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On the Threshold of Galilean Science: Domingo de Soto and Tommaso Campanella

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Abstract

In this paper we investigate some aspects of the philosophy and epistemology of two authors of the Early Modern Age, Domingo de Soto and Tommaso Campanella, both Dominicans, who can be placed between the beginning and the middle phase of the "Scientific Revolution". In particular, on the one hand we analyze how Soto deals with the notion of "cause" and with the *demonstratio circularis*, a type of demonstration that also affected Galileo's method. On the other hand, we examine Campanella's conception of science and its based-on-experience elements (or the *historia*) for seeking some points of contact or contrast with the nascent Galilean science.

Keywords: Domingo de Soto, Tommaso Campanella, Galileo Galilei, science, demonstration, experience

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1 INTRODUCTION

In this paper we investigate some aspects of the epistemology of two Authors, both Dominicans, which rank significantly between the beginning and the middle phase of the "Scientific Revolution" of the Modern Age.

Domingo de Soto (1494–1560), co-founder with Francisco de Vitoria of the "Escuela de Salamanca", published in 1543 — the same year in which Copernicus printed *De Revolutionibus Orbium Coelestium* — his Commentaries on Aristotle's *Posterior Analytics*. His contribution to the history of science, particularly mechanics, has long been known (see Duhem 1910–1912, Koyré 1958, Clagett 1959, and especially the works and the papers of Wallace). But it is certainly interesting to detect the contribution of Soto to the birth and development of modern science, along the path of its "Christian origins" (Hodgson 2002), investigating in particular on how he dealt with the notion of "cause" and with the *demonstratio circularis*, a type of demonstration that affected even Galileo's science (see Wallace 1995, Blum 2012).

Tommaso Campanella (1568–1639) published in Paris his *Philosophia universalis* or *Metaphysica*, in 1638, in which books III, IV and V were devoted to the methodology of science, the demonstrative and the based-on-experience elements (or the *historia*). Again, it can be interesting to deepen the understanding of the science of this Author who, on the one hand, esteemed Galilean experimental approach (see Campanella 2001 and 2006), but, on the other hand, moved away from the "mathematization" of physical knowledge realized in those years not only by Galilei but also by René Descartes (1596–1650) — in fact, the publication of the *Discourse on method* is dated 1637.

The path of science at the beginning of the modern age, then, is more complex than it seems; in that the role of some Christian thinkers — and perhaps precisely because of a religious foundation of their philosophical and epistemological reflection — is relevant to a deeper understanding of modern scientific rationality (see Husserl 2000, Wallace 2001, Plantinga 2014, Habermas 2015, and Waddell 2015).

2 SCIENCE, CAUSALITY AND *DEMONSTRATIO CIRCULARIS* ACCORDING TO DOMINGO DE SOTO

For over forty years William A. Wallace analyzed the historical origin of Galilean science, identifying the "continuity thesis" an essential point of his historiographical reconstruction. He offered an answer to the questions left open by Alexandre Koyre (Koyré 1958), confirming the hypothesis of

Pierre Duhem, and identifying two links that bound the *doctores parisienses* to Galileo: Domingo de Soto and the "Collegio Romano" of the Jesuits (see Wallace 1984).

According to Wallace, Soto certainly represented the culmination of the historical line that had moved from William of Heytesbury and the "Mertonians" (XIVth Century) and a key feature of the so-called "Spanish connection". Therefore, Soto and his pupils constituted a common source of both the physician Giovanni Battista Benedetti (1530–1590) and the Roman Jesuits, whose lecture notes on logic and natural philosophy were the proximate source of young Galileo (Wallace 1968, 399; and Wallace 1990, 241–42).

To shed light on some elements of continuity or discontinuity in the history of science in Medieval and Modern Age, in particular, we can observe two issues that exerted some influences on Galileo's "New Sciences": the concept of causality (Di Liso 2014) and the use of the demonstrative *regressus* (Wallace 1995).

2.1 *Causality: logical and physical approaches*

On the Thomistic and Soto's view, physics is a "real science" (*scientia realis*), which studies the motion of bodies (the *ens mobile*) and demonstrates its properties (*passiones*). So, since science is — Aristotelically — a knowledge through the causes (*scire per causas*), then, causality is a key feature of the scientific explanation or demonstration.

