidente, andasse com o proprio e progressiuo mouimento do Occidente para o Oriente este ainda que muito mais apressadamente se mouera com a nao para o Occidente que com o mouimento proprio para o Oriente contudo se dissera que per accidens se moue com o mouimento da nao para o Occidente porque realmente he mouimento alheo, mas per se se mouera para o Oriente porque caminhara per se com o mouimento proprio o que tambem avemos de disser dos orbes coelestes" (Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 18*v*).

16 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 28*v*-29*r*.

them in drawing further conclusions from the astronomical observations of the early 1610s. As already mentioned, while at the Collegio Romano, Lembo embarked on a programme of astronomical observations that led him to pay close attention to the phases of Venus and, to a lesser extent, to Mercury. He continued this observational programme while in Lisbon.

These telescopic observations proved crucial for Lembo's cosmological thinking. Unlike his fellow Jesuit Collegio Romano mathematicians (Clavius, Grienberger and Maelcote included), who seemed much more cautious in drawing cosmological consequences from the observation that Venus waxed and waned, Lembo did acknowledge that the phases of Venus proved that the planet actually orbited the Sun. Furthermore, although telescopic observations were not so evident on this point, he recognised that Mercury also revolved around the Sun.[17] In Lembo's own words, "to save their appearances, which are so similar to those of the Moon, we must confess that Venus and Mercury move around the Sun and that sometimes they are below it and sometimes above, sometimes they move before it and sometimes after".[18]

The heliocentric orbit of Venus and Mercury, however, did not persuade Lembo to accept the geo-heliocentric system of Tycho Brahe, as would prove the case with other Jesuit mathematicians, who followed him in the Class on the Sphere.[19] Because of the intersection between the orbits of the Sun and of Mars, the Tychonic system required the celestial region to be fluid, a cosmological principle that, as pointed out above, Lembo utterly refuted.[20] Furthermore, while recognising that Tycho Brahe was "a most meticulous and modern observer of the path of the planets and stars",[21] he disagreed with the paths and dimensions that the Danish astronomer had attributed to the orbits of Jupiter and Saturn. According to Lembo, the orbits of these planets did not move away and back around the Earth as Tycho conceived.[22] They were instead concentric to the Earth. As regards the orbit of Mars, despite the fact that the diagram representing his planetary system included an independent orb for Mars **[fig. 4]**, Lembo promised further telescopic observations of this planet in order to check if "the orb of Mars should be placed in the same manner as Tycho did and it seems to me that Plero [*sic* Kepler] proves that in his *Nova astronomia*, so that sometimes it is close to the Earth and sometimes far away from it".[23] This excerpt not only seems in contradiction with the drawing of his system **[fig. 4]**, but it also reveals Lembo's unfamiliarity with Kepler's *Nova astronomia*.

Be that as it may, Lembo put forward a partially geo-heliocentric planetary system, which differed radically from that of Tycho Brahe. [24] Based

17 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 35*v*.

18 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 33*v*. See Document II.

19 Carolino, "The Making of a Tychonic Cosmology"; Ingaliso, *Filosofia e cosmologia*, 81-113.

20 On the Tychonic system and its cosmological consequences, see, apart from Schofield, *Tychonic and Semi-Tychonic*; Thoren, *The Lord of Uraniborg*; Granada, *El debate cosmológico*, 31-59; Lerner, *Tre saggi*, 73-104; Lerner, *Le Monde des Sphères*. Vol. 2, *La fin du Cosmos*, 39-66.

21 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 34*r*: "Tycho Brah dilligentissimo e mais moderno obseruador do curso dos Planetas e estrellas".

22 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 36*r*.

23 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 36*r*. See Document IV.

24 Giovanni Battista Riccioli labelled this planetary model as "semi-Ptolemaic". See Gambaro, *Astronomia e tecniche di ricerca*, 26. In other instances, Riccioli also designated this plan-

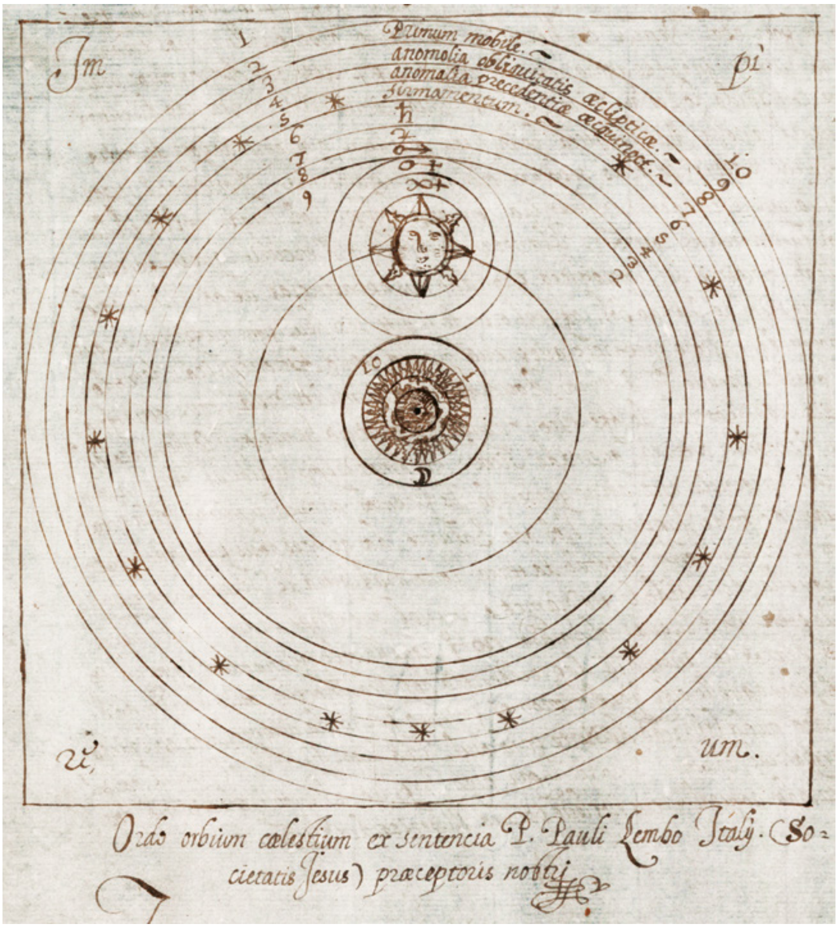


Figure 4 The geo-heliocentric system of Giovanni Paolo Lembo (*Tratado da Esfera*, ANTT, MS Liv. 1770, f. 36*v*)

upon the principle of celestial solidity and the astronomical evidence regarding the phases of Venus and Mercury, the Italian astronomer argued that Venus and Mercury moved around the Sun in epicycles with their centres coinciding with the Sun's centre.[25] Thus, the Sun, Venus and Mercury occupied a shared solid and impenetrable orb: "having shown and proven this [the phases of Venus and Mercury], who would disagree in placing the Sun, Venus and Mercury in the same orb, excluding at least two orbs from the number traditionally recognised so far [...]?".[26] The Sun, together with the remaining planets (Moon, Mars, Jupiter and Saturn) and the fixed stars, were supposed to move inside solid orbs concentric to the Earth. Above Saturn's orb, three further celestial spheres were factored in order to account for the precession of the equinoxes (Firmament), the two oscillatory movements and diurnal motion (*Primum mobile*, First mover). The Empyrean heaven thus acted to seal the universe **[fig. 4]**.

In Lisbon, Lembo presented this system as his own as the caption to the diagram displaying the planetary arrangement states: "the order of the celestial orbs according to the opinion of our professor Father Paolo Lembo, Italian, of the Society of Jesus" (*Ordo orbium coelestium ex sentencia* [sic] *P. Pauli Lembo Italij (Societatis Jesus) praeceptoris nostri*) **[fig. 4]**.[27] Nevertheless, this world system was in no way new. It had first been put forward by Martianus Capella in the late fourth-early fifth centuries and profusely debated during the early Middle Ages.[28] In the sixteenth century, the reference made by Copernicus to the Capellan system in the first book of *De revolutionibus* and alongside a diagram included in Valentine Naibod's *Primae de coelo et terra institutiones*, published in 1573, contributed to its diffusion. The Capellan system thus represented an additional solution available to astronomers involved in the planetary debate.

Some of these astronomers adhered to this planetary system while trying to transform the heliocentric system into a geostatic model. Dissatisfied with the cosmological implication of the Copernican theory and persuaded that were the roles of the Earth and of the Sun reversed and the daily motion of the Earth transposed to the Prime Mover, an equivalence would emerge between the heliocentric and the geo-heliocentric theories, authors, such as Paul Wittich, devise a Capellan geo-heliocentric system akin to that which Lembo would develop later, in which Mercury and Venus orbited the Sun while the Sun, together with the superior planets, revolved around the Earth.[29]

However, Lembo followed a different path. Rather than transforming the Copernican system into a plausible geo-heliocentric model, he was very much engaged in elaborating on an Aristotelian-Ptolemaic worldview. The Italian astronomer was most likely familiar with the Capellan system ei-

etary rearrangement as "reformed Ptolemaic" and "semi-Tychonic". Cf. Marcacci, *Cieli in contraddizione*, 90.

25 For the case of Venus, see, for example, Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 34*v*.

26 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 36*r*. See Document IV.

27 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 36*v*.

28 Eastwood, "The Chaster Path of Venus"; "Astronomical Images".

29 Gingerich, Westman, *The Wittich Connection*; Goulding, "Henry Saville".

ther through his Naples' professor Giovanni Giacomo Staserio[30] or through Copernicus's reference and Naibod's diagram. Thus, differently from some Northern European astronomers, Lembo came to a Capellan solution while elaborating on a system that incorporated the outputs of the new telescopic observations and simultaneously retained intact the foundations of Clavius's astronomical and cosmological ideas.

Ugo Baldini has recently argued, based upon the diagram included in his lecture notes, that Lembo's source of inspiration was the *Fundamentum astronomicum* by Nicolaus Raimarus Ursus and the *Ephemerides* by David Origanus, books that existed in the Collegio Romano library.[31] Nevertheless, detailed analysis of Lembo's lecture notes demonstrates not only that his planetary system differs to those of Ursus and Origanus but also that Lembo disagreed with Ursus and Origanus on some crucial cosmological tenets, such as the fluidity of the heavens (shared by both Ursus and Origanus), the Earth's daily rotation on its axis (Ursus and Origanus), the circumsolary orbit of the superior planets (Ursus and Origanus) and the intersection of the orbits of the Sun and Mars (Origanus).[32] Thus, Lembo's solution should not be characterised as a semi-Tychonic system. Lembo most likely decided to rework the Capellan system in order to face the new cosmological challenges created by the telescopic observations.

In putting forward this planetary system, Lembo came to terms with the telescopic novelties and particularly with the brand-new observations of the phases of Venus and Mercury. [33] Furthermore, he did this without jeopardising the traditional Aristotelian-Ptolemaic cosmology then endorsed by Clavius and the majority of Jesuit mathematicians and philosophers. In fact, while arguing that Venus and Mercury moved around the Sun in a common orb, he maintained the cosmological postulate of the solidity of the heavens and maintained the explanation of the dynamics of celestial bodies as resulting from the motions of the spheres. From this point of view, Lembo's system configured a sort of conservative and yet updated response to the Galilean telescopic novelties.

The traditional character of Lembo's cosmology likewise explains the absence of a central topic in the early seventeenth-century cosmological debate, the discussion around comets and new stars, from his *Tratado da Esfera*. There is no evidence of Lembo, whether still at the Naples college or already in Rome, observing the comet that appeared in the skies in September and October of 1607. Nevertheless, he was most likely aware of the fact that Tycho Brahe and other expert astronomers considered the comets (and the new stars) to move above the Moon. Therefore, they were seri-

30 Giovanni Giacomo Staserio discussed this topic in a letter to Clavius in 1604. Clavius, *Corrispondenza*, 5, 1: 97-8 (7 May 1604). On the correspondence between Staserio and Clavius on astronomy and planetary issues (with particular focus on Copernicus), see Gatto, *Copernico tra i gesuiti*, 180-7.

31 Baldini, "Giovanni Paolo Lembo's lessons in Lisbon", 158.

32 On Ursus and Origanus, see Granada, *El debate cosmológico*, 77-107; Jardine, Segonds, *La Guerre des Astronomes*, 1: 26-42; Omodeo, "David Origanus's Planetary System".

33 He did not discuss any of the other Galilean novelties, with which he was also familiar, namely the satellites of Jupiter, the three-bodied Saturn, the Moon's irregular surface and the starry composition of the Milky Way. Nevertheless, in the case of the satellites of Jupiter and the three-bodied Saturn, he could have come up with a similar solution in arguing that the satellites move inside the same solid orb as Jupiter and potentially Saturn.

ously undermining the notion of celestial solidity and perfection.[34] As Lembo ignored the topic in his lecture-notes, it is therefore impossible to know precisely what his cometary understanding would have been. Nevertheless, there is sound evidence suggesting that he probably did not recognise the celestial nature and location of comets. Not only did Lembo advocate the notion of celestial solidity but he also argued in favour of celestial perfection. As he declared in his lecture-notes, "next to the elementary region there is the aethereal region, [which is] bright and, because of its essence, which the philosophers called the fifth essence, it is immutable and indifferent to any kind of change and moves continuously with a circular motion".[35] Again, Lembo endorses a traditional cosmological view based both upon the ontological distinction between the heavenly region and the terrestrial realm and upon the notion of celestial solidity and perfection.

In short, Lembo put forward a conservative geo-heliocentric system that, on the one hand, came to terms with the telescopic novelties revealed in 1610 by the Galilean *Sidereus Nuncius* but, on the other hand, retained the traditional cosmological postulates regarding solid spheres, celestial dynamics and the ontological divide between the celestial and the terrestrial regions, as endorsed by Clavius, his followers and the large majority of Jesuit philosophers in the early seventeenth century.

34 On the overwhelming impact of the celestial novelties on the astronomical and cosmological debate, see, among many others, Granada, *Novas y Cometas* and Tessicini, Boner, *Celestial Novelties*.

35 Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, f. 15*r*.

Document IV

Lembo's account of his geo-heliocentric system. Giovanni Paolo Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 35*v*-36*r*

O que dissemos de Venus se pode proporçionadamente dizer de Mercurio no quoal ainda que como dissemos por razão de se apartar menos do Sol, senão possao obseruar nelle tão commodamente e amiudo as cousas que se obseruarão em Venus; contudo pello que delle disserão os Astronomos mais antigos pondo o humas [vezes] abaixo outras assima do Sol e pello que delle julgou Ticho e muito mais pello que se pode obseruar e pella congruençia a quoal nos persuadira ser assim ainda que nenhuma outra cousa delle se podesse ver do que se vee hora estar antes hora depois do Sol muito [35*v*] mais amiudo do que em Venus se pode sem duuida affirmar que elle se moue ao redor do Sol do mesmo modo que Venus. O que posto e prouado desta maneira quem duuidara de poer o Sol, Venus e Mercurio no mesmo orbe e pello menos tirar dous orbes do numero que atee agora comummente se poz atee que Astronomos mais dilligentes, com ajuda do longemira, e outras nouas inuençoins ainda não discubertas das quoais a nossa Mathematica he muito rica prouem averemse de poer de outra maneira por onde os orbes coelestes se podem ordenar nesta forma. Pondo no primeiro lugar o orbe da Lua que çerca a circunferençia conuexa do fogo. No segundo lugar o orbe da Lua digo do Sol juntamente com os dois Planetas Venus e Mercurio, que perpectuamente çercão o mesmo sol com ficca prouado nas apparencias atras. No terceiro orbe de Marte ao redor do orbe do Sol o quoal orbe de Marte se se deue poer na forma em que Ticho o poem e que [Ke]Plero me pareçe que proua na sua noua Astronomica de modo que humas veses se chegue muito à terra, e outras se aparte muito della, o que ainda fora muito mais na disposição de Copernico, na quoal por ventura he maior a differença de se aparta e cheguar à terra que na de Ticho, veremos depois de algumas observaçoins que com mais deligençia este anno querendo Deos faremos açerca do mesmo Planeta. No quarto lugar o orbe de Juppiter. No quinto o de Saturno, dos quoaes dous planetas certo he que nem se cheguão, nem afastão da terra como na figura de Ticho se vee porque não tem aquella diuersidade no diametro visual que terião se assim estiuessem como os elle poem no sexto lugar afirmando no sétimo aquelle orbe que na outra disposição dos Astronomos era o nono da anomalia da preçedentia dos aequinoctios ou do mouimento do oitavo orbe. No oitavo lugar aquelle orbe que os Astronomos punhão por décimo da anomalia da obliquidade do Zudiaco ou da libração do Norte para o sul. No nono lugar finalmente o primeiro mouel, o quoal na outra disposição era [o] décimo primeiro. E no décimo lugar o çeo Impireo, assento foeliçissimo dos bem auenturados ao quoal Deus nos leue por sua Misericordia. [36*v*]

Document IV

English translation. Lembo's account of his geo-heliocentric system.
Giovanni Paolo Lembo, *Tratado da Esfera*, ANTT, MS Liv. 1770, ff. 35*v*-36*r*

We can extend to Mercury what we have just said about Venus, although – as already stressed – the same phenomena cannot be so easily and frequently observed in it as in Venus, which is further away from the Sun. However, one can argue that Mercury moves around the Sun in the same way as Venus, based on the ancient astronomers, who placed Mercury sometimes below the Sun and sometimes above it, as well as on Tycho, and above all on the observations and on its similitude [with Venus], which, although we can observe nothing of it more often than in Venus, nevertheless it persuades us that Mercury sometimes appears before the Sun, sometimes after it. [35*v*] Having said and proved this, who would disagree in placing the Sun, Venus and Mercury in the same orb, excluding at least two orbs from the number [i.e. the astronomical system] traditionally recognised so far when more diligent astronomers, with the help of the telescope (*longemira*) and other discoveries not yet revealed – in which our mathematics is rich – prove that the celestial orbs should be ordered otherwise? Thus, the heavenly orbs should be arranged in this way. In the first place stands the orb of the Moon surrounding the fire's convex circumference. In the second place, there is the orb of the Moon, I mean of the Sun, which is surrounded perpetually by the two planets Venus and Mercury, as the celestial appearances mentioned above prove. In the third orb, one finds Mars above the orb of the Sun. Whether the orb of Mars should be placed in the same manner as Tycho did, and it seems to me that [Ke]pler proves that in his *New Astronomy*, so that sometimes it is close to the Earth and sometimes far away from it (according to Copernicus these distances would perhaps be even greater than in Tycho's model), we will see later after a few observations of this very same planet [Mars] that we aim to carry out with a greater diligence this year if God wishes. In the fourth place, one finds the orb of Jupiter, and in the fifth place, that of Saturn. There is no doubt that these two planets neither come close nor move away from the Earth, as in Tycho's system, because their visual diameters do not change as it would be the case if they were as he poses them. In the sixth place, one finds the orb that corresponds in other astronomers' systems to the ninth sphere comprising the anomaly of the equinoxes' precedence or the motion of the eighth orb. In the eighth place, there stands the orb that the astronomers [traditionally] considered to be the tenth orb, which accounted for the anomaly of the Zodiac's obliquity or the libration motion from the North towards the South. In the ninth place, one finds finally the First mobile, which in the other astronomer's arrangement corresponded to the eleventh orb. And the tenth orb is the Empyrean heaven, the most pleasing shelter of the Blessed, to which God, by His mercy, will take us. [36*v*]

6 The Jesuit Censorship of Tycho Brahe

Despite Giovanni Paolo Lembo's successful attempts to integrate the Galilean novelties into the Aristotelian-Ptolemaic worldview as Clavius theorised it, his fellow Jesuit mathematicians followed a different path. As Michel-Pierre Lerner demonstrated in a seminal paper on the Jesuit reception of the Tychonic system in the early seventeenth century, the interpretation of Clavius's enigmatic plea led the majority of Jesuit astronomers to the adoption of a Tychonic geo-heliocentric cosmology.[1] In fact, a group of Jesuits familiar with Clavius's project and work, while not belonging to his inner circle, interpreted his words as opening the way to denying celestial solidity and advancing with a geo-heliocentric system that took celestial fluidity for granted. Accordingly, Christoph Scheiner remarked that Clavius's sentence:

> rightly announces that the system presented above [i.e. the Ptolemaic system] does not stand up to the phenomena observed as it is a fact for all astronomers that Venus revolves around the Sun because, by reflecting the light in that manner, it emulates the Moon. Galileo equally applies this principle to Mercury.[2]

1 Lerner, "L'entrée de Tycho Brahe". See also Lattis, *Between Copernicus and Galileo*, 181; Schofield, *Tychonic and Semi-Tychonic*, 277-81; Weichenhan, *'Ergo perit coelum…'*, 301.

2 Scheiner, *Disquisitiones mathematicae*, 51: "Haec ille [Clavius's words], satis declarant, Systema praemissum cum datis phoenomenis non stare; cum certum sit apud omnes Astronomos Venerem, quia Lunam imitatur lucendi modo, circa Solem girari: cui pariter legi subijcit Mercurium S. Galilaeus".

DOI 10.30687/978-886-969-661-9/006

Alongside Scheiner, this group included other young Jesuit astronomers, such as Cristoforo Borri and Giuseppe Biancani.[3]

Nevertheless, to adopt the Tychonic system, a twofold problem had to be solved. As one learns from the Jesuit internal censorship of Biancani's book *Aristotelis loca mathematica* (1615), apart from the question of the celestial fluidity itself,[4] there was the highly sensitive issue of the religious belief of Tycho Brahe. While examining Biancani's book, the Jesuit censor Giovanni Camerota resolutely condemned all the eulogies made by the Jesuit mathematics professor in Parma to astronomers who were either 'heretic' or 'strongly suspected'.[5] In his report elaborated in the Collegio Romano, he advised Biancani:

> To entirely abstain from praising the heretical authors, as in the first book of Meteors (chapter 4, post number 129, page 57 at the end and page 58 in the beginning), where he praises Tycho Brahe and others, including Landgrave Wilhelm [IV] of Hesse[-Kassel], Michael Maestlin, Cornelius Gemma, Helisäus Röslin, Christoph Rothmann.[6]

The turning point in the Jesuits' reception of Tychonism occurred in 1620. A copy of Tycho Brahe's *Astronomiae instauratae progymnasmata* was submitted to the Holy Office early that year. This book, originally published in 1602, contained Tycho's investigations into the new star of 1572 as well as his solar theory, research on the lunar theory and a comprehensive catalogue of stars.[7] Nevertheless, it was not the scientific contents that distressed the Catholic authorities but rather the religion or, more properly, the religious beliefs of its author.[8]

As it happened, the Jesuit Roberto Bellarmino was by then an influential member of the Congregation of the Inquisition, in addition to being a participant in the Congregation of the Index. Hence, Bellarmino, who had already played a key role in the 1616 condemnation of heliocentrism and censure of Galileo, was also to play an important part in the reception of Tycho Brahe's astronomical system and ideas into the mainstream of Catholic intellectuals.[9]

Celestial fluidity, upon which the Tychonic system rested, presented no major difficulty to the influential Jesuit Cardinal. While teaching theology at Louvain, in 1570-72, Bellarmino had already endorsed a cosmological model di-

3 See Lerner, "L'entrée de Tycho Brahe", 159, 171.

4 Camerota's censorship is included in Baldini, *'Legem impone subactis'*, 229-31.

5 "Constat enim aut hos omnes, aut ex his plerosque, atque adeo ipsum Tichonem, quem tanti facit, aut haereticos fuisse, aut valde suspectos". Baldini, *'Legem impone subactis'*, 230-1.

6 "Omnino tamen abstineat laude Scriptorum Haereticorum. Ut in primum Meteor. cap. 4, post numº. 129 pag. 57 in fine, et 58 in princ. ubi laudat Tichonem Brahe, et alios, qui sunt Gulielmus Landgravius Hassiae, Michael Maestlinus, Cornelius Gemma, Helisaeus Roeslin, Christophorus Rothmannus". Camerota in Baldini, *'Legem impone subactis'*, 230.

7 On this book's composition process, see Thoren, *The Lord of Uraniborg*, particularly 283-5, 262, 282.

8 On this process, see particularly Lerner, "Tycho Brahe Censured". See also Bucciantini, *Galileo e Keplero*, 91-2; Tutino, *Empire of Soul*, 279-80; Tirapicos, "On the Censorship".

9 On the role played by Bellarmino in establishing the theology orthodoxy and striving for the intellectual leadership of the Catholic Church, see particularly Tutino, *Empire of Soul*. A critical analysis of some historiographical rehabilitation of Bellarmino can be found in Omodeo, "'Jesuit Science'".

vided into three heavens – the *aereum*, the *sidereum* and the *empireum* – that assumed the planetary heaven (the *sidereum*) to be a fluid body. In the *caelum sidereum* – as he stated – "the stars are not moved together with the motions of the heavens, but they move by themselves (*motu proprio*) like the birds through the air and the fishes through the water".[10] W.G.L. Randles convincingly demonstrated that Bellarmino's cosmology stemmed from his *Hexameron* reflections.[11] Indeed, a reflection on "the work of the Days", described in the Book of Genesis, would also lead other Jesuits to support a tripartite division of the cosmos and potentially to endorse the notion that planets move in a fluid region. This was, for example, the case of the Spanish theologian Luís de Molina, professor at the University of Évora, Portugal. While discussing the issue of the creation of the heavens, Molina argued for the existence of the same three heavens: the *caelum aereum*, including the region from the earth to the orb of the Moon, the *caelum sidereum*, consisting of the incorruptible celestial orbs made up of water, and the *caelum empireum*.[12]

As far as the issue regarding the confessional identity of Tycho Brahe is concerned, Bellarmino offered a puzzling assessment. Although recognising Tycho as likely to be a 'heretic' – as he praised Luther, Melanchthon, Beza and Chytraeus – Bellarmino nevertheless suggested that he might have converted to Catholicism at some point as his children dedicated the book to the Catholic Emperor Rudolph. Even so, the Jesuit Cardinal recommended the book to be expurgated of all the eulogiums bestowed on Protestant authors as well as the letters received from the Landgrave Wilhelm IV and addressed to other Protestant princes. In his words:

> It seems, both from the praises with which the author honours the heretic Luther, Melanchthon, Beza, Chytraeus and from his close friendship with the heretic Lutheran Landgrave Wilhelm of Hesse, that this author was a heretic.
>
> [Nevertheless], it seems from the fact that, upon his death, his children dedicate his books to the Emperor Rudolph and call their father a man of pious memory, that he had probably been a Catholic. The Emperor himself ordered, thereafter, some of his works to be prepared at his own expenses as it is clear in the book published in folio, which is the third volume, so to speak. It is indeed hardly credible that a Catholic emperor promoted the publication of the works of a heretic author.
>
> This book could perhaps be amended by suppressing the honours addressed to the heretics and the letters of the heretic prince as well as the letters sent to the heretic princes.[13]

10 Bellarmino, *The Louvain Lectures*, 19: "stellas non moveri ad motum coeli, sed motu proprio sicut aves per aerem, et pisces par aquam".

11 Randles, *The Unmaking*, 44.

12 Defending the Creation of the Empyrean heaven on the First Day, Molina stated, "Solet etiam positio caeli empyrei confirmari. Primo, ex illo 2 ad Corinth. 12, *Scio hominem in Christo ante annos quatuordecim raptum usque ad tertium coelum*. Quasi ex Scriptura sacra […] triplex caelorum genus sit constituendum, aereum primum, quod usque ad orbem lunae incorruptibilem pertingit; sydereum secundum, quod orbes omnes incorruptibiles ex aqua factos, in quibus astra omnia sunt collocata, comprehendit, et empyreum tertium, quod est sedes beatorum, atque ad hoc tertium raptus fuerit Paulus in consortium beatorum" (Molina, *Commentaria in primam*, 705).

13 In Godman, *The Saint as Censor*, 307: "Quod hic auctor fuit haereticus, videtur intellegi posse tum ex laudibus, quibus ornat haereticos Lutherum, Melancthonem, Bezam, Cythreum, tum quia erat amicissimus Gulielmi Hussiae Lantgravii, haeretici Lutherani".

An appropriate censure would thus turn Brahe's *Astronomiae instauratae progymnasmata* into a suitable book for a Catholic audience. The Congregation of the Holy Office accordingly decreed the book to be expurgated from the praises addressed to Protestants.[14] As Michel-Pierre Lerner has already stressed, even though this book was not included in the Roman *Index librorum prohibitorum*, it most likely circulated in the Jesuit milieu.[15] The Jesuit professors of the Class on the Sphere provide a good example of this circulation, as one learns from the copy of Tycho Brahe's *Astronomiae instauratae progymnasmata* (1610), which belonged to the mathematics library of the College of Santo Antão.[16]

The Lisbon Jesuit copy of Tycho's *Astronomiae instauratae progymnasmata* contains two sorts of censorship that both deal with religious issues. First and foremost, the erasures included in the typescript were intended to suppress sympathetic references to the religious beliefs of Brahe and his Lutheran and Calvinist fellows. Thus, along with favourable allusions to Luther,[17] the names of distinguished Lutherans, such as Philip Melanchthon and his disciple, the University of Rostock professor David Chytraeus, were eliminated from the text.[18] Tycho Brahe's criticism of Catholic authors was also subject to censorship. Brahe was particularly harsh regarding the eschatological interpretation of Theodorus Graminaeus, a former professor of mathematics at the University of Cologne and tutor to the Dukes of Cleves, who abhorred Protestantism and became a champion of the Counter-Reformation.[19] Accordingly, Brahe's sentences criticising the anti-Luther statements of the Catholic Graminaeus were also inked out of the text.[20]

Quod fortasse fuerit Catholicus, videtur colligi ex eo, quod filii eius post mortem ipsius dedicant eius libros Rudolpho imperatori et vocant parentem suum piae memoriae virum. Deinde ipse idem imperator suis sumptibus iussit excudi aliqua eius opera, ut patet ex libro in folio edito, qui est quasi tertius tomus. Vix est autem credibile imperatorem Catholicum iussisse excudi opera hominis haeretici.

