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".

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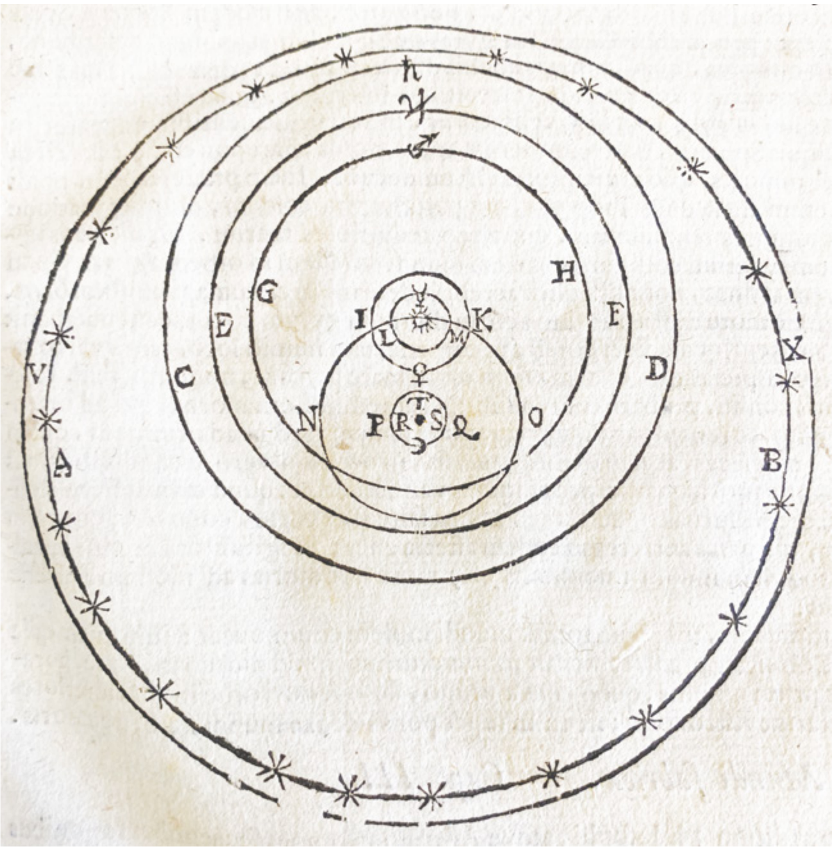

Figure 6 The Tychonic system according to Giuseppe Biancani (Biancani, *Sphaera mundi*, 1653, 56)

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

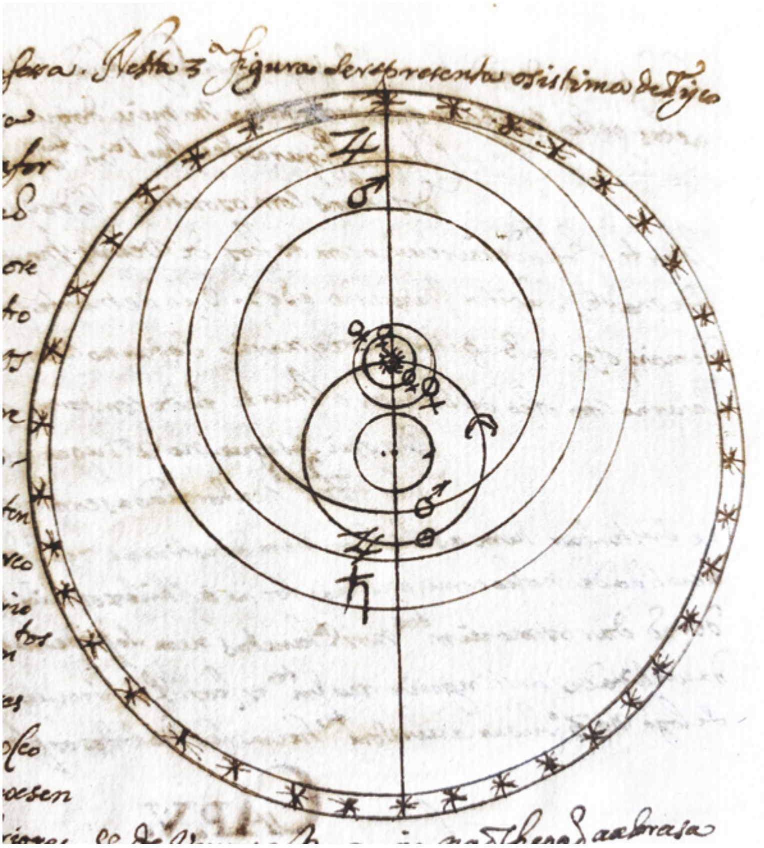

Figure 7 Tycho Brahe's planetary system according to J.C. Gall (*Tratado sobre a e*[*s*]*phera*, BNP, cod. 1869, fol. 65*r*)

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]

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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]**.