Causal relations of various kinds are a pervasive feature of human language and theorizing about the world. In a broad and logical (or "Stoic") sense, a cause could be said to be "something which explains or produces or accounts for something else" (Sorabij 1980 and Taylor 1993). A logical type of "causation" is that in which the elements are propositions, or sentences which express propositions: the word 'because of' is a linguistic indicator of this sort of relation and "explanation" is viewed purely in terms of relations between propositions or "consequences" (Taylor 1993, 6–8).

In medieval logic, the notion of "consequence", which can be seen either as a relation between propositions or as a kind of hypothetical proposition, was the cause of a peculiar intertwining of perspectives in Soto's analysis of consequences. The research conducted by Angel d'Ors (D'Ors 1981, D'Ors 1983 and D'Ors 1986) offered a detailed and critical analysis of Soto's notion of good consequence, where he highlighted the central role of the phrase "*virtute illius*" in Soto's definition of the *bona consequentia*: "*Consequentia bona est cuius antecedens infert consequens, idest, cuius antecedens non potest* *esse verum quin virtute illius consequens sit verum.*" (Soto 1543, II, IV, 3ª n. 5, 2 quoted by D'Ors 1981, 551).

Domingo de Soto discussed the "consequences" as a kind of hypothetical proposition and as a way of knowledge (*modus sciendi*), but in both cases the discussion of the former was entwined with the discussion of the latter (D'Ors 1981, 545–51 and 764–93; see also Moody 1953, Bottin 1975 and Boh 1982). He also defined "argumentation" (*argumentum* or *argumentatio*) as a perfect speech in which, given a thing (or proposition), then another one follows (or "given one, another follows") (D'Ors 1981, 548). In this relationship between two propositions (antecedent and consequent), the medium (*medium* or *argumentum*) is what "involves" or "implies" (or "produces", or "causes") the truth of the conclusion, and the connectives (or *notae illationis*) "if", "therefore" and "because of" (*si*, *ergo*, *quia*) are the terms by which the sequence is denoted or signified (D'Ors 1981, 549).

Thanks to Angel D'Ors' studies, now we can clarify Domingo de Soto's notion of good consequence by making a contrast between this notion and both the modern notion of material condition and the modern notion of formal implication.

A good consequence is not equivalent to a logically valid conditional: the impossibility of the conjunction of its antecedent with the negation of its consequent is not a sufficient condition for a good consequence. Domingo de Soto is explicit in saying that necessarily such conjunction is impossible, by virtue of the repugnance between its antecedent and the contradictory of its consequent.

Again, the notion of repugnance is of crucial importance: the requirement of repugnance adds the cause of the required impossibility, so that the truth of one part removes the truth of the other one. This is exactly what the important phrase "*virtute illius*" conveys, and it is the grounding for a "causal" reading of the consequence relation. Every good consequence constitutes a formal implication, but not every formal implication constitutes a good consequence, since the *bona consequentia* adds a causal requirement that a formal implication does not need to meet (D'Ors 1981, 770–72, Read 1993).

In logic — as we pointed out — Soto defined the *bona consequentia* as a relation between two propositions, antecedent and consequent, so that the former cannot be true without the latter also being true "because of that" (*virtute illius*). In other terms, the truth of the antecedent is the "cause" of the truth of the consequent. In this way, Soto suggested a "syntactical" meaning of the notion of cause.

On the other hand, if we observe causality in a philosophical and medieval-scholastics closer sense, we draw different settings and meanings. In particular, the notion of efficient cause — *id quod facit* — owes its success to the Avicennian interpretation of Aristotle, who conferred on the agent cause (*causa agens*) no longer just the "natural" meaning of a starting-point initiating the movement (*principium unde incipit motus,* or rather *principium motionis*), but also and above all the "metaphysical" one belonging to *principium essendi.* In the natural world, all changes are the actualizing of what potentially exists, and that is produced by two intrinsic principles, i.e. form and matter, and by two extrinsic principles, i.e. efficient cause and final cause.

The lexical "splitting" — for Etienne Gilson: "*dédoublement*" — of the traditional meaning of "cause", that is *causa movens*, into two meanings, that is motor cause and efficient cause (*causa efficiens*), codified by Peter of Auvergne (died 1304), had already been made by Albert the Great (approx. 1200–1280), when he established in his commentary on Aristotle's *Metaphysics* not only the difference between motor cause and efficient cause, but the priority — according to the metaphysical and logical order — of the latter over the former: "*causa efficiens est ante causam moventem secundum naturae et intellectus ordinem*" (quoted by Gilson 1962, 20).