Posset fortasse corrigi liber, sublatis laudibus haereticorum et epistolis principis haeretici et epistolis ad principes haereticos missis".

14 Lerner, "Tycho Brahe Censured", 96-7.

15 Neither was it included in the Portuguese *Index auctorum damnatae memoriae*. Spain provides the exception. In fact, the Spanish *indexes* ordered 'corrections' not only in the *Astronomiae instauratae progymnasmata* but also in three other books: the *De Mundi Aetherei recentioribus phaenomenis*, the *Epistolae Astronomicae* and the *De disciplinis Mathematicis oratio*. Lerner, "Tycho Brahe Censured", 97-8; Tirapicos, "On the Censorship", 102. On the Spanish Inquisitorial censorship of scientific books, see Pardo Tomás, *Ciencia y Censura*.

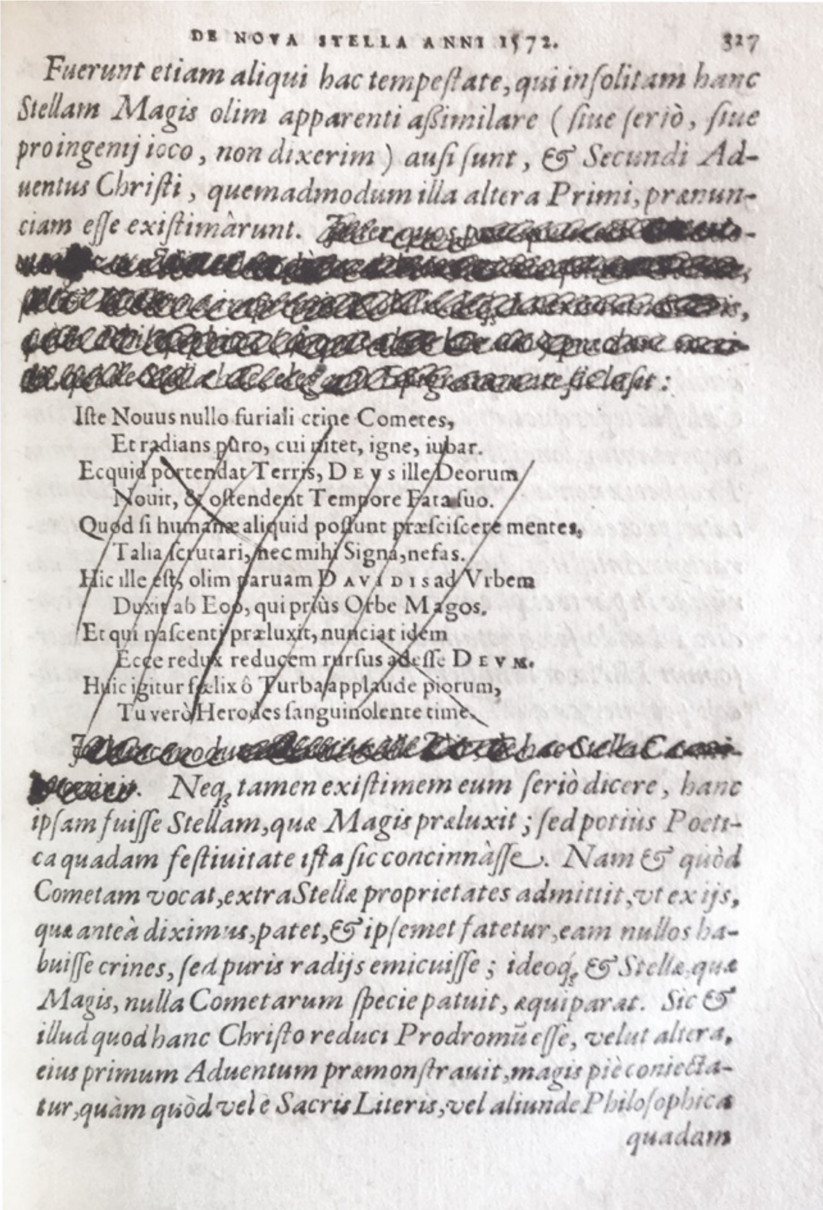
16 This copy is preserved in the Biblioteca da Ajuda, Lisbon (35-XI-7) – henceforth BA, copy 35-XI-7. The front page of the book includes an explicit reference to its former owner: "da livraria da Mathematica de Santo Antão" ('from the mathematical library of the [College of] Santo Antão'). Along with the expurgation of sentences, the BA copy is provided with some mathematical annotations in the same ink as that of the erasures. The style of handwriting is typical of the seventeenth century.

17 For example, while referring to Theodorus Graminaeus's interpretation of the Abbott Joachim Lichtenberg's *vaticinia*, which Tycho Brahe considered to be odiously (*odiose*) pitched against Luther, the Jesuit censor erased the word *odiose*. A negative statement was thus turned positive. Brahe, *Astronomiae instauratae progymnasmata*, BA, copy 35-XI-7, 776. Cf. Brahe, *Astronomiae instauratae progymnasmata* in *Opera Omnia*, 3: 290.

18 Brahe, *Astronomiae instauratae progymnasmata*, BA, copy 35-XI-7, 711. Cf. Brahe, *Astronomiae instauratae progymnasmata* in *Opera Omnia*, 3: 225.

19 On Theodorus Graminaeus, see particularly Vermij, "Theodorus Graminaeus".

20 *Astronomiae instauratae progymnasmata*, BA, copy 35-XI-7, 777. Cf. Brahe, *Astronomiae instauratae progymnasmata* in *Opera Omnia*, 3: 291.



DE NOVA STELLA ANNI 1572. 327

Fuerunt etiam aliqui hac tempestate, qui insolitam hanc Stellam Magis olim apparenti assimilare (siue seriò, siue pro ingenij ioco, non dixerim) ausi sunt, & Secundi Aduentus Christi, quemadmodum illa altera Primi, praenunciam esse existimàrunt. [redacted]:

Iste Nouus nullo furiali crine Cometes,
Et radians puro, cui nitet, igne, iubar.
Ecquid portendat Terris, DEVS ille Deorum
Nouit, & ostendent Tempore Fata suo.
Quòd si humanae aliquid possunt praescifcere mentes,
Talia scrutari, nec mihi Signa, nefas.
Hic ille est, olim paruam DAVIDIS ad Vrbem
Duxit ab Eoo, qui priùs Orbe Magos.
Et qui nascenti praeluxit, nunciat idem
Ecce redux reducem rursus adesse DEVM.
Huic igitur foelix ô Turba applaude piorum,
Tu verò Herodes sanguinolente time.

[redacted]. *Neq; tamen existimem eum seriò dicere, hanc ipsam fuisse Stellam, quae Magis praeluxit; sed potiùs Poetica quadam festiuitate ista sic concinnàsse. Nam & quòd Cometam vocat, extra Stellae proprietates admittit, vt ex ijs, quae anteà diximus, patet, & ipsemet fatetur, eam nullos habuisse crines, sed puris radijs emicuisse; ideoq; & Stellae, quae Magis, nulla Cometarum specie patuit, aequiparat. Sic & illud quod hanc Christo reduci Prodromũ esse, velut altera, eius primum Aduentum praemonstrauit, magis piè coniectatur, quàm quòd vel è Sacris Literis, vel aliunde Philosophica*

quadam

Figure 5 Brahe's quotation of Theodore Beza censured (Brahe, *Astronomiae instauratae progymnasmata*, Biblioteca da Ajuda, 35-XI-7, 327)

In some cases, this involved suppressing extensive parts of the text. This was the case, for example, with Theodore Beza's poem on the eschatological meaning of the new star of 1572. Beza was a preeminent figure in French Calvinism. Upon Calvin's death, the French theologian and biblical scholar became the religious leader of the Geneva Republic.[21] Brahe, who praised Beza for being "very famous and a nobleman, not only by birth but especially by knowledge, who plainly deserves to be praised in sacred letters as well as in philosophy",[22] established an analogy between the 1572 *nova* and the Biblical Star of Bethlehem. The Jesuits deemed unacceptable not only this interpretation of the new star as a token of the second advent of Christ but also the praise of Beza's theological and philosophical scholarship.[23] Accordingly, the Jesuit censor eliminated Brahe's just-cited elogium as well as Beza's poem **[fig. 5]**.

Less frequent, yet of no less significance, was the exclusion of any excerpts that seemed to jeopardise the authority of the *Bible*. Although Brahe did not question the authority of the *Bible* in the scientific domain, the Jesuit censor found a couple of sentences worthy of suppression. Those sentences vaguely challenged the *Bible*'s absolute authority. The criticism that Brahe elaborated on Paul Hainzel's location of the new star of 1572 represents a case in point. According to the Dane, despite recognising that the new star was deprived of observable parallax, the German astronomer paradoxically persisted in claiming that it appeared below the Moon. From Brahe's viewpoint, this approach was typical of those scholars who, despite sound evidence that they were wrong, continued to follow the well-received authorities uncritically. Brahe established an analogy between this sort of scholar and those who argued in favour of long- and well-established theories with the sole purpose of supporting the biblical account:

> For that reason, I should not be further surprised if, in matters of religion, they fight to such an extent in favour of the ancestral principles in whatever way the Holy Scripture would sufficiently and openly prevail over the enemy on certain occasions.[24]

This sentence was accordingly inked out of Brahe's text.

The Lisbon Jesuit copy of *Astronomiae instauratae progymnasmata* was therefore censored according to the Roman guidelines. The quill of Bellarmino the censor had reached Lisbon. It was most likely brought by the hand of a Jesuit mathematician with close ties to the Roman circle.

21 Gordon, "Beza, Theodore"; MacCulloch, *The Reformation*, 236, 244, 298, 303, 599-600.

22 Brahe, *Astronomiae instauratae progymnasmata* in *Opera Omnia*, 3: 325: "Inter quos praecipuus est Theodorus Beza, Vir admodum celebris, et non solum Genere, sed et Doctrina imprimis Nobilis, deque Literis tam Sacris, quam Philosophicis (si quis alius hoc aeuo) praeclare meritus".

23 Brahe, *Astronomiae instauratae progymnasmata*, BA, copy 35-XI-7, 327.

24 Brahe, *Astronomiae instauratae progymnasmata*, BA, copy 35-XI-7, 542; Brahe, *Astronomiae instauratae progymnasmata* in *Opera Omnia*, 3: 56: "ideoque iam non amplius mirum in Religionis negocio adeo pro auitis decretis pugnari, vtvt Sacrae literae satis aperte contrarium nonnunquam euincant".

7 The Virtues of the Tychonic 'Geo-Heliocentric Compromise'

In 1620, the same year that Bellarmino dealt with the idiosyncrasies of Brahe's *Astronomiae instauratae progymnasmata*, Giuseppe Biancani, a mathematics professor at the Jesuit College of Parma, published his *Sphaera Mundi*.[1] As it comprised the first Jesuit defence in print of Tycho Brahe's system and – no less importantly – it was preceded by a distressing process of internal censorship, the publication of *Sphaera Mundi* is regarded as marking the official entrance of Tychonism into the Jesuit milieu.[2] It was nevertheless a somewhat timid entrance. Although Biancani recognised that the celestial novelties led necessarily to the adoption of the Tychonic geo-heliocentric system, while presenting it, he consciously omitted the name of Tycho Brahe. In his words:

> This figure **[fig. 6]** shows all the parts of the world and its structure through which places and order the structure of the world is made out, according to the general opinion of both the Ancient and the Modern authors, as will be evident in what follows. In this work my aim is, in fact, to deliver first the theories generally received originally from the Ancient authors but also to distrust them in such a way that – as I have considered – the new observations and innovations carried out by the Moderns

1 As Michel-Pierre Lerner has already pointed out, it was certainly no coincidence that the publication of Biancani's book followed Bellarmino's efforts to turn Brahe's *Astronomiae instauratae progymnasmata* into a suitable book for a Catholic audience. Lerner, "Tycho Brahe Censured", 100.

2 Baldini, '*Legem impone subactis*', 217 ff.; Lerner, "L'entrée de Tycho Brahe".

DOI 10.30687/978-886-969-661-9/007

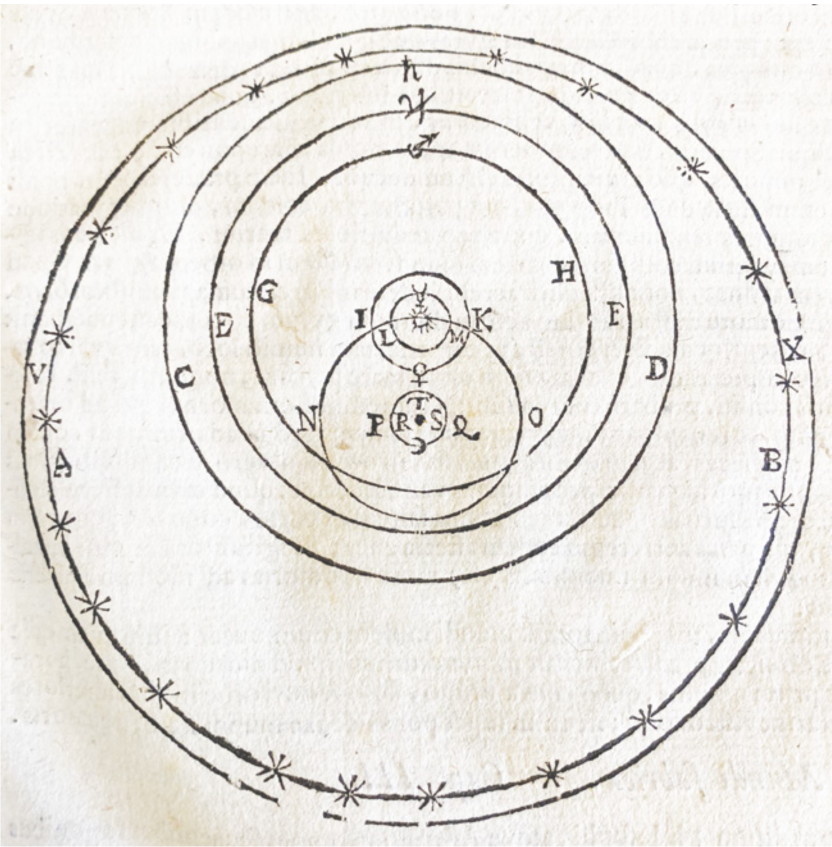


Figure 6 The Tychonic system according to Giuseppe Biancani (Biancani, *Sphaera mundi*, 1653, 56)

must by no means be neglected, to obtain, in this way, comprehensive knowledge of astronomy, and allow everyone to be free to discuss extensively this issue.

In this figure, therefore, the little black ball placed in the middle and designated with the letter T refers to the globe of the Earth and water, whose centre corresponds to the centre of the entire universe (*mundus*). The space RS, around the Earth, is the place of the air and aether spanning continuously to the orbit of the Moon; PQ represents the orbit of the Moon around the elemental sphere; NO, the Sun's orbit around the Earth; LM, the Mercury's orbit around the Sun; IK, the Venus's orbit around the Sun; GH, the Mars' orbit; EF, the Jupiter's orbit; CD, the Saturn's orbit, all these three orbits move around the Sun. AB is the eighth sphere of the fixed stars or the Firmament around the centre of the Earth and the universe. VX refers to the Empyrean heaven, which encompasses the seat of the blessed souls and all the structure of the world (*mundi fabrica*).[3]

3 Biancani, *Sphaera mundi*, 56-7: "Quae quidem figura ostendit omnes Mundi partes et quo situ, quoue ordine ex iis Mundi Fabrica construatur: et id quidem secundum communem tam antiquorum, quam recentiorum sententiam, ut deinceps patebit: mens mea, et scopus est, in hoc

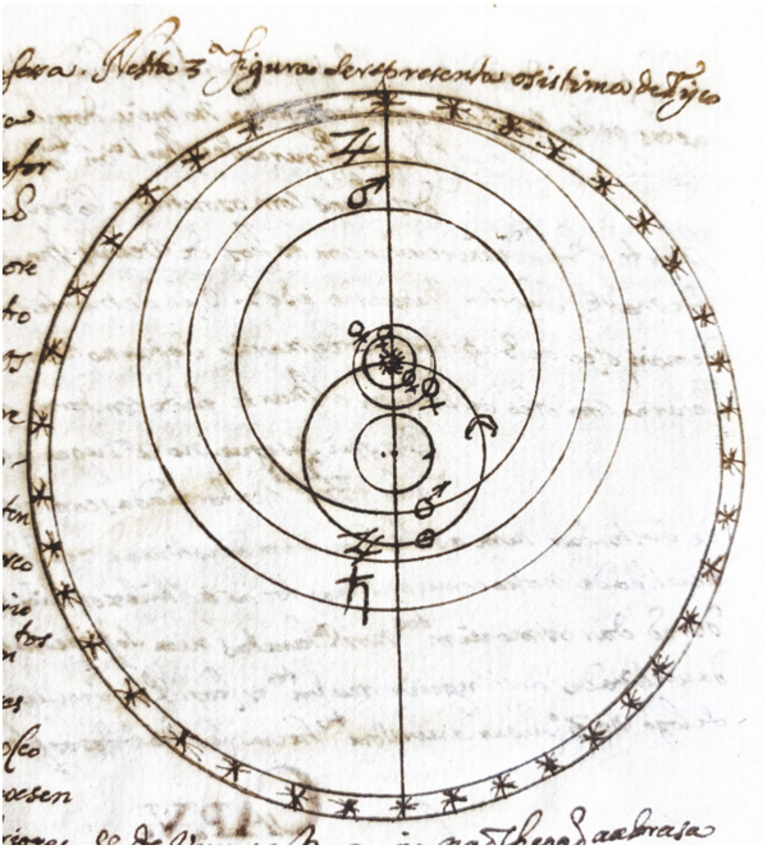


Figure 7 Tycho Brahe's planetary system according to J.C. Gall (*Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, fol. 65*r*)

Although Biancani explicitly relied on Brahe's astronomical computation and planetary observations, no reference was made to Tycho Brahe's authorship of this planetary rearrangement. The Jesuit professors of the Lisbon Class on the Sphere were driven by the same purpose, but they followed a different strategy. They identified Brahe as the source of the planetary system, which they regarded as the only suitable compromise between the groundbreaking telescopic observations that rendered the Ptolemaic geocentric system untenable and Copernicus's revolutionary theory that they rejected on religious and physical grounds. The Santo Antão mathematicians even

opere veterum hypotheses communiter receptas primo tradere, atque ijs insistere: ita tamen ut etiam recentiorum nouas obseruationes, et inuenta minime negligenda censuerim; ut scilicet rerum Astronomicarum plena cognitio tradatur, et cuique liberum sit de tota hac materia abunde philosophari.

In hac igitur fugura, globulus niger in medio situs, ac litera T, notatus, Terrae, et Aquae globulum refert, cuius centrum, est centrum totius Mundi. Spatio RS, circa Terram, est locus Aeris et Aetheris, usque ad gyrum Lunae. PQ est gyrus Lunae circa elementarem sphaeram. NO, gyrus Solis circa Terram. LM, gyrus Mercurij circa Solem. IK, gyrus Veneris circa Solem. GH, gyrus Martis; EF, gyrus Iouis; CD, gyrus Saturni: omnes circa Solem. AB, octaua sphaera stellarum fixarum, seu Firmamentum circa Terrae ac Mundi centrum. VX, refert Empyreum Caelum, Beatarum mentium Sedem, totam hanc Mundi Fabricam ambiens".

did not spare Tycho words of admiration for his astronomical abilities, yet they strove to confine the Lutheran astronomer to the exclusive realm of mathematics. By doing so, they paved the way for the consolidation of the traditional classification of science, wherein mathematics occupied a subordinate position with respect to natural philosophy.

The Jesuit mathematicians active in Lisbon adhered to the geo-heliocentric model put forward by Tycho Brahe soon after the authorities of the Society of Jesus accepted it in Rome. In the early 1620s, Johann Chrysostomus Gall included a description of the Tychonic system in his lecture notes, stating that the Earth stands still in the centre of the universe, around which move the Sun, the Moon and the fixed stars, with the planets revolving around the Sun **[fig. 7]**.[4] From that moment, Tycho became the astronomical authority in matters of planetary theory at the College of Santo Antão.

Kenneth J. Howell argued that conceiving of the Tychonic system as a compromise between "an ancient Ptolemy and a modern Copernicus" does not account for Tycho's own view.[5] The same further applies to the very few Jesuits who decided in favour of the Tychonic system prior to the 1616 condemnation of heliocentrism and the official 1620 acceptance of Tycho Brahe by the Jesuit authorities. This was, for example, the case of Cristoforo Borri, who advocated the Tychonic system based on what he regarded as its intrinsic astronomical value while teaching at Brera Academy, Milan, in the early 1610s.[6]

Unlike these cases, the Jesuit astronomers (or the majority) who moved to the Tychonic solution after the Galilean affair of 1616 nevertheless seemed to have regarded Tycho Brahe's system as a 'compromise' between the astronomical requirements imposed by the Galilean observations and the need to avoid the physical and biblical 'inconveniences' of Copernicanism.[7] This was the case of the Class on the Sphere's mathematicians. Gall, for example, stressed how Tychonic geo-heliocentrism permitted the incorporation of the astronomical achievements of the Copernicus system without having to accept the idea of a Sun-centred universe:

> This opinion [the Tychonic system] is greatly supported by the system of Copernicus who, apart from the movement of the Earth and the stability of the Sun and the Firmament, because of his persistence and diligent observations, deserved to be praised by our Clavius, who called him *alterum Ptholomeum e*[*t*] *restitutorem astronomiae egrerium*.[8]

From this point of view, the Tychonic compromise solution, like the Copernican system, accounted for the entirety of the celestial novelties revealed by the telescope while simultaneously preserving the central assumption of

4 Gall's first defence of Tycho's system dates back to 1621. See Document III.

5 Howell, "The Role of Biblical Interpretation", 516.

6 Carolino, "The Making of a Tychonic Cosmology".

7 This point had already been made by, among others, Schofield, *Tychonic and Semi-Tychonic*, 227.

8 Gall, *In Sphaeram*, BGUC, MS 192, f. 17*r*: "Favoresse muito a esta opinião o sistema de Copernico, o qual tirando o mouimento da terra, e a consistencia do Sol e do firmamento mereseu com sua industria e diligentes observacoins, o louuor que lhe deu o nosso Clavio chamando-o *alterum Ptholomeum e*[*t*] *restitutorem astronomiae egrerium*".

Ptolemaic cosmology, the Earth's centrality.[9] Given that this was the case, Gall extended to Brahe the sort of encomiums that Clavius had previously addressed to Copernicus: Brahe was the "Ptolemy of this age" (*Tolomeo destes tempos*)![10]

Nonetheless, the Tychonic system also raised some delicate cosmological issues, albeit not as pressing as those put forward by Copernicus. Tycho's system deeply challenged, for example, the notion of celestial solidity that structured the Aristotelian-Ptolemaic worldview. Furthermore, the proponent was a Lutheran astronomer. Gall was acquainted with these challenges as he recognised, for example, for those who advocated the Tychonic system "neither the [celestial] solidity nor the real destruction of the celestial orbs (*céus*) can be sustained".[11]

The German Jesuit, while teaching in Lisbon, circumvented these challenges in a somewhat conventional way. If, in the astronomical theses, which were published and discussed at the end of his first year as a professor in the Class on the Sphere, the German Jesuit chose not to mention Tycho Brahe's name when briefly describing his astronomical system,[12] he followed a different strategy while lecturing his Lisbon students. He sidestepped the cosmological upshots originating from Tychonic geo-heliocentrism by circumscribing Tycho's contributions to the realm of mathematics. A similar approach to Tychonism had already been undertaken by his astronomy professor at the University of Ingolstadt, Johann Baptist Cysat.[13] Thus, Gall took Tycho as the ultimate authority on a whole gamut of topics concerning the astronomical observations and measurements. Computations regarding the celestial location of new stars (1572) and comets (1577), the number of fixed stars or the likely dimensions of the universe and its constituents were all the domain of Tycho Brahe.[14] The accuracy of his astronomical instruments and the precision of his computations made him the definite authority that one should follow in mathematical astronomy:

> I do not intend to determine anything in these matters even if, in what concerns the calculation or astronomical computation, I follow only Tycho Brahe as astronomers very rightly do nowadays.[15]

9 Gall mentioned Venus's phases, the four satellites of Jupiter, the apparent three-bodied Saturn, comets and sunspots. Gall, *In Sphaeram*, BGUC, MS 192, ff. 17*r*-18*r*. See Document V.

10 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 86*v*.

11 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 65*v*: "não se pode sustentar nem a solidade nem a destrução real dos ceos planetarios".

12 Gall, *Assertationes astronomicae*, 3.

13 In his *Mathemata astronomica de loco, motu, magnitude et causis de cometae*, Cysat presents a detailed discussion on the 1618 comet that he located in the celestial region and ran counter to a Tychonic world system; nevertheless, he did not discuss either the Tychonic system or Brahe's cosmological ideas. Cysat, *Mathemata astronomica*, 57. On Cysat's contribution to the Tychonic technical astronomy, see Siebert, *Die große kosmologische Kontroverse*, 316-25.

14 For example, Gall, *In Sphaeram*, BGUC, MS 192, ff. 17*v*, 38*v*; Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, ff. 70*r*-70*v*, 86*v*.

15 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 92*r*: "Eu não pretendo determinar cousa alguma nestas materias ainda que no calculo ou contas astronomicas segueria so a Tico Braij como o fazem hoie os Astronomos com muita razão".

However, despite taking up Tycho as the astronomy authority, Gall never integrated any of his ideas about physics or the cosmological foundations of his planetary system into his Lisbon lectures. According to Gall, Tycho Brahe was a mathematician rather than a natural philosopher. Accordingly, he never alluded to the Danish astronomer while mentioning cosmological issues. In fact, apart from the fact that Brahe was a Lutheran believer, Gall himself refrained from drawing any cosmological consequences from the astronomical theories that he endorsed. For example, while discussing the number and division of the celestial region, Gall alluded to the authors who argued, based on observations of the comets, that there was only one heaven from the Moon concave to the Empyrean heaven. Nevertheless, he immediately added, "it is not right for me to decide on these questions".[16] Elsewhere, upon presenting Tycho's system, he urged philosophers to accommodate the notion of celestial solidity. As he put it, "if this system is true, let those to whom it concerns see how they would preserve the solidity of the heavens".[17]

By integrating Tycho Brahe, the Lutheran astronomer, into the realm of the Jesuit astronomical authorities, while simultaneously rejecting his cosmological views, Gall, like other leading Jesuit mathematicians of his time, such as Cysat, reinforced the traditional distinction between mathematics and natural philosophy. At a time when astronomers were increasingly delving into the study of the physical causes of planetary motion, Gall continued to argue that "that question belongs more to the natural philosopher than to the astronomer because the philosopher considers the cause of the natural motions and the astronomer mainly their quantity and proportion".[18]

16 Gall, *In Sphaeram*, BGUC, MS 192, f. 7*v*: "A mim me não esta bem meterme em desedir estas opinioins".

17 Gall, *In Sphaeram*, BGUC, MS 192, f. 18*v*. See Document V.

18 Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 69: "Respondo que isso mais pertence ao Philosopho natural que ao astronomico, pois o philosopho considera as causas dos mouimentos naturaes e o astronomico principalmente a quantidade e proporção delles".

Document V

Gall on the Tychonic system. Johann Chrysostomus Gall, *In Sphaeram*, BGUC, MS 192, ff. 14*v*-18*v*

Sistema terceiro

O terceiro sistema he de Tycho Brahe no Liuro 2º de resentioribus phenomenis, capítulo 8º, e contenta a muitos dos modernos que não seguem a Copernico, poem este autor a terra com os mais elementos no meo [f. 14*v*] do uniuerso sercados com o ceo da Lua que fas consentrico [com] a terra como tambem o do Sol, que se segue immediatamente ao da Lua do corpo solar como de centro descreue os ceos dos mais planetas nesta ordem, primeiro o de Mercúrio, segundo de Vénus, terceiro de Marte, quarto de Júpiter, quinto do Saturno e sobre todos o firmamento consentrico com a terra, Lua, e Sol como se ue nesta figura, na qual o A he a terra o B a Lua etc. **[fig. 8]**.