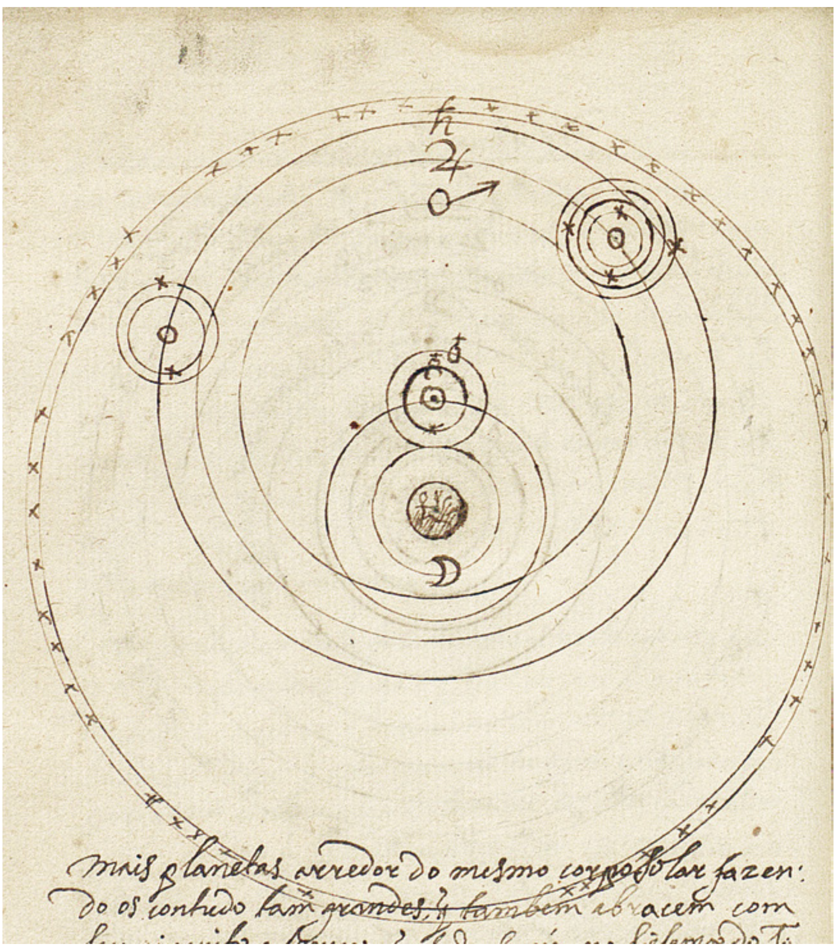

Figure 8 Tycho Brahe's planetary system depicted in J.C. Gall's lecture notes (Gall, Sphaeram, BGUC, MS. 192, f. 15*v*)

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]**.

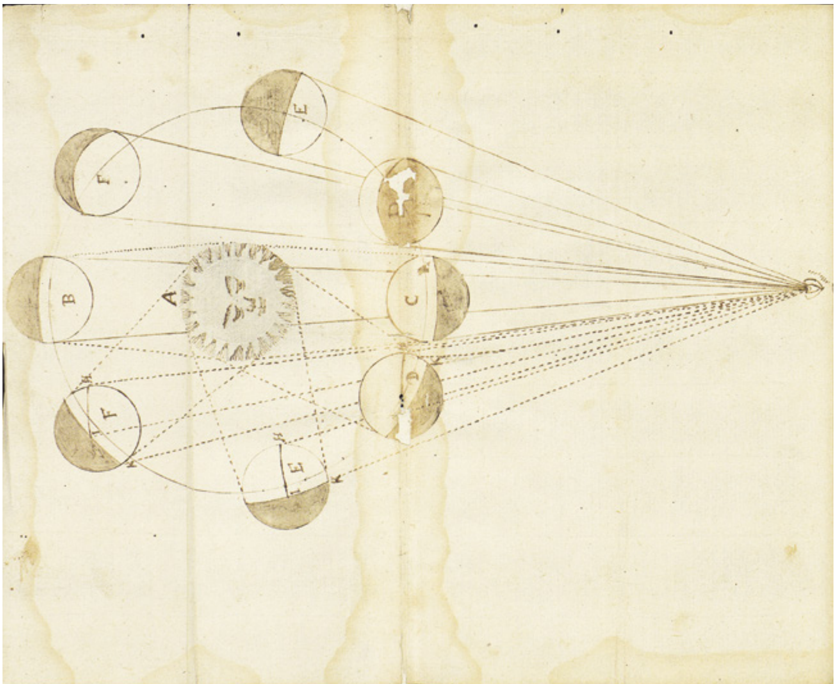

Figure 9 The phases of Venus in J.C. Gall's lecture notes (Gall, Sphaeram, BGUC, MS. 192, f. 16*v*)

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*]