Franco Giudice

GALILEO'S COSMOLOGICAL VIEW FROM THE *SIDEREUS NUNCIUS* TO *LETTERS ON SUNSPOTS*

ESTRATTO

da

GALILÆANA

STUDIES IN RENAISSANCE
AND EARLY MODERN SCIENCE

Anno XI - 2014

Leo S. Olschki Editore
Firenze

museo galileo
Istituto e Museo di Storia della Scienza

GALILÆANA

Studies in Renaissance and Early Modern Science

Anno XI - 2014

Leo S. Olschki Editore

museo galileo

Istituto
e Museo
di Storia
della Scienza

GALILÆANA

Studies in Renaissance and Early Modern Science

Anno XI - 2014

Leo S. Olschki Editore

GALILÆANA
Studies in Renaissance and Early Modern Science

As indicated by its new subtitle – *Studies in Renaissance and Early Modern Science* – the objective of *Galilaeana* is to publish studies on the life and work of Galileo, as well as research not directly pertaining to Galileo, but which nevertheless focuses on related figures and themes from the early modern period. *Galilaeana* is sponsored by the Museo Galileo and is published annually under the auspices of the University of Florence, the University of Padua, the University of Pisa, and the Domus Galilaeana.

An index of all past issues of *Galilaeana*, including the tables of contents of the articles published, lists of the accompanying source material and documentation (manuscripts and printed works, iconographic material), and links to digitalized copies of the material in this archive, may be accessed at the website of the Museo Galileo www.museogalileo.it/galilaeana.html

THOMSON REUTERS

INDEX

NOTES & GLEANINGS

OBITUARY

ESSAY REVIEWS

Galilæana, XI, 2014, pp. 49-63

Franco Giudice

GALILEO'S COSMOLOGICAL VIEW FROM THE *SIDEREUS NUNCIUS* TO *LETTERS ON SUNSPOTS**

SUMMARY

The Copernican question is a thread that runs through Galileo's entire research. This paper analyses Galileo's position towards Copernicanism in the period between the publication of the *Sidereus Nuncius* (1610) and *Letters on Sunspots* (1613). It also intends to show that one of the main reasons for Galileo's decision to give up his project of an expanded edition of the *Sidereus* was the discovery of sunspots. It was especially this new discovery that convinced Galileo of the need to write another book, one entirely devoted to the Sun in order to highlight the value of this new and extraordinary telescopic observation. *Letters on Sunspots* contains Galileo's strongest endorsement of Copernicanism, as well as his first attempt to found a new science of motion based on Copernican cosmology.

Keywords: Copernicanism, Jupiter's satellites, phases of Venus, sunspots, cosmology, principle of inertia.

Since the time of his condemnation by the Inquisition in 1633, the facts, causes, issues and implications of Galileo's trial have continued to be one of the most studied events of Western cultural and intellectual history. As a result, we are faced with countless interpretations and evaluations about the legitimacy of his condemnation, the relationship between science and

Università di Bergamo: franco.giudice@unibg.it

* An earlier version of this paper was presented to the workshop «Heavenly Imperfection: Galileo's Discovery of Sunspots» at Harvard University on 4 October 2013. I wish to thank Peter Galison, who invited me, and the participants in that workshop. Thanks also to Eileen Reeves and Nick Wilding for helpful comments and questions.

religion, and so on.[1] In comparison with the growing interest in the *Galileo Affair*, however, there are very few studies that do not consider Galileo's activities during the years 1610-1616 to be only a prelude to the events of 1632-1633.[2] But, if such an approach does not hinder the explanation of the condemnation of heliocentrism by the Church of Rome, it is doubtful that, by focusing on the final event of a battle started two decades before, this approach represents the best way to fully understand all aspects of the *Galileo Affair*. These aspects, in fact, are more comprehensible if we carefully analyse the years of Galileo's great astronomical discoveries and his commitment to Copernicanism.

The aim of my essay is to examine Galileo's position towards the Copernican system in the period between the publication of the *Sidereus Nuncius* (1610) and *Letters on Sunspots* (1613). In the final part I also intend to show that one of the main reasons for Galileo's decision to give up his project of an expanded edition of the *Sidereus* was the discovery of sunspots.

1. Galileo's Copernicanism Prior to Astronomical Discoveries

Before proceeding with this analysis, it is worth highlighting that the Copernican question is a thread that runs through Galileo's entire research. Copernicanism is one of the elements, perhaps the most crucial, of Galileo's project to establish a new science that could unify and explain both celestial and terrestrial phenomena. Therefore it is misleading to separate, as often happens,[3] Galileo's research on motion that would characterize nearly all his time spent in Padua from his astronomical studies, which coincided with the publication of the *Sidereus Nuncius*. We could of course use the succinct description by Maurice Clavelin that Galileo's Copernican-

---

[1] For a recent overview, see Massimo Bucciantini – Michele Camerota – Franco Giudice (eds.), *Il caso Galileo: Una rilettura storica, filosofica, teologica*, Firenze, Olschki, 2011; see also Maurice A. Finocchiaro, *Retrying Galileo, 1632-1992*, Berkeley and Los Angeles, University of California Press, 2005.