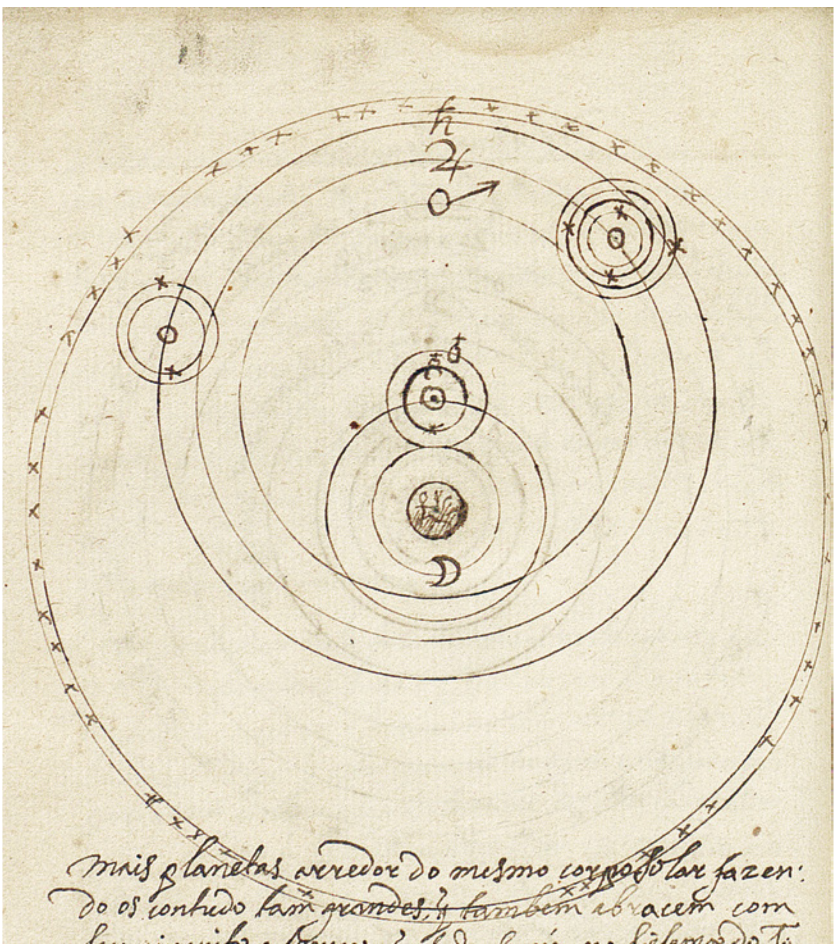


Figure 8 Tycho Brahe's planetary system depicted in J.C. Gall's lecture notes (Gall, Sphaeram, BGUC, MS. 192, f. 15*v*)

Este sistema achasse de alguma maneira discripto e louuado no capítulo 10 do primeiro liuro reuolutionum de Copernico, o qual afirma que Marciano Capela na sua Ensiclopedia com outros latinos (qual he Vitruuio no capítulo 4 do nono liuro) puzerão o orbe da Venus, e o do Mercúrio ao redor do corpo solar, donde tomando occasião dis que aquelle não errará que da mesma maneira puzer os orbes dos [f. 15*r*] mais planetas arredor do mesmo corpo solar fazendo os contudo tam grandes que tambem abracem com seu circuito a terra, o que tudo se ue no sistema do Tycho louuado muito do famosissimo Astronomo Antonio Magino em certa carta que escreueu ao mesmo Tycho, na qual depois de louuar a diligencia, industria e modo tam exacto de obseruar, acresenta estas palauras: In magna uersor expectatione tuarum huiusmodi obseruationum et speculationum, quas et probare et sequi minime erubescant.

Somente achaua este autor huma deficuldade, a qual he que neste sistema o ceo de Marte, e do Sol se partem entre si, contudo confessa, que isso necessariamente se ade conceder, se Tycho obseruou que Marte se chega mais pera a terra [f. 15*v*] que o Sol, o que ouuio de hum dos obseruadores de Tycho.

E quanto ao que toca a Vénus e a Mercúrio reuoluerense ao redor do Sol, facilmente se pode colegir da diuersidade de opinioins que sobre estes dous planetas tiuerão os antigos, huns dos quais os puzerão sobre o Sol, outros abaxo delle, o que he sinal que fazendo em diuuersos tempos diuersas obseruacoins ia os acharão em sima, ia abaxo e porque iuntamente confessam todos que ambos estes planetas nunca se afastão muito do Sol, paresse mui prouauel que andão o redor delle, descreuendo delle seos orbes, como de seu centro.

Fauoresse muito esta opinião o sistema de Copernico, o qual tirando o mouimento da terra, e a consistencia do Sol e do firmamento mereseu com sua industria, e diligentes obseruaçoins o louuor que lhe deu o padre nosso Clauio este lugar chamandoo alterum Ptholomeum e[t] restitutorem astronomiae egrerium. Este autor como se ue na figura pos a Mercúrio primeiro e depois a Vénus arredor do Sol não abarçando a terra com os orbes destes planetas como abracou e os demais planetas.

E a Vénus mudando sua grandeza uizual, e figura alumiada ao olho paresse mui prouauel que não se moue só em sima ou somente abaxo do Sol senão orredor delle a figura seguinte declarará isto milhor. Seia o Sol A e Vénus quando mais afastada da terra B e quando mais uezinha C apartasse do C para D e do D para E, e do E para o F primeiramente em todos estes lugares ficara igualmente alumiada, segundo ficara mais alumiada que a metade, terceiro uersea do olho G menos que a metade, quarto uersea no B e debaxo de hum ângulo [?] menor que puder ser em C, debaxo do maior que pode ser em E, debaxo de maior que em F, e de menor que em D, e porque a parte alumiada não tem [f. 17*r*] em todos estes lugares o mesmo sitio a respeito do olho G uersea somente a parte della metida entre os arcos HI, IK, id est, em F não perfeitamente redonda em E, a metade della em D se uera como a Lua noua em C totalmente dezaparecera, em B se uera perfeitamente redonda conforme as obseruacoins quotidianas que não se podem saluar milhor que deste modo **[fig. 9]**.

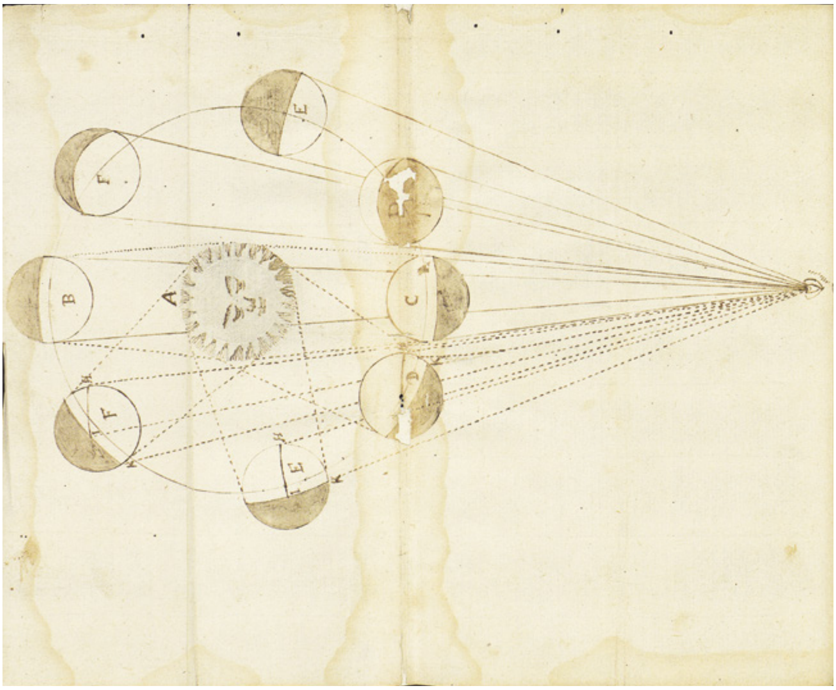


Figure 9 The phases of Venus in J.C. Gall's lecture notes (Gall, Sphaeram, BGUC, MS. 192, f. 16*v*)

E que os outros três planetas tenhão da mesma maneira o centro de seu mouimento no corpo do Sol prouauelmente se colhe porque quando estão opostos por diametro ao Sol se ouseruou que estauão mais iuntos a terra, tanto que Marte fica as uezes mais uizinho a terra que o mesmo Sol como se colhe assi do sistema de Tycho como tambem da carta de Magino de que assima fizemos menção por onde deuense de distruir e desterrar dos ceos que os antigos puzerão o de Mercúrio e de Vénus e mudarense em orbes pequenos ou epiciclos que não rodeão a terra. a estes pequenos orbes se deuem acresentar outros seis semelhantes, quatro por rezão dos quatro planetas de Júpiter, e dois por rezão dos dois planetas de Saturno nem estes só bastam porque tambem as maculas do Sol requerem hum orbe, ou muitos orbiculos parciais, não debaxo do Sol, mas a orredor delle, como se colhe das diligentes e continuas obseruacoins, que por espaço de dez annos ou mais se tem feitas.

Acresentemos a estes os ceos dos cometas, hum dos quais achou Albumasar sobre Vénus no anno de 844, e Proclo no anno de 390 achou outro sobre Júpiter e Tycho Brae achou outro sobre Vénus anno de 1577, outro achou o mesmo Tycho sobre Marte anno de 1580 e finalmente nos uimos, e obseruamos no anno de 1618 outro que o nosso padre Bautista Sizado publico professor da mathematica na uniuersidade de Ingolstadio, com grande erudição demonstrou que ficaua sobre Vénus nem á por uentura autor que o puzesse [f. 17*v*] debaxo da Lua saluo alguns que ou quizerão perdoar a trabalho de ouseruar ou estabelecer o que imaginauão, sendo tam facil o dezemaginarse que só com os olhos puderão saber, destes mathematicos (não sei quais em special) refutou hum nosso philosopho na india oriental, não tanto com demonstracoins geometricas, e ouseruacoins tomadas com instrumentos mathematicos, quanto com rezoins tomadas só da uista dos olhos, com as quais os constrangeo a fazerem a sphera do ar muito maior do que de antes a fizerão não fugindo ainda com isto a força de seos argumentos a outros forcou a recolher seos tratados os quais sobre este cometa tinhão feito, e ia os estauão para imprimir.

A qual uitoria do philosopho peripatetico contra estes mathematicos não posso deixar de louuar grandemente, e paresse mui a prepozito porque della colhem os mathematicos não dar tanto credito a algumas opinioins que lhes deixarão seos antepaçados, que deixando as obseruacoins e demonstracoins, como proprias de mathematicos, philosophem de suas couzas as escuras, e insinem couzas de pouca probabilidade.

Auermos de dar a estes cometas distintos orbes dos orbes dos planetas nos constrangem a isso seus mouimentos desimilhantes a todos os mouimentos dos planetas como uimos neste ultimo cometa e se pode uer assi nos mathematicos alegados, como tambem nas obras de Tycho, o que confirmam cartas de [f. 18*r*] nossos padres escriptas da Etiopia, China e India porque de Etiopia se escreue que hum daquelles dous cometas que a menos de dous annos aparecerão, se mouia para o Sul, o outro para o Norte; porem da China só se fas menção do mouimento de hum delles, a saber daquelle que se mouia para o Sul, o outro nos o uimos mouerse para o norte. Os quais mouimentos nunqua forão obseruados, nem nos planetas, nem nas estrellas fixas, como bem se nota em huma carta, que este anno nos escreuerão de Cochim, porque os mouimentos ou de tripidação, ou de libração, não sam tam aprecados nem tam grandes, nem se fazem iuntamente para o sul e para o norte alem doutras muitas couzas, em que differem.

Deste terceiro sistema facilmente se colhe que auiamos de dizer do numero e ordem dos ceos. O qual se he uerdadeiro, ueião aquelles a quem isto compete, como defenderão a solidade. Porem nos tratemos do que falta. [f. 18*v*]

Document V

English translation. Gall on the Tychonic system. Johann Chrysostomus Gall, *In Sphaeram*, BGUC, MS 192, ff. 14*v*-18*v*

The third system

The third system is that of Tycho Brahe exposed] in the second book of *De recentioribus phaenomenis*, chapter 8), and it pleases many of the moderns who do not follow Copernicus. This author places the Earth together with the other elements at the centre [f. 14*v*] of the universe surrounded by the heaven of the Moon, which he makes concentric [with] the Earth as well as by that of the Sun, which immediately follows the heaven of the Moon. The solar body is the centre around which the heavens of the planets describe their movements in this order: first, that of Mercury; second, that of Venus; third, that of Mars; fourth, that of Jupiter; fifth, that of Saturn; and above all these heavens, there is the Firmament concentric with the Earth, the Moon, and the Sun, as seen in the figure, in which A is the Earth, B the Moon, etc. **[fig. 8]**.

This system is somewhat described and praised in chapter 10 of Copernicus's first book of *De revolutionibus orbium caelestium*, which states that Martianus Capella (in his *Encyclopaedia*), with other Latins (including Vitruvius in chapter 4 of the ninth book), placed the orb of Venus and Mercury around the solar body. He also states there that those who place [f. 15*r*] the orbs of the other planets around the solar body, conceiving them, however, with such big dimensions that they also embrace the Earth with their orbit, will not get it wrong. All this is found in Tycho's system, much praised by the most famous astronomer [Giovanni] Antonio Magini in a particular letter that he wrote to the same Tycho, in which, after praising the diligence, industry, and his most precise method of observation, he adds these words: *In magna uersor expectatione tuarum huiusmodi obseruationum et speculationum, quas et probare et sequi minime erubescant*.

This author found only one difficulty, which was the fact that, in this system, the heaven of Mars and that of the Sun collide. However, he confesses that one must necessarily accept this since Tycho observed that Mars comes closer to the Earth [f. 15*v*] than the Sun, as he was told by one of Tycho's observers.

As far as Venus's and Mercury's orbits are concerned, it can easily be stated, from the diversity of opinions of the ancient authors on these two planets, that they move around the Sun. Some placed them above the Sun, others below it, which shows that at different times, different observations found them either above or below the Sun, and since all authors agree in unison that both these planets are never very far from the Sun, it seems most likely that they move around it, describing their orbits with the Sun as its centre.

This opinion is very much favoured by the system of Copernicus, who except for the motion of the Earth and the theories of the Sun and the Firmament, has, because of his industry and diligent observations, merited the praise of our priest Clavius, who calls this author the *alterum Ptholomeum e*[*t*] *restitutorem astronomiae egrerium*. Copernicus, as is seen in the figure,[19] placed Mercury first and then Venus around the Sun, not including the Earth, as he did with the other planets.

By changing its visual appearance (*grandeza*, 'magnitude') and illuminated figure, Venus appears to move very likely not only above or below the Sun but also around it, as shown in the following figure. Let the Sun be A and Venus B, at the furthest point from the Earth, and C, at the nearer position to it C. As it moves from C to D and from D to E and from E to F, in the first place, it will be equally illumined in all these places; secondly, it will be more than half as illumined; thirdly, it will be less than half as seen from eye G; fourthly, it will be seen at B and under a smaller angle [?] that may be at C; under the greatest that may be at E, greater than that at F, and smaller at D. Because the illuminated part has not [f. 17*r*] the same place with respect to eye G in all these locations, one will see only that part of it which lies between the arcs HI, IK, id est, at F not perfectly round; at E, the half of it; at D it will be seen as the new moon; at C it will disappear completely; at B it will be seen perfectly round according to the everyday observations. There is no better way to save these observations **[fig. 9]**.

The conclusion that the other three planets revolve likewise around the Sun is based probably on the evidence that, when they are in opposition to the Sun, it has been observed that these planets are nearer the Earth, which means that Mars sometimes is nearer the Earth than the Sun itself, as it is described in Tycho's system and also in the above-mentioned letter of Magini. Therefore, we must destroy and exclude the orbs that the ancient authors attributed to Mercury and Venus and transform them into small orbs or epicycles that do not encircle the Earth. One must add six similar spheres to these small orbs, four on account of the four planets of Jupiter, and a further two in virtue of the two planets of Saturn.[20] But these are not enough because the Sun's spots also require one orb, or many partial ones, not under the Sun, but around it, as it is clear from the diligent and continuous observations made during the last ten or more years.

Let us add to these the heavens of comets, one of which Albumasar found above Venus in the year 844; Proclus found another above Jupiter in the year 390; Tycho Brahe found another above Venus in the year 1577; the same Tycho found another one above Mars in the year 1580; and finally, we sighted and observed an extra comet in 1618, which our father Baptist Cysat, public professor of mathematics at the University of Ingolstadt, demonstrated, with great erudition, that stood above Venus. There is probably no author who locates the comets [f. 17*v*] below the Moon, excluding those who wish to avoid the trouble of observing or seek to establish what they had previously imagined (and it was so easy for them to recognise that they could only know through their eyes). I do not know who were the mathematicians that a philosopher of ours [i.e., a Jesuit philosopher] refuted in East India, not so much through geometrical demonstrations and observations with mathematical instruments as by reasons drawn from the use of sight alone. Based on that, he constrained those mathematicians to conceive the sphere of air with greater dimension than they had previously thought and, not conceal-

19 Picture representing the Copernican system, which Gall had previously presented (Second System).

20 Here, Gall does not mean physical orbs but rather orbits or heavenly regions.

ing the force of his arguments, forced others to withdraw the treatises they had written on this comet which were already preparing to print.

I cannot but greatly praise the victory of this Peripatetic philosopher over those mathematicians. This example seems a very telling case because it shows us that mathematicians should not give so much credit to some inherited positions (giving up the observations and demonstrations which are proper to mathematicians) nor philosophise about their subjects in the dark or teach unlikely issues.

The fact that comets display movements that differ from those of the planets constrain us to give them distinct orbs from those of the planets. The late comet [of 1618], the works of the mathematicians mentioned above and those of Tycho showed it to us. Letters penned by our priests from Ethiopia, China and India also established it. Letters from Ethiopia reported that one of those two comets, which appeared less than a couple of years ago, moved towards the south and the other towards the north. But only one is mentioned in letters from China, the one moving southwards. We noticed the other moving towards the north. As noted in a letter that we received this year from Cochin, these movements have been observed neither in the planets nor in the fixed stars. Apart from other differences, the motions of trepidation or libration are neither so fast nor so great nor made simultaneously towards the south and the north.

With this third system, we can easily conclude our considerations about the number and order of the heavens. If this system is real let those whom it concerns see how to preserve the solidity of heaven. But let us move to the remaining topics. [f. 18*v*]

8 Tycho Brahe Catholised

In 1627, Gall taught his last mathematical course at the College of Santo Antão. A couple of years later, he departed for India, where he would eventually die as a missionary. In Lisbon, Gall was replaced by a mathematician who, in turn, came back to Europe after a decade's experience as a missionary, an astronomer and occasionally a soldier in the Far East: the above-mentioned Cristoforo Borri. Borri was, to a certain extent, the right man to fill the position left vacant by Gall's imminent departure for Asia. Borri had been an engaged supporter of Tycho Brahe's theories ever since he was appointed Professor of Mathematics at Brera Academy back in 1611-12. On that occasion, apart from endorsing the theory of celestial fluidity, a notion that had not yet been accepted by the Jesuit authorities, he attributed it to the Lutheran Tycho Brahe. Unsurprisingly, Borri was removed from teaching at Milan College.[1] Two decades later, he followed a more cautious path. Certainly aware of the censorship process of Tycho Brahe's work in Rome, he decided to use Tycho's ideas in the cosmological discussion but omitted the name of the Danish astronomer. In Lisbon, Borri's effort was to attribute the very same ideas of celestial fluidity and celestial matter that he put forward in Brera to the Church tradition.

Borri thus followed a different strategy from his predecessor at the College of Santo Antão. While Gall had endeavoured to confine Tycho Brahe's contributions to the domain of mathematics – that is, to a realm epistemologically inferior to natural philosophy – Borri accepted the cosmological validity of Brahe's ideas. However, contrary to his former experience at Brera Academy, in Lisbon, he did not recognise Tycho's authorship.

1 Borri, *Al molto Reu. Pre. Generale*, ANTT, Armário dos Jesuítas, vol. XIX, f. 314*r*.

DOI 10.30687/978-886-969-661-9/008

As with the large majority of his Jesuit fellows, Borri was a keen advocate of biblical literalism. The *Bible* was to be understood literally whenever its proper meaning could be corroborated. In interpreting the biblical text, the consensus of theologians, and particularly that of the Church Fathers, was an additional principle of authority. Thus, Borri vigorously refuted the theory of accommodation put forward by "Kepler and others":

> Because that interpretation of the Holy Scripture is so far from exposing the [proper] sense that it rather adulterates it, nor indeed an opportunity to ascribe a particular meaning to the Scripture is offered, without any one necessity, when men's common opinion bears otherwise and the Scripture exposes itself *ad literam* without displeasing anyone.[2]

In advocating such an understanding of the biblical text, Borri was strictly aligned with the Catholic Church's guidelines, reinforced by the Council of Trent. In fact, the text just cited echoed the celebrated decision taken at the Council's Fourth Session, held on 8 April 1546, which prohibited "distorting the Holy Scriptures in accordance with his own conceptions" and reserved the monopoly of determining the meaning of the Scripture to the Church in keeping with the "unanimous teaching of the Fathers".[3]

In his effort to build a cosmological edifice based on foundations other than the Aristotelian principles, Borri turned to the "unanimous teaching of the Fathers". The early Church Fathers had endorsed cosmological theories that, in some cases, differed radically from those of the Aristotelian tradition that became hegemonic throughout Western Europe in the late twelfth and thirteenth centuries. Borri explicitly quoted them while discussing critical issues such as the elemental nature of celestial matter, its fluidity, the tripartite division of the cosmos or the unicity of the sidereal heaven (see Document VI). Borri emphasised that these notions were neither new nor collided with the *Bible*'s common interpretation. Furthermore, they were sanctioned by the early Fathers. Thus, the theory according to which the planetary heaven is a fluid and tenuous body was proved "*ab authoritate Sanctorum Patrum*", namely by Saints Augustine, Basile and Chrysostom.[4] This fluidity was due to the fact that, according to the *Bible*'s interpretation of Chrysostom and Beda – as Borri pointed out – the planetary heaven was made up of an airy element. For example, Borri claimed, "Beda, in the first chapter of *Genesis*, [states that] the golden ether is divided into the heavens of which these are the names: air, ether [*aether*], Olympus, the re-

2 Borri, *Collecta astronomica*, 44: "quia illa Sacrarum literarum explicatio tantum abest, ut sensum exponat, ut potius sensum corrumpat: neque vero cuilibet extra necessitatem facultas datur singularem adscribere sensum Scripturae, quando communis hominum opinio fert aliter; et ipsa sese Scriptura sine cuiusquam offensionem ad literam exponit".

3 *The Canons and Decrees*, 18-19: "Furthermore, to check unbridled spirits, it decrees that no one relying on his own judgment shall, in matters of faith and morals pertaining to the edification of Christian doctrine, distorting the Holy Scriptures in accordance with his own conceptions, presume to interpret them contrary to that sense which holy mother Church, to whom it belongs to judge of their sense and interpretation, has held and holds, or even contrary to the unanimous teaching of the Fathers, even though such interpretations should never at any time be published". On the impact that the Church's principle of authority and tradition in interpreting the *Bible* had on science, see particularly Blackwell, *Galileo, Bellarmine, and the Bible*.

4 Borri, *Collecta astronomica*, 233-5.

gion of fire, the Firmament".[5] The early Fathers' biblical exegesis on *Genesis* also corroborated, according to the Italian Jesuit, the tripartite division of the cosmos into the *caelum aereum*, the *caelum sidereum* and the *caelum empyreum* (see Document VI).[6]

Edward Grant suggested that the diffusion of the early Church's Hexameron literature in sixteenth- and seventeenth-century Europe paved the way to the increasing acceptance of the idea that the celestial region was made up of one or more terrestrial elements.[7] Obviously, all Jesuits became acquainted with those commentaries on *Genesis* in the course of their philosophical and especially their theological studies.[8] Additionally, the notion of the tripartite division of the heavens and the possibility of their elemental nature was a widely held conception among Jesuit theologians concerned with biblical exegesis, for example Luís de Molina and Roberto Bellarmino.[9]

Nevertheless, the source of inspiration for those Jesuit mathematicians striving to provide the geo-heliocentric planetary system with a new cosmological foundation was dated much closer in time. The notion of celestial matter, a critical issue for those advocating the Tychonic system, provides a case in point. According to Borri, and the majority of his followers in the mathematical chair at the Santo Antão College, the sidereal heaven was made up of an airy substance called *aura aetherea*: "the heaven of all the planets is no more than only one, and it is pure and tenuous like the air; therefore, it shall be called ether (*aether*) or *aura aetherea*".[10] Although it was substantially the same element as the common air, this 'celestial' air was named differently because it was in a pristine state and not mixed up with terrestrial exhalations.[11]

The source of this interpretation was to be found, according to the Italian Jesuit, in the Church Fathers' tradition itself. Thus, Borri relied on Bede to state:

> Above all, the aforementioned opinions on heaven's secondary matter [i.e. not the *materia prima*], the hypothesis that pleased us the most is the one that argues that this tenuous heaven is nothing but pure air. Nevertheless, taking into account that the three regions [of air] close to the Earth are less pure and, therefore, that the [air's] superior region, to which the vapours and exhalations of the Earth never reach, is in the utmost pure condition, it is better to call that highest air the most limpid *aura aetherea* or ether (*aether*) to distinguish it from our thick and foggy air.

5 Borri, *Collecta astronomica*, 263: "Et Beda in caput 1 Genesis, scinditur auricolor caeli ether, cuius haec sunt nomina Aer, aether, Olympus, spatium igneum, firmamentum". Borri refers to the following excerpt of Beda Venerabilis's *In Pentateuchum Comentarii*, 192B: "Coelum hic proprie dicuntur, quia multi sunt, ut, Scinditur auricolor coeli septemplicis aether, quorum haec sunt nomina, aer, aether, olympus, spatium igneum, firmamentum, coelum angelorum, et coelum Trinitatis".

6 Borri, *Collecta astronomica*, 263-71.

7 Grant, *Planets, Stars, and Orbs*, 267.

8 On the importance of the Church Fathers' Hexameron literature in the early modern cosmological debates, see Randles, *The Unmaking*, particularly 1-57. See also Williams, *The Common Expositor*, 40-65.

9 See de Molina, *Commentaria in primam*, 705; Bellarmino, *The Louvain Lectures*, 17.

10 Borri, *Collecta astronomica*, 161: "Omnium planetarum unicum duntaxat est caelum, illudque purum, ac tenue instar aeris, ideo aether sive aura aetherea".

11 Borri, *Collecta astronomica*, 324.

> This was the understanding of Venerable Bede, who stated in his exposition of the works of the fifth day that: *the word Firmament also means ether, that is, the upper space of air that ranges from this stormy and gloomy region, wherein the birds fly, continuously to the stars. It is believed not unreasonably that the Firmament is entirely serene and full of light. And furthermore, the seven planets, which God made to wander in this region of ether, are said by the Scripture to be placed in the Firmament of heaven*. It certainly seems that this notion is shared by all those who, based on sacred as much as secular texts, widely use the term aethereal heaven and *aura aetherea*.[12]

Borri explicitly quoted the event of the creation of birds on the fifth day of the Creation from Bede's Hexameron commentary to support his views on the nature of the Firmament. Nevertheless, Bede had presented a different theory on this subject earlier in this same book on *Genesis*. On the second day, according to Bede, God divided supracelestial waters from terrestrial waters by solidifying the firmament of heaven. The Firmament was therefore made of water, the ice-like solidity of which prevented the supracelestial waters from falling. In Bede's words:

> Therefore it is known that the starry heaven was created in the midst of the waters, nor does anything prevent a belief that it was also made from the waters. For what prevent us, who know how great the firmness is as well as the transparency and purity of the *crystalline rock*, which is known to have been made from *the congealing of waters*, from believing that the same Disposer of the things of nature solidified the substance of waters in the firmament of heaven?[13]

On the fourth day of the Creation, according to Bede, after separating the sea and the lands on the previous day, God provided the Firmament with lights "to divide the day and the night".[14] This view certainly accounts for the fact that Bede argued, in another work, that the Firmament had a "fiery nature".[15]

Borri intentionally omitted Bede's foundational notion of the Firmament as a solid body made of water. Nevertheless, this interpretation of Bede's thought was widespread among Jesuit theologians at the turn of the seventeenth century. Benedito Pereira, for example, exposed it in his

12 Borri, *Collecta astronomica*, 324-5: "Supra omnes praedictas sententias de materia secunda Caeli haec nobis maxime placet, quae asserit Caelum hoc tenue nil aliud esse, quam merum aerem; cum hac tamen distinctione, ut regione [*sic*] tres vicinae terris sint minus purae, ex inde regio illa superior sit purissima, ad quam terrae vapores et exhalationes raro, vel nunquam ascendant; ideo ad huius nostri aeris crassi, et vaporosi distinctionem, melius vocabitur ille superior limpidissima aura aetherea, sive aether.

Fuit haec sententia Venerabilis Bedae, qui in expositione operis quinti diei haec habet: *Firmamenti nomine etiam aether intelligitur, hoc est superius illud aeris spatium quod a turbulento hoc et caliginoso loco, in quo aves volant, usque ad astra pertingit: et etiam tranquilum prorsus, ac luce plenum firmamentum non immerito creditur; nam et errantia sidera septem, quae in hoc aetheris spatio vaga Deus fecit, perhibentur a Scriptura in firmamento Caeli esse posita*. Videtur etiam esse haec sententia eorum omnium, tam e sacris, quam e profanis qui caelum aetherem, et auram aethereaam passim vocitant".