Thomas Aquinas had not shown an equally explicit interest in this same point, making indiscriminate use of the term "*causa efficiens*" to indicate both the principle of motion and that of being. Despite this, in the Thomistic *corpus* the efficient cause not only acts in such a way so as not to be included in a pure physics of causes, but it seems to prefigure a sort of "theologization" of the motor causality, considered as the first efficient creative cause (Di Liso 2014, 244–45; see also Gilson 1962, 23–31, Frede 1980, and Carraud 2002, 75–77).

Moving on to the definition and divisions of cause, even if he recognized the value of different traditions (see Frede 1980 and Boulnois 2002), Domingo de Soto approved of the Aristotelian division: the material cause is that out of which (*ex quo*) something is generated; the formal cause is the shape, form or pattern, or the *ratio* and definition (*per quid*); the efficient cause is the primary source of change or coming to rest (*a quo*); the final cause, lastly, is the purpose or end for which a thing is done (*propter quid*) (Soto 1572b, 36, II, q. 3).

Nevertheless, he defined the action of the efficient cause as an "influx" that is not self-sufficient or perfect, but rather "participatory" to the effect ("*modus agendi causae efficientis est concurrere influendo in effectum*"), whereas the Jesuit Francisco Suárez (1548–1617) — in whose teachings and writings someone emphasized Domingo de Soto's influence (see f.e. Orrego

Sánchez 2014) — insists on the primacy of the efficient cause, anticipating the *causa efficiens et totalis* of Descartes (Carraud 2002, 179) and the scientific explanation of Galileo's Science (Schnepf 2001).

In fact, investigating the real reason for the ebb and flow of the tides, Galileo aims to identify the root cause (*prima causa*) independently of those secondary or concurrent: "*una sola ha da esser la vera e primaria causa de gli effetti che son del medesimo genere*" (Galilei 2005, 498–500, "Giornata quarta"). The primary cause of the tides, says further Galileo, resides in the motion of acceleration and deceleration of the Earth. From here, we can draw a theory of causation focused on the following principles: (1) the knowledge of the effects leads to the identification of the causes; (2) there is a single cause for each effect (or effects of the same genus) and it must be distinguished from accidental causes; (3) there is a correspondence between the changes in the effects and those in the causes; (4) the rule is that, if that having placed the cause so is placed the effect, and if that is removed, also the effect is removed ("*se è vero che quella, e non altra, si debba propriamente stimar causa, la qual posta segue sempre l'effetto, e rimossa si rimuove*") (quoted by Helbing 2002, 403; see also Machamer 1978, and Di Liso 2011).

In accordance with the Thomistic intent, Soto confirmed, within the traditional system of the Aristotelian-Scholastic science (see Di Liso 2000, 252–278), the pivotal role of formal causality and the priority of final cause as the end and the aim in causation ("*primus concursus est causae finalis*") (Soto 1572, 40–42, II, q. 4).

Unlike Soto, Suárez accelerated the process that marks the "decadence" of the theory of plurality of the causes and of the primacy of the final cause and decidedly accentuates the indispensable role of the concept of "action" and of that of "dependence" on which causality is also centered for Galilei (Di Liso 2014, 254; see also Olivo 1997, 103, and Schnepf 2001, 42).

2.2 *From the* demonstratio circularis *to the demonstrative* regressus

Another significant case that we will consider now is the question of the *demonstratio circularis*, in order to evaluate the conception of Domingo de Soto and its proximity to or difference from the demonstrative *regressus* of Galileo's Science.

Within a section relating to the discussion of science and demonstration notions (Soto 1583, 292–308, In poster. I, q. 2), Soto defines "science" the knowledge of the reality (*cognoscere res in se ipsa*) through a demonstration which is based on a true cause (*syllogismus qui facit scire*). Therefore, science is not merely the acquisition of a *notitia apprehensiva*, nor a probable knowledge based on human or divine authority (*opinion* or *fides*), but it is the habit of the true, certain and evident conclusions demonstrated from their own causes ("*scientia est habitus verus, certus et evidens ex propriis rei causis genitus*") (Soto 1583, 295, In poster. I, q. 2).