[2] Some exceptions are: Bucciantini, *Contro Galileo. Alle origini dell'*affaire, Firenze, Olschki, 1995; Annibale Fantoli, *Galileo: per il copernicanesimo e per la Chiesa*, Città del Vaticano, Specola Vaticana-Libreria Editrice Vaticana, 1997[2]; and Maurice Clavelin, *Galilée copernicien*, Paris, Albin Michel, 2004.

[3] See, for instance, Stillman Drake, *Galileo Studies. Personality, Tradition, and Revolution*, Ann Arbor, University of Michigan Press, 1970, p. 125; Id., *Galileo at Work: His Scientific Biography*, Chicago, University of Chicago Press, 1978, pp. 109-110; William A. Wallace, *Galileo and his Sources*, Princeton, Princeton University Press, 1984, pp. 259-260; William R. Shea, *Copernico, Galileo, Cartesio: Aspetti della rivoluzione scientifica*, Roma, Armando, 1989, pp. 160-161.

ism prior to the *Sidereus* was «silent Copernicanism»,[4] i.e. still lacking the passionate commitment to the Copernican theory which he would publicly display after his extraordinary astronomical discoveries. It is undeniable however, as various studies have shown,[5] that from the start Galileo's new concept of motion was closely connected to the new Copernican cosmology. Consequently, when Galileo in his famous letter to Kepler dated 4 August 1597[6] declared himself to be a follower of the heliocentric theory, it was not because he was just «a Copernican sympathizer», as instead Biagioli maintains.[7] In that letter Galileo described Copernicus as «our teacher» (*noster praeceptor*) and said that because of the Copernican theory he had discovered «the causes of many natural effects which are doubtless inexplicable by the current hypothesis».[8] Galileo also said that he had written «many reasons as well as refutations of arguments to the contrary».[9] As Massimo Bucciantini has shown, he was referring to the argument against the motion of the Earth proposed by Tycho Brahe in the debate with the Copernican Christoph Rothman, included in the 1596 publication of his *Epistolae astronomicae*,[10] which is a significant demonstration that Galileo considered cosmology and mechanics closely connected during his time in Padua. He was well aware that in order to replace Aristotle's theory of motion with a new concept of motion it was necessary to defend the hypothesis of motion of the Earth from accusations of absurdity.[11]

---

[4] See Clavelin, *Le copernicanisme padouan de Galilée*, in *Tribute to Galileo in Padua. International Symposium*, Trieste, LINT, 1995, pp. 149-166: 158.

[5] See Paolo Galluzzi, *Galileo contro Copernico. Il dibattito sulla prova galileiana di G.B. Riccioli contro il moto della Terra alla luce di nuovi documenti*, «Annali dell'Istituto e Museo di storia della scienza», II, 1977, pp. 87-148; Winifred L. Wisan, *Galileo's «De systemate mundi» and the New Mechanics*, in Galluzzi (ed.), *Novità celesti e crisi del sapere*, Firenze, Giunti, 1984, pp. 41-47 ; Clavelin, *Le copernicanisme padouan de Galilée* (cit. note 4).

[6] On the importance of this letter, see Bucciantini, *Galileo e Keplero: Filosofia, cosmologia e teologia nell'Età della Controriforma*, Torino, Einaudi, 2003, pp. 49-68; see also Robert S. Westman, *The Copernican Question: Prognostication, Skepticism, and Celestial Order*, Berkeley and Los Angeles, University of California Press, 2011, pp. 357-360.

[7] See Mario Biagioli, *Galileo, Courtier*, Chicago, University of Chicago Press, 1993, p. 100. Finocchiaro reaches conclusions that are analogous though not identical to Biagioli, see Finocchiaro, *Defending Copernicus and Galileo: Critical Reasoning of the Two Affairs*, Dordrecht, Springer, 2010, pp. 48-51.

[8] OG, X, pp. 67-68: «ex tali positione [i. e. from Copernicus's theory] multorum etiam naturalium effectuum causae sint a me adinventae, quae dubio procul per comunem hypothesim inexplicabiles sunt» Very likely one of these «natural effects» was that of tides, see OG, XIV, p. 85: Galileo to George Fortescue, February 1630.

[9] *Ibid*., p. 68: «multas conscripsi et rationes et argumentorum in contrarium eversiones».

[10] See Bucciantini, *Galileo e Keplero* (cit. note 6), pp. 56-62.

[11] See Maurizio Torrini, *Galileo copernicano*, «Giornale critico della filosofia italiana», LXXII (LXXIV), I, 1993, pp. 26-42: 30.