13 Bede, *On Genesis*, 76.

14 Bede, *On Genesis*, 80.

15 Bede, *On the Nature*, 76.

Commentarius et disputationes in Genesim, in which he discussed Bede's aforementioned excerpt, though the Spanish Jesuit had a different understanding of the nature of the Firmament.[16] Albeit not exploring Bede's theory in particular, Luís de Molina argued in favour of a view of the Firmament as a heaven created on the second day of the Creation out of the water and solidified ever since.[17] It is thus hard to believe that Borri was not familiar with Bede's full position on the matter. In fact, Bede's notion of the Firmament as a solid heaven was at odds with his own views on that matter.[18]

Alongside other likely sources, such as the Stoicism-inspired ideas of Jean Pena,[19] Borri was most likely inspired by one of Tycho Brahe's most eminent correspondents, Christoph Rothmann,[20] whose letters he accessed through Tycho's *Epistolarum astronomicarum libri* (Uraniborg, 1596).[21] In the letters addressed to Tycho, Rothmann defended the idea that there was nothing but elementary air between the Earth and the fixed stars.[22] The only difference was that the air in the heavenly environment was in a purer state than the sub-lunar air, a point that Borri would later make. Rothmann also expounded this theory in his *Descriptio accurata cometae anni 1585*, a treatise that Borri probably knew after its publication in 1619.[23] There, Rothmann stated "that between the sphere of the fixed stars and the Earth there is nothing but this animate air, and that the seven wandering stars hang in air alone".[24]

16 Pereira, *Prior tomus Commentariorum*, 111. On Pereira's commentary on *Genesis*, see Williams, *The Common Expositor*, 40-65 and Randles, *The Unmaking*, 47-8. See also Blum, *Studies on Early Modern Aristotelianism*, 139-82.

17 Molina, *Commentaria in primam*, 1941-2; Randles, *The Unmaking*, 48-9. An introduction to the theological views of de Molina, though without reference to his views on Genesis and cosmology, can be found in Kaufmann, Aichele, *A Companion to Luis de Molina* and MacGregor, *Luis de Molina*.

18 On Bede's cosmological ideas, see Di Pilla, "Cosmologia e uso delle fonti", 137-44. An introduction to Bede's natural philosophy can be found in Wallis, "Bede and Science".

19 On the influence of Pena's ideas, see, among others, Barker, "Stoic Alternatives", 61-2, 165-86 and Granada, *Sfere solide e cielo fluido*, 3-46.

20 W.G.L. Randles already suggested this influence in his *The Unmaking*, 177. See also Carolino, "The Making of a Tychonic Cosmology", 326.

21 *Epistolarum astronomicarum libri* was later reprinted in 1601 (Nuremberg) and in 1610 (Frankfurt). On the correspondence between Brahe and Rothmann on the nature of celestial matter, see Randles, *The Unmaking*, 63-77. See also Mosley, *Bearing the Heavens*, 70-80, 89-96.

22 As Rothman wrote to Brahe on 2 October 1587, "inter Terram, vt scis, et inter Sphaeram Stellarum Fixarum nihil aliud contineri statuo quam Aërem septem Errantia sidera ambientem" (Brahe, *Tychonis Brahe Dani Epistolae Astronomicae*, 6: 112).

23 *Descriptio accurata cometae anni 1585* was originally sent by Rothmann in manuscript form to Tycho Brahe, in 1586, and later published as an appendix to van Snell, *Descriptio cometae*, 69-155. In the fifth chapter, Rothmann defended that, instead of celestial orbs, the region between the earth and the fixed stars is filled by air: "nos […] ostendemus, inter sphaeram stellarum fixarum et tellurem nihil aliud esse, quam animalem hunc aërem septemque errantia sidera tantum in aëre pendere" (Rothmann, "Descriptio", 102-3; Rothmann's exposition at 102-18). On this treatise of Rothmann, see Granada, *Sfere solide e cielo fluido*, 47-66; "Introduction". It is most unlikely that Borri had access to Rothmann's text in manuscript form. Consequently, in the period before the publication of *Descriptio cometae*, if Borri had direct knowledge of Rothmann's ideas on celestial matter, it could only be by means of the Brahe-Rothmann correspondence published in Brahe's *Epistolae Astronomicae*. After its publication, it is probable that Borri had access to the *Descriptio cometae*, as van Snell ("Smelius" from Snellius) is mentioned by Borri as one of the "modern" astronomers defending the celestial location of comets. Borri, *Collecta astronomica*, 120.

24 Rothmann, "A Discourse on the Comet", 121.

Rothmann, most likely under the influence of Pena, based his position on two arguments: the observation of comets moving in the heavens and the lack of atmospheric refraction.[25] As far as the latter argument is concerned, Rothmann maintained that, if there was a difference between the celestial substance and the air, atmospheric refraction should reveal it, which was not the case. According to Rothmann, atmospheric refraction was instead caused by clouds and vapours ascending from the Earth.[26] Borri did not approach the question regarding refraction, considering only the cometary movement.

Borri also followed Rothmann in recognising that, being made of air, the celestial region was subject to processes of generation and corruption, which gave rise to phenomena such as the appearance of comets and new stars. As the Italian Jesuit put it: "*est enim eadem omnino materia prima caeli cum nostra hac sublunari*".[27] That is to say, there was a substantial identity between celestial and terrestrial matter.

Once already part of the Jesuit philosophical *corpus*, Borri's understanding of *aura aetherea* and celestial fluidity and corruptibility became a *topos* in the Jesuit mathematical milieu. It was indeed profusely referenced by the professors who followed Borri in the College of Santo Antão's mathematics chair.[28] Borri's strategy of attributing this 'old' idea to the Church Fathers also continued, as did the silence regarding the Tychonic source. The English Jesuit Ignace Stafford, who took the chair of mathematics when Borri departed for Madrid and from there to Rome, where he eventually died in 1632, for example, stated that:

> Whoever carefully reads the writings of the ancient Fathers would find that they did not make any case for the gentile philosophers [such as Aristotle] – rather, they challenged them at every step with the utmost freedom – and everything they taught about the fluidity and corruptibility of the heavens and the heavenly bodies was based upon the Sacred Scripture.[29]

The notions of celestial fluidity and corruptibility, against which generations of Aristotelians had stood in opposition, therefore represented true and proper 'Catholic' theories. Excited by the prospect of putting forward a new-fangled Tychonic cosmology, the English Jesuit even went so far as to

25 On Rothmann's position and the likely influence of Pena, see Rosen, "The Dissolution of the Solid Celestial"; Lerner, "Le problème de la matière céleste"; Goldstein, Barker, "The Role of Rothmann"; Granada, *Sfere solide e cielo fluido*, 115-36; Randles, *The Unmaking*, 58-77.

26 See, among other letters, those of Rothmann to Brahe, 2 October 1587; Brahe to Rothmann, 17 August 1588; Rothmann to Brahe, 13 October 1588; Brahe to Rothmann, 21 February 1589; and Rothmann to Brahe, 22 August 1589, respectively in Brahe, *Tychonis Brahe Dani Epistolae Astronomicae*, 110-19, 134-48, 149-61, 166-81, 181-4. See, also, Rothmann, "A Discourse on the Comet", 121-7.

27 Borri, *Collecta astronomica*, 309.

28 See, for example, Fallon, *Compendio Speculativo*, BNP, cod. 2258, f. 105*v* and Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 9*r*.

29 Stafford, *Tractado das Theoricas*, BNP, cod. 4323, ff. 79*v*-80*r*: "Porem realmente quem ler com atenção nos escritos dos Padres antigos achara que não fazem nenhum caso de philosopho gentio, antes a cada passo os impugnão com suma liberdade, e que tudo o que insenarão da fluidade, e corrutibilidade dos Ceos, e corpos celestes o fundão na Sagrada Scriptura". There are copies of Stafford's *Tractado das Theoricas* in BNP (Stafford, *Varias obras mathematicas*, PBA, 240, ff. 351-93) and BACL (*Tratado das theoricas das estrellas fixas, e errantes*, 1637, MS Serie Vermelha 587).

claim that “the father Christoph Clavius adhered to the notion of celestial fluidity upon observing the comet of 1572”![30] Clavius was actually famous for his lifelong commitment to supporting the Ptolemaic claim regarding the solidity of celestial orbs.[31]

In short, for confessional reasons, Cristoforo Borri and his Jesuit mathematician fellows never recognised Tycho’s paternity of their notion of ‘celestial air’, nor did they quote any other contemporary theory of celestial matter. For them, it was strategic to ascribe the idea to the Church Fathers, aiming not only to match Aristotle in authority but also to remain in line with the Counter-Reformation guidelines. Hence, Tycho Brahe’s cosmological ideas were correspondingly integrated into Jesuit natural philosophy even if the Dane was never granted the status of authority in philosophical matters among the Jesuits.

30 Stafford, *Tractado das Theoricas*, BNP, cod. 4323, f. 79*v*: “O Padre Christouão Clauio se reduzio à doctrina do ceo fluido depois que obseruo o Cometa de 1572”.

31 On Clavius’s astronomy and cosmology, see Lattis, *Between Copernicus and Galileo*.

Document VI

Borri on the Patristic foundations of the existence of one single Sidereal heaven. Cristoforo Borri, *Collecta astronomica*, 264-6

De Caelo Sidereo

Quod sub nomine Caeli siderei veniat universum spatium, quod comprehendit sidera omnia tum errantia, tum inerrantia, manifestum sit ex eo, quod tam proprie sint, et vocentur sidera Planetae, quam Stella inerrantes, cum non appareat ratio diversitatis, et indifferenter communi modo loquendi vocentur hae atque illae; ut ipsa canit Ecclesia de Planeta: Iam lucis orto sidere. Et sacra Scriptura astra errantia clare, et distincte Sidera vocat in Epistola Iudae. Ut vero quamplurimis supra adductis rationibus, et authoritatibus non philosophorum modo, sed etiam Scripturae et patrum accedat iterum authoritas S. Chrisostomi qui et concludat totum hoc quod de Caelo Sidereo dicimus solito suo aureo ore: legatur ipsius homiliam 4 in capitulo primo Genesis dum ex explicat illa verba: *Vocavit Deus firmamentum Caelum*, ubi ait *Deus postquam firmamenti usum declaravit*; [264] *dividendi nimirum aquas ab aquis, tunc firmamento nomen imposuit (et vocavit firmamentum Caelum) et quomodo dicunt aliqui factos multos Caelos? non ex divina Scriptura hoc didicerunt sed ex suis opinionibus impelluntur, Beatus autem Moyses nihil his amplius docet; Nam ut dixit (in principio creavit Deus Caelum, et terram) et dein causam docuit, quare terra sit invisibilis, nimirum, quod obtecta a tenebris, et aquis abyssi post formationem lucis, ordine, et consequentia quadam utens dixit Deus (fiat firmamentum) quod aquarum separationem faceret (et illud vocavit Caelum) Quis igitur post tantum doctrinam ferret eos, qui ex suo capite loqui, et contra divinam Scripturam multos Caelos dicrere audent? Porro dicunt ecce Beatus David laudem offerrens* [*sic*, offerens] *dixit (laudate Deum Caeli caelorum) Ne turberis dilecte, neque putes sacram Scripturam sibi ipsi alicubi adversam, sed disce potius dictorum veritatem, et tenens diligenter eius doctrinam, obtura aures illis contraria dicentibus, et quid hoc sit, quod dicere volo audite magna eum attentione. Omnes divini libri veteris testamenti Hebraeorum lingua ab initio sunt compositi, et in hoc nobiscum consentiunt omnes; dicunt igitur qui linguae eius gnari sunt, Caeli nomen plurali numero ab Hebraeis vocari, et nemo ea lingua dicit, Caelum, sed caeli, et idcirco sic dictum est, quod a Beato David dictum, Caeli caelorum; non quod multi sint Caeli (non enim hoc nos docuit Beatus Moyses) sed quia mos est linguae Hebraicae unam rem plurali numero nominare, si enim multi essent caeli, non omisisset Spiritus Sanctus per linguam Prophetae, quin illorum formationem nos doceret. Haec diligenter observate obsecro, ut possi* [265] *tis obstruere ora eorum qui contraria Ecclesiasticis doctrinis asserunt, et videatis virtutem eorum quae in Scriptura continentur.*

Ex his omnibus multo etiam magis confirmata manet nostra de caelo Planetarum doctrina.

Hactenus verba sunt Chrysostomi, qui cum nostam [*sic*, nostram] de caelo sidereo sententiam tam aperte valideque firmet, non est cur probationes alias congeramus. Unum videtur opere praetium [*sic*, pretium], quod moneamus: nimirum S. Chrysostomum et si hic mentionem de Caelo Empyreo non fecerit, nunquam tamen voluisse illud excludere; nam cum plures uno Caelos non esse affirmet, semper loquitur de Caelo visibili, et quod sub aspectum nostrum cadit, quale solum est firmamentum, quod se visibile nobis per suas Stellas et Planetas exhibet, quod minime convenit Caelo Empyreo; quod ideo ab ipso sancto, et ab aliis Caelum intelligibile, et non visibile vocatur. Caeterum moneatur etiam lector D. Chrisostomum, quando unum duntaxat constituit Caelum ex Moyse, loqui solum de Sidereo, circa quod totum eius intentum versabatur; contra multiplicitatem videlicet caelorum a Ptolemaicis introductam: nunquam tamen eius mentem fuisse negare aerem etiam Caelum esse, et a scripturis vocari. Unde constat idem omnino esse aureum Doctorem asserere unicum dari Caelum sidereum, ac duos esse Caelos una cum aereo, et tres cum Empyreo. [266]

Document VI

English translation. Borri on the patristic foundations of the existence of one single sidereal heaven. Cristoforo Borri, *Collecta astronomica*, 264-6

On the sidereal heaven

That by the term 'sidereal heaven' is meant the whole space that comprises all the heavenly bodies, both the wandering and the fixed, is clear from the fact that the heavenly bodies are properly stars, and are called planets and fixed stars since no difference is clear, and therefore they are commonly called in either way, as the Church does on the planet [i.e. the Sun] in the hymn *Iam lucis orto sidere*.[32] And the Sacred Scripture, in the *Epistle of Jude*, conspicuously and distinctly calls stars the wandering celestial bodies. However, in order, on the one hand, to add the authority of Saint Chrysostom to the many reasons mentioned above and the authorities, not only of philosophers but also of the Scripture and the Church Fathers, and, on the other hand, to conclude our reasoning over the sidereal heaven with Saint Chrysostom's usual golden words, let us recite his fourth homily, the first chapter of the *Genesis*. While explaining the meaning of the words *God called the Firmament heaven*, he affirms: *God afterwards revealed the use of the Firmament,* [264] *undoubtedly that of dividing the one part of the waters from the other; then, He imposed a name on the Firmament (and called it Firmament heaven) and yet how is it that some authors claim that several heavens were created? They did not learn it from the Sacred Scripture, but they were driven by their own opinions on the matter. In fact, blessed Moses teaches us nothing other than this; that is, he says, in the beginning, God created heaven and the Earth, and, afterwards, He taught us the reason why the Earth is invisible – because it was doubtless concealed by the darkness and the waters of the abyss – and told us, making use of some order and causal reasoning that, after the creation of the light, God* [*said*] *let the Firmament be made and separate the waters and He called it heaven. Therefore, who could support those who get such a theory out of their imagination and dare to claim, against the teachings of the Sacred Scripture, that there are several heavens? Furthermore, they claim, See how the blessed David, singing the praises of God, declares "Praise God, the heaven of heavens". Do not be concerned, dearly beloved, nor think that Sacred Scripture ever contradicts itself, but learn better the truth of its sayings and, diligently holding its truth, close your ears to those who speak against it. And this being the case, listen very carefully to what I have to say. All the Sacred Books of the Old Testament were originally written in Hebrew and everybody agrees with us about this. Accordingly, those who are well versed in that language point out that the word heaven is used in the plural among the Hebrews and that no one says, in that language "the heaven" but "the heavens". On that account the words by the blessed David – the heaven of heavens – do not mean that there were several heavens (this was not what the blessed Moses taught us) because it is idiomatic in the Hebrew language to use a singular name in the plural. If there were several heavens, the Holy Spirit would not have failed indeed to*

32 Now in the Sun's new dawning ray.

teach us, through the tongue of the Prophet, the creation of the other ones. Keep a close watch over these matters, I implore you, [265] *so that you will be able to silence those who go against the Church's doctrine and perceive the virtue of those teachings that are contained in the Scripture*.

Our theory on the planetary heaven remains even more well established from all these teachings.

These are so far the words of Chrysostom, which, since they so openly and strongly support our theory on the sidereal heaven, there is no need for us to collect further proofs. One issue seems worth advising: there is no doubt Saint Chrysostom did not mention the Empyrean heaven here; yet, he never meant to reject it. In fact, while asserting that there were no heavens other than a single one, he was consistently referring to the visible heaven and, by the sight with which we observe it, it can only be the Firmament that renders visible to us through the stars and planets. This passage hardly applies to the Empyrean heaven, which, for that reason, is named by Saint [Chrysostom] himself and others as unintelligible and unseeable heaven. The reader of the other authors should also be warned that, when Doctor Chrysostom mentions strictly speaking one single heaven from Moses, he means the Sidereal heaven. He fully supports this view in opposition – it is clear – to the theory of the multiplicity of heavens, introduced by the followers of Ptolemy. Nevertheless, he never intended to deny that there is also the airy heaven mentioned in the Scripture. It is likewise utterly established from this that the august Doctor claims that there exists only one sidereal heaven; two, with the airy heaven; three, with the Empyrean one. [266]

9 Jesuit Tychonic Cosmology

By the late 1620s, the mathematicians of the College of Santo Antão had successfully integrated the Tychonic ideas into a Catholic cosmological framework. Accordingly, they maintained that celestial bodies moved according to the planetary rearrangement put forward by Tycho in his *De mundi aetherei recentioribus phaenomenis* (1588) in a universe that they divided into three regions or 'heavens'. Nevertheless, the cosmological debate had strengthened since Tycho produced *his* geo-heliocentric system. Aside from the recent issues that emerged in the aftermath of the telescope's construction, there were still the problems that Tycho left unsolved, especially the question of celestial dynamics, that is, an inquiry into the causes of heavenly motions. The celestial orbits, which Tycho conceived as being circular, also became an issue of discussion after Kepler's elliptical orbits proved to be better suited to celestial computation, somehow suggesting the superiority of the Copernican system over the geostatic ones. Crucially, there was also the need to integrate the Tychonic system into a worldview in which there was room for the Empyrean heaven, the metaphysical heaven in which God, the Saints and the Blessed were to be found,[1] even while Brahe and a large majority of the Protestant philosophers and astronomers opposed the existence of this latter heaven.[2] The Jesuit mathematicians of the College of Santo Antão, particularly Cristoforo Borri, spared no efforts to put forward a coherent cosmological view that integrated all these questions.

1 On the Empyrean heaven notion, see Maurach, *Coelum Empyreum*; Lerner, *Le Monde des Sphères*. Vol. 1, *Genèse et triomphe*, 215-21; Randles, *The Unmaking*, 133-50.

2 Randles, *The Unmaking*, 133.

DOI 10.30687/978-886-969-661-9/009

While teaching in the Class on the Sphere, in the 1627-28 academic year, Borri stressed to his students that Tycho's sudden death prevented him from offering a comprehensive account of his cosmological theories, a task that the Danish astronomer had intended to perform in a book, which probably would receive the title *Theatrum astronomicum* or *Opus astronomicum*.[3] The question of the planetary motion was a pressing one. In fact, Tycho's theory explaining planetary motion by means of a heavenly vital spirit that was supposed to animate the planets appeared to astronomers, such as Rothmann and Kepler, as the main weakness in Tycho's theory.[4] It did describe how the planets performed their motions, but it failed to identify the cause of the planetary motions.[5] This being the case, and moved by the desire to see the Tychonic astronomical system fully demonstrated and accepted, Borri felt obliged to take up the task of providing such evidence of Tychonic theory as came to hand, though in a succinct way. As he informed his Portuguese audience:

> Since death led him to pass over what he had promised in silence without proving it as this illustrious astronomer [Tycho Brahe] wished, desirous to see this excellent theory clarified and proved, we considered ourselves obliged to prove it, though in a brief and summarised way for now.[6]

Although Borri had previously endorsed a different theory regarding the cause of planetary motion – namely, the theory according to which the celestial bodies were moved by an intrinsic virtue[7] – in Lisbon, the Italian Jesuit taught his students that angels were indeed responsible for celestial motion. As he explained in his *Collecta astronomica*, a book upon which he relied heavily in his Lisbon lectures, the constancy of the celestial order required the planets and the stars to be governed by superior entities. Being thought of as purely intellectual entities, and therefore superior to other beings in ontological terms, angels were assumed to be charged with this role of perpetually maintaining the exact distances and proportions between the celestial bodies.[8] As he put it rhetorically: Is there a better and more suitable extrinsic cause to explain the complexity, perpetualness and certainty of celestial motions than the angels?[9]

This understanding of the cause of celestial dynamics was consistent with the Thomist conception of providence that the Jesuit hierarchy supported

3 Dreyer, *Tycho Brahe*, 180; Thoren, *The Lord of Uraniborg*, 312.

4 Brahe, *Avthor Lectori svo de praecentibvs Rothmanni litteris et ad eas responsione* in Brahe, *Tychonis Brahe Dani Epistolae Astronomicae*, 221: "Cum et Coelum animatum esse, ipsaque coelestia corpora animantia quaedam Coeli vitali spiritu praedita, non abs re sensisse videatur Divina illa Platonicorum Philosophia".

5 Schofield, *Tychonic and Semi-Tychonic*, 100, 222 ff.; Granada, "The Defence of the Movement", 100-1.

6 Borri, *Nova astronomia*, BGUC, MS 44, f. 117*v*: "Como a morte lhe foi occasião de ficar em branco sem provar o que prometeu e deseiava levar ao cabo tão insigne astronomo[Brahe]. Nos pello deseyo que tinhamos de ver aclarada e provada huma doutrina tão boa nos demos por obrigados provala ainda que breve e recopiladamente por agora". Borri also made this point in his *Collecta astronomica*, 187-8.

7 Carolino, "The Making of a Tychonic Cosmology", 327. This theory was developed by Medieval Oxford Aristotelians, such as John Blund and Robert Kilwardby, who later influenced John Buridan's notion of celestial *impetus*. Weisheipl, "The Celestial Movers", 164-9.

8 Borri, *Collecta astronomica*, 235-6.

9 Borri, *Collecta astronomica*, 172.

and reaffirmed in the Order's statutes and in the *Ratio studiorum*.[10] According to this view, God governed the created world through the mediation of secondary causes. In proportion to the different roles that they assumed in the Creation, secondary causes received a transient influx from God, which enabled them to move other causes responsible for lower effects, thus preserving the order of the Creation.[11] A good example was precisely the angelical action of moving the planets according to divine intentions. Angels moved the planets and indirectly brought about planetary influence over the terrestrial region, upon which life on earth was thought to depend. Alluding to Jean Buridan's concept of *impetus*, Borri stated:

> I do not mention that force (*virtute*) which God, if He would have wanted to, could have impressed to the planets and the remaining celestial bodies, through which they could carry out those proper, numerous and certain movements. In fact, as theologians assert and philosophers corroborate, God did not wish these things to be moderated by Him, but instead, for proper employment, love and connection amongst things, He endowed secondary causes with such a power in order that the humblest beings are governed by the noblest, these by the sublime beings – which the angels are – and successively the angels by God.[12]

Borri therefore put forward the notion of a universe provided with an internal order corresponding to the different degrees of being and levels of perfection. It was against this theological and metaphysical background that Borri maintained that angels moved the planets. Though assigned a vast sphere of action, the power of the angels was limited, so a single angel could move various stars but was unable to move all the celestial bodies.[13] A certain number of angels were, therefore, required to drive the planets and stars in their complex and precise motions through the heavens.[14]

This understanding of celestial dynamics was shared by Borri's fellow mathematician, the Jesuit Simon Fallon, who taught in Lisbon a decade after Borri. Although not delving into details like his Italian confrère, the Irish mathematician asserted that "it is right that the planetary bodies do not move by themselves, but are moved by angels, who carry them like torches in their hands to illuminate the world".[15]

10 It is a well-known fact that the regulations of the Society of Jesus recommended that Jesuits follow the doctrines of Thomas Aquinas on theological matters. As Ignatius of Loyola put it in the founding *The Constitutions of the Society of Jesus*: "in theology there should be lectures on the Old and New Testaments and on the scholastic doctrine of Saint Thomas". de Loyola, *The Constitutions*, 220. See also "Ratio atque institutio", 386.

11 For details of Thomas Aquinas's account, see Aquinas, *Summa Theologica* 1a, q.105, a.5.

12 Borri, *Collecta astronomica*, 172-3: "Neque hic mentionem facimus de virtute illa, quam Deus, si voluisset poterat Planetis, reliquisque corporibus caelestibus imprimere, cuius beneficio suos illos, et multiplices, certosque cursus conficerent. Nam ut habent Theologi, Philosophique assentiuntur, Deus per se ista moderari noluit, sed ut occupatio amorque ac rerum nexus esset inter se, causis secundis imperium commisit, ut humiliora ab maioribus, et haec a summis, qui Angeli sunt, Angeli tamen a Deo regerentur".

13 Borri, *Collecta astronomica*, 243, 246.

14 Hence, Borri rejected the thesis that, because angels were spiritual entities, a single angel was able to move all the celestial bodies by itself. See Borri, *Collecta astronomica*, 244-5.

15 Fallon, *Compendio Spiculativo*, BNP, cod. 2258, f. 109*r*: "Contudo he certo que os Astros senão mouem de sy, senão por Anjos, que os leuão, como tochas na mão para ilumiar o mundo".

By explaining celestial motion by means of angelical agency, Borri and Fallon discarded the understanding that celestial bodies were endowed with an intrinsic virtue that gave them an inclination to their natural movements. This sort of understanding, which commonly identified the intrinsic principle of planetary motion with the planets' 'substantial form', in the way that the Mertonians theorised in the fourteenth century, was most likely the view supported by Ignace Stafford.[16] Furthermore, the theory of angelical agency allowed them, at the same time, to reject Gilbert's and Kepler's concepts of a *virtus magnetica* by which the Sun was held to cause the planets to move round it at speeds proportional to their distance from it. According to Borri, the Keplerian *virtus magnetica* did not successfully explain the motion of all the celestial bodies, especially that of the Moon.[17] The postulate of the centrality of the Earth therefore remained unquestioned.

Nevertheless, providing a consistent explanation for the cause of celestial motion was not enough to impose Tychonism as the leading cosmological model. Further explanation of the shape of planetary orbits was needed. Brahe, like Ptolemy and Copernicus before him, maintained that the orbits described by the planets and stars had a circular shape.[18] Nevertheless, while studying Mars, Kepler came up with the idea that planets performed elliptical orbits. He used this new idea to (re)calculate the positions of planets, the computations being printed, in 1627, in his *Rudolphine Tables*. These tables proved to be more accurate than any previous ones based on the principle of the circularity of planetary orbs. They, therefore, presented a challenge that the Jesuit professors of the Class on the Sphere could not escape.

They did not adhere to the Sun-centred elliptical hypothesis. Instead of the Keplerian suggestion, Cristoforo Borri – and all the mathematics professors who followed him – put forward a theory according to which the planets perform a single motion in helicoidal form (or spiral form, as he named it).[19] With this single motion, it was possible to explain not only the 'direct' motion of the planets but also the 'retrograde' motion and their periodic stationary state.

Borri provided a detailed account of this theory in the *Collecta astronomica*. Retrieving an idea that originated with the medieval Arab astronomer al-Bitruji (Alpetragius in Latin),[20] Borri argued that all the celestial bodies perform one single motion from east to west with different veloci-

In his *Tratado sobre a Theorica dos Planetas*, Fallon also argued that celestial bodies were most likely moved by angels. Fallon, *Tratado*, BNP, cod. 2127, f. 219*r*.

16 Stafford indeed criticised the theory of angelical agency. Stafford, *Tractado das Theoricas*, BNP, cod. 4323, f. 82*v*. Taking into account the Jesuit scholastic constraints with respect to the animate nature of celestial bodies (see Grant, *Planets, Stars, and Orbs*, 469-87 and Dales, "The De-Animation of the Heavens"), it is most likely that the English Jesuit endorsed the Mertonian understanding of celestial dynamics.

17 Borri, *Collecta astronomica*, 173; Fallon, *Compendio Spiculativo*, BNP, cod. 2258, ff. 62*v*-63*r*.

18 On Tycho's defence of the circularity of the celestial orbs, see Granada, *El debate cosmológico*, 31-59 and Thoren, *The Lord of Uraniborg*, 236-64.

19 Before Borri, Gall had already argued, in his astronomical thesis of 1621, that the fixed stars performed a spiral shape motion, which was the outcome of the two circular motions over the pole plus the trepidation movement. No reference was made there to the shape of planetary orbits. Gall, *Assertationes astronomicae*, 2.