According to the Aristotelian text (*Posterior Analytics* I, 13), Soto initially distinguishes two types of demonstration: the *demonstratio quia*, that is a demonstration "of the fact" (e.g. the proof that the moon is a sphere from its having phases); and the *demonstratio propter quid*, that is the demonstration "of the reasoned fact" (it uses the fact of the moon's being to provide the reason why it exhibits phases). By the union of the two types of demonstration we have a circular process (*demonstratio circularis*) from the effects ("having phases") to the cause ("being a sphere"), and then it goes back from the cause to the effect with which the reasoning has started (Wallace 1995, 77–78).

Examining the question, Soto refers to the Aristotelian example of the steam and the rain (*elevatio vaporis ex descensu pluviae* and *descensus pluviae ex elevatione vaporis*) and he notes that it necessarily does not return to the same starting point. Hence he discusses two arguments (*dubia*) to clarify this position (Soto 1583, 473–75, In poster. II, chap. 13).

The first doubt concerns the possibility of proceeding *ad infinitum* in the research of the causes of the phenomena: "*in causis tam efficientibus quam materialibus quam finalibus est devenire ad primam causam, autem in circulo non datur prima*". But, Soto replies, the cause itself (*per se*) does not imply circularity. Actually, the efficient cause of rain is the warmth of the sun; and rain cannot be the cause of solar heat. We can accept a specifically (*in specie*) not numerically (*in numero*) identity of causes. Indeed, the rain that produces the steam is not the same element produced by the previous steam; if it were be the same element, we would have a "vicious circle", that Soto absolutely refutes. In other words, the correct process suggested by Soto is the following: from the water "a" the steam "b" is generated; and from the steam "b" the water "c" is generated; and from the water "c" the steam "d" is generated; and so on. For these reasons, when we observe some physical process or phenomenon, we do not go on infinitely but we have to find a "first" cause of the process.

The second doubt concerns the Aristotelian thesis that there is no circularity in the logical and scientific demonstrations. Soto points out that the circularity is forbidden in the numerically identical causes (*in eisdem causis numero*), if "a" is proved by "b", and "b" is proved by "a"; but it is allowed when we have specifically identical causes (*in eisdem causis secundum species*), especially when premises and conclusions are convertible. In other words: through the *demonstratio quia* we find the cause from the effect, and through the *demonstratio propter quid* we demonstrate the effects by means of the cause.

Soto's discussion about this issue is really scant, so it could be helpful to recall some texts of Francisco de Toledo (1533–1596), a Soto's pupil at the University of Salamanca, and Cosme de Lerma, a seventeenth-century Dominican friar, follower of the Soto's philosophy, where the treatment of this subject contains some useful points of clarification.

The logic course of Toledo, held at the "Collegio Romano" in 1559–1560, provided the first teaching to the Roman Jesuits students. His writings, with the *Additamenta* of Ludovicus Carbone (1545–1597), constituted the first material of the so-called "Spanish Connection" that arrived to Galileo (Wallace 1984, 6–14; see also Dietz Moss and Wallace 2003, 45–57).

Toledo discusses the demonstrative regress in his *Commentaria* on the *Posterior Analytics*, chapter 3, in the first question of the first book (Toledo 1577, 162r). He takes for granted Soto's solutions about the *demonstratio circularis* — "*difficultas non est in eodem genere causae, nec in diversis generibus causarum, nec inter causam et effectum*", he says — and broadens and deepens other aspects and implications, dealing with the following doubt: whether the regress is a proof, and whether, by that proof, we can have a scientific knowledge ("*difficultas est, an talis regressus syllogisticus sit aliqua probatio, et per talem regressum probemus, et cognoscemus*").

He refers to recent scholars (*iuniores*), perhaps including some Paduan Masters, who have identified two demonstrations: a perfect demonstration (*demonstratio potissima* or *demonstratio causae et esse*), by which we can show the cause and by which we prove the existence of the effect; and a demonstration "only of the cause", but not of the existence of the effect (*demonstratio causae tantum*). Only the former, says Toledo, is not circular and provides a proof, because that demonstration returns from the cause to the effect, the existence of which was initially unknown or confused.