We can find more evidence for Galileo's attraction to the Copernican hypothesis in his 1604 research on the *nova*. He studied the *nova* for a number of years, from his first observations in October 1604, with the lessons he gave at Padua University in the following December, until at least 1606.[12] He thought that the phenomenon could have a decisive role in the question of *de systemate mundi*. Galileo considered that the cause of the phenomenon was due to the rectilinear motion of the *nova* and that it had its origins in the terrestrial exhalations illuminated by the Sun. In a letter dated January 1605 to an unknown correspondent, Galileo expressed his intention of writing a treatise on the subject, and indicated that as a result he expected «great consequences and conclusions» (*grandissime conseguenze et conclusioni*).[13] He did not specify what these «consequences and conclusions» would be. However, from the annotations to Brahe's *Progymnasmata* (1602), written by Galileo in the period between 1604 and 1607, we can try to imagine what he was thinking. In one of these annotations Galileo reported the opinion of astronomer Elias Camerarius, who also supported the rectilinear motion of the 1572 *nova*. Brahe had refuted Camerarius' thesis, but Galileo noted that Camerarius' opinion could be correct, provided that it acknowledged the annual motion of the Earth.[14] Confirming the cosmological value ascribed by Galileo to the appearance of the *nova* there is another annotation, where Galileo transcribed a well-known passage from Book Seven of Seneca's *Naturales Quaestiones*, in which the Stoic philosopher had highlighted how, through the examination of comets, one could infer a possible motion of the Earth around its axis.[15] For Galileo therefore the appearance of unpredicted phenomena, such as comets or *novae*, could offer important clues for determining the possibility of terrestrial motion.[16] We know that Galileo's research on the *novae* was inconclusive, but it does show his constant commitment to the Copernican question.

So if we consider that for Galileo «the opinion of the Pythagoreans and of Copernicus about the motion and location of the Earth», as he wrote to

---

[12] See Bucciantini, *Galileo e la* nova *del 1604*, in Bucciantini – Torrini (eds.), *La diffusione del copernicanesimo in Italia*, Firenze, Olschki, 1997, pp. 237-248.

[13] OG, X, p. 135.

[14] See OG, II, pp. 281-283.

[15] *Ibid*., p. 283. For an analysis of this passage, see Bucciantini, *Galileo e Keplero* (cit. note 6), pp. 134-135. See also Eileen Reeves, *Painting the Heavens: Art and Science in the Age of Galileo*, Princeton, Princeton University Press, 1997, pp. 59-60.

[16] In this context the presence among Galileo's annotations of two drawings, clearly Copernican, concerning the *nova* of 1604 (see OG, II, pp. 621-622), becomes evident, see Fantoli, *Galileo. Per il copernicanesimo e per la Chiesa* (cit. note 2), p. 95, note 13.

Jacopo Mazzoni on 30 May 1597, was «much more probable than the other one of Aristotle and Ptolemy» (OG, II, p. 198),[17] I can now move on to the question of Copernicanism in the *Sidereus* and in *Letters on Sunspots*.

2. Evidence for the Copernican System in the *Sidereus Nuncius*

It is not easy to give credence to the idea that in the *Sidereus* Galileo did not explicitly declare himself in favour of Copernicanism.[18] In fact we can say that the opposite is true, namely that in the *Sidereus* we have the first declaration, public and explicit, of Galileo's cosmological belief in favour of the Copernican system. Already in his dedicatory letter to Cosimo II de' Medici, while explaining to the Grand Duke of Tuscany the importance of the four satellites, Galileo emphasized that these

> four stars […] make their journeys and orbits with a marvellous speed around the star of Jupiter, the most noble of them all, with mutually different motions, like children of the same family, while meanwhile all together, in mutual harmony, complete their great revolutions every twelve years *about the center of the world, that is, about the Sun itself*.[19]

Then, in the first pages of the *Sidereus*, in Galileo's list of «the great things» offered in his short treatise «for inspection and contemplation by every explorer of Nature», when speaking about the discovery that «greatly exceeds all admiration», he emphasized once again that these satellites, «like Venus and Mercury, around the Sun, have their periods around a certain star notable among the number of known ones, and now precede, now follow, him, never digressing from him beyond certain limits».[20] This comparison with Venus and Mercury may seem ambiguous. In the Ptole-

---

[17] OG, II, p. 198: «la opinione de i Pitagorici e del Copernico circa il moto della terra; la quale sendo da me stata tenuta per assai più probabile dell'altra di Aristotile e Tolomeo».

[18] Biagioli, for instance, states that the *Sidereus Nuncius* is «a book in which Galileo did not commit himself explicitly to Copernicanism» (*Galileo, Courtier*, cit. note 7, p. 92).

[19] Galileo, *Sidereus Nuncius or The Sidereal Messenger* (henceforth SN), translated with introduction, conclusion, and notes by Albert Van Helden, Chicago and London, University of Chicago Press, 1989, p. 31 (italics added). OG, III.1, p. 56: «quatuor Sydera… quae quidem disparibus inter se motibus circum Iovis Stellam caeterarum nobilissimam, tanquam germana eius progenies, cursus suos orbesque conficiunt celeritate mirabili, interea dum unanimi concordia *circa mundi centrum, circa Solem nempe ipsum*, omnia simul duodecimo quoque anno magnas convolutiones absolvunt».