20 al-Bitruji, *De Motibus Celorum*, 97-8; Lerner, *Le Monde des Sphères*. Vol. 1, *Genèse et triomphe*, 104-10; Samsó, *On Both Sides*, 529-45.

ties.[21] Celestial bodies that are placed farther away from the Earth move faster than those that are closer to the Earth. For this reason, the planets move more slowly than the fixed stars in such a way that they actually seem to perform a west-east motion.[22]

As in other cases, Borri remained silent with respect to his sources on this matter, mentioning neither al-Bitruji nor any other philosopher involved in the revival of the notion of the 'unidirectionality' of celestial motions at the turn of the century. The notion of a helicoidal motion path of the planets was particularly widespread among neo-Stoic philosophers. The Portuguese astronomer Manuel Bocarro Francês, for example, in his treatise on the comet of 1618 (published in 1619), based his work on "the entire School of the Stoics" (*toda a escola dos Stoicos*), maintaining that the planets and the stars progress according to a spiral path (*por caracol e espiras*) by themselves, without any external mover.[23] Borri did not cite Bocarro Francês's *Tratado dos cometas*, a book that he was certainly acquainted with as it existed in the Lisbon Jesuit libraries, such as the *Casa de São Roque*'s public library.[24]

Borri explained the helicoidal planetary motion using the analogy of the spiral flight of a bird of prey attacking a fowl. As he put it in his *Collecta astronomica*, a planet performs a three-dimensional motion, namely (1) by orbiting around the sun, as the centre of the circumference that the planets describe; (2) by progressing along with the sun from east to west in a daily motion around the Earth; and finally (3) by descending from the apogee to the perigee of the eccentric.[25] Because of this helicoidal motion, planets sometimes appear to slow down their motions, stop and initiate a backward motion.

Thus, having established the variance of velocities according to the distance of the planets from the Earth and stating that the planets progress according to a three-dimensional motion, Borri was eventually in a position to explain all the 'celestial appearances' by means of a single motion. The helicoidal motion of the planets accounted not only for the proper motion of the planets and the fixed stars but also for the west-east motion, the direct, stationary and retrograde planetary motions, the eccentricities of the orbits and, finally, trepidation.[26]

Furthermore, the theory of the helicoidal motion of the planets could most significantly provide a hypothetical explanation for all the 'celestial appearances' without having to take into account heliocentric theory and particularly Kepler's theory of the solar system and elliptical orbs. It is thus not surprising that the Jesuit mathematicians who followed Borri in teaching astronomy in Lisbon endorsed this explanation of the celestial motion. As Stafford put it, around 1633:

21 Borri, *Collecta astronomica*, 175-81.

22 Borri, *Collecta astronomica*, 181.

23 Bocarro Francês, *Tratado dos cometas*, ff. 4*r*-5*r*. On the cosmology of Bocarro Francês, see Randles, *The Unmaking*, 100-1; Carolino, "Manuel Bocarro Francês".

24 A copy of Bocarro Francês's *Tratado dos cometas*, preserved in the Biblioteca da Ajuda (50/X/47), includes an explicit reference to its former owner: "Da livraria publica de S. Roque".

25 Borri, *Collecta astronomica*, 211-12. A description of Borri's theory can be found in Schofield, *Tychonic and Semi-Tychonic*, 227-9.

26 Borri devoted a substantial part of section III to proving this point. Borri, *Collecta astronomica*, 189-212.

> No celestial body presents a circular motion but a spiral one, with which its declinations vary; even if we admit that the stars have a motion from west to east, they cannot yet perform a circular motion according to Aristotle's definition *motus circularis est qui circa medium est*.[27]

The strict Aristotelians rejected this notion on the grounds that a natural body such as a planet could not move simultaneously in two distinct directions. Probably considering the sort of analogy of the flight of a bird of prey with which Borri explained the helicoidal path, Fallon argued that the "spiral motion [...] is not and cannot be considered two motions, but it comprises one simple movement, even if it is a mixed and composite one".[28]

Alongside the Lisbon mathematicians, this conception that celestial bodies moved according to a helicoidal orbit became popular among the Jesuit community of astronomers throughout the seventeenth century, being endorsed by figures such as Giovanni Battista Riccioli and Valentin Stansel.[29] These Jesuits also agreed on the existence of the Empyrean heaven. Although Tycho Brahe and the large majority of Protestants denied the existence of this metaphysical heaven, engaged in putting forward a coherent cosmology based on Tycho's geo-heliocentric system and consistent with the Catholic dogmas, the Jesuits argued that the universe was sealed by this resplendent heaven, where God, the Saints and the Blessed were supposed to live for eternity.

No physical evidence proved the existence of the Empyrean heaven; it was a central tenet of the Catholic Church. As Borri argued, "it must be acknowledged that it is a generally accepted and completely certain truth in the Church that there is the Empyrean heaven, the beautiful home of the Blessed".[30] Nevertheless, because of its nature and the lack of physical evidence, mathematicians refrained from discussing its characteristics. "In this treatise – John Rishton warned – we do not discuss the Empyrean heaven because its existence depends purely on the principles of faith and not on the natural sciences".[31]

The exception was Borri, who aimed to provide a comprehensive view of the 'machina mundi' consistent with Catholic theology in his *Collecta astro-*

27 Stafford, *Tractado das Theoricas*, BNP, cod. 4323, f. 81*v*: "nenhuma estrella tem mouimento circular, senão espiral com que varia [de] declinação, [a]inda que admitamos que as estrellas tem mouimento de occidente para oriente, não podem ter mouimento circular conforme a definição de Aristóteles, motus circularis est qui circa medium est". See also Stafford, *Tractado das Theoricas*, BNP, cod. 4323, ff. 90*r* ff.; *Elementos*, BA, cod. 49-II-80, ff. 18*v*,20*r*; *Elementos*, BNP, cod. 4256, f. 16*r*.

28 Fallon, *Compendio Spiculativo*, BNP, cod. 2258, 108*v*: "Respondemos que não, Spira não são, nem se podem dizer dous mouimentos, senão hum só, ainda que mixto e composto". See also Fallon, *Tratado*, BNP, cod. 2127, ff. 119*v*-120*r*.

29 Riccioli, *Almagestum novum*, Pars posterior, 253; *Astronomia reformata*, prolegomena, ff IV-V; Stansel, *Uranophilus*, 164. There has been recent interest in Riccioli. See, among others, Gambaro, *Astronomia e tecniche di ricerca*; Borgato, *Giambattista Riccioli*; Dinis, *A Jesuit Against Galileo?*; Marcacci, *Cieli in contraddizione*. On Stansel, a less studied yet no less interesting character, see above all Camenietzki, "Esboço Biográfico"; "Baroque Science"; "The Celestial Pilgrimages".

30 Borri, *Collecta astronomica*, 268: "Dicendum est veritatem esse communiter in Ecclesia receptam et omnino certam dari caelum empyreum pulcherrimum Beatorum domicilium".

31 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 12*r*: "Advirtasse que neste tratado não desputamos do ceo impireo: porque a noticia deste depende puramente dos principios da fee, enão de sciencias naturaes".

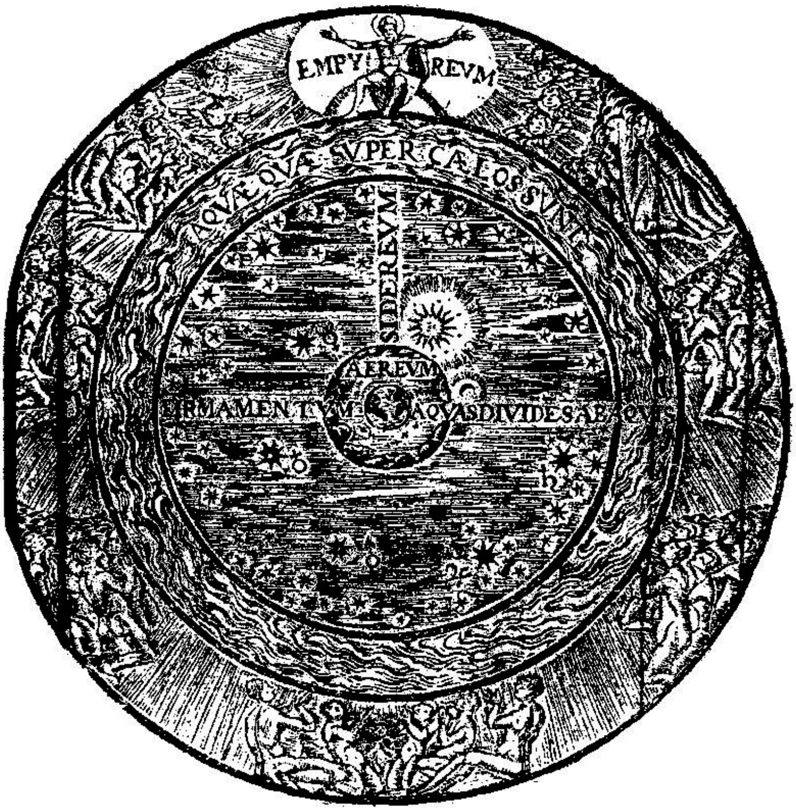


Figure 10 Cristoforo Borri's tripartite universe, sealed by the Empyrean heaven (Borri, *Collecta astronomica*, 293)

nomica and, therefore, entered into details on the nature of the Empyrean heaven.[32] According to the Italian Jesuit, God created the Empyrean heaven on the first day of Creation. Although imperceptible to human senses, it was supposedly the most perfect, incorruptible and luminous heaven. This superior heaven was most likely provided with a spherical shape and solid nature **[fig. 10]** and devoid of motion.[33]

Below the Empyrean heaven stood the sidereal and airy heavens, according to Borri. As already mentioned, he conceived the *caelum sidereum* as a fluid environment comprising the planets and fixed stars. Stafford and Fal-

32 Borri's purpose is clear in the front of his book, since the subtitle describes the *Collecta astronomica* as an "opus sane mathematicum, philosophicum et theologicum sive scripturarium". Randles (*The Unmaking*, 175-6) has considered this work to be "one of the last thorough attempts by a Catholic astronomer to integrate astronomy with the Bible".

33 Further details about Borri's conception of the Empyrean heaven can be found in Carolino, "O paraíso do astrónomo".

lon also endorsed the tripartite division of the universe.[34] Nevertheless, Fallon distinguished between the planetary heaven and the heaven of the fixed stars. According to the Irish astronomer, planets moved in a fluid inferior heaven, corresponding to the space extending between the Earth and Saturn (the planetary heaven). Above it, there was a solid heaven, wherein the fixed stars moved (the sidereal heaven) and, finally, the Empyrean heaven.[35]

In short, Stafford and Fallon shared basically the same sort of astronomical and cosmological ideas that had already been developed by Borri in his efforts to establish a Tychonic cosmology. Nevertheless, they introduced some variations of the initial outline proposed by Borri. The Santo Antão professors agreed to divide the cosmos into three heavens; however, whereas Borri and Stafford distinguished between the airy heaven, the sidereal heaven, wherein planets and the fixed stars moved, and the Empyrean heaven, Fallon preferred to allocate the planets to the heaven that extended from the Earth to Saturn, to which he added a solid heaven where fixed stars moved and, finally, the Empyrean heaven.[36] Nevertheless, Fallon agreed with Borri in sustaining that celestial bodies were pushed by angels, while Stafford argued that planets and fixed stars were moved by their own intrinsic nature. Both Stafford and Fallon maintained that celestial bodies followed a spiral path in their motion, an idea elaborated in detail by Borri in his *Collecta astronomica*.

As for the planetary rearrangement, Stafford and Fallon endorsed the Tychonic system, just as Gall and Borri had done before them. What is more, they unanimously considered the Tychonic system to be the accurate representation of the world.[37] As Fallon put it: "the order according to which the planets and the stars move, and therefore the constitution of the universe (*mundo*) that we follow as true, is that of Tycho Brahe".[38]

34 Stafford did not discuss this topic in detail. Nevertheless, since he argued, in his *Elementos astronomicos e geographicos*, that the planets as well as the fixed stars moved in a fluid heaven, he most likely assumed that all the celestial bodies move in the same heaven (the sidereal heaven). Stafford, *Elementos*, cod. 49-II-80, ff. 18*r*-18*v*; *Elementos*, BNP, cod. 4256, f. 16*r*.

35 Fallon, *Compendio Spiculativo*, BNP, cod. 2258, f. 107*r*.

36 Fallon, *Compendio Spiculativo*, BNP, cod. 2258, f. 107*r*. Stafford did not discuss this topic in his course on planetary theory.

37 Nevertheless, Santo Antão's Jesuits maintained that the Ptolemaic planetary system should serve as an instrument for planetary computations. Gall, *Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, f. 65*v*; Stafford, *Tractado das Theoricas*, BNP, cod. 4323, f. 100*v*.

38 Fallon, *Compendio Spiculativo*, BNP, cod. 2258, f. 105*v*.

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Capítulo 5. Poense a nossa e verdadeira hypothesi, que he a Tichoniana. Simon Fallon, *Compendio Spiculativo*, BNP, cod. 2258, ff. 105*v*-107*r*

Diguo em primeiro lugar, que do que dissemos nestes dous capítulos passados se colhe claramente ser fluido todo o espaço do concauo da Lua até Saturno inclusiuamente, porque de outro modo não he intelligiuel saluarensse as apparencias, principalmente modernas.

Preguntará alguem, de que materia será este espaço? Respondemos que da mesma materia do ar, en que uiuemos, ainda que mais tenue, e defecado, porque a elle não chegão as exhalações e vapores, que condensão o nosso Ar: e por isso para distincão deste nosso ar, que diuidimos comumente nas três regiões, infima, mea e suprema, se pode chamar aquelle espaço Aura Etherea, ou Planetaria, por andatem por elle os Planetas.

Diguo en segundo lugar, que os Planetas não andão nesta aura etherea, liure, e irregularmente, como os pexes na agoa, e Aves no ar, senão com grande ordem e regularidade, descreuendo seus Periodos no Zodiaco, en tempos certos e determinados, como na hypothesi Ptholomeica.

Diguo en terceiro lugar, que a ordem porque se mouem os Planetas e estrellas, e conseguintemente a constituição do mundo, que seguimos como verdadeira he a seguinte de Tichobrahe. A terra A no centro do Vniuerso, ao redor o circulo BCD reprezenta o caminho da Lua, e a este se segue EFG caminho do Sol: do Sol como de centro, se descreuem os caminhos de todos os [f. 105*v*] mais Planetas, porque he certo que sempre guardão igual distancia delle, e assy o circulo HIK he o caminho de Mercurio: LMN o de Venus: o PQ o de Marte: o qual corta o caminho do Sol: RST o de Júpiter: VXZ o de Saturno: sobre o qual se seguem as estrellas fixas como tudo representa esta figura **[fig. 11]**:

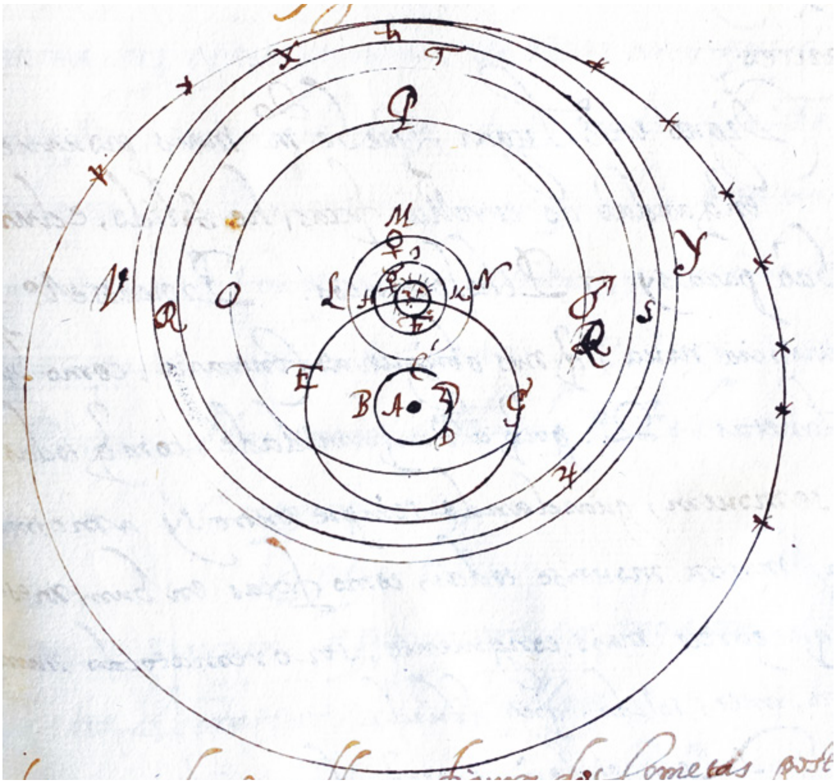

Figure 11 The Tychonic system according to Simon Fallon

Com a qual se entenderá melhor a figura dos Cometas posta no capítulo atraz.

Diguo en quarto lugar: que he prouauel, que o espaço, que occupão as estrellas fixas, he tambem da mesma materia fluida e tenue, como a Aura planetaria, sem distinção alguma, mais que serem as estrellas superiores no sitio, e ordem dos Planetas. Prouasse primeiro porque se não pode facilmente dar maior rezão de huma cousa, que da outra. Segundo, aquella estrella da Cassiopeia, de que falamos no capítulo passado, proua ser tambem fluido o espaço, en que ella andou, porque a materia della, ou forão varios corpos luminosos; que se poserão em conjunçam per modo de cometa digno, conjunção per modo de cometta, e depois se forão desunindo: ou foi na verdade estrella que sobio continuamente [f. 106*r*] a maior distancia, ate que de todo desappareceo. Terceiro, porque a Via Lactea he huma continua reuolução de estrellas mais meudas, que os semi-planetas de aura Planetaria.

Diguo en quinto lugar, que he muito mais prouauel que o espaço en que andão as estrellas fixas, he solido, e duro, na forma en que tinhão para sy os Ptholemaicos. Prouasse primeiro porque não há apparencia noua, que nos obrigue ao contrario, como há no espaço dos Planetas. Segundo porque a uniformidade, com que todas as estrellas se mouem, guardando sempre entre sy a mesma distancia, e ordem mostra mouerse todas, como fixas en hum mesmo corpo. Terceiro porque parece mais congruente ser o remate do mundo de parte conuexa, antes solido, que fluido.

Nem obstão as resões da opinião contraria, porque a primeira fica solta ex dictis. A segunda da estrella da Cassiopeia, diguo, que acerca de sua altura, ou distancia da Terra, somente [?] podia demonstrar, estar ella sobre Saturno (de Saturno para sima diremos adiante, não se poder saber certeza, por não auer Paralaxes) e como he prouauel, que o spaço fluido, e planetario não acaba onde está o corpo de Saturno, ainda quando em maior distancia, podiasse formar a dita estrella de varios semiplanetas, per modo de Cometa no espaço fluido, que há sobre Saturno, sem ser ainda na distancia, que tem as estrellas fixas da Terra. A terceira resão da Via Lactea, por ser confirmação da nossa opinião, a saber que consta não de semiplanetas, mas de semistrellas, que por guardarem sempre uniformidade, mostrão bem serem fixas [f. 106*v*] em algum corpo: Assy que por remate deste capitulo se auerigua que alem do Ceo Empireo, que Deos fez para seus Predistinados, não há outro ceo duro, e solido, tirando o en que estão as estrellas fixas, que pella conta tem o lugar do primeiro mouel: abaixo deste todo o espaço que há, não só até o concauo da Lua, mas ainda até a suprema superficie conuexa do nosso ar, que demonstramos no segundo tratado, ser en distancia de 52 milhas da Terra, he huma Aura Etherea, ou Planetaria, pella qual se mouem os Planetas, semiplanetas e cometas, com muita regularidade, na forma que reprezentão os circulos atraz e assy se pode dizer que são três ceos, Planetario, e Fluido, e Ethereo: o segundo sydereo, e fixo, o terceiro Empyreo. [f. 107*r*]

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English translation. Chapter 5. Our and the true hypothesis is proposed, which is the Tychonic one. Simon Fallon, *Compendio Spiculativo*, BNP, cod. 2258, ff. 105*v*-107*r*

I declare, in the first place, that we conclude, based on what we have said in the two preceding chapters, that the whole space from the concave of the Moon to Saturn, including it, is fluid because otherwise, it is not clear how the [celestial] appearances, especially the modern ones, could be saved.

Some may ask, what is this space made of? We answer that it is made of the same matter as the air in which we live, although it is more subtle and purified because the exhalations and vapours that condense our air do not reach it. And for this reason, in order to distinguish it from our air, which we commonly divide into three regions [i.e. the airy region], the lowest, the middle and the highest region, we may call that superior air *Aura Aetherea* or Planetary Aura, because the planets move in it.

I declare, in the second place, that the planets do not move freely and irregularly in this *Aura Aetherea*, like fishes in water and birds in the air, but move with perfect order and regularity, describing their motions in the Zodiac, in precise and determined periods, as in the Ptolemaic hypothesis.

I declare, in the third place, that the order in which the planets and stars move, and consequently the constitution of the world that we follow as the true one, is that of Tycho Brahe. The Earth A [is] in the centre of the universe; around it, the circle BCD represents the Moon's path; then follows the Sun's orbit, EFG; all the planets describe their paths [f. 105*v*] having the Sun as the centre of their orbits because there is no doubt that they are always at the same distance from it. Thus, the circle HIK is the path of Mercury; LMN, that of Venus; PQ, that of Mars, which cuts the orbit of the Sun; RST, that of Jupiter; VXZ, that of Saturn, upon which the fixed stars follow, as the figure represents **[fig. 11]**.

With this figure, it will be easier to understand the orbits [*figura*, 'figure'] of the comets referred to in the preceding chapter.

I declare, in the fourth place, that it is likely that the space occupied by the fixed stars is also of the same fluid and tenuous matter as the planetary *aura*, with no distinction apart from the fact that they stand in a superior position and order of the planets. This is proved, firstly, because one cannot easily give stronger arguments in favour of one rather than of the other position. Secondly, the star of Cassiopeia, about which we have spoken in the last chapter, proves that the space in which it moved was also fluid because its matter was either several luminous bodies, which were placed in conjunction in the manner of a comet (I say, in conjunction in the manner of a comet) and dissolved afterwards, or it was in truth a star that ascended continually [f. 106*r*] to the greatest altitude until it disappeared completely. [We prove it], because the Milky Way consists of a continuous revolution of stars, which are finer than the semi-planets of the planetary aura.

I declare, in fifth place, that the space in which the fixed stars move is much more likely a solid and hard body, as the followers of Ptolemy stand for themselves. This is proved, firstly, because no new appearance compels us to admit the opposite, as it occurs in the planetary area. Secondly, the uniformity with which all the stars move, always keeping the same distance and order, shows us that they all move as fixed in the same body. Thirdly, it seems more appropriate for the limit of the world, in its convex part, to be solid rather than fluid.

Nor do the reasons in favour of the contrary opinion stand, because the first is resolved *ex dictis*. The second reason, on the star of Cassiopeia – I mean the reason based on its height or distance from the Earth – could only prove that it was placed above Saturn (above Saturn – we shall say later – it cannot be known for sure, because there is no visible parallax) and since it is probable that the fluid and planetary space does not finish where the body of Saturn is, even if is at a greater distance, the said-star could be formed from several semi-planets as a comet in the fluid space above Saturn, without being in the space of the fixed stars towards the Earth. The third reason, on the Milky Way, is a confirmation of our opinion that it does not consist of semi-planets but rather of semi-stars. The fact that they keep the same regularity indicates that these semi-stars are well fixed in some body. Thus, in closing this chapter, it is held that, beyond the Empyrean heaven, which God made for his Predestined, there is no other hard and solid heaven than that in which the fixed stars are found, occupying the place of the first mobile. Below this, the whole space that exists, not only down to the concave of the Moon, but still down to the supreme convex surface of our air – which we have shown in the second treatise to have a distance of 52 miles from the Earth – is made of an *Aura Aetherea* or Planetary Aura, in which the planets, semi-planets, and comets move, with much regularity, in the way represented above. Thus, one must argue that there are three heavens, the planetary heaven, fluid and aethereal; the second, the sidereal heaven, fixed; the third, the Empyrean heaven. [f. 107*r*]

10 Philosophers' Reception of the Tychonic Cosmology

The mathematicians who taught at the Class on the Sphere were not the only scholars engaged in the cosmological debate at the College of Santo Antão. Alongside them, the professors of philosophy displayed a vivid interest in astronomical discussion. While teaching the fundamentals of Aristotelian cosmology and meteorology, they discussed the impact that the celestial novelties had on the traditional cosmos.

As elsewhere in the Jesuit colleges, the Lisbon philosophers' community echoed the ideas and debate developed among mathematicians.[1] Nevertheless, they were not passive readers of avant-garde mathematicians. On the contrary, philosophers debated and accommodated the notions that they considered to be more in tune with the Aristotelian framework.[2] Those ideas did not necessarily exclude a Tychonic conception of the universe. Conversely, the acceptance of notions such as the elemental nature of celestial matter, its fluidity and its corruptibility, which were developed within the context of the Tychonic discussion, led to an upgrade of the Aristotelian cosmological framework among the Portuguese Jesuits in the first half of the seventeenth century. Although they continued to regard themselves as the guardians of Aristotle's teachings, those philosophers elaborated a cosmological worldview that was entirely consistent with a Tychonic plan-

1 As Renée J. Raphael has shown, the Collegio Romano is probably the most notable example. Raphael, "Copernicanism in the Classroom".

2 There is abundant literature on the pluralism, diversity and dynamism that characterised early modern Aristotelianism. See, among others, Schmitt, *Aristotle and the Renaissance*; Des Chene, *Physiologia*; Ariew, *Descartes among the Scholastics*; Mercer, "The Vitality and Importance".

DOI 10.30687/978-886-969-661-9/010

etary rearrangement. Thus, while historians have tended to emphasise the existence within the Jesuit Order of strict disciplinary distinctions and different scholarly practices between mathematicians and philosophers, this chapter shows that there was no such clear divide.

Philosophers and mathematicians nevertheless operated in different disciplinary and institutional settings. In fact, philosophers were not supposed to discuss the planetary system – which was a task reserved for mathematicians – but instead were meant to analyse cosmological issues such as the nature of celestial matter. Because of that, the Santo Antão philosophers privileged the debate on comets and new stars over the other celestial novelties. Furthermore, unlike their mathematician counterparts, professors taught philosophy only transitorily at the College of Santo Antão. Usually, on completing the theological course, Jesuits were asked to teach philosophy before embarking on a theology teaching career, a government profession or missionary activities. Alongside the University of Évora, the College of Arts of the University of Coimbra and the College of Saint Paul in Braga, the College of Santo Antão was one of the institutions in Portugal where philosophy teaching took place for most of the seventeenth century. Accordingly, Santo Antão's philosophers usually taught this subject only once during their career, beginning with logic, proceeding with natural philosophy and finishing the three-year course with ethics and metaphysics. The philosophy professors thus formed a volatile community in Lisbon, even though they were deeply interested in the cosmological debate.[3]

The period spanning from the 1610s to the late 1630s was a critical one for this philosophical community as the recently observed comets and new stars seemed to jeopardise the foundations of their Aristotelian cosmology. In the late 1610s, despite mathematicians' argument that comets moved above the Moon, the Lisbon philosophers still argued in favour of the traditional view according to which comets were made up of exhalations that ascended from the Earth's surface to the upper region of air, where they deflagrated when coming into contact with fire. This was precisely the theory advocated in a philosophical course produced at the College of Santo Antão and published in 1618 under the title *Doctrina philosophica*.[4] According to this teacher of Santo Antão,

> Comets do not consist of celestial but sublunar matter. Their matter is the hot and dry, viscous and greasy terrestrial exhalations which, once in contact with the fire, last for some time according to the quality and quantity of the exhalations.[5]

3 In the period from the early 1610s until the late 1630s, when the cosmological debate was at its peak at the College of Santo Antão, the teaching of philosophy was assigned to the following professors: Luís Brandão, 1612-15; Baltazar do Amaral, 1615-18; Apolinário de Almeida, 1618-21; António Correia, 1621-22; Diogo Lopes, 1622-24?; Diogo Leitão, 1624-27; Francisco Rodrigues, 1627-30; Domingos Barbosa, 1630-33; António Bandeira, 1633-36, and Martim Leitão, 1636-39. ARSI, Lus. 39 and Lus. 44 II.

4 The *Doctrina Philosophica* was published under the authorship of Luís Dias Franco. Franco has been considered to be a pseudonym used by the Santo Antão philosopher Baltazar do Amaral since the seventeenth century. The Jesuit historian João Pereira Gomes, however, attributed the authorship of this work to Luís Dias Franco himself, a student who finished the philosophical course at the College of Santo Antão in 1615. On this issue, see Gomes, "Franco (Luís Dias)".

5 Franco, do Amaral, *Doctrina Philosophica*, 198: "Dicendum igitur est cum Philosopho lib. 1 huius operis c. 7 et aliis, cometas non constare materia caelesti, sed sublunari, et illorum

This notion that comets were transient phenomena produced in the Earth's atmosphere left intact the fundamental principle of medieval cosmology, according to which there was a strict distinction between celestial and terrestrial regions. Unlike the Earth and its atmosphere, the heavenly region was considered to be a perfect region. Therefore, no processes of substantial change occurred in the area where the heavenly bodies moved supposedly in perfect circles embedded in rigid orbs.

Nevertheless, once he arrived in Lisbon in the early 1620s, Johann Chrysostomus Gall made it public that he had observed one of the comets of 1618 moving across the celestial region. As already mentioned, the German Jesuit took part in the astronomical observations carried out at the University of Ingolstadt led by Johann Baptist Cysat, who unequivocally proved that the comet moved above Venus.[6] A few years later, Cristoforo Borri explicitly associated the celestial location of comets with the corruptibility of celestial matter. The ontological divide between celestial and terrestrial regions was therefore at stake.