More precisely, according to Toledo, we have a demonstrative and not circular *regressus* when we proceed from an imperfect and particular knowledge of an effect to the knowledge of the cause; once we have found the cause, by means of intellectual speculations, we know more fully the cause; then we can return to the effect, which at this point is universally known: "*aliquando praecessit aliqua cognitio imperfecta effectus, dices, si illa cognitio effectus fuit imperfecta, et particularis, cum per eam pervenerimus in causam, etiam cognitio causam erit imperfecta, dico, non ita esse, nam illa cognitio effectus fuit via ad causam inveniendam: tamen ex ipsa causa inventa, et aliis intellectus speculationibus, perfectius cognoscimus causam, adeo ut per eam* *regrediamur ad effectum universaliter cognoscendo*" (Toledo 1577, 162v).

Unlike Toledo, Cosme de Lerma lived and published his works, the *Cursus philosophici ex doctrina sapientissimi Fr. Dominici Soto*, in the thirties and forties of the XVIIth Century, when Galilean science or the "Scientific Revolution" had been taking place. Lerma's treatment of the *demonstratio circularis*, followed a more traditional terminology, closer to Soto's texts. He distinguished one circular demonstration, that he qualifies as uniform (*uniformis*), from another one that he qualifies as not uniform (*difformis*).

The "uniformly circular demonstration" is when from a conclusion formally involved, known and made evident by premises, those same premises are demonstrated ("*ex conclusione formaliter ut illata, cognita, et manifestata ex praemissis ipsae praemissae demonstrantur*"), so that it generates a vicious circle ("*demonstrationem circularem uniformem semper esse vitiosam*").

The "not uniformly circular demonstration" is when either we conclude to one kind of cause from a different kind of cause, or when from an effect, by experiment (*experimentaliter*), we demonstrate the existence of the cause and, to the opposite, by the cause we demonstrate the effect — not only the existence of the effect, but its "why": "*per effectus experimentaliter cognitos demonstramus causam esse; et rursus per causam demonstramus effectus a priori, et non solum quod sint, sed propter quod sint*". In this case the cause absolutely taken (*secundum se*) is more known than the effect, but the effect, according to the kind of the experimental knowledge (*in genere cognitionis experimentalis*), is more known than the cause. So, from the effect to the cause and from the cause to the effect we have not a vicious circle (Lerma 1659, 1132–37, De Posterioribus Lib. 8, q. 11).

As it is well known, Wallace's studies about Galileo's logic and physics focused that the Pisan scientist had come to know the theory of the *regressus* in his early studies of motion, probably through the mathematician Christopher Clavius (1538–1612), and thank to him Galileo had obtained a copy of the lectures about the logic of Paulus Vallius (1561–1622) and Ioannes Lorinus (1559–1634). Vallius' explanation of the regress followed that of Jacopo Zabarella (1533–1589), who represented the culmination of the teaching and writing tradition of the Paduan Masters of logic and physics — from Pietro d'Abano (1257–1315) to Paul of Venice (1369?–1428), from Pietro Pomponazzi (1462–1525), Agostino Nifo (1470–1538) and Marcantonio Zimara (1475–1537) to Girolamo Balduino (fl. 1550).

As Wallace highlighted (see Wallace 1984; Wallace 1988; and Wallace 1995, 93–95), in his logical treatises Galileo used the demonstrative regress as an original synthesis of the demonstration *quia* and of the demonstration *propter quid*. Galileo refers to the two demonstration, *quia* and *propter* *quid*, as two *progressiones*. The first progression argues from the effect to the cause, and the second reverses the direction, regressing from the cause to the effect.

In the first phase the effect must be better known than the cause. Then, after the first progression, we have to reflect and wait until we formally (*formaliter*) know the cause, that we first knew only materially (*materialiter*): "*ut facto primo primo progressu, non statim incipiamus secundum, sed expectemus donec causa, quam cognoscimus materialiter, formaliter cognoscamus*" (Galilei 1588–1589, 148). This is the essential step — that was named from Toledo's "intellectual speculations" (*intellectus speculationes*), from Nifo "dealing" (*negotiatio*) and from Zabarella "work" (*labor* or *examen mentale*), by which the mind passes from knowing the cause confusedly to grasping it distinctly (Wallace 1995, 92) — introduced by Balduino to distinguish the *regressus* from the *demonstratio circularis*: "*Regressus est processus artificialis, scientificus, monstratio ad invicem effectus cum causa, converso modo cum maiore, non eodem modo demonstrationis, nec ad eandem rem quaesiti*" (Balduino 1557, 9r; see also Papuli 1967).