[20] SN, p. 36. OG, III.1, p. 60: «instar Veneris atque Mercurii circa Solem, suas habent periodos, eamque modo praeeunt, modo subsequuntur, numquam extra certos limites ab illa digredientes».

maic system, the orbits of the spheres of Mercury and of Venus, called *deferents*, rotate around the Earth, but the two planets in turn rotate at the *epicycles*, fixed to their deferents so that they rise or set always a little earlier or a little later than the Sun. In the fourth century B. C., however, Heraclides of Pontus had devised an alternative system, where Mercury and Venus moved around the Sun.[21] Consequently, Galileo's comparison is not ambiguous if we consider that he had this alternative scheme in mind. He was convinced that the satellites of Jupiter were not carried by the epicycles, but had «their proper and particular motions», as his letter to Belisario Vinta, secretary to the Grand Duke of Tuscany, dated 30 January 1610 shows:

> I have discovered four new planets, and I have observed *their proper and particular motions*, different among each other and from all the other motions of the stars; and these new planets move around another very large star, *not otherwise than Venus and Mercury, and by chance the other known planets as well, move around the Sun*.[22]

The discovery of the satellites of Jupiter also demonstrated that the motion of celestial bodies could have centres other than the Earth. One of the arguments against the Copernican theory was how there could be two centres of rotation in the universe. Galileo's response was very clear:

> We have […] an excellent and splendid argument for taking away the scruple of those who, while tolerating with equanimity the revolution of planets around the Sun in the Copernican System, are so disturbed by the attendance of one Moon around the Earth while the two together complete the annual orb around the Sun that they conclude that this constitution of the universe must be overthrown as impossible. For here we have not only one planet revolving around another while both run through a great circle around the Sun: but our vision offers us four stars wandering around Jupiter like the Moon around the Earth while all together with Jupiter traverse a great circle around the Sun in the space of 12 years.[23]

---

[21] See MICHEL-PIERRE LERNER, *Le monde des sphères*, 2 vols., Paris, Les Belles Lettres, 2008², vol. I, p. 203.

[22] OG, X, p. 280: «ho ritrovati quattro pianeti di nuovo, et osservati *li loro movimenti proprii et particolari*, differenti fra di loro et da tutti li altri movimenti dell'altre stelle; et questi nuovi pianeti si muovono intorno ad un'altra stella molto grande, *non altrimenti che si muovino Venere et Mercurio, et per avventura li altri pianeti conosciuti, intorno al sole*» (italics added). See GALILEO, *Sidereus Nuncius. Le messager céleste*, texte, traduction et notes établis par Isabelle Pantin, Paris, Les Belles Lettres, 1992, p. 57-58, note 8.

[23] SN, pp. 84-85. OG, III.1, p. 95: «Esimium praeterea praeclarumque habemus argumentum pro scrupulo ab illis demendo, qui in Systemate Copernicano conversionem Planetarum circa Solem aequo animo ferentes, adeo perturbantur ab unius Lunae circa Terram latione, inte-

According to Galileo, the discovery of Jupiter's satellites removed an important objection to the Copernican theory, as they demonstrated that our Moon could revolve around a moving Earth. It should also be noted that in the manuscript of the *Sidereus*, in a passage that was omitted in the printed book, when Galileo was referring to the «Copernican system» he added «which I consider the closest to the truth» (*quod apprime veritati consonum existimo*).[24]

The passages quoted so far are well known and are all about the conclusions that Galileo makes from the satellites of Jupiter. But there is another less known passage, or perhaps less quoted though equally important, as Galileo makes a statement that is clearly Copernican, in a context where the reference to the motion of the Earth was not necessary. It is when Galileo, in order to illustrate «more clearly» «the relationship and similarity between the Moon and Earth»,[25] explains that the Moon and the Earth illuminate each other, based on the light they receive from the Sun which they then reflect. He states:

> Let these few things said here about this matter suffice. We will say more in our *System of the world*, where with very many arguments and experiments a very strong reflection of solar light from the Earth is demonstrated to those who claim that the Earth is to be excluded from the dance of the stars, especially because she is devoid of motion and light. For *we will demonstrate that she is movable* and surpasses the Moon in brightness.[26]

---

rea dum ambo annuum orbem circa Solem absolvunt, ut hanc universi constitutionem, tanquam impossibilem, evertendam esse arbitrentur: nunc enim, nedum Planetam unum circa alium convertibilem habemus, dum ambo magnum circa Solem perlustrant orbem, verum quatuor circa Iovem, instar Lunae circa Tellurem, sensus nobis vagantes offert Stellas, dum omnes simul cum Iove, 12 annorum spatio, magnum circa Solem permeat orbem».

[24] OG, III.1, p. 46. See CAMEROTA, *Galileo Galilei e la cultura scientifica nell'età della Controriforma*, Roma, Salerno Editrice, 2004, p. 169.

[25] SN, p. 53. OG, III.1, p. 72: «ut *cognatio* atque similitudo inter Lunam atque Tellurem clarius appareat» (italic added). Copernicus in the first book of *De revolutionibus* (see COPERNICUS, *Complete Works*, vol. 2, *On the Revolutions of Heavenly Spheres*, translated by Edward Rosen, ed by J. Dobrzyscki, Wroclaw, Polskiej Akademii Nauk, 1978, p. 22) had written: «the Moon has the closest kinship with the Earth» (*maximam Luna cum Terra 'cognationem' habet*). And Galileo, to highlight the affinity between Moon and Earth uses the same term: *cognatio*.

[26] SN, p. 57. OG, III.1, p. 65: «Atque haec pauca de hac re in praesenti loco dicta sufficient, fusius enim in nostro Systemate Mundi; ubi, complurimis et rationibus et experimentis, validissima Solaris luminis e Terra reflexio ostenditur illis, qui eam a Stellarum corea arcendam esse iactitant, ex eo potissimum quod a motu et a lumine sit vacua; vagam enim illam ac Lunam splendore superantem, non autem sordium mundanarumque fecum sentinam, esse demonstrabimus, et naturalibus quoque rationibus sexcentis confirmabimus». See GALILEO, *Sidereus Nuncius. Le messager céleste* (cit. note 22), p. 76, note 84.

