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MATHEMATICS, THE "BOOK OF NATURE" AND THEOLOGY: GALILEO GALILEI AND THE FOUNDATIONS OF MODERN SCIENCE

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Abstract

Starting from the cycle of letters known as The Copernican Letters (1613-1615) and following through to the 1632 Dialogue, I will attempt to outline the context in which Galileo Galilei's work is constituted as a veritable theory of nature research based on mathematics. Galilei rests on the principles of science to ground his choice for the Copernican model, as well as the separation of natural research from theology, but his concern for a unified philosophy of the natural world is intertwined in his work with the dignity of creation understood as "the great book of the world" by which divinity talks to man in the language of mathematics.

Keywords: Galileo Galilei; Foundations of Modern Science; Copernican model; scientific knowledge;

1. INTRODUCTION

On June 16, 1633, the Holy Congregation pronounced: "Sanctissimus decreed that said Galileo is to be interrogated on his intention, even with the threat of torture, and, if he sustains [the test], he is to abjure de *vehementi* [i.e., vehement suspicion of heresy] in a plenary assembly of the Congregation of the Holy Office, then is to be condemned to imprisonment at the pleasure of the Holy Congregation, and ordered not to treat further, in whatever manner, either in words or in writing, of the mobility of the Earth and the stability of the Sun; otherwise he will incur the penalties of relapse.

The book entitled *Dialogo di Galileo Galilei Linceo* is to be prohibited. Furthermore, that these things may be known by all, he ordered that copies of the sentence shall be sent to all Apostolic Nuncios, to all Inquisitors against heretical pravity, and especially the Inquisitor in Florence, who shall read the sentence in full assembly and in the presence of most of those who profess the mathematical art." (Giorgio de Santillana, *The Crime of Galileo*, 1955, pp. 317-318).

2. THE DIALOGUE CONCERNING THE TWO CHIEF WORLD SYSTEMS, PTOLEMAIC AND COPERNICAN

The Dialogue Concerning the Two Chief World Systems, Ptolemaic and Copernican, is considered Galileo's most important work; started in 1610, under the title *De sistemate seu constitutione universe* (*On the System or the Composition of the Universe*), the text had been published in Florence in 1632, having been finished in 1630, and after the request for publication license requested from the Holy Congregation, which Galileo obtained due to his friendship with Pope Urban VIII. Nevertheless, even though Galileo is put on trial by the Inquisition for this text, throughout his life, he had written works that had drawn the attention and thorough analysis of the Church authorities, the texts comprised in the *Copernican Letters* (*Lettere copernicane*) (1613-1615) being a telling example in this respect. It is not by hazard that the same Cardinal Bellarmino, who had instrumented in 1600 the trial against Giordano Bruno, is present in the "hermeneutic adventure" Galileo had embarked on with the *Copernican Letters*, through a letter dated April 12, 1615, addressed to Paolo Antonio Foscarini and through his appointment as the representative of the Inquisition in Galileo's trial.

What is the reason why, upon reading the sentence, the ones who practise maths are targeted? Can mathematics be suspected, so that the ones who study it need to be warned? Before Galileo, Copernicus had been considered a man of the Church and a scholar, but his system had been considered sooner an ingenious mathematic tool that could not pretend anything related to physical reality, and mathematics "was rated at the time as a thing for technicians and virtuosi, as they were called, with no claim to philosophical relevance" (Santillana, p. XXV). To Galileo's mind, mathematics could no longer be just an instrument. Archimedes had been translated into Latin, and the acquaintance with his works prompts Galileo to build a science of mathematics capable of studying the movement phenomenon the same way Archimedes had studied statics, and the Greek scholar becomes his "scientific model" (Santillana, pp. XXIV; Horia Roman Patapievici, *Preface* to Galileo Galilei, *Două lecții despre Infernul lui Dante [Two Lessons on Dante's Inferno]*, 2021, p. 18). Before initiating this lifetime-long project, Galileo throws himself (or is thrown) in an adventure: in the year 1587, he is invited at the Platonic Academy in Florence to solve the dispute between two ways of imagining Dante's Inferno. It is worth mentioning that young Galileo (he was only 23 years old at that time) is called in his capacity as a *mathematician*! Why adventure? Because during these two lectures, Galileo makes an error of which he becomes aware only later, which is, otherwise, the reason why the *Lessons* on *Inferno* stop being distributed. One more thing: nowhere in these *Lessons* is any mention of velocity or any indication of the temporal representation. We can regard the *Lessons* as a hermeneutic adventure because the Florentine model of the *Inferno*, that the Academy favoured, should have been considered more exact; but how comfortable was Galileo with applying mathematics – geometry – to the field of the imaginary (as dominant as it was at the time), we cannot know.