In other words, the *regressus* moves in the form of a triangle: from the effect's existence to the cause's existence; then from the cause's existence to the "why" (*propter quid*) of the effect's existence (Wallace 1995, 88). If the second step were to the effect's existence, rather than to the "why" of that existence, the argument would be circular. But, in the *regressus* it does not happen: "*Ex quo unum infertur, istum regressum non esse vere circulum*" (Balduino 1557, 9v).

After this second period or intermediate stage, the second progression starts and the unique cause — having been grasped formally and precisely that it is "the" cause — is shown to be connected necessarily with the effects. Only at this stage the knowledge is scientific (Wallace 1995, 95).

The historical line that links Soto to Galileo *via* Zabarella, Toledo and the "Collegio Romano" showed few mutations revealing essentially the same doctrine about the *demonstratio circularis* and *regressus*. Thus, instead of attributing Galileo's inspiration to the "secular and anti-clerical spirit" of Latin Averroism of the University of Padua (Randall 1940, 180), we can confirm that his basic inspiration came to him by way the scholastic, or broadly Thomistic and religious thought of the Dominican and Jesuits scholars (Wallace 1988, 145–46).

3 TOMMASO CAMPANELLA: SCIENCE AND EXPERIENCE (*HISTORIA*)

Tommaso Campanella knew of Domingo de Soto, and of his teacher and colleague, friar Francisco de Vitoria (1483–1546), some texts and especially the political theories concerning Emperor's titles for the conquest of the New World (Ernst 2001, 146–47: see also Vitoria 1995 and Lamacchia 1995).

Besides, he dedicated an entire work, *Apologia pro Galileo*, published in 1622 in Frankfurt, to defend the freedom of thought (*libertas philosophandi* and *libertas theologizandi*) of Galileo Galilei against the accusations and condemnations of some theologians of the Catholic Church (Campanella 2001 and Campanella 2006; see Ponzio 1998).

One of the key features of Galileo's science, according to Campanella, is the "sensible experience" (*sensata experientia*) that precisely characterizes the demonstrative and experimental process of science and that is distinguished from the common experience (*communis experientia*), by which people were used to interpret the Bible (Ponzio 2001, 145–58; Campanella 1992; see also Martínez).

The principle of "experience" was the crucial point within Campanella's epistemology. Actually, as he said in the *Philosophia rationalis*, "science" is a certain and evident understanding of a thing, that is deduced from other things. So, the "understanding of the thing" (*notitia rei*) is founded on the sensible observations and on the rational argumentations: "*Scientia est certa et evidens notitia rei, ex necessariis notisque deducta*" (quoted by Ponzio 2001, 59–60).

However, experience cannot be absolutely and universally achieved, because its phenomena are connected with a temporal and spatial context, i.e. they have a historical character. So the historical experience constitutes a limit to the completeness of knowledge: "*perfecta scientia non datur ulla*" (quoted by Ponzio 2001, 61).

Hence, we can infer a fundamental principle for the acquisition of the human science: history. In his *Metaphysics*, Campanella states that history is the basis of both the theological disciplines and of the philosophical and scientific ones, since we draw from the historical experiences the effect, or "known" (*notum* or *quod patet*), from which we proceed, by means of necessary reasons and demonstrations, towards the cause, or "unknown" (*ignotum* or *quod latet*): "*principia scientiarum sunt nobis historiae. Historiam dico etiam, quod non ab alio audivimus, sed nostris patuit oculis et sensibus: ex eo enim, quod patet historice, ad investigandum quod latet proficiscimur*" (Campanella 1967, 366, Lib. II, chap. 2, art. 2).

It is just this kind of "experimental" or "historical" investigation that allows us to observe directly (by the *sensata experientia*) or indirectly (by the *fides humana*) new facts or phenomena, like the discovery of the New World and the astronomical observation of a new star in 1572, referred by Tycho Brahe (Campanella 1967, 368–70, Lib. II, chap. 2, art. 2).