Obviously, with the celestial discoveries described in the *Sidereus Nuncius* Galileo did not have unquestionable proof of the truth of the heliocentric system.[27] He was nonetheless convinced that his discoveries, especially the satellites of Jupiter, were crucial elements in support of the validity of the Copernican system. His discoveries were also dismantling the traditional belief that there was an ontological difference between celestial bodies such as the Moon and terrestrial ones. The existence of mountains on the Moon demonstrated that there was no such difference, as the Moon was made of the same matter as the Earth. So it is not surprising that Galileo would announce in the *Sidereus* his intention of writing his own «system of the world»,[28] where he would provide an overall view to explain the truth of Copernicanism.

The Copernican implications of the *Sidereus* were immediately evident to his contemporaries, and not only to those who shared Galileo's Copernican beliefs, such as Kepler or his pupil Benedetto Castelli. We have the important testimony of a person who has been largely forgotten in Galilean historiography, but who was quite well known at the time – the high prelate Bonifacio Vannozzi from Pistoia, apostolic proto-notary and future secretary to Pope Paul V, and who attended the court of Cosimo II.[29] Between August and September 1610 Vannozzi wrote from Florence to a fellow citizen, magistrate and scholar Gerolamo Baldinotti:

> Regarding Galileo I am of one mind with you, and any good theologian will laugh at those who maintain that the Earth really moves, *since it can never be moved* [*non inclinabitur in speculum*] and that the Sun stands still, since it moves by itself [*motu suo agit*]. Such things have been said on other occasions as hypothesis, not as truth. To say that the Moon is earthlike, with valleys and hills, is as if to say that there are flocks that graze there and cowherds who cultivate it. We must stand by the Church, which is the enemy of anything new, according to the teachings of St. Paul. These are thoughts from brilliant minds, but they are dangerous, and I prefer to be a theosophist rather than a philosopher, as you too seem to be.[30]

---

[27] The discovery of Jupiter's satellites, for example, was compatible with the Copernican system as well as with the Tychonic one. However Galileo doesn't seem to have considered the solution by Brahe, since Galileo envisioned it always as a purely mathematical compromise, with no possible physical justification; see CLAVELIN, *Galilée copernicien* (cit. note 2), p. 68.

[28] See SN, pp. 55, 57, 86; see also Galileo's letter to Belisario Vinta, 7 May 1610, OG, X, p. 351.

[29] See LUIGI GUERRINI, *Galileo e la polemica anticopernicana a Firenze*, Firenze, Edizioni Polistampa, 2009, pp. 25-26, 30-32; REEVES, *Variable Stars: A decade of historiography on the* Sidereus Nuncius, «Galilaeana», VIII, 2011, pp. 37-72: 41-42.

[30] BONIFACIO VANNOZZI, *Delle lettere miscellanee… volume terzo*, Bologna, Bartolomeo Cochi, 1617, p. 407: «Io sono con V. Sig. nel fatto del Galileo, e ogni buon teologo si riderà di

Vannozzi's position was not an isolated one, as we can see from the much better known case of the Aristotelian Ludovico Delle Colombe, who wrote a piece at the end of 1610 or early 1611 with the title of *Contro il moto della Terra* (*Against the motion of the Earth*), where he listed several biblical passages against the Copernican system. Although this work was never formally published, it is well known that the manuscript was widely circulated and that Galileo himself read it and wrote notes on it.[31] In early 1611 Francesco Sizzi published a small treatise entitled *Dianoia astronomica, optica, physica*, where, with arguments taken from the Bible, he criticized the astronomical discoveries of Galileo. Sizzi disputed the existence of Jupiter's satellites, citing the authority of the Bible about the number of existing planets.[32] But Sizzi also criticized the Copernican system.[33] He criticized «the new school of astronomers [*sc.* the Copernicans], who maintain that the Earth does not stand still but is endowed with movement, and that all the planets move around the Sun».[34] In another passage Sizzi ascribed explicitly to Galileo the thesis of the movement of the Earth: «the Earth is endowed with movement (as the author of *Sidereus Nuncius* puts it) ».[35] A sentence that shows without doubt that Sizzi had understood the Copernican implications of *Sidereus* very well.

These statements not only demonstrate that Galileo was considered a Copernican, but also that Copernicanism was thought to be opposed both to the traditional system of the world and theological principles. They are at the core of the conflict between science and religion that, a few years later, would put Galileo in opposition to the Church of Rome. By the end of

---

chi dica da vero che la Terra si muove, che *Non inclinabitur in seculum* e che il Sole stia fermo, che *motu suo agit*. Son cose dette altre volte per via di suppositione, non di verità. Che la Luna sia terrea, con valli e colline, è tanto dire che vi son degli armenti che vi pascono e de' bifolchi che la coltivano. Stiancene con la Chiesa, nemica delle novità da sfuggirsi, secondo l'ammaestramento di S. Paolo. Son pensieri da belli ingegni, ma pericolosi e io voglio essere anzi teosofo, che filosofo, come mi par che sia anco V. S.». *Theosophist*, according to Vannozzi, were Dominican preachers, who defended traditional Aristotelian system of the world, while *philosophers* were Galileo and Copernicans; on this point, see Guerrini, *Galileo e la polemica anticopernicana a Firenze* (cit. note 29), pp. 30-32. On Vannozzi in the intellectual context of Florence, see Buccianti – Camerota – Giudice, *Il telescopio di Galileo. Una storia europea*, Torino, Einaudi, 2012, pp. 201-202.