If Galileo developed, as early as in his youth, a natural philosophy based on mathematics, then he saw in Nicolas Copernicus' *De Revolutionibus Orbium Coelestium* a path opening towards a new cosmology. The Copernican text had been completed in 1530 and published a year before its author's death, in 1543, which means that it had been known for at least 50 years in the time of Galileo.

Once again, how did mathematics become responsible for the earthquake that hit the image of the world at the end of the 16th and the beginning of the 17th century? Galileo introduced himself in the *Dialogue*, through Salviati's voice, who was furthering his philosophy, as a "Pythagorean mathematician and philosopher", showing that "the human understanding can be taken in two modes, the *intensive* or the *extensive. Extensively*, that is, with regard to the multitude of intelligibles, which are infinite, the human understanding is as nothing even if it understands a thousand propositions; for a thousand in relation to infinity is zero. But taking man's understanding *intensively*, in so far as this term denotes understanding some proposition perfectly, I say that the human intellect does understand some of them perfectly, and thus in these it has as much absolute certainty as Nature itself has. Of such are the mathematical sciences alone; that is, geometry and arithmetic, in which the Divine intellect indeed knows infinitely more propositions, since it knows all. But with regard to those few which the human intellect does understand, I believe that its knowledge equals the Divine in objective certainty, for here it succeeds in understanding necessity, beyond which there can be no greater sureness." (Galileo, *Dialogue...*, 1967, p. 103). A daring speech, remarks the good Peripatetician Simplicio, one which Salviati summarizes unequivocally and

even more daringly: "These are very ordinary propositions and far from any shade of temerity or boldness. They do not detract in the least from the majesty of Divine wisdom, just as saying that God cannot undo what is done does not in the least diminish His omnipotence. But I question, Simplicio, whether your suspicion does not arise from your having taken my words equivocally. So in order to explain myself better, I say that as to the truth of the knowledge which is given by mathematical proofs, this is the same that Divine wisdom recognizes".

Mathematics represents, in Galileo's view, the human being's participation to divine knowledge (Marius Dumitrescu, *Geneza barocă a Filosofiei Moderne [The Baroque Genesis of Modern Philosophy]*, 2016, p. 361), but the foundations of the new natural philosophy and cosmology were mathematical – Galileo had joined Copernicus in the elaboration of this project, which had been affirmed in the *Copernican Letters*, where, in the letter to Benedetto Castelli (December 21, 1613) argued in favour of the heliocentric system to explain the cosmic phenomenon occurring during Joshua's fight with the five rival armies, when God stopped the Sun in the sky: "I hold that this openly confutes the Ptolemaic and Aristotelian system, while admirably agreeing with the contrary hypothesis of Copernicus" (Galilei, *Scrisori copernicane*, 2010, pp. 81).

Some theologians' suspicion was legitimate: in their opinion, this was an attack at the foundations of faith, which also included Ptolemy's cosmological model and Aristotelian philosophy. On April 12, Cardinal Bellarmino wrote to Paolo Antonio Foscarini: "First I say that it seems to me that your Paternity and Mr Galileo are proceeding prudently by limiting yourselves to speaking suppositionally and not absolutely, as I have always believed that Copernicus spoke. For there is no danger in saying that, by assuming the Earth moves and the sun stands still, one saves all of the appearances better than by postulating eccentrics and epicycles; and that is sufficient for the mathematician. However, it is different to want to affirm that in reality the sun is at the centre of the world and only turns on itself, without moving from east to west, and the earth is in the third heaven and revolves with great speed around the sun; this is a very dangerous thing, likely not only to irritate all scholastic philosophers and theologians, but also to harm the Holy Faith by rendering Holy Scripture false." (Finocchiaro 1989, pp. 67-69). The history of that time recorded several events preceding the 1633 trial: on February 24, 1616, the Holy Congregation vets the two sentences referring to the stability of the Sun and motion of the Earth; on February 26, 1616, Cardinal Bellarmino summons Galileo, demanding that he should abandon the censored conception on the stillness of the Sun and motion of the Earth, and on March 3, 1617, Copernicus's *De revolutionibus orbium caelestium* is banned, pending corrections.