At first, the Santo Antão philosophers reacted with scepticism to the celestial novelties publicised by foreign colleagues. Accordingly, Diogo Leitão and Francisco Rodrigues, who taught philosophy in the late 1620s, explicitly mentioned the new cometary observations carried out by their mathematician counterparts. Nevertheless, they disagreed with them.[7] Leitão and Rodrigues preferred to shelter themselves from any sort of cosmological debate by claiming that the observations needed further inspection.[8]

According to these philosophers, comets were nothing but meteorological phenomena that resulted from the ascension of terrestrial exhalations to the boundary with the 'region of fire'.[9] In this context, Rodrigues opposed, among others, the thesis that comets resulted from planetary conjunctions. This could not be the case, Rodrigues argued, because the appearance of comets rarely coincided with the occurrence of celestial conjunctions. Thus, he informed his philosophy students at the College of Santo Antão in 1629 that:

> Other authors have considered the comet to be the conjunction of the seven planets. However, this statement is false, first, because, even though these planets are far apart, comets often appear; second, because the planets always meet in the Zodiac, which is not the case with comets; third, because the conjunction of two planets occurs for a brief time and the comet lasts for a long time. Therefore, the comet cannot be the conjunction of the seven planets.[10]

materiam esse exhalationes terreas, calidas, et siccas, ac multum pingues et crassas, in quibus ignis semel accensus per aliquod tempus detinetur pro qualitate et quantitate exhalationum".

6 See ch. 3.

7 Leitão, *In Libros*, BA, cod. 50-III-11, f. 110*r*; Rodrigues, *Compendium*, BGUC, MS 2316, f. 4*r*.

8 See, for example, Leitão, *In Libros*, BA, cod. 50-III-11, f. 110*r*.

9 Leitão, *In Libros*, BA, cod. 50-III-11, f. 131*r*; Rodrigues, *Compendium*, BGUC, MS 2316, ff. 4*r*-4*v*.

10 Rodrigues, *Compendium*, BGUC, MS 2316, f. 4*r*: "Alii dixere cometam esse coniunctionem 7 planetarum, haec tamen sententia falsa est. 1º quia quanquam istae planetae sunt disiunctae cometae videntur saepe saepit [?]. 2º quia planetae semper sunt in zodiaco cometae vero non ita. 3º quia coniunctio unaquaeque[?] planetae cum alio brevi tempore durat, cometa vero longo tempore perseverat; ergo cometa non potest esse coniunctio 7 planetarum".

Rodrigues finished teaching his philosophical course in 1630. With the new decade, a new philosophy professor, Domingos Barbosa, came forward. As far as comets were concerned, Barbosa shared the view of his predecessor that they were made up of "a great number of exhalations that are viscous and greasy and well compacted among themselves which is inflamed by fire".[11] However, Barbosa made a new point. According to him, recent astronomers had demonstrated that some comets actually rose above the heavens of the Moon, Mercury, Venus and the Sun.[12] Thus, despite consisting of exhalations, comets could, in some circumstances, ascend to the heavenly region. This very same view was corroborated by Barbosa's successor in the Santo Antão philosophical chair, António Bandeira.[13]

The celestial location of comets raised several issues for the traditional cosmological model. Among these, the ascension of comets through the heavens questioned the existence of a succession of solid orbs within which the planets and fixed stars moved; the rise of obnoxious matter, like terrestrial exhalations, into the heavens, a supposedly perfect and immutable zone, also raised doubts about the principle of celestial incorruptibility.

For the first question, having recognised that comets could ascend to the celestial region, Barbosa and Bandeira discarded the traditional notion that the heavenly region was divided into several rigid orbs. For both the philosophers, the upward and downward movement of comets throughout the celestial region and the planets' orbits required the heavens to be fluid.[14]

Like their fellow mathematicians, Barbosa and Bandeira adhered to a tripartite division of the universe, though with some particularities. They argued that the heavens should be divided according to the matter that composed them, distinguishing between the *caelum aereum* and the *caelum igneum*, to which they added the *caelum empyreum*. The *caelum aereum* was basically made up of air and corresponded to the region that extended from the Earth's surface to the 'heaven' of Venus, whereas the *caelum igneum* comprised the region from the Sun up to the fixed stars, where fire was the predominant element.[15] As the Moon and the other planets were not embedded in solid and rigid orbs but wandered in an airy or fiery environment, there was room for the terrestrial exhalations to ascend over the Moon's region.

As for the question of celestial incorruptibility, despite asserting that the heavens were composed of air or fire and acknowledging that comets could ascend to heaven, Barbosa and Bandeira still maintained the principle that no substantial change took place in the celestial region. According to them, the heavens and the terrestrial region were both made up of elemental matter;[16] however, an external agency prevented the celestial bodies from suffering any process of coming to be and passing away.[17] Using the scholastic theory of hylomorphism, Barbosa and Bandeira advocated the idea that the heavens were composed of matter and form, but, unlike what

11 Barbosa, *Philosophia*, BGUC, MS 2368, f. 80*v*: "Cometa est multitudo exhalationum pinguum et crassarum et bene cohaerentatarum[?] quae igne accendurri".

12 Barbosa, *Philosophia*, BGUC, MS 2368, f. 80*v*.

13 Bandeira, *Recopilatio*, BGUC, MS 100, ff. 86*r*-86*v*.

14 Barbosa, *Philosophia*, BGUC, MS 2368, f. 65*r*; Bandeira, *Recopilatio*, BGUC, MS 100, f. 68*v*.

15 Barbosa, *Philosophia*, BGUC, MS 2368, f. 70*v*; Bandeira, *Recopilatio*, BGUC, MS 100, f. 70*v*.

16 Barbosa, *Philosophia*, BGUC, MS 2368, f. 65*r*; Bandeira, *Recopilatio*, BGUC, MS 100, f. 68*v*.

17 Barbosa, *Philosophia*, BGUC, MS 2368, f. 66*r*.

happened with terrestrial bodies, for which there was a constant substantial change, in the celestial bodies, matter and form were, by divine will, in an inseparable state. Therefore, there was no privation and hence no substantial change.[18] That is to say, even if they were provided with the conditions responsible for the change (i.e. being composed of form and matter), these conditions were not operative for an external reason. In other words, even though they were made up of corruptible matter, the heavenly bodies remained incorruptible and immutable *ab extrinseco*: "*caelos esse corruptibiles ab intrinseco et solum ab extrinseco esse incorruptibiles et indissolubiles*", Bandeira proclaimed.[19]

By arguing in favour of celestial incorruptibility, Barbosa and Bandeira disagreed with their fellow mathematicians and particularly with Borri and his followers in the Class on the Sphere. Thus, Jesuit philosophers were not only aware of the new theories advocated by their mathematical confrères but also read them critically. As a result, they accepted some theories, even though they elaborated them differently; they rejected others that seemed contrary to the core aspects of Aristotelianism; and, above all, they developed a new theoretical framework that eventually allowed them to integrate these new theories.

The notion of celestial incorruptibility offers a case in point. Based on the ontological divide that structured the Aristotelian cosmology, the philosophers who taught at the College of Santo Antão were much more reluctant to recognise the existence of a substantial change in the heavenly region than to acknowledge, for example, the celestial fluidity. Nevertheless, they eventually accepted it. This was the case of Bento Rodrigues, who taught philosophy at the Lisbon College in the early 1660s. As he put it:

> It is proved, in the first place, by the observation of new heavenly bodies (that is, the 'new star' discovered in Cassiopeia) and of comets, which modern and most learned mathematicians, on Tycho's commission, have recognised to be newly generated. It is proved, in the second place, because various changes are observed every day on the Moon, and the same happens on other planets and on the Sun, where diverse spots are now seen and observed by mathematicians, which were previously undiscovered. These phenomena occur only because new generations took place on the Sun's surface, as the mathematicians themselves testify.[20]

Bento Rodrigues was in tune with the great majority of the Portuguese Jesuit philosophers, who, in the second half of the seventeenth century, acknowledged the corruptibility of the heavens based on astronomers' observations. Among these, Cristoforo Borri deserves a prominent place as he was commonly quoted in Portuguese philosophical textbooks.[21] A few years

18 Barbosa, *Philosophia*, BGUC, MS 2368, ff. 5, 65-6.

19 Bandeira, *Recopilatio*, BGUC, MS 100, f. 68*v*.

20 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 5: "Probatur 1º ex observatione novorum syderum (et talis communiter dicitur nova stella in Cassiopeia inventa) et cometarum, quae de novo genita deprehenderunt novi et doctissimi mathematici a Tychone allegati. Probatur 2º quia in luna quotidie conservantur [sic, observantur] variae mutationes, idemque est in aliis planetis et in sole videntur modo et observantur a mathematicis quaedam maculae, quae antea non videnbantur, sed hoc sol a nova ibi generatione data poterat provenire, ut ipsi testantur".

21 See Carolino, "Cristoforo Borri".

later, another professor from Santo Antão was equally explicit in defending the theories of celestial fluidity and corruptibility based on astronomical observations. This was Manuel Veloso, who taught at the Lisbon College in 1668, after a sojourn in Rome, where he met the Jesuit mathematician Athanasius Kircher, the famous mathematics professor at the Collegio Romano by that time.[22]

Nevertheless, just like their colleagues in the early 1630s, Bento Rodrigues and Manuel Veloso had a critical understanding of the scientific contributions of their mathematician confrères. They discussed the cosmological consequences of the *new astronomy* (*nova astronomia*), as they called it, but had their own views on the subject. Thus, for example, both Rodrigues and Veloso argued in favour of a tripartite division of the cosmos, but, while Rodrigues maintained that the universe was divided into *caelum aethereum*, *coelum stellatum* and *coelum empyreum*,[23] Veloso considered, along the lines of Borri's *Collecta astronomica*, that the *coelum aereum* was followed by the *coelum sydereum* and the *coelum empyreum*.[24] These two philosophy professors also advocated, like Borri and the mathematicians of the Class on the Sphere, the principle of celestial fluidity, but, even so, Rodrigues distinguished the heavens of the planets from that of the fixed stars and restricted fluidity to the planetary heaven. He argued against Borri and Stafford – and in line with Fallon – that the heaven of the fixed stars was a solid body.[25]

Veloso, in his turn, while corroborating Borri's thesis of the fluidity of the physical heavens, vehemently disagreed with Borri's and Fallon's understanding of the movement of the celestial bodies. He considered that celestial bodies' intrinsic virtue moved planets and stars.[26] On this very same topic, Rodrigues agreed with the two mathematicians in arguing that angels were responsible for the motion of celestial bodies.[27]

Moreover, although these philosophers maintained, in unison with Borri, the corruptibility of the heavens, using, among others, the argument of the astronomical observation of comets moving throughout the celestial region, only Bento Rodrigues explained the appearance of comets as a result of the condensation of the celestial matter itself, as Borri had exposed in his *Collecta astronomica*.[28]

Finally, regarding the composition of celestial matter, none of these philosophers shared the understanding put forward by their mathematician confrères, according to which the heavens were made up of *aura aethera*. Despite recognising that the celestial bodies were composed of elementary matter, neither Rodrigues nor Veloso maintained that celestial matter was exclusively air in a purer state. According to Veloso, the celestial bodies were composed of air, fire and water. Rodrigues, in turn, argued that the planetary heaven was made up of aether, yet he understood aether to be a

22 Veloso, *Opus physicum*, BNP, cod. 4813, f. 166*v*.

23 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 11-12.

24 Veloso, *Opus physicum*, BNP, cod. 4813, f. 173*v*.

25 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 3.

26 Veloso, *Opus physicum*, BNP, cod. 4813, ff. 179*v*-81*r*.

27 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 15, 18.

28 Note, nevertheless, that Bento Rodrigues also accepted the thesis that comets were celestial exhalations. Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 42.

mixture of air and fire in its purest state.[29] An elemental material composition was also found in the *caelum stellatum* for, as Rodrigues unequivocally stated, "this heaven is an elemental body made up of the four terrestrial elements".[30]

In other words, the philosophers who taught at the College of Santo Antão were utterly familiar with the astronomers' contributions, yet they had a critical understanding of their cosmological meaning. They did not discuss the planetary rearrangement. Accordingly, they did not explicitly express their views on the geo-heliocentric system of Tycho Brahe. Nevertheless, the main cosmological issues that entered the philosophical debate by the hand of Tychonic astronomers (that is, the celestial fluidity and corruptibility, the tripartite division of the cosmos or even the helicoidal path of planetary orbits)[31] were all integrated by philosophers into an Aristotelian-inspired worldview during the seventeenth century. These ideas shaped their cosmological conceptions.

29 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 7.

30 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 7: "Tale caelum est corpus elementare constans ex quatuor nostris elementis".

31 Rodrigues, *Philosophia naturalis*, BNP, cod. 4838, 18.

Document VIII

Quaestio prima. *De natura caelorum*. Francisco Rodrigues, *Philosophia naturalis*, 1663, BNP, cod. 4838, 1-16

Articulus primus

An caeli sint fluidi, an solidi?

Suppono primo quod caeli sint quaedam corpora composita ex materia et forma quia iam in metaphysica uidimus nullum dari corpus compositum quod esset simplex physice. Suppono secundo quod materia caelestis, et sublunaris sint eiusdem speciei, ut iam uidimus in physica. Suppono etiam non esse quaestionem de caelo Empyreo; nam cum hic sit Beatorum sedes, iure optimo condenda est firmitas et soliditas. Igitur solum est quaestio de aliis duobus caelis (tres enim dabimus tamen infra) nempe de Aethereo et Stellato.

Prima conclusio sit Caelum aethereum seu Planetarum est fluidum. Ita communiter auctores quos citat et sequitur Soares Lusitanus, [*Cursus philosophicus*], De Caelo Disputatio 1, numero 16. Probatur primo ex uariis experimentis: nam saepe obseruatum est Cometas permeare caelos et ascendere supra Solem et usquam ad stellas fixas. Obseruatum est deinde Martem aliquando uersus nos descendisse Veneremque et Mercurium ascendisse supra Solem. Probatur secundo qui cum in Luna dentur montes, ualles et cauitates profundae si Luna moueretur per corpus solidum daretur uacuum: ergo ut impleantur illae cauitates aptius erit quod caelum sit fluidum. Probatur tertio quia si Caelum Planetarum esset solidum, non facile ad nos descenderet Lux Astrorum. Neque dicas posse esse diaphenum, quia respondeo diaphaneitatem non inueniri in corpore nimis crasso ut sunt caeli. [...] [1]

Secunda conclusio. Caelum stellatum est solidum. Ita Soares Lusitanus, [*Cursus philosophicus*], numero 21 et pro hac sententia citari possunt omnes illi Auctores, qui dicunt caelos esse solidos. Probatur primo quia sic melius intelligitur dari tres caelos scilicet, unum fluidum, alterum solidum, et alterum Empyreum: nam si secundum caelum constaret etiam eadem fluiditate qua primum tantum differrent accidentaliter. Secundo quia melius sic intelligitur cur stellae aliquae fixae appellentur fixae enim sunt in soliditate illa, et ideo semper conservant eandem inter se distantiam: et sic ab uno tantum motore omnia possunt moueri, quod quid non ita foret si caelum secundum esset fluidum, nam necessarium erat admittere tot motores, quot sunt Astra: sed est superfluum fieri per plura quod potest fieri per pauciora: ergo si unus tantum motor sufficit, admissa soliditate dicendum est secundum caelum solidum esse. Confirmatur quia sic mellius intelligitur quomodo secundum caelum supra se aquas contineat (iuxta illa Aquae quae supra caelos sunt) quantenus hae ad nos difluant.

Articulus secundus
Utrum Astra sint corpora solida?

Prima conclusio. Sol est corpus fluidum constans massa fluida, et lucida per modum auri liquati motu feruentis ac undantis. Ita Soares Lusitanus [*Cursus philosophicus*], numero 35. Probatur quia ita observatum est a mathematicis ope tubi obtici ut uidere est apud ipsum Soares numero 34. Secunda conclusio. Luna, Planetae et Stellae fixae massa magis solida et compacta constant; hoc etiam nobis constat ex eisdem obseruationibus, et quidem de Stellis probatur facile quia sunt tanquam aurei claui in caelo tanquam in rota fixi. [...] [4].

Quaeres secundo. An Caeli sint corruptibiles? Respondeo affirmate cum Soares Lusitanus et aliis quam plurimis. Probatur primo ex obseruatione nouorum siderum (et talis communiter dicitur noua stella in Cassiopeia inuenta) et cometarum, quae de nouo genita deprehenderunt noui, et doctissimi mathematici a Thicone allegati. Probatur secundo quia in Luna quotidie conseruant [*sic*, observantur] uariae mutationes, idemque est in aliis Planetis et in Sole uidentur modo et obseruantur a mathematicis quaedam maculae, quae antea non uidebantur: sed hoc solum a noua ibi generatione data poterat proueniri, ut ipsi testantur: ergo etc. Confirmatur ex Sacra Pagina praecipue ex illo psalmi 102 Opera manuum tuarum sunt caeli ipsi peribunt, et omnes sicut uestimentum ueterascent, et mutabunt: deinde patet ex Apocalipse Vidi Caelum nouum et terram nouam. Neque dicas Caelum dissoluendum esse per miraculum quia respondeo frustra recurri ad miracula, cum res possit fieri naturaliter: et quidem naturaliter in die iudicii caelum dissoluturum iri colligunt ex uerbis assignatis graues Auctores. [...] [5]

Articulus tertius
Quae sit natura Caelorum, et ex qua materia constet Caelum stellatum, Sol, et alia sidera?

Non est quaestio de Caelo Empireo: nam de hoc alibi dicendum. Igitur de primo Caelo [6] sit resolutio. Tale Caelum nihil aliud est quam aula [*sic*, aura] purissima et limpidissima quae ex magis puro aeris et ignis deducta utriusque mixturam habet. Ita Soares Lusitanus [*Cursus philosophicus*], numero 60, cum aliis. Probatur quia ut supra uidimus primum Caelum est fluidum, et in illo stellae mouentur (iuxta communem explicationem) sicut aues in aere, aut pisces in aqua: ergo, etc.

Circa secundum Caelum resolutio sit. Tale caelum est corpus elementare constans ex quatuor nostris elementis. Ita id Soares cum aliis Ecclesiae Patribus. Probatur quia nulla nos necessitas cogit admittere substantiam aliam peculiarem quam contrarii quintam substantiam uocant: ergo, etc. Probatur secundo quia tale Caelum iuxta Theodoretum ideo uocatur firmamentum quia ex aqua prius labili et postea indurata concreuit: ergo, etc. Confirmatur primo quia tale Caelum in die Judicii est dissoluendum, sicut etiam eius stellae: ergo est corpus elementare. Confirmatur secundo quia tale Caelum potest uideri et palpari: sed quia ita se habent constant ex elementis: ergo, etc. [...] [7]

Quaestio secunda
De numero et motu Caelorum, et Stellarum, de istarum figura, et magnitude

Articulus primus
De numero Caelorum

Resolutio sit. Tres tamen dantur Caeli. Ita Soares Lusitanus [*Cursus philosophicus*], numero 132, magister Soares [i.e. Francisco Suárez], Teles, Hurtado, Oviedo, et alii. Probatur primo authoritate Sanctorum Patrum, Augusti, Ambrosii, Chrisostomi et aliorum. Probatur secunda ratione, quia nulla est necessitas admittendi plures caelos, nec pauciores, quam tres: primum scilicet aethereum, in quo uersantur omnes septem Planetae, nempe Luna, Mercurius, Venus, Sol, Mars, Jupiter, Saturnus. Secundum stellatum, et solidum in [11] quo sunt stellae fixae. Tertius Empireum, quod est sedes Beatorum, de hoc infra agemus specialiter. Probatur tertio efficaciter ex uerbis Apostoli Scio hominem raptum usque ad tertium caelum. Quod de Empyreo communiter intelligitur, quia ibi audiuit Apostolus arcana inefabilia. [...] [12]

Articulus secundus
De motu Caelorum, et Stellarum figura, numero et magnitudine

Circa motum Caelorum et stellarum sit resolutio. Caelum et Astra mouentur ab Angelis. Ita sententia quam tenent Soares Lusitanus [*Cursus philosophicus*], numero 190, cum paene 20 Auctores. Probatur primo ex illo Job: sub quo curuantur qui portant Orbem, quae uerba de Angelis intelliguntur, qui tanquam Athlantes substinent Orbes Caelesles et Planetas.

Probatur secundo quia tales orbes non mouentur immediate a Deo ut putabat Albertus magnus, quia Deus solum agit mediis secundis. Dices cum Sol ad uocem Josuae stetit dicitur in texto obedeisse Deum uoci hominis: ergo Deus immediate regit Solem. Respondeo negando consequentiam, quia Deus immediate audiuit uocem, et tunc fecit quod Angelus solem sisteret. Probatur tertio praecipue de Planetis, quia tales Planetae non mouentur a Sole per uirtutem magneticam, ut male putarunt aliqui, nam et hoc modo assignarent causam motus rapti, non assignabant causam accessus et recessus.

Probatur quarto quia Astra non mouentur a propria forma, ut plures tenuere: et firmo hoc primo quia Astra non sunt animata, sed solum res animatae ab intrinseco mouentur (definitur enim Vita ab se principium motus): ergo etc.. Dices Elementa non sunt uiuentia, et tamen mouentur ab intrisenco: ergo non bene stat nostra ratio. Respondeo concessa maiore, et data minore, cum maiore ratione quia cuilibet elementorum dedit natura [15] suum motum: et ideo ad illum acquirendum deberet etiam dare motum, et quid quidem extrinseco generandi tribuitur: at uero Astra non habent proprium motum a natura: et ideo si mouentur ab intrinseco, propriae formae tribueretur motus, ac proinde haec esset uiuens [*sic*, essent viventes]. Neque dicas. Astra tendunt ad ubicationes naturales: quia respondeo nullas Astris esse ubicationes a natura constitutas: unde si ad illas fieret motus, non naturae sed Astris tribueretur. Confirmatur secundo quia Astra ualde regulariter mouentur, et Sol modo accedit, et modo recedit a signo Tauri: sed hoc solum ab agente intellectuali fieri potest: ergo non a se ipsis mouentur Astra, sed ab Angelis [...]. [16]

Document VIII

English translation. Rodrigues on the nature, number and motion of the heavens and celestial bodies. Francisco Rodrigues, *Philosophia naturalis*, 1663, BNP, cod. 4838, 1-16

First question

On the nature of the heavens
First article
Whether the heavens are fluid or solid?

In the first place, I assume that the heavens are a kind of bodies composed of matter and form as we already saw, in *Metaphysics*, that no composite body (*corpus compositum*) is physically simple. In the second place, I consider, as we already observed in *Physics*, that the celestial and terrestrial matters are of the same species. I presume furthermore that there is no dispute concerning the Empyrean heaven. Since it is the dwelling-place of the Blessed, one should rightfully acknowledge its steadiness and solidity. Therefore, the inquiry focuses only on the two other heavens (in fact, we will discuss the three below), namely the aethereal heaven (*Caelum aethereum*) and the starry heaven (*Caelum stellatum*).

The first conclusion is that the Aethereal heaven, or the heaven of planets, is fluid. This is the general understanding of the authors, whom Francisco Soares Lusitanus quotes and follows [*Cursus philosophicus*], On the Heaven, Disputatio 1, number 16. This conclusion is firstly proven by means of different experiments. It was often observed that the comets penetrate the heavens and lift above the Sun up to the fixed stars. Then, it was seen that Mars sometimes came down towards us while Venus and Mercury rose above the Sun. Second, it is proven because, since mountains, valleys and deep cavities exist in the Moon, if the Moon moved within a solid body, the vacuum would occur. Therefore, to fill [the space of] these cavities, it would be more appropriate for heaven to be fluid. Third, it is proven, because if the Planetary heaven were solid, the light of the stars would not easily come down to us. Do not say that it could be diaphanous, for I reply that diaphaneity is not to be find in bodies excessively thick, such as the heavens. […] [1]

The second conclusion stands that the starry heaven is solid. This is the understanding of Soares Lusitanus [*Cursus philosophicus*], number 21, and we can cite in favour of this notion all those authors who affirm that the heavens are solid. This is proven first because, in this way, we can better understand the existence of three heavens, that is to say, one fluid, another solid and the other one is the Empyrean, for if the second heaven kept the same fluidity as the first one, they would differ only in an accidental manner. Second, because, in this way, we can better understand for what reason some stars are called fixed stars for they are fixed in that solidity and, for that reason, they always keep the same distance between them, being moved, therefore, by means of one single motive agent (*motor*). If this were not the case and the second heaven were fluid, it would be necessary to accept as many motive agents as the number of celestial bodies. It is needless, nevertheless, to employ many agents in what can be produced by fewer means. Accordingly, if one single motive agent is enough, once recognised the celestial solidity, it should be argued that the second heaven is solid. The proof is because, in this way, we can better understand how the second heaven holds together the waters above it (those waters that are placed above the heavens), so that they do not flow down upon us.

Second article
Whether the celestial bodies are solid?

The first conclusion states that the Sun is a fluid body formed from a fluid and luminous matter like liquid gold, boiling and waving in motion, as Soares Lusitanus [*Cursus philosophicus*], number 35, argues. This view is proven because it was thus observed by the mathematicians through the telescope, as can be found in the same Soares, number 34. The second conclusion is that the Moon, the planets, and the fixed stars are formed from a more solid and compacted matter. This notion is consistent with the same observations. They have easily proven that the fixed stars are just as golden nails fixed in the heaven as if they were wheels. […] [4]

You ask furthermore whether the heavens are corruptible. I answer affirmatively with Soares Lusitanus and the great majority of authors. This point is proven firstly by the observation of new stars (such is generally recognised to be the case of the new star devised in Cassiopeia) and comets that modern and very skilled mathematicians commissioned by Tycho [Brahe] found out to be produced anew. This conclusion is proven secondly because various changes are daily observed on the Moon and on the other planets. Similarly, some spots, which were previously unseen, are [now] seen and detected in the Sun by the mathematicians. Nevertheless, as these mathematicians declare, those spots could only be made there through a newfangled generation; therefore etc. It is confirmed by the Sacred Scripture, chiefly in *Psalm* 102: [*Initio terram fundasti; et*] *opera manuum tuarum sunt caeli Ipsi peribunt,* [*tu autem permanes*]*; et omnes sicut uestimentum ueterascent,* [*et sicut opertorium mutabis eos*]*, et mutabunt*.[32] Then, as it is exposed in the *Apocalypse, Vide Caelum nouum et terram nouam*.[33] Do not tell me that the heaven must be destroyed by miracle because I respond that it is useless to resort to miracles when the phenomena can be explained conformably to nature and, in fact, the influential authors deduced from assigned words that the heavens will be destroyed by natural means on Judgment Day. […] [5]

Third article
What is the nature of the heavens and of what matter are the starry sky, the sun and the other stars composed?

The question does not focus on the Empyrean heaven, for it will be discussed elsewhere. Therefore, about the first heaven, we claim [6] that this heaven is nothing but a very pure and limpid aura that derives from purest air and fire and contains a mixture of both the elements. This position is held by Soares Lusitanus [*Cursus philosophicus*], number 60, with others. It is proven because, as we saw above, the first heaven is fluid, and the celestial

32 "[Long ago you laid the foundation of the earth, and] the heavens are the work of your hands. They will perish, [but you endure]; they will all wear out like a garment. [You change them like clothing,] and they pass away". Translation in *The Holy Bible*.

33 "Then I saw a new heaven and a new earth". *The Holy Bible*.

bodies move in it (according to the common opinion) just like the birds in the air or the fishes in the water, therefore etc.

On the second heaven, we argue that this heaven is an elemental body made up of our four elements. This view is supported by Soares Lusitanus [*Cursus philosophicus*], number 60, and other Church Fathers. The proof is because no reason compels us to accept a peculiar component, which the adversaries call the fifth element (*quinta substantia*): therefore etc. It is proven furthermore as, according to Theodoret, this heaven is called Firmament precisely because it was made of the water that previously flew and hardened afterwards: therefore etc. This understating is confirmed, first, because that heaven will be destroyed on Judgment Day as well as their stars; it is therefore an elemental body. This theory is also confirmed because that heaven can be perceived with the eyes and felt. It is, thus, formed of elements: therefore etc. […] [7]

Second question

On the number and motion of the heavens and the celestial bodies
On the figure and magnitude of the celestial bodies
First article
On the number of the celestial bodies

We argue that there are three heavens. This notion is supported by Soares Lusitanus [*Cursus philosophicus*], number 132, master Soares [i.e. Francisco Suárez], Teles, Hurtado, Oviedo, and others. It is proven, first, by the authority of the Saint Fathers, Augustine, Ambrose, Chrysostom and the others. It is proven, second, by the use of reason because there is no need to admit either more or fewer than three heavens, that is to say: the first is the aethereal heaven (*Caelum aethereum*), where all the seven planets move, namely the Moon, Mercury, Venus, the Sun, Jupiter [and Saturn]. The second is the starry heaven (*Caelum stellatum*), and solid, where [11] the fixed stars stand. The third is the Empyrean heaven (*Caelum Empireum*) which is the dwelling-place of the Blessed. We will address this topic in more detail below. It is effectually proven, third, by the Apostle's words, *Scio hominem raptum usque ad tertium caelum*,[34] which are commonly interpreted as meaning the Empyrean heaven because there the Apostle heard the secret words that cannot be said. […] [12]

Second article
On the motion of the heavens and the figure, the number and magnitude of the stars

Concerning the movement of the heavens and the stars, we argue that the heavens and the heavenly bodies are moved by angels. This doctrine is held by Soares Lusitanus [*Cursus philosophicus*], number 190, along with almost twenty authors. It is proven, first, from Job's *sub quo curuantur qui portant Orbem*.[35] These words are perceived as referring to the angels, which sustain the celestial orbs and planets just as the Atlantes.