[31] See OG, III.1, pp. 251-290.

[32] On Sizzi, see Camerota, *Francesco Sizzi. Un oppositore di Galileo tra Firenze e Parigi*, in Ferdinando Abbri – Buccianti (eds.), *Toscana e Europa. Nuova scienza e filosofia tra '600 e '700*, Milano, F. Angeli, 2006, pp. 83-107.

[33] This is an important fact, which however eluded Biagioli, see his *Galileo Courtier* (cit. note 7), p. 95, note 294.

[34] See OG, III.1, pp. 217: «recens astronomorum schola, et Terram motu praeditam et immobile asserens, omnes planetas circa Solem circumduci statuit».

[35] *Ibid*. p. 227: «Terra (ut vult Siderei Nuncii auctor) motu praedita est».

1610, however, no one could doubt Galileo's adhesion to the Copernican system. Communicating to Christoph Clavius, the chief mathematician at the Collegio Romano, his discovery of the phases of Venus, Galileo wrote:

> Now, Sir, we can rest assured that Venus goes around the Sun […], doubtless the centre of the revolutions of all planets. We are certain that the planets are intrinsically dark and only shine by being illuminated by the Sun, […] and that the planetary system is surely different from what is commonly believed.[36]

The phases of Venus, similar to those of the Moon, could not correspond with Aristotelian-Ptolemaic astronomy, because their observation showed that the planet revolved around the Sun. The phenomenon was compatible not only with the Copernican system, but also with the Tychonic. But in Galileo's opinion the Tychonic system was only a mathematical compromise, with no physical justification. According to Galileo, the phenomenon was a further confirmation of the validity of Copernicanism. It is true that from the optical viewpoint, the Tychonic system was equivalent to the Copernican system, and could therefore account for the phases of Venus. However, the important thing to note is that if Brahe proposed a hybrid system in which the Earth remained at centre of the universe, this did not depend solely on optical reasons, but also on his adhesion, despite the significant innovations he introduced, to several elements of traditional cosmology – such as the ontological separation between celestial world and terrestrial world, the symmetry between the parts of the cosmos and the impossibility of diurnal motion – over considerations of a physical order. In the Tychonic system, which at eyes of Galileo was nothing more than a simple variation of Ptolemy's geocentrism, how was it possible to accept telescopic discoveries concerning the corruptibility of celestial bodies?

The discovery of the phases of Venus, together with the observation of Saturn's peculiar shape, concluded a cycle of extraordinary discoveries that Galileo started in the Fall of 1609. It was also in order to give information of these new discoveries that he had decided to publish a new edition of the *Sidereus*. He had had this idea just a week after publication of the *Sidereus*, since the 550 copies of the book, as he wrote to Belisario Vinta on 19 March 1610, had immediately been snapped up. Galileo was thinking about a new expanded edition, enhanced with new celestial observations

---

[36] OG, X, p. 500: «Hora eccoci, Signor mio, chiariti come Venere […] va intorno al Sole, centro senza dubbio delle massime rivoluzioni di tutti i pianeti; inoltre siamo certi come essi pianeti sono per sé tenebrosi et solo risplendono illustrati dal Sole […] et come questo sistema de i pianeti sta sicuramente in altra maniera di quello che si è comunemente tenuto».

and beautiful images of the entire Moon cycle, and with «many celestial images with all the stars that are truly there». The new edition would be written in vernacular and not in Latin like the first one.[37]

By June the scope of the project had increased even more. The book was going to include all the objections and doubts from his opponents, together with Galileo's answers «so that everything will be utterly irrefutable».[38] In the meantime, having made improvements to his telescope, he was hoping to have other discoveries to report. At the end of July Galileo confided in Vinta as to the amazing configuration of Saturn, and asked him not to divulge the news «until I have published it in the work I am reprinting [*sc.* the *Sidereus*]».[39] By August though, Galileo's project had become too complicated. Besides the Horky affair,[40] his friend Alessandro Sertini, who was going to manage the reprinting in Florence, informed Galileo that Francesco Sizzi was writing a treatise against his discoveries.[41] In addition, in his new work Galileo intended to answer the doubts raised by Kepler in his *Dissertatio*, which could well be used by his opponents.[42] In addition, Galileo intended to include a letter by Kepler and another piece, both against Horky. In short, as time went by, the original project was changing more and more, so much so that the expanded reprint of the *Sidereus* was turning into another book altogether, with a structure that was totally different. This resulted in Galileo gradually abandoning the project, to the point where even the constant urging by Federico Cesi, founder of the Accademia dei Lincei and sponsor of Galileo in Rome, fell on deaf ears.[43]

One of the causes that led Galileo to abandon the *Sidereus* reprinting project was undoubtedly the publication in 1611 of Kepler's *Dioptrice*. In its preface Kepler had made known both the discovery of Saturn's peculiar shape and that of the phases of Venus,[44] thus depriving the *Sidereus* reprint of that sense of novelty that such discoveries would have brought. In the meantime, in the Summer of 1611, Galileo was involved in a controversy with several Aristotelian philosophers close to Medici court about

---

[37] OG, X, p. 299: «molte immagini celesti con tutte le stelle che veramente vi sono».