Galileo remains in search and formulation of that *mathesis universalis* also sought by his contemporary, René Descartes, who was sharing the Copernican view but who was more interested in not suffering because of his ideas. Descartes wrote to Mersenne in April 1634 about the fact that the Inquisition would not accept even a hypothetical discussion of the Copernican theory: "I'm astonished that an ecclesiastic should dare to write about the earth's motion, whatever excuses he may give. For I have seen official documents about Galileo's condemnation, printed at Liège on 20.ix.1633, which contained the words *quamvis hypothetice a se illam proponi simularet*, even if he pretended he was putting his view forward only hypothetically'; thus they seem to forbid even the use of this ·as a· hypothesis in astronomy. So I don't dare tell anyone any of my thoughts on the topic." (Descartes, *Correspondence*, 2017, p. 29).

After the *Copernican Letters*, the Florentine publishes, in 1623, *Il Saggiatore*, which explicitly reveals his preoccupation for a unified philosophy on the natural world. For Galileo, philosophy signifies science in general, that is more than "natural philosophy", and its object is "the great book of nature*": "La filosofia è scritta in questo grandissimo libro che continuamente ci sta aperto innanzi a gli occhi (io dico l'universo), ma non si può intendere se prima non s'impara a intender la lingua, e conoscer i caratteri, ne' quali è scritto. Egli è scritto in lingua matematica, e i caratteri son triangoli, cerchi, ed altre figure geometriche, senza i quali mezi è impossibile a intenderne umanamente parola; senza questi è un aggirarsi vanamente per un oscuro laberinto."* (Galileo Galilei, *Opere*, I, 1964, pp. 631-632). [Philosophy is written in this great book that is continually open before our eyes (I say the universe), but it cannot be understood unless one first learns to understand the language, and to know the characters, in which it is written. It is written in mathematical language, and the characters are triangles, circles, and other geometric figures, without which it is humanly impossible to understand a word; without these it is a vain wandering through a dark labyrinth.]

3. **CONCLUSION**

In the "Dedication" to Grand Duke Ferdinand II de Medici, at the beginning of the *Dialogue* (February 1632), Galilei affirms the same principle of a philosophy which, by dignity of its object, should be considered the most important in the order of human knowledge: "The constitution of the universe I believe may be set in first place among all natural things that can be known, for coming before all others in grandeur by reason of its universal content, it must also stand above them all in nobility as their rule and standard." (Galileo, *Dialogue*, 1967, pp. 3-4).

This is the philosophy which grounds, in Galileo's case, genuine research principles, since, in the *Copernican Letters* and not only, he circumscribes the field of scientific research to the area of those phenomena that can only be known with the help of the human mind's natural ability (*naturali apprensibili*), without the support of the divine revelation. In this way (as shown in the letter to Benedetto Castelli, December, 21, 1613, and in the most extensive one from 1615, to Cristina de Lorena), Galileo clearly distinguishes between scientific research and theological undertaking: "I think it would be more prudent to prevent anyone from using excerpts from the Scriptures, somehow forcing them to affirm some conclusions on nature, conclusion which, at some point, may be contradicted by senses and demonstrative and necessary reasoning." (*Scrisori copernicane*, p. 75).

At the same time, with the foundation of modern science, starting from Galileo, secularization opens the path towards the study of this world and reveals the "ingenuity of the creator" (Amos Funkenstein, 1998, p. 12) that the Florentine turned into a symbol of modernity never ceased cherishing.

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