Since it was necessary — Campanella added — to collect and classify all new knowledges and experiences, and since a man alone cannot encompass the whole knowledge, mathematics were invented. Mathematics consider not the things, but some properties of bodies and presupposes what the senses know: "*Mathematica non de rebus, sed tantum de affectione quadam corporum, quae est magnitudo et numerus, quae de his sensus novit*" (Campanella, 386, Lib. V, chap. 2, art. 1). So it is an instrument to measure the things of nature or apply what is known to what is unknown, so that we can universalize the experience or history of the natural elements: "*Naturali vero ex historia elementorum, et siderum, et aquarum, et lapidum, et metallorum, et plantarum, elicit propositiones universales [. . .]. Cumque magnitudines et numerum praedictorum scire oporteret, neque sufficeret homo ad omnia scibilia, inventa est mathematica de numeris et magnitudinibus*" (Campanella 1967, 370, Lib. II, chap. 2, art.2).

Unlike Galileo, Campanella considers mathematics not as a real science but an instrumental science or a science which proceeds through signs (*ex signo*). So physicians using mathematics ignore the real order of things and can only imagine it (*fingunt*) (Campanella 1967, 372–74, Lib. II, chap. 2, art.2). In the science of nature, at the core of its investigation, there is a knowledge through the senses: we investigate things through the senses; when something exceeds our senses, then thanks to the researches and knowledges of others, and by meditations and speculations, we can seek connections of invisible causes: "*in rebus naturalibus invenitur multa quae sensum superant, licet sensu hauriantur; et connexio causae invisibilis cum visibili relucet, hoc autem omnino considerare nequit recte, nisi qui res omnes perlustravit sensu suo, et alienis et considerationes*" (Campanella 1967, 368, Lib. II, cap. 2, art.2).

Therefore, Campanella, while accepting in his physics and cosmology the value of the sensible knowledge, thus defending the experimental observations and proofs of Copernican's hypothesis provided by Galileo (see Campanella 2001, 58–63; Campanella 2006, 24–35, chap. 2), does not share his realistic-mathematical approach: "*mathematica mihi scientia rerum minime videtur esse, sed sciendi modus, sicut logica*" (Campanella 1967, 370, Lib. II, chap. 2, art.2). Paradoxically, according to Campanella, it is the shortage of experiments and the excess of confidence in mathematical procedures to lead Galileo to error on several points, for example on the issue of the tides (Ponzio 2001, 200–17).

4 TOWARDS THE PRESENT AGE: GALILEAN SCIENCE AND THE "LIFEWORLD"

Edmund Husserl's critique of Galileo's science is well known (Husserl 2000, 51–88, §§ 8–10). According to Husserl, Galilean science and the "mathematization" of the world have replaced the sensible and subjective world of experience (considered by modern science "less real" or "not real") with the world of objective and measurable properties (considered "real"). But this way, Galileo, Descartes and the other modern scientists hid the fact that in the real world, in the "lifeworld" (*Lebenswelt*), there are not such mathematical idealizations (Soffer 1990, 67–82; De Palma 2013, 1–5).

Husserl maintains that the lifeworld is prior to the world of science, because it is prior in the order of reality or existential validity (*Seinsgeltung*). In other words, the reality and quality of lifeworld objects (based on actual and sensible perceptions) could not be "cancelled" by any scientific theories. Indeed, scientific theories and philosophical positions, no matter how well verified or firmly believed, could not change the modal quality of actual experience of the subjects, not only for the scientifically naïve, but for the scientists themselves. This does not imply not to have fulfillment or founded perceptions of the entities and states of affairs described by mathematical physics, but it means only that the corresponding fulfillment is less immediate than in the case of everyday or lifeworld perceptions (Soffer 1990, 83–88).

So we can say that mathematics and natural sciences, as well as philosophy, cannot establish new facts about the world, but they can enable us to understand with greater clarity the facts we already know or come to know from other sources (Dummett 2003, 17), namely the "lifeworld" or, in Soto's and Campanella's words, the *opinio* and the *fides* ("*fides est habitus medius inter scientia et opinio*") (see Soto 1572, 435–43, In poster. I, q 8) or the *communis experientia* and the *historia* ("*quod alicui est sensus, alteri est fides, quam diximus assensum: quoniam aliorum sensu quasi sentimus: quod tamen multis visum est facit scientiam humanam*") (Campanella 1967, 366, Lib. II, chap. 2, art. 2).

Therefore, if we can use a daring metaphor, both Soto's and Campanella's philosophy and epistemology can be considered as "sentinels" of the "lifeworld" or "common sense": their conceptions help us to recall the ground and the "life context" (*Sitz im Leben*) from which the modern rationality and Galileo's science have arisen.

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