[38] *Ibid*., p. 373: Galileo to Vinta, 18 June 1610: «acciò che il tutto resti indubitatissimo».

[39] *Ibid*., p. 410: «sin che nell'opera che ristamperò sia da me pubblicata».

[40] On this affair, see Bucciantini – Camerota – Giudice, *Il telescopio di Galileo* (cit. note 30), pp. 87-104.

[41] OG, X, p. 412.

[42] *Ibid*., p. 421; Galileo to Kepler, 19 August 1610.

[43] OG, XI, p. 175.

[44] See Kepler, *Dioptrice*, in *Gesammelte Werke*, W. Von Dyck – M. Caspar – F. Hammer (eds.), München, Beck, 1937-, vol. IV, pp. 343-354.

the phenomena of condensation and rarefaction of fluids.[45] So, at the request of Cosimo II, in May 1612 he published his *Discorso intorno alle cose che stanno in su l'acqua* (*Discourse on Floating Bodies*). While writing his *Discourse*, Galileo was also responding to Welser and Scheiner's queries on the discovery of sunspots. And it was especially this new discovery that convinced Galileo of the need to write another book, one entirely devoted to the Sun in order to highlight the value of this new and extraordinary telescopic observation. It is important to note, however, that in order to show his constant commitment to the astronomical discoveries, in the introduction to the *Discourse* Galileo presented his calculations of the orbital periods of Jupiter's satellites, and in the second edition of the *Discourse*, published in the Fall of 1612, he gave for the first time his explanation of sunspots.[46]

3. Copernicanism in *Letters on Sunspots*

Galileo published the book on sunspots in March 1613, in the aftermath of the controversy with Christoph Scheiner about the priority of the discovery and about the interpretation of the nature of the phenomenon.[47] The book, which became famous as *Letters on Sunspots*, had a significant title: *Istoria e dimostrazioni intorno alle macchie solari* (*History and Demonstrations concerning Sunspots and their properties*). Not only a «history» book then, or a simple reporting of phenomena as was the *Sidereus*, but also a book of «demonstrations», that is of philosophy, of necessary and conclusive reasons that have the task of explaining the true constitution of the universe, because, according to Galileo, «this constitution exists, and it exists in a way that is unique, true, real, and impossible to be otherwise».[48]

---

[45] See Galluzzi, *Tra atomi e indivisibili. La materia ambigua di Galileo*, Firenze, Olschki, 2011, pp. 29-54.

[46] See OG, IV, p. 64. See John L. Heilbron, *Galileo*, Oxford, Oxford University Press, 2010, pp. 187-188.

[47] On the controversy, see Biagioli, *Galileo's Instruments of Credit: Telescopes, Images, Secrecy*, Chicago, University of Chicago Press, 2006, pp. 135-217; for a critical discussion of Biagioli's book, see Giudice, *Only a Matter of Credit? Galileo, the Telescopic Discoveries, and the Copernican System*, «Galilaeana», IV, 2007: 391-413. See also Keith Hutchison, *'Eppur si muovono': Galileo, Sunspots, and Precession*, «Galilaeana», X, 2013, pp. 3-24; Luigi Ingaliso, *"Mater una vera, veritas una phenomeni est": la* Theorica Solis *nella* Rosa Ursina *di Christoph Scheiner*, *ibid*., pp. 25-39; Philippe Boulier, *L'inaltérabilité du ciel pose un problème théologique*, *ibid*., pp. 41-71.

[48] Galileo – Christoph Scheiner, *On Sunspots* (henceforth *On Sunspots*), translated and introduced by E. Reeves and A. Van Helden, Chicago, University of Chicago Press, 2010, p.

Galileo had no doubts: the true constitution of the universe was the Copernican one.

In his first letter already Galileo emphasized how the phases of Venus, which he had discovered «almost two years ago», «lead with absolute necessity to the conclusion – one consistent with the positions of the Pythagoreans and of Copernicus – that its revolution is about the Sun, around which, as the centre of their revolutions, all other planets run».[49] And in the third letter, Galileo stated with renewed energy that for «the most expert in the science of astronomy it was enough to have understood what Copernicus writes in his *Revolutions* to assure themselves of the revolution of Venus about the Sun and of the truth of the rest of his system».[50]

In the debate with Scheiner, Galileo argued that sunspots were clouds, similar to terrestrial clouds that form and break up constantly, generating irregular movements, and as such they were different from the satellites of Jupiter which «are true and real stars, permanent and perpetual» and «have most regular motion and fixed periods».[51] For Galileo

> the sunspots have a single great, common and orderly motion with which they travel across the body of the Sun in uniform fashion and in parallel lines. We are informed by the particular characteristics of this motion, first, that the body of the Sun is absolutely spherical, and second, that it moves of itself and about its own center, carrying the said spots with it in parallel circles, and finishing an entire cycle in about one lunar month, with a revolution similar to that of the orbs of the planets.[52]

To explain the rotation movement of the Sun about its own centre, Galileo used a physical argument:

95; OG, V, p. 102: «tal costituzione è, ed è in un modo solo, vero, reale ed impossibile ad esser altramente». See BUCCIANTINI, *Galileo e Keplero* (cit. note 6), p. 217.

