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

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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

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.

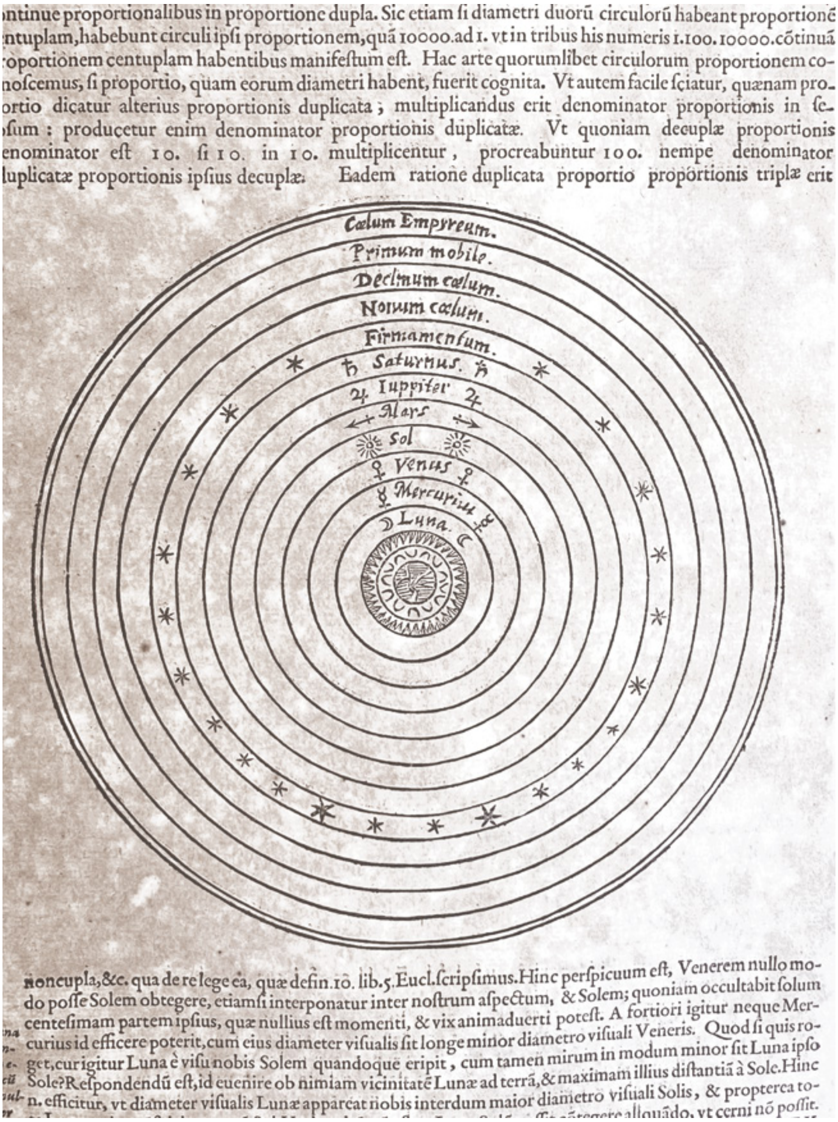
According to the last version presented by Clavius, the universe comprised thirty-three partial orbs, twenty-seven moving around the Earth plus six epicycles.[24] These partial spheres were then encompassed within twelve complete spheres, the inner and outer surfaces of which were actually con-

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.


ntinue proportionalibus in proportione dupla. Sic etiam si diametri duorũ circulorũ habeant proportionẽ ntuplam, habebunt circuli ipsi proportionem, quã 10000. ad 1. vt in tribus his numeris 1. 100. 10000. cõtinuã oportionem centuplam habentibus manifestum est. Hac arte quorumlibet circulorum proportionem conoscemus, si proportio, quam eorum diametri habent, fuerit cognita. Vt autem facile sciatur, quænam proortio dicatur alterius proportionis duplicata; multiplicandus erit denominator proportionis in seɔsum: producetur enim denominator proportionis duplicatæ. Vt quoniam decuplæ proportionis enominator est 10. si 10. in 10. multiplicentur, procreabuntur 100. nempe denominator luplicatæ proportionis ipsius decuplæ. Eadem ratione duplicata proportio proportionis triplæ erit

noncupla, &c. qua de re lege ea, quæ defin. 10. lib. 5. Eucl. scripsimus. Hinc perspicuum est, Venerem nullo modo posse Solem obtegere, etiamsi interponatur inter nostrum aspectum, & Solem; quoniam occultabit solum centesimam partem ipsius, quæ nullius est momenti, & vix animaduerti potest. A fortiori igitur neque Mercurius id efficere poterit, cum eius diameter visualis sit longe minor diametro visuali Veneris. Quod si quis roget, cur igitur Luna è visu nobis Solem quandoque eripit, cum tamen mirum in modum minor sit Luna ipso Sole? Respondendũ est, id euenire ob nimiam vicinitatẽ Lunæ ad terrã, & maximam illius distantiã à Sole. Hinc n. efficitur, vt diameter visualis Lunæ appareat nobis interdum maior diametro visuali Solis, & propterea totũ ... cõtegere aliquãdo, vt cerni nõ possit.

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*]

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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*]