34 "I know a person who was caught up to the third heaven". *The Holy Bible*.

35 "They stoop that bear up the world".

It is proven, second, because those orbs are not moved directly by God, as Albert the Great thought, because God only acts through secondary causes. You declare that since the Sun stops moving upon the order of Joshua, it is said in the text that God acted following the human command: therefore, God guides the Sun directly. I answer denying the consequence because God heard the order directly and then made the angel stop the Sun. It is proven, third, especially regarding the planets, because those planets are not moved by the Sun through a magnetic influence (*virtus magnetica*), as some authors wrongly thought for, this way, they identified the cause of the daily movement of the Prime mobile (*motus raptus*) but not that of the motion of the approach and recession (*motus accessus et recessus*).

It is proven, fourth, because the celestial bodies are not moved by their internal form (*propria forma*) as several authors argued. I make this point, first, because the celestial bodies are not animate beings; however, only the animate beings are moved in an intrinsic way (*ab intrinseco*) (life is indeed defined as the principle of movement in itself); therefore etc. You declare that the elements are not living beings and yet they move by themselves (*ab intrinseco*): therefore, our argument is not well grounded. Conceded the major [premise] and granted the minor, I respond with greater reason because nature provided whatever element you pleased [15] with its own motion and for that reason in order to get it, [the celestial bodies] should also have been furnished with motion and, this way, it is considered being produced in an extrinsic way (*extrinseco*). Nevertheless, in truth, the celestial bodies do not receive their own motion from nature and, therefore, if they moved by themselves (*ab intrinseco*), the movement would be attributed to their own internal form (*propria forma*) and, hence, these would be living beings. Do not even claim that the celestial bodies tend towards their natural places because I answer you that nature assigns no such places to the celestial bodies. Accordingly, if the movement tends towards the natural places, this is due not to nature but to the celestial bodies. It is confirmed, second, because the celestial bodies are moved in an exceedingly constant way, and the Sun regularly approaches and recedes the Taurus constellation. Nevertheless, this regular motion can be produced only by an intellectual entity: therefore, the celestial bodies are moved not on their own but by the angels. […] [16]

11 The Final Boundary. The Ecclesiastic Ban on Copernicanism

By the mid-seventeenth century, while the Portuguese philosophy professors increasingly adhered to the cosmological ideas that stemmed from the Tychonic system, in Europe, some Jesuit astronomers seemed gradually less confident about the truthfulness of this planetary system. Although geocentrism remained an article of faith, they started looking at the rival Copernican model with fresh eyes.

After the condemnation of 1616, it was possible to delve into the Copernican system as long as it was considered a simple hypothesis or a tool for astronomical computation. As such, it was taught for decades in Jesuit colleges throughout Catholic Europe. As in Lisbon, Jesuit professors usually closed the exposition of Copernicus's theories by stressing its biblical caveat and physical implausibility.

Nevertheless, as the seventeenth century progressed, the 'physical' arguments became a source of more serious contention. In this context, an increasing number of Jesuit astronomers adhered to the Galilean reasoning based on the application of his proto-inertial physics and mechanics to the cosmological discussion. This was the case, for example, of Andreas Tacquet, Honoré Fabri and Charles François Milliet Dechales, mathematicians who, based on the Galilean tradition, refuted all the physical arguments traditionally evoked in favour of a motionless Earth and showed a true interest in Copernican cosmology. Accordingly, as Ivana Gambaro has convincingly demonstrated, by the late 1650s and the 1660s, a more ambiguous attitude towards the Copernican system emerged within this scholarly community. After Riccioli's attempt to prove the Earth's immobility and to justify Galileo's condemnation in his *Almagestum novum* (1651), the leading authori-

DOI 10.30687/978-886-969-661-9/011

ties of the Jesuit mathematical community tended to recognise that Copernicus's heliocentric system offered a simpler and more reliable account of the celestial phenomena.[1]

In Lisbon, this novel approach to the study of world systems was epitomised very early on by the Belgium-trained English Jesuit John Rishton, who taught mathematics at Santo Antão in the 1651-52 academic year. He was the first Jesuit mathematician at the Lisbon College to take the Copernican system seriously as a viable model. Nevertheless, unlike Riccioli, who by then had published a comprehensive analysis of the heliocentric system (*Almagestum novum*, 1651), he did not aim to give a definitive treatment of the subject. Therefore, Rishton did not enter into detail on the use of mathematical arguments in the physical debate, as some of his Jesuit confrères did. The discussion on the Copernican system arose in the context of his mathematical course.[2]

The viability of this system stemmed first from the mathematical equivalence that existed between the planetary system of Ptolemy and that of Copernicus.[3] Even though the argument was not new, it was crucial to Rishton's reasoning in favour of the plausibility of the geo-heliocentric model. The English mathematician proved his point by drawing two partially juxtaposed circumferences representing respectively the apparent motion of the Sun around the Earth and the annual motion of the Earth orbiting the Sun (**[fig. 13a]**, Document IX). These circumferences share two equal semidiameters that account for the motions around the 'eccentre' and the Earth or the Sun, according to the different models. Since these two semidiameters are not only equal but also parallel to each other, and the Sun and the Earth were supposed to move at the same pace in both planetary models, the true and apparent motions of the Sun could be transposed to the Earth.[4] Moreover, Rishton proceeded to demonstrate that the equinoxes and the solstices, as well as the precessional movement of the Firmament and the slow movement of the vernal equinox, could easily be explained by the heliocentric model. Thus, he concluded that "all the celestial phenomena can be solved by Copernicus's system".[5]

Having solved the issues related to mathematical astronomy, Rishton concentrated his efforts on the physical discussion. He aimed to refute the traditional arguments according to which Copernicus's model was physically absurd. Being closely acquainted with the plurality of arguments raised against Copernicus, he knew that one of the central issues was the Aristotelian theory of motion, which stood in deep contrast to the Earth's diurnal rotation and orbital revolution around the Sun. As Rishton recalled, the traditional astronomers argued, along with Aristotle, that the Earth could neither move with two (or more) different motions nor perform a circular and perpetual motion. Being a simple body, the Earth could have only one nat-

1 Gambaro, "Geo-heliocentric Models".

2 After introducing his students to the theory of the spheres and trigonometry, Rishton examined the fundamentals of the "elemental sphere", in which he included the discussion on the astronomical systems. Then, he continued with lectures on geometry, spherical trigonometry and its use in geography, nautics and astronomy. He also lectured on mathematical instruments, including sundials and "pantometra".

3 Curiously enough, the geo-heliocentric system of Tycho Brahe was not discussed in this point.

4 For further details, see Proposition 3 below.

5 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 140*v*.

ural movement. Furthermore, the terrestrial elements consisted of earth and water and, therefore, were supposed to move in straight lines towards the centre of the universe.

Rishton stood up to both these Aristotelian criticisms. As regards natural motion, he refuted the principle according to which a simple body could not perform more than one simple motion by claiming that the motions that Copernicus assigned to the Earth were not contrary among themselves. He insisted that a sphere can move with a straight motion and, at the same time, move circularly around its centre. These movements occur on different planes, and thus they were not contrary when judged by reference to the same fixed point.[6] As far as the inability of the Earth to move in perpetual circles is concerned, the English Jesuit conceded that the Earth's motion is violent. Nevertheless, he added that the straight motions of the heavy bodies towards the centre of the universe and the motions of the planets are also violent. Therefore, he claimed that "the centre is no more appropriate to the Earth than any other place".[7] Furthermore, despite being subject to a violent motion, the Earth keeps constantly moving around the Sun and its axis because the extrinsic cause that moves it always operates in accordance with the same virtue and in the same manner.[8] Thus, Rishton dissociated the notion of a violent motion from the idea of temporal finitude raised by Aristotelian philosophers.

In his effort to argue that the Copernican theory did not necessarily run counter to physics, the English mathematician denied some of the central tenets of the Aristotelian natural philosophy, such as the theory of motion and natural places, and more particularly the idea that heavy bodies move towards the centre of the world in straight lines because of their internal nature. Rishton explicitly refuted this idea. According to him, the motion of natural bodies was produced by external causes or by a motive soul. In his words, "no body requires [a particular] motion because there is no principle in the matter inclining it to motion: therefore, the motion of bodies either proceeds from extrinsic causes or from the living soul (*alma vivente*): thus, it is not proper to the [heavy] body as such to seek the place below".[9] This is the reason why he considers the straight motion of the heavy bodies towards the centre of the world or the circular motion of heavenly bodies to be a violent and not a natural motion, as Aristotelians claimed. Rishton did not enter into the discussion of celestial dynamics. Nevertheless, taking into account the Jesuit criticism of the animate nature of celestial bodies, it is most likely that, alongside his confrères Borri and Fallon, who had previously taught mathematics in Lisbon, he endorsed the view that celestial bodies were moved by unrelenting and unvarying angels.

Moreover, from the physical point of view, Rishton considered that the Earth did not risk collapsing if it moved because the Earth was supposed-

6 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 141*r*. It is interesting to note that Clavius had already applied the same sort of argument in his dispute with the advocates of homocentric cosmologies. Clavius, *In sphaeram* (1611), 29.

7 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 141*v*.

8 Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 141*r*-141*v*.

9 Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 113*v*-114*r*: "Nenhum corpo de sua materia pede mouimento quia não se vê principio nenhum na materia que a incline a mouimento: ergo o movimento dos corpos ou procede de causas extrínsecas ou da alma viuente: ergo não he proprio do corpo ut tale buscar o lugar mais abaixo".

ly provided with a "unifying virtue" that constantly keeps together all its parts, "overcom[ing] the violence of the movement".[10] Rishton elsewhere described this "unifying virtue" as an attractive virtue that entices two bodies according to their density/rarity and distance (he gave no mathematical treatment of this correlation). As far as the heavy bodies are concerned, they were supposedly attracted to the centre of the Earth, the uppermost heavy body, the core from which this attractive virtue emanates. Rishton designated this attractive virtue "gravity" (*gravidade*). In his words:

> Gravity consists of the mutual attractive virtue of two bodies according to their density or rarity,[11] through which, if separated but within the sphere of the virtue, they would join each other – if there is no further impediment – and remain unified in the same body. This virtue is so suitable for the bodies that they cannot be separated without destruction of the nature. This notion stems from the experiments made on gravity. First, [we see that] the earth tends towards the Earth, and air to the air, because each one of these elements has a mutual attractive virtue that led them to unite with its whole and similar. This theory is also proven by the movement of the heaviest things through straight lines perpendicular to the Earth's surface. This happens because the attractive virtue occurs not only in the body that descends but is also very much found on Earth, from whose centre it spreads everywhere in straight lines like the rays of the Sun. A similar body must therefore be attracted by this attractive virtue, conforming its motion to the direction of these rays, which are perpendicular to the surface of the Earth. Accordingly, those things that we call heavy will always descend perpendicularly to the surface of the Earth.[12]

This powerful virtue that emanates from the centre of the Earth not only impedes the Earth from collapsing but also accounts for the fact that buildings would not fall if the Earth moved. They would be pushed towards the centre of the Earth in straight lines perpendicular to the Earth's surface, resisting the fast movement of the Earth around its axis. Furthermore, an extra force does not affect the buildings because the air also moves with the Earth's axial rotational movement.[13] The association of gravity with the air movement alongside the terrestrial motion also explains why an object

10 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 141*v*.

11 Literally, "which symbolise between them in the density or rarity of their parts".

12 Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 114*r*-114*v*: "A grauidade consiste na mutua vertude atractiua de 2 corpos, que simbolisam entre si na densidade, ou raridade das partes por meio da qual a virtude sendo separadas com tanto que huma parte estiver dentro da sphera da virtude da outra se leuam a unirse entre si senão ouuer empedimento e unidas se conseruem na mesma figura; esta vertude he tão própria dos corpos que se lhes não pode separar sem destruição da natureza. A qual difinição posta dasse a resão das experiencias, que se achão açerca da grauidade. Primeira quia a terra vai para a terra, e ar para o ar, quia cada hum destes tem mutua virtude atractiua para unierse com seu todo e semelhante. Dasse tambem a resão do mouimento das cousas mais graues perpendicularmente a superficie da terra por linhas rectas quia como quer que esta virtude atractiua não só se da no corpo que desse mas muito na terra donde se defunde por todas as partes a roda por linhas rectas saindo radicalmente do centro como os rayos do Sol, força he que o corpo semilhante se deixe arrabatar desta virtude atractiua, e que se conforme em seu mouimento à direcção destes rayos, os quaes são perpendiculares a superficie da terra et consequenter as cousas que chamamos graues sempre desecerão perpendicularmente para a superficie da terra". Cf. Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 142*r*.

13 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 142*r*.

that is thrown upwards always falls in the same place. It shares gravity with the Earth and moves with the air.[14]

This line of reasoning only applies, however, to inanimate bodies. Rishton made this point by using the well-known example of the flight of birds. As the English Jesuit acknowledged, those who stand against the Earth's rotational movement argue that, if the Earth moved, birds flying for a long time in the air would not be able to find their nest and would fly more easily towards the east than towards the west. Rishton contended that this would not be the case because the birds are involved in the motion of the air and thus – the reader deduces – conserve the Earth's rotational motion. Nevertheless, this air movement did not carry birds along with it. Like all beings that are provided with the capacity of self-movement, birds could move wherever they wished because air moving at the same pace as the Earth would not push them. Here, the analogy with the prototype of animate beings is clear: "moving the air with the same speed as the Earth does neither hamper nor help the movement of man. Thus, we see that a man in a ship walks as easily for or against the motion of the ship".[15]

Although Rishton never quoted Galileo in his lecture notes, the resemblance between his position and that put forward by Salviati on the second day of Galileo's *Dialogue Concerning the Two Chief World Systems* is astonishing. Rishton's reasoning reverberates in Salviati's words, according to which "what keeps that motion unaltered in the birds is the air itself through which they wander. This, following naturally the whirling of the earth, takes along the birds and everything else that is suspended in it".[16] Rishton also followed Galileo's argument about birds' self-movement ability. As Salviati argued, birds can adjust their velocity to the Earth's rotational motion by adding or subtracting simple degrees of diurnal motion.[17]

The influence of Galileo is even more consequential in Rishton's definitive argument that, "if the Earth were to move, such a move would not be felt by men".[18] Although again omitting his source of inspiration, Rishton clearly drew on the Galilean argument that motion is relative to the position of the observer against a frame of reference. Should the observer move with the Earth, with no external reference point, he could not notice the Earth's motion. As the English Jesuit expressed it:

> Let us suppose that, according to the sentence of Copernicus, the starry sky does not move, the Sun occupies the centre of the world, and the Earth moves with diurnal and annual movements. It shall be proved that the observer would not perceive such a movement because motion is detected only with reference to a fixed point. If the observer is placed not far away from the moving object or at least with respect to the objects that move slower or faster to one another […], it would be impossible to perceive their motion because the [moving] objects keep the same dis-

14 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 142*r*.

15 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 143*r*.

16 Galileo, *Dialogue Concerning the Two Chief World Systems*, 213.

17 Galileo, *Dialogue Concerning the Two Chief World Systems*, 216.

18 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 134*v*.

tance between themselves and the observer.[19]

Provided with this key notion, Rishton was in an excellent position to tackle the case of the bullets shot towards the east and the west. As the argument goes, a bullet shot in the same direction of terrestrial rotation (eastwards) was supposed to range much farther than one shot in the opposite direction (westwards). As this is not the case, the conclusion to be drawn was that the Earth does not rotate around its axis. Rishton contended this conclusion by distinguishing two different planes, one measuring the range of the shot relative to an observer placed on the Earth's surface – the 'space of Earth' – and the other relative to the 'space of the world'. If the shot is observed in a position relative to the moving Earth, the range covered by the bullets shot eastwards is the same as that covered by the bullets shot westwards (one league, in Rishton's example). Nevertheless, if the same shot was analysed by an observer placed far away from the Earth, the bullet shot towards the east would be seen moving much farther than the westward projectile. In fact, observed from a position with reference to the universe, the relative distance travelled by the bullet shot eastwards corresponds to nine leagues, comprising the absolute distance covered by the bullet (one league) plus the distance traversed by the gun following the rotational motion of the Earth (eight leagues to the east, according to Rishton). Nevertheless, in the case of the bullet shot westwards, the relative distance equals seven leagues to the east, corresponding to the absolute distance travelled by the bullet (one league to the west) minus the distance traversed by the gun (eight leagues to the east). Thus, for an observer placed on the Earth's surface, both bullets range approximately the same distance.[20]

Rishton concluded, therefore, along with Galileo,[21] that, if the Earth rotated around its axis, as Copernicus argued, an observer placed on the Earth's surface could not perceive the difference in the bullets' eastward and westward movements. From this point of view, the English Jesuit had no doubt that "the system of Copernicus is not physically impossible" (*O sisthema de Cupernico não he naturalmente impossiuel*).[22]

Nevertheless, Rishton recognised that there were a few arguments against the possibility of terrestrial movement. Among these were the reason derived from astronomy, namely the fact that astronomers observed no stellar parallax, which was an expectable phenomenon in Copernicus's hypothesis [fig. 12]. The probable lack of scale of the universe thus discouraged contemporary astronomers from advocating this hypothesis.[23]

However, the main obstacle to the adoption of Copernicanism was a theological one: "the authority of the Sacred Scripture, which in various places clearly attributes motion to the Sun and stillness and stability to the Earth", Rishton claimed, quoting the common passages from the *Bible*.[24] Further-

19 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 134*v*.

20 Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 142*v*-143*r*.

21 Galileo discussed the question of the east-west gunshot in the second day of his *Dialogue* (Galilei, *Dialogue*, 195-8). Rishton's analysis is a subsidiary of this discussion.

22 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 140*v*.

23 Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 143*v*-144*v*.

24 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 146*v*: "Probatur tertio praecipue pela authoridade da sagrada scriptura a qual sinaladamente em varios lugares atribue mouimento ao

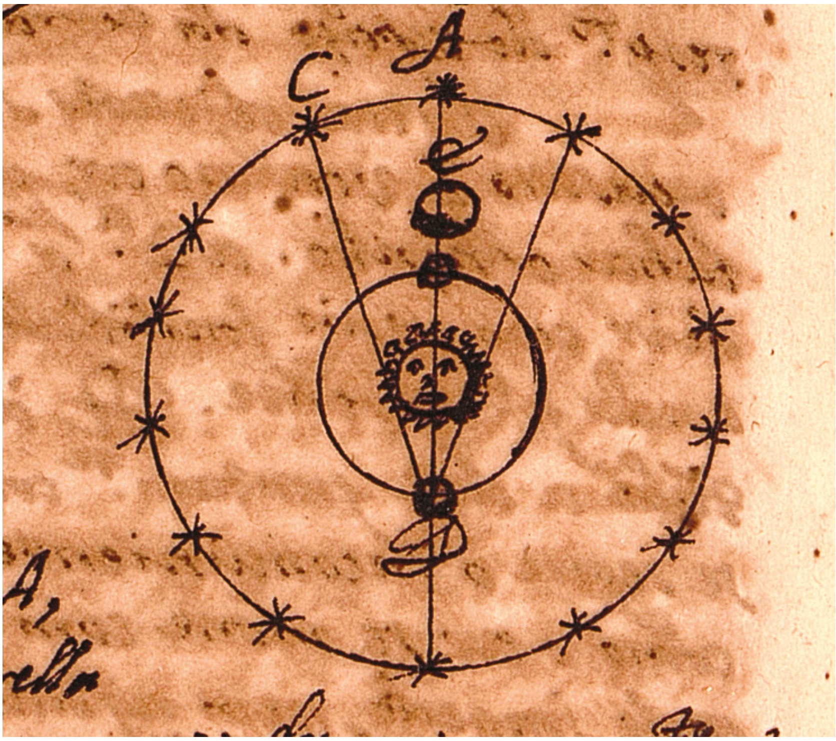

Figure 12 Rishton's demonstration of the lack of stellar parallax in Copernicus's planetary system (Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 143*v*)

more, the English Jesuit asserted that the *Bible* should be "explained literally" and according to the "unanimous consensus of Saint Fathers".[25] Finally, the professor of mathematics evoked the celebrated condemnation of Galileo by Pope Urban VIII and the inquisitorial cardinals: "it should be referred that the collegium of cardinals established by Urban VIII to examine ecclesiastical controversies has prohibited the opinion of the terrestrial movement".[26]

In the age of confessionalisation, the adoption of Copernicanism was impossible for someone restrained by the dictates of the Council of Trent, such as John Rishton. Although not based on the specific proto-inertial arguments

Sol, e quietude, ou firmeza a terra" ('It is proved in the third place, mainly by the authority of the sacred scripture, which in several places explicitly attributes movement to the Sun, and stillness, or firmness to the Earth').

25 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 147*r*: "Notesse primeiro que he regra de S. Agostinho para interpretar as sagradas scripturas, que se ande explicar literalmente se senão seguir absurdo, ou implicação do sentido literal. Notesse segundo que não he licito interpretar as sagradas scripturas contra o unanimo consensso dos Santos Padres e todos elles concordam no mouimento do Sol, e firmeza da terra" ('Firstly, one should note that, according to the rule of St. Augustine for interpreting the sacred scriptures, these are to be explained literally if no absurdity or contradiction of the literal sense follows from it. Secondly, one should note that it is not licit to interpret the sacred scriptures against the unanimous consensus of the Holy Fathers, and they all agree on the movement of the sun and the firmness of the earth').

26 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 147*r*: "Notesse terceiro que o collegio dos cardeaes, o qual tribunal foi instituido por Urbano 8 para difinir controversias ecclesiasticas proohibio a opinião do mouimento da terra".

developed by Galileo, he was aware of the critical arguments used in the *Dialogue Concerning the Two Chief World Systems* in favour of heliocentrism. Nevertheless, biblical literalism, the Patristic consensus and the ecclesiastic ban remained the last and decisive boundary preventing him, as a Catholic astronomer, from adhering to the ideas of Copernicus.

Such being the case, the geo-heliocentric system of Tycho Brahe emerged as the only solution that Rishton and the entire community of Jesuit astronomers ought to be following.[27] The Tychonic system was the achievable compromise between ancient Ptolemy and modern Copernicus:

> [Copernicus] observed that the planets, provided with their proper motions, revolved around the Sun as their centre [and], therefore, the system of Ptolemy could not be true. For the same reasons, Tycho Brahe, a renowned astronomer, tried to open his safe path between the principles of Ptolemy's ancient system and those of Copernicus's modern system. He rejected what seemed false in both systems and chose what appeared to be according to reason and the truth of celestial phenomena; he reversed both the systems and created [a new] one.[28]

Similarly to his fellow Jesuits, who taught mathematics at the College of Santo Antão before him, Rishton endorsed the geo-heliocentric system put forward by Tycho Brahe. Furthermore, he explicitly conceived it as a 'compromise' system, a system that conciliates the mathematical innovations of Copernicus's heliocentric and geokinetic views with the biblical imperatives of an immobile Earth. From this point of view, the adoption of the cosmological ideas of a Lutheran astronomer made the Copernican shift acceptable from a mathematical and physical perspective. Ecclesiastic authority remained as the last boundary.

27 It is important to note that, despite Rishton seeming to be well informed about books that had only just been published (for example, quoting from the influential *Cursus Philosophicus* by the Portuguese Jesuit philosopher Francisco Soares, published in 1651, f. 147*r*), he made no reference to Riccioli's *Almagestum novum* (Bologna, 1651).

28 Rishton, *Curso de Mathematica*, BNP, PBA. 54, f. 133*r*: "[Copérnico] obseruou que os planetas com seus mouimentos proprios rodeauão o Sol, como seu centro; portanto o sisthema de Tholomeu não pode ser verdadeiro pelas quaes resões Thico bray insigne Astronomo intentou abrir hum caminho seguro entre os principios do sisthema antigo de Tholomeu, e o moderno de Cupernico. Engeitou o que parecia falso em ambos e escolheo aquillo que parecia conforme a resão, e verdade dos phaenomenos celestes, inuertou ambos os sisthemas e fes hum só".

Document IX

Capítulo 3º
Do lugar e estabilidade da Terra. John Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 134*v*-143*v*

Proposição 1ª
Referem-se várias hipóteses ou sistemas do mundo

Proposição 2ª
Dado que a terra se mouesse o tal mouimento não se auia [de] sentir dos homens

Suponhamos que o ceu estrellado não se moue, e que o sol ocupa o centro do mundo, e a terra se mouesse com mouimento diurno, e annuo [conforme] a sentença de Cupernico. Se a de prouar que a vista não auia de perceber o tal mouimento.

Prova-se quia a vista não percebe mouimento senão por ordem a ponto fixo, e que não está mui remota do objecto mouel, ou por lo menos em respeito de alguma cousa que se moue mais tarda, ou velozmente que outra, do que resulta mais, ou menos distância entre os objectos quia assi os objectos [que] guardam a mesma distância entre si e a vista obram no olho da mesma maneira nem há por onde se possa colher mouimento e assi vemos que [f. 134*v*] os nauegantes, quando estam dentro da nao que vai andando, não podem distinguir com a vista que a nao anda cuja resão he asima dita quia todas as partes da nao se mouem com o mesmo mouimento e guardam entre si o mesmo sitio, e distância, e distão igualmente da vista: ergo não ha por onde se possa colher o mouimento local da nao: cuja resão he quia o mouimento não sendo objecto proprio da vista não se percebe imediatamente em si: ergo se todas as outras cousas ficam da mesma maneira não se percebera o mouimento mas em caso que a terra se mouesse todas as cousas auiam de guardar o mismo sitio, e a mesma distancia entre si, e o olho: ergo o tal mouimento não se auia de perceber, quod erat demonstrandum.

Proposição 3ª

Se a terra se mouesse com mouimento annuo, e o sol estiuesse quedo no centro, como no sisthema [de] Cupernico seguirsehia o mesmo mouimento apparente do Sol que no sisthema de Tholomeu

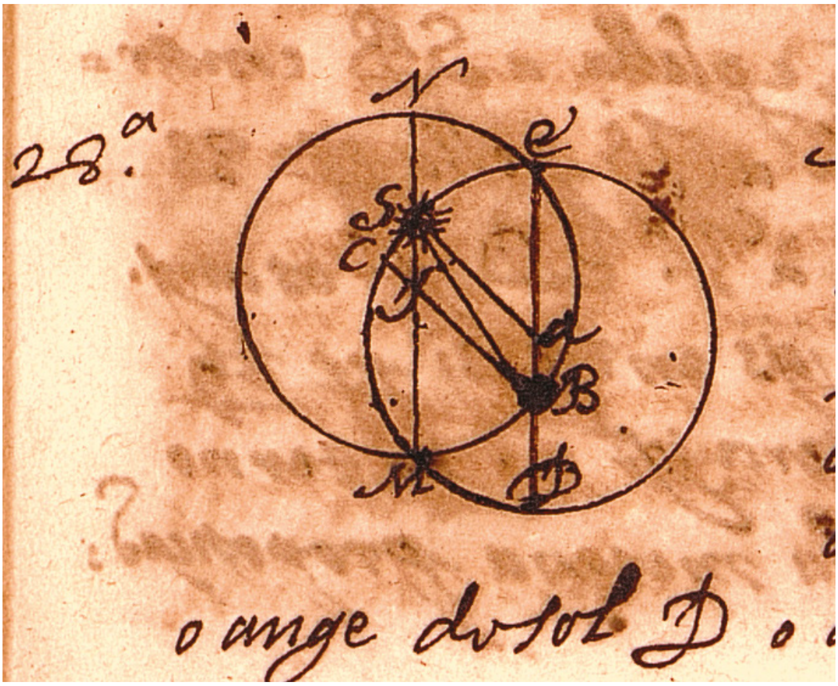

Figure 13a John Rishton's representation of the Sun annual motion according to the Ptolemaic system

Seja o orbe annuo do sol, ou linha ecliptica no sisthema de Tholomeu na figura 28a [here fig. 13] ESD cujo centro A; lugar da terra, B a linha da excentricidade BA, a qual continuada por ambas as partes athe a circunferência o ponto [E] sera o auge do sol D o antauge, ou perigeo. [f. 135*r*] Mouesse o sol de seu apogeo te o ponto S tirasse as linhas AS BS manifesto he que a linha do mouimento meio do sol sera AS, e o [angulo do] mouimento meio EAS, a linha do mouimento verdadeiro BS o qual também se chama apparente, e o angulo EBS o angulo do mouimento verdadeiro, ou apparente, e o angulo BSA a paralaxe do orbe annuo, ou distância entre o mouimento meio e o apparente do Sol, agora do centro da terra B tiresse a linha BC paralela a AS e em BC tomesse a linha BJ igual a linha AS do ponto J ao interuallo JB descreuesse o circolo NBM, o qual sera igual ao circulo ESB [*sic*, ESD] difere do circulo por serem os semidiametros iguais, paralela construção e lançada do ponto J em S huma linha a qual se continua por ambas as partes te NM, e ponhamos que o Sol esteja immouel no ponto S, e que a terra se moua no orbe annuo MBN, cujo centro J, excentricidade JS auge M, anteauge N, e mouase a terra de seu auge M te o ponto B e no mesmo tempo em que no hypotesis de Ptholomeu que o sol se mouia no seu E ate o ponto S. Digo que em ambos os casos assi o mouimento apparente, como o meyo do Sol serà apparentemente igual.