[49] *On Sunspots*, p. 93; OG, V, p. 99: «con assoluta necessità conchiuderanno, conforme alle posizioni de i Pitagorici e del Copernico, il suo rivolgimento esser intorno al Sole, intorno al quale come centro delle loro revoluzioni, si aggirano tutti gli altri pianeti».

[50] *On Sunspots*, p. 261; OG, V, p. 195: «a i molto periti nella scienza astronomica bastava l'aver inteso quanto scrive il Copernico nelle sue Revoluzioni per accertarsi del rivolgimento di Venere intorno al Sole e della verità del resto del suo sistema».

[51] *On Sunspots*, p. 287; OG, V, pp. 226-227: «sono stelle vere e reali, permanenti e perpetue […] hanno i loro moti regolatissimi ed i lor periodi certi».

[52] *On Sunspots*, p. 109; OG, V, p. 117: «[le macchie solari] hanno un massimo e comune ed universal moto, col quale uniformemente ed in linee tra di loro parallele vanno discorrendo il corpo del Sole: da i particolari sintomi del qual movimento si viene in cognizione, prima, che il corpo del Sole è assolutamente sferico; secondariamente, ch'egli in sé stesso e circa il proprio centro si raggira, portando seco in cerchi paralleli le dette macchie, e finendo una intera conversione in un mese lunare circa, con rivolgimento simile a quello de gli orbi de i pianeti».

heavy bodies are indifferent to horizontal motion, to which they have neither inclination, because it is not toward the centre of the Earth, nor aversion, because it is not away from the same centre; and therefore, with all the external impediments removed, a heavy body on the spherical surface concentric to the Earth will be indifferent to rest and to movement towards any part of the horizon, and it will remain in the state in which it has been put.[53]

So, Galileo pointed out, «the Sun, a body of spherical shape, suspended and balanced around its own centre […] has neither an intrinsic aversion nor an external impediment to such a rotation».[54]

It was the first time that Galileo formulated his principle of inertia in a published work, also the example of a ship that would later become famous in the *Dialogue on the two chief world systems*:

> And thus a ship, for example, having received one single time some impetus, would move continuously through a quiet sea around our globe without ever stopping, and if one were to bring it gently to rest it would perpetually remain at rest, provided that in the first case all the extrinsic impediments could be removed, and in the secondo ne that no external mobile cause came upon it. [55]

This was not in a treatise on mechanics, but in an astronomical work. In *Letters on Sunspots,* therefore, Galileo was not only declaring publicly his explicit and definitive adhesion to the physical reality of Copernican cosmology, but he was also establishing an inseparable connection between cosmology and mechanics, introducing a natural philosophy which was different and alternative compared to the traditional one. All elements, therefore, that make *Letters on Sunspots* «the first text of *Galilean philosophy*», a work in which Galileo's «great challenge» of founding a new science of motion upon the new constitution of the universe finds «its first

---

[53] *On Sunspots*, p. 125; OG, V, p. 134: «gl'istessi gravi al movimento orizontale, al quale non hanno inclinazione, poi che ei non è verso il centro della Terra, né repugnanza, non si allontanando dal medesimo centro: e però, rimossi tutti gl'impedimenti esterni, un grave nella superficie sferica e concentrica alla Terra sarà indifferente alla quiete ed a i movimenti verso qualunque parte dell'orizonte, ed in quello stato si conserverà nel qual una volta sarà posto».

[54] *On Sunspots*, p. 125; OG, V, p. 134: «ora il Sole, corpo di figura sferica, sospeso e librato circa il proprio centro, […] non ha egli, a tal conversione, intrinseca ripugnanza né impedimento esteriore».

[55] *On Sunspots*, p. 125; OG, V, p. 134: «E così una nave, per essempio, avendo una sol volta ricevuto qualche impeto per il mar tranquillo, si moverebbe continuamente intorno al nostro globo senza cessar mai, e postavi con quiete, perpetuamente quieterebbe, se nel primo caso si potessero rimuovere tutti gl'impedimenti estrinseci, e nel secondo qualche causa motrice esterna non gli sopraggiugnesse».

and mature form of application».[56] It is not surprising therefore that at the end of 1613, just after publication of *Letters on Sunspots*, Copernicanism became an important question in the public debate, forcing Galileo to defend himself and the Copernican system not only from philosophical and astronomical criticism, but also from those that called into question the theological plausibility of Copernicanism.

[56] Cfr. Bucciantini, *Galileo e Keplero* (cit. note 6), pp. 217, 222.

FINITO DI STAMPARE
PER CONTO DI LEO S. OLSCHKI EDITORE
PRESSO ABC TIPOGRAFIA • SESTO FIORENTINO (FI)
NEL MESE DI OTTOBRE 2014

ISSN 1971-6052