Quia a linha JB sendo igual e paralella a SB [*sic*, SA] construçcção [*sic*, consequentemente] a linha AB sera igual, e paralella a JS pella proposição 35 [*sic*, 33] do livro [I dos *Elementos* de Euclides], ergo a linha NM será paralella à linha ED, ergo os angulos alternos EBS, MSB, seram iguais entre si [pela] proposição 29 do livro e o angulo externo EAS sera igual ao externo opposto alternativamente MJB, pella mesma proposição [f. 135*v*] mas o angulo MJB he mouimento meio da terra e MSB mouimento seu apparente do lugar do sol, S e o mouimento meio do sol como està dito he o angulo EAS e o apparente visto da terra he o angulo EBS, ergo em ambas as hipotesis assi o mouimento verdadeiro como o meio he apparentemente igual.

Corollarios

Daqui se enfere tambem que em caso que o sol fosse [i]mouel, e a terra se mouesse no orbe annuo a mesma avia desser a paralaxis do orbe annuo em ambas hipotesis, quia em caso do mouimento do sol o angulo BSA he a paralaxi do orbe annuo, ou a distância entre o mouimento verdadeiro e [o] meio, em caso de mouimento da terra e quietude do sol SBJ, mas estes dois angulos são iguais por ser alternativamente oppostos e as linhas AS, JB paralellas [pela] proposição 29 do livro, ergo a mesma auia de ser a paralaxi do orbe annuo em ambas as hipotesis.

Inferesse tambem que a distância do sol a terra auia de ser amesma em ambos os casos, poes a mesma linha SB he a distância do sol em ambos os casos, ergo etc.

Inferesse [em] terceiro [lugar] que a excentricidade do orbe annuo seria a mesma quia AB [é] igual a linha SJ na mesma figura 28a.

Quarto quia a mesma equação do tempo auia de ser em ambas as hipotesis ASB igual ao angulo SBA [*sic*, SBC].

[Por] ultimo se infere que a mesma opposição, e conjunção dos planetas auia de acontecer porquanto estes dependem do mouimento annuo do sol, e dos planetas, e como quer que [f. 136*r*] o mouimento apparente do sol he o mesmo, e o mouimento dos planetas não se muda, seguesse que o mesmo auia de ser nas conjuncões, e opposições, e os demais aspectos dos planetas com o sol.

Proposição 4ª
Do mouimento annuo do sol no sisthema de Cupernico se segue o mouimento diurno [ff. 136*v*-137*v*]

Proposição 5ª
Explicansse os equinocios, e os solsticios na hipotesis do mouimento da terra [ff. 137*v*-139*r*]

Proposição 6ª
Explicasse como se saluão os outros mouimentos na mesma hipotesi [ff. 139*r*-140*v*]

Proposição 7ª
O Sisthema de Cupernico não he naturalmente impossiuel

Primeiro quia não importa cousa que contem em si implicação ou absurdo contra as Leis da natureza: ergo não he impossiuel. [f. 140*v*] Oppones primo he impossiuel que o mesmo corpo se moua com dois mouimentos diverços mas na dita hipotesis a terra mouesse com dois, e mais mouimentos diverços: ergo a dita hipotesis he impossiuel. Consequentia patet minor consta ex dictis. Probatur maior, quia se hum corpo se mouesse com diverços mouimentos sequeretur que o mesmo corpo natural podia estar em dois lugares diverços: siquidem diversus motus diversum consequentur ubi: ergo por dois mouimentos diuersos alcançaria dous ubis diuersos. Repondeo negando maiorem do primeiro silogismo; nem a premissa he efficas, quia ainda que seja impossiuel que o mesmo corpo se moua por dois mouimentos totalmente contrarios ou para termos [?] oppostos, contudo he certo, que hum corpo se poder mouer com varios mouimentos não sendo os otros dos taes mouimentos entre si contrarios; assi vemos que hum globo se moue em plano com mouimento recto progressiuo, e no mesmo tempo se moue com mouimento circular a roda de seu centro; os quaes mouimentos estam tam longe de encontrar hum ao outro, que se ajudam entre si; e se o globo for de matéria mais pesada de huma parte que da outra logo se notara outro mouimento de declinação, e não serà o mouimento por linha recta no plano.

Agora applicando isto a nosso propósito, Digo, que os ditos mouimentos que a dita hipotesis attribue a terra não são contrários entre si, ou para termos oppostos, e assi não se segue implicação alguma.

Oppones secundo, o mouimento sircular não pode ser natural à terra, porquanto he corpo graue: mas todo o corpo graue uai naturalmente para o centro do mundo: ergo a terra naturalmente se ade mouer com mouimento recto para o centro do mundo, e consequentemente o mouimento sircular não pode competir a terra. [f. 141*r*] Respondeo concedendo maiorem et negando minorem, quia o mouimento recto dos corpos graues para o centro do mundo he igualmente violento, como o mouimento circular ut sequitur probatum est nem a terra appetece mais o centro, que qualquer outro lugar.

Jubebis [?] pello menos o mouimento da terra sera violento: ergo não pode ser perpetuo. Respondeo primo que argumento ande soltar todos, quia este mouimento da terra nesta hipotesis não he mais violento, que os outros mouimentos dos planetas, os quaes etiam são corpos graues, como a terra. Respondeo secundo negando consequentiam nem aquelle principio em que se funda de força do argumento he verdadeiro sinão quando as cousas excentricas que obram tem virtude deffectiua, e fatigauel, mas no nosso caso a causa excentrica que assiste sempre obra eodem modo, e com a mesma virtude: ergo, não se segue que ainda que este effeito seja violento, não seja perpetuo, nem isso acontesse sò no mouimento da terra, mas também nos planetas, etc.

Arguira alguem contra esta solução, que da tal violencia se seguiria destruição da terra, quia a agitação he inimiga da união das partes. Respondeo primo que com mais resão se pode temer, que os corpos celestes se desfação, que a terra: por serem seus mouimentos mais velozes. Respondeo secundo que a virtude unitiva das partes da terra he tanta, que sem difficuldade vence a violencia do mouimento que he igualissimo. [f. 141*v*]

Oppones quarto se a terra se mouesse seguirsehia, que todos os ediffícios auião de cair. Respondeo negando sequellam verdade he que se este mouimento fora tremulo se auia de seguir este effeito, como vemos nos terremotos, mas sendo uniforme, e rigular e pezando sempre os edificios por linhas rectas para o centro não ha que timer que aja menos firmeza nos edificios, em caso de mouimento da terra, do que se senão mouesse, praecipue se dicermos que juntamente com a terra o ar vezinho tambem se leua com o mesmo mouimento.

Oppones quinto contra esta sentença, seguirsehia do mouimento da terra, que as cousas lançadas para sima não auiam de cair ponto do mesmo lugar donde se lançarão, quia estando separadas da terra a qual se moue entre tanto mui veloxmente para o oriente, a deçida do corpo graue correspondera a outro ponto da terra mais occidental. Respondeo primo que se o ar não se mouesse também por ventura teria este argumento alguma difficuldade, mas mouendosse e todas as outras cousas, que participam alguma cousa da grauidade com o mesmo mouimento da terra; força he que todas as cousas lançadas para sima caiam da mesma sorte na hipotesis do mouimento da terra, como se estiuesse firme.

Replicasse pello menos seguirsehia, que se duas balas de artelharia se desparassem huma para o oriente, outra para poente com o mesmo impeto, a bala, que se desparasse para o oriente auia de chegar mais longe, que a que se dispara para o occidente; porquanto o mouimento proprio se ajuntou com o mouimento do impulso da poluora, os quaes ajudam hum ao outro; porem na segunda o mouimento impulso da força da poluora se encontra com o mouimento [f. 142*r*] proprio, e consequenter não podem deixar de retardar hum ao outro.

Confirmasse esta objecção do mouimento de duas embarcações huma, das quaes nauega com mare, e vento em popa, e outra com vento, mas contra mare, certo he que a primeira nauegara mais depreça, que a segunda porquanto os dois impulsos do vento, e mare ambos concorrem, e hum ajuda a outro: mas no segundo caso se encontram e o mais fraco impulso impede ao mais forte.

Respondeo se este argumento proua alguma cousa seria que a terra de facto não se moue, mas não fas nada contra a possibilidade deste mouimento que defendemos. Respondeo secundo ou esta comparação dos dois mouimentos se fas em respeito do espaço do mundo, que as duas balas andam, ou em respeito do espaço da terra, se em respeito do primeiro [?] que a bala atirada para o oriente anda mais, que a bala atirada para o occidente; se em respeito do interuallo da terra, digo que ambos os mouimentos ou são iguais, ou pello menos a distância he tam pouca que senão sente. Declarasse isto mais explicando a qualidade de ambos os mouimentos, mouesse a primeira bala, que se dispara para o oriente com o impeto da poluora huma legoa v.g. no spaço de hum minuto de tempo e quia o mouimento da terra he muito mais velox no mesmo tempo se mouera perto de 8 legoas para o mesmo oriente, e quia a bala participa tambem deste mouimento mouerse ha 9 legoas para o oriente, em respeito do spaço do mundo, e huma sò em respeito da terra, quod idem est caira huma legoa distante do spaço da terra, onde se disparou, mas a bala que se disparou para o occidente com igual impeto no spaço de hum minuto se mouerà [f. 142*v*] tambem huma legoa; e porquanto o mouimento que abala participa da terra he 8 vezes mais velox, e encontrando com este, abala em respeito do espaço do mundo a de bater tanto, quanto he o mouimento impulso, e assi mouera 7 legoas do occidente para o oriente em respeito do spaço do mundo, e chegara huma legoa para o occidente em respeito do lugar, onde se disparou: De modo que os mouimentos das duas balas comparados em respeito do spaço da terra, ou he igual ou a distância he tam pouca, que senão ve. Porem em respeito do spaço do mundo ha tanta distância entre os mouimentos quanta he a soma de ambos os mouimentos em razão[?] do spaço da terra.

Quanto à confirmação [?] totum o que dis, mas dahi não se segue, que o mouimento das balas seja desigual em respeito do espaço da terra, senão do mundo.

Outras objeccões são semelhantes a esta a primeira, que o passaro que voa no ar, para buscar que comer não auia de achar o ninho. A segunda que quem anda para o oriente auia de ir com mais facilidade, e menos canceira do que o que anda para o poente. Respondeo à primeira que visto que o ar se moue que tambem a aue juntamente com o mouimento da terra, e o ar não se segue o inconueninte. A segunda Respondeo negando sequellam, quia como o ar se moue com a mesma velocidade que a terra não impede, nem ajuda o mouimento do homem, e assi vemos que quem anda em hum nauio tam facilmente anda contra o mouimento do nauio, como sim elle.

Que do mouimento a terra auia de aqueser, quia o mouimento principaliter violento est causa caloris sed este calor não se percebe: ergo a terra não se moue. Respondeo primo que este argumento não impugna a possibilidade do mouimento senão do mouimento actual. Respondeo secundo negando o asumpto se se entende de calor sensiuel, quia não vemos que o mar aquesa com o mouimento o qual etiam he violento, e aquelles corpos só aquecem com mouimento que são em potencia calidos. [f. 143*r*] O ultimo argumento contra esta sentença he, que os fructos da terra não auião de crescer se a terra se mouesse com mouimento diurno. Respondeo negando sequellam poes vemos por experiência que se huma pouca de terra se puzer em hum vaso, e se preparar [?] diuidamente e se puzer ao ar, e as influencias do ceo em algum nauio sem embargo do mouimento do nauio não he menos apta para producir flores, e outros fructos, que se semeam. [f. 143*v*]

Document IX

Chapter 3

English translation. On the Earth's place and stability. John Rishton, *Curso de Mathematica*, BNP, PBA. 54, ff. 134*v*-143*v*

Proposition 1
Various hypotheses or systems of the world

Proposition 2
If the earth were to move, men would not feel such a movement

Let us suppose that, according to the sentence of Copernicus, the starry sky does not move, the Sun occupies the centre of the world, and the Earth moves with diurnal and annual movements.

It shall be proved that the observer would not perceive such a movement because motion is detected only with reference to a fixed point. If the observer is placed not far away from the moving object or at least with respect to the objects that move slower or faster to one another [...], it would be impossible to perceive their motion because the [moving] objects keep the same distance between themselves and the observer. [f. 134*v*] Accordingly, we see that, while inside a ship that is moving, the sailors cannot perceive the motion of the ship because of the reason mentioned above, that is, all the parts of the ship are moving with the same motion, keeping the same place and distance between them. Furthermore, they are equally distant from the observer. Therefore, there is no way to perceive the ship's local movement. Thus, if the movement is not subject to the observer, it cannot be perceived. Therefore, if the Earth moved, all things [in it] would keep the same distance between themselves and the observer; therefore, its movement would not be perceived, *quod erat demonstrandum*.

Proposition 3

If the Earth moved with an annual movement, and the Sun remained stationary in the centre [of the universe], as in the system [of] Copernicus, the same apparent movement of the Sun would follow as in the system of Ptolemy

Let ESD, in figure 28a [here **fig. 13**], be the Sun's yearly orb or the ecliptic line according to the system of Ptolemy, whose centre is A; the place of the Earth, B; and the eccentricity line, BA, which continued to both parts of the circumference, the point [E] corresponds to the Sun apogee, and D the anti-apogee (*anteauge* in Portuguese) or the perigee. [f. 135*r*] If the Sun moves from its apogee to the point S and the lines AS BS are drawn, it is obvious that the line of the middle motion of the Sun will be AS, and the [angle of the] middle motion EAS; the line of the true motion, which is also called apparent, [corresponds to] BS, and the angle EBS [corresponds] to the angle of the true or apparent motion; the angle BSA is the parallax of the annual orb or the distance between the middle and apparent motions of the Sun. Now from the centre of the Earth B draw the line BC parallel to AS and in BC consider the line BJ equal to the line AS. From the point J to the semicircle

JB, draw the circle NBM, which will be equal to the circle ESB [*sic*, ESD]. It differs from this circle because the semidiameters are equal in parallel construction. From the point J in S launch a line which continues on both sides to NM, and let us assume the Sun is immovable in point S, and the Earth moves in the yearly orb MBN, whose centre is J, the eccentricity is JS, the apogee is M, the anti-apogee [or perigee] is N. Let move the Earth from its apogee M to the point B spending the same time as the Sun when it moves from E to the point S in the Ptolemaic hypothesis. I declare that the apparent and the middle motions of the Sun will be apparently equal in both cases.

Because the line JB is equal and parallel to SB [*sic*, SA], the line AB will consequently be equal and parallel to JS by the proposition 35 [*sic*, 33] of the book [I of Euclid's *Elements*]; therefore, the line NM will be parallel to the line ED and the alternate angles EBS, MSB will be equal between themselves [by] the proposition 29 of the book and the external angle EAS will be equal to the external opposite MJB, by the same proposition. [f. 135*v*] The angle MJB is the middle motion of the Earth and MSB is its apparent motion from the place of the Sun S, and the middle motion of the Sun – as already declared – is the angle EAS and the apparent motion seen from the Earth corresponds to the angle EBS angle. Therefore, in both hypotheses, both the true and the middle motions are apparently equal.

Corollaries

From here it is also emphasised, [first], that in case the Sun rested still and the Earth moved in the annual orb, the parallax of the annual orb should be the same in both hypotheses, because, in the case of the moving Sun, the angle BSA is the parallax of the annual orb or the distance between the true and the middle motions; in the case of the motion of Earth and the stillness of the Sun, the parallax corresponds to SBJ. Since these two angles are equal because they are alternatively opposite and the lines AS and JB are parallel [by] proposition 29 of the book, the parallax of the annual orb would, therefore, be the same in both hypotheses.

[Second], it would also infer that the distance from the Sun to the Earth would be the same in both cases, because the line SB corresponds to the distance from the Sun in both cases; therefore etc.

Third, the eccentricity of the yearly orb would be the same because AB equals the line SJ in the same figure 28a [here **fig. 13b**].

Fourth, because the equation of time would be the same in both hypotheses, that is ASB equal to the angle SBA [*sic*, SBC].

Finally, it follows that the same opposition and conjunction of the planets had to happen because they depend on the annual motion of the Sun and planets, and since the apparent motion of the Sun is the same and the motion of the planets does not change, it follows that the same conjunctions and oppositions and other aspects of the planets with the Sun had to take place.

Proposition 4
The diurnal movement follows from the yearly movement of the Sun in Copernicus's system [ff. 136*v*-137*v*]

Proposition 5
Explanation of the equinoxes and the solstices according to the hypothesis of the Earth's movement [ff. 137*v*-139*r*]

Proposition 6
Explanation of how to save the other movements according to the same hypothesis [ff. 139*r*-140*v*]

Proposition 7
The system of Copernicus is not physically impossible

First, one should not consider something that has in itself an implication or an absurdity against the laws of nature: therefore; it is not impossible. [f. 140*v*] *Oppones primo*, it is impossible for the same body to move with two distinct movements, but in the above-mentioned hypothesis the Earth moves with two and more distinct movements: therefore, the above-mentioned hypothesis is impossible. *Consequentia patet minor consta ex dictis. Probatur maior*, because if a body moved with different movements *sequeretur* [i.e. 'it would follow'] that the same body could be in two different places: *siquidem diversus motus diversum consequentur ubi*: therefore, by following two different motions, it would reach different places (*ubis*). I answer *negando maior* of the first syllogism. The premise is not effective because even if it is impossible for the same body to move with two totally opposite movements and opposite directions, however, there is no doubt that a body can move with several movements, if those movements are not contrary to each other. So we see a globe can move in a plane with a straight progressive motion and, at the same time, move with a circular motion around its centre, movements which never collide with each other and, in fact, help each other mutually; and if the globe is made of up heavier matter in one part than in the other part, soon another motion of declination – which will not be in a straight line in the plane – will be noticed.

Now applying this [conclusion] to our purpose, I declare that the above-mentioned movements that the [Copernican] hypothesis attributes to the Earth are not contrary to each other or do not move in opposite directions. Therefore, no implication follows from it.

Oppones secundo, the circular motion cannot be natural to the Earth, because the Earth is a heavy body, and every heavy body naturally moves towards the centre of the world. Therefore, the Earth would naturally move with a straight motion towards the centre of the world. Consequently, the circular motion cannot be attributed to the Earth. [f. 141*r*] *Respondeo concedendo maiorem et negando minorem*, because the straight motion of the heavy bodies towards the centre of the world is equally violent in the same manner as the circular motion, *ut sequitur probatum est*, the centre is no more appropriate to the Earth than any other place.

Jubebis [?], at least, the Earth's movement must be violent. Therefore, it cannot be perpetual. *Respondeo primo* that this reason should solve all the others because, according to this hypothesis, the Earth's motion is no more violent than the other motions of the planets, which, like the Earth, are heavy bodies. *Respondeo secundo negando consequentiam*, by claiming that the principle on which the strength of the argument is based is not true except when the extrinsic operating causes have a defective and limited virtue. But in our case, the extrinsic cause is always operating in the same way and with the same virtue. Therefore, it does not follow that even if this effect is violent it is not perpetual, nor does it happen only in the Earth's motion, but also in the planets etc.

Someone shall argue against this solution that it would follow, from such a violent motion, the destruction of the Earth because the physical movement is the enemy of the unification of the parts. I argue first that more reasonably should one fear the collapse of the heavenly bodies than the Earth, for they move much faster. I argue second that the unifying virtue of the parts of the Earth is so great that without difficulty it overcomes the violence of the movement, which is always the same. [f. 141*v*]

Oppones quarto that if the Earth were to move, all the buildings would fall. *Respondeo negando sequellam*, this effect would indeed follow if this motion were tremulous, as we see in earthquakes, but being uniform, regular, and always pushing the buildings to the centre by straight lines, there is no reason to fear that buildings are less resistant in case the Earth moves than if it stands still, especially if we consider that the air also moves with the same motion along with the Earth.

Oppones quinto against this sentence that it would follow from the movement of the Earth that the things thrown upwards would not fall in the same place from where they were previously thrown up, because being separated from the Earth, which is moving very fast towards the east, they would drop in a more occidental point of the Earth. *Respondeo primo* that this argument would be right if the air did not move, but since it moves along with all the things that partially share the gravity with the motion of the Earth, the objects thrown upwards will necessarily fall in the same way regardless of the movement or the steadiness of the Earth.

Some would at least contend that if two artillery bullets were fired, one to the east and the other to the west, with the same momentum, the bullet fired to the east would reach farther than the one fired to the west. This would happen because the momentum generated by the gunpowder's impetus was joined to the proper momentum, collaborating with each other. Nevertheless, in the second case, the momentum generated by the gunpowder's impetus faces the proper motion [f. 142*r*] and *consequenter* they can only delay each other.

This objection is corroborated by the movement of two ships, one of which goes with the flow and the wind behind, and the other with the wind behind, but against the flow. There is no doubt that the first ship will sail faster than the second one because, in this case, both the impulses of the wind and the flow concur, and one helps the other, while, in the second case, both impulses collide and the weaker one slows the stronger.

Respondeo, if this argument proves anything, it would be that the Earth in fact does not move, but it does not stand against the possibility of this movement that we defend. *Respondeo secundo* that either this comparison of the two movements is made with respect to the space of the world, in which the two bullets move, or with respect to the space of the Earth. If it is made with respect to the former, the bullet shot to the east moves farther than the bullet shot to the west; if it is made with respect to the Earth's space, I declare that both movements are equal, or at least the difference in distance is so small that no one could perceive it. Further explanation of the quality of both the movements is required to prove this point. The first bullet, which is shot towards the east with the gunpowder's impetus, moves one league, e.g. in the space of one minute. Nevertheless, since the movement of the Earth is much faster, moving in the same time close to eight leagues to the east, and the bullet takes part of this movement, the bullet shot towards the east moves nine leagues to the east with respect to the space of the world but only one with respect to the Earth, *quod idem est*, it will fall one league away from the place on Earth where it was fired. Nevertheless, the bullet that was shot to the west with the same impetus will also move one league in one minute, [f. 142*v*] but, since the movement it shares with the Earth is eight times faster, when the bullet encounters the terrestrial movement, with respect to the space of the world, it would move as much as the impetus's movement. Therefore, it would move seven leagues from the west to the east with respect to the space of the world, and one league to the west with respect to the place from where it was fired. Accordingly, if we compare the movements of the two bullets with respect to the space of the Earth, they are either equal or the difference in the distance reached is so short that it is not perceptible. Nevertheless, with respect to the space of the world, there is as much distance between the two motions as the sum of both motions in relation to the space of the Earth.

As for the confirmation, [I agree with] *totum* [i.e. 'all'] you say, but it does not follow from that that the movement of the bullets is different with respect to the space of the Earth, but only with respect to the world.

There are other similar objections, [namely] that the bird that flies in the air in search of food on its way back would not find the nest. The second states that the bird that flies towards the east would go more easily and with less fatigue than the one that flies towards the west. *Respondeo* to the first argument that there is no such reason because the air is also moving together with the bird and the Earth. *Respondeo negando sequellam* to the second argument, because moving the air or at same speed as the Earth does neither hamper nor help the movement of man. Thus, we see that a man in a ship walks as easily for or against the motion of the ship.

[A further objection claims] that the movement would warm the Earth *principaliter* because the local movement *est causa caloris sed* this heat is not perceptible: ergo the Earth does not move. *Respondeo primo* that this argument does not object to the possibility of motion but only to the actual movement. *Respondeo secundo*, denying the subject if the topic of discussion is the sensible heat. We do not see the sea warming because of the motion, which is violent. Only the potentially hot bodies warmed because of the movement. [f. 143*r*] The last argument against this sentence is that the earthly fruits would not grow if the Earth moved with a diurnal motion. *Respondeo sequellam*, because we see by experience that if a little portion of earth is put into a pot, is well prepared and exposed to the air and to the celestial influences within a ship, it will be no less fit to produce flowers and other fruits, which are sown regardless of the ship's movement. [f. 143*v*]

12 Concluding Remarks

In the first half of the seventeenth century, the international community of Jesuit mathematicians active at the Lisbon College of Santo Antão came to terms with the planetary system of Tycho Brahe. This geo-heliocentric rearrangement accounted for the astronomical novelties of the late sixteenth and early seventeenth centuries while simultaneously retaining the principle of a stationary Earth intact, itself a cornerstone of the traditional cosmology and, above all, of the prevailing literal understanding of the *Bible*.

However, the adherence to the Tychonic system was not without some resistance.

Initially, the mathematics teachers of the Class on the Sphere tried to reformulate Christoph Clavius's geocentric system, a planetary system inherited from the Ptolemaic tradition that made its way to Lisbon by the hand of João Delgado, a Portuguese Jesuit who studied at the celebrated mathematics academy run by Clavius at the Collegio Romano. Nevertheless, as Clavius himself recognised, the telescopic observations of 1610 and 1611 rendered the traditional Ptolemaic system untenable. Following Clavius's plea to rearrange the celestial orbs in such a way that these new phenomena might be saved, the Italian Giovanni Paolo Lembo, who came from Rome to teach in Lisbon in 1615-17, set forth a geo-heliocentric system of Capellan inspiration. This system, alternative to that of Tycho, retained intact the foundations of Clavius's Aristotelian-Ptolemaic worldview, namely the idea that the celestial region was divided into a dozen of solid orbs and made up of a purer and incorruptible matter.

DOI 10.30687/978-886-969-661-9/012

By 1620, upon the arrival of the German Johann Gall in Lisbon, the foreign astronomers who taught at the Class on the Sphere moved resolutely towards the system of Tycho Brahe. They all lectured and argued in favour of the Tychonic geo-heliocentric system. Nevertheless, there was a major caveat in this system from the viewpoint of the confessional divides of the time: it had been put forward by a Lutheran astronomer. In a context in which the Counter-Reformation was gaining momentum and in which any criticism of the Aristotelian theoretical framework was perceived as an attack on Catholicism, the integration of the 'impious' Tycho Brahe into the pantheon of Jesuit authorities emerged as rather problematic. Nevertheless, as this analysis of Tycho's integration process among the professors of the College of Santo Antão demonstrates, it did prove possible to convert Tycho into a 'Catholic' *auctoritas*.

Besides purging Tycho's Brahe's works of any Protestant overtones, the Jesuit professors in Lisbon initially strove to confine his influence to the realm of mathematics. As Gall argued, Tycho Brahe exceeded in the domain of mathematical astronomy, but cosmology did not concern him, nor did the mathematicians, but rather the philosophers. Tycho's ideas on celestial fluidity and other issues were thus not to be considered. Accordingly, Jesuit mathematicians, such as Gall, initially reinforced the traditional distinction between mathematics and natural philosophy.

From the late 1620s onwards, when Jesuit astronomers became increasingly involved in the physical discussion of the structure and composition of the cosmos, they made recourse to Tychonic ideas on topics such as celestial matter and fluidity. This was particularly the case of the Italian Cristoforo Borri, later followed by the English Ignace Stafford and John Rishton and the Irish Simon Fallon. Nevertheless, these Jesuits still explicitly avoided crediting Tycho Brahe and his correspondents with these new notions. Despite availing themselves of the cosmological ideas originated in Tycho's milieu, Santo Antão's professors strove to ascribe those cosmological views to the early Church Fathers. In doing so, they tried not only to match Aristotle in authority but also to be consistent with the Counter-Reformation guidelines. The guidelines issued by the Council of Trent recommended, among other matters, emphasising the role of the Church Fathers in the interpretation of philosophical and theological subtleties of the *Bible*. Those interpretations, together with the literalistic understanding of the *Bible* and the ecclesiastic orders, prevented the Jesuit mathematicians active in Lisbon from sincerely adhering to the heliocentric system of Copernicus, even after Rishton's demonstration that this system was plausible from the mathematical and physical points of view.

It was against this complex confessional background that the Santo Antão mathematicians adopted the geo-heliocentric system put forward by Tycho Brahe. Furthermore, they explicitly conceived it as a 'compromise system', a solution that accounted for the Galilean telescopic observations while simultaneously avoiding the biblical 'inconveniences' of Copernicanism. In doing so, they paved the way for the entrance of Tycho Brahe into the restricted selection of Jesuit authorities. Not only the mathematicians but also the Santo Antão professors of philosophy relied heavily on the Dane's notions. Nevertheless, since these Jesuits did not acknowledge the Lutheran astronomer's authorship of the cosmological ideas, they never came to grant Tycho Brahe the full status of an *auctoritas*. In an age of deep confessionalisation, philosophy *apparently* remained in the realm of Catholic orthodoxy.

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Knowledge Hegemonies in the Early Modern World

This is a book about the confessionalisation of science in the early modern period. It discusses the cosmological controversies raised by the appropriation of Tycho Brahe's astronomical theories within the Jesuit milieu, by focusing on the international community of Jesuit mathematicians who taught astronomy at the College of Santo Antão, Lisbon, between 1615 and 1652. The author argues that the cultural politics of the Counter-Reformation Church curbed the reception of Tycho Brahe in this community. Despite supporting the Tychonic geo-heliocentric system and exploring cosmological ideas produced in Tycho's Protestant milieu, the Jesuits active in Lisbon strove to confine the authority of the Lutheran astronomer to the domain of mathematics. Philosophy was expected to remain the realm of Catholic orthodoxy.

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