FILOZOFIA I NAUKA
Studia filozoficzne i interdyscyplinarne
Tom 11, 2023

Giacomo Borbone

THE PHYSICAL PLATONISM OF GALILEO GALILEI: ERNST CASSIRER'S INTERPRETATION IN HIS PUBLISHED AND UNPUBLISHED WRITINGS

doi: 10.37240/FiN.2023.11.1.10

ABSTRACT

The struggle undertaken by Galileo Galilei against Aristotelian physics—and his subsequent defense of Nicolaus Copernicus's theories—led the Pisan scientist to bring about the so-called modern scientific revolution and to lay the foundations of the experimental method, the fundamental result of which was to deprive the natural world of subjective qualities and to reconfigure it in purely quantitative terms. On the purely historical level, agreement among historians of science and philosophy is almost unanimous, while the same cannot be said for questions concerning interpretations of Galilei's *modus operandi* and the basic philosophical options adopted by Galilei during his demolition of the entire Aristotelian-scholastic framework. Not all experts in the Galilean thought or of science, in fact, agree in tracing the Galilean reflection within the Platonic tradition, but one authoritative voice that has instead argued for its deep intertwining between Plato and Galilei is the German philosopher Ernst Cassirer. In this contribution I will attempt to demonstrate, partly considering two unpublished manuscripts of Cassirer, the plausibility of the Cassirerian thesis about Galilei's physical Platonism.

Keywords: abstraction; Cassirer; Galileo Galilei, idealization; science.

1. INTRODUCTION

There is an important passage from Galileo Galilei's 1632 *Dialogue* where the speaker is the peripatetic Simplicio, who states as follows:

> "I have known some very great Peripatetic philosophers, and heard them advise their pupils against the study of mathematics as something which makes the intellect sophistical and inept for true philosophizing; a doctrine diametrically opposed to that of Plato, who would admit no one into philosophy who had not first mastered geometry" (Galilei, 2020 (1632), p. 397).

The Pisan scientist expresses with incomparable clarity and conciseness the field on which the gigantomachy between the old Aristotelian and Copernican perspectives would take place. The struggle engaged by Galilei against Aristotelian physics—and the consequent defense of Nicolaus Copernicus's theories—lead the Pisan scientist to bring about the so-called modern scientific revolution and to lay the foundations of the experimental method, the fundamental achievement of which consisted in eliminating subjective qualities from the natural world and instead reconfiguring it in purely quantitative terms (Skidelsky, 2012, p. 486). On a purely historical level, agreement among historians of science and philosophy is almost unanimous, while the same cannot be said for questions concerning interpretations of Galilei's *modus operandi* and the basic philosophical options adopted by Galileo during his demolition of the entire Aristotelian-scholastic framework. It must be said that Cassirer's view of Galilei's Platonism is not isolated in the history of science, especially if we think about authors such as Alexandre Koyré, Alfred North Whitehead (1967 (1925)) and Edwin A. Burtt (1932) who, in various respects, did not hesitate to find in Galilean reflection not a few philosophical and scientific connotations of distinctly Platonic inspiration. But there have been also diametrically opposed positions; consider John H. Randall Jr. (1940, pp. 177–206), Ludovico Geymonat (1957), William A. Wallace (1984), Gary Hatfield (1990) and, more recently, Richard H. Schlagel (2001), who are decidedly more inclined to bring Galilean methodological reflection back into the tradition of Aristotle rather than Plato.

However, this is certainly not the place for a critical analysis of the various hermeneutical proposals put forward by leading experts on Galilei's work (cf. De Caro, 2012; Coniglione, 2016; Borbone, 2019; Borbone, 2023); rather, this essay will examine the main insights of Cassirer's exegetical proposal, which is notoriously marked by tracing Galilei's theoretical-conceptual background to the Platonic tradition. This operation will be based also on two unpublished manuscripts dedicated to the method and Platonism of the Pisan scientist.

They are two manuscripts belonging, respectively, to GEN 98, series No. II, Box 39, Folder 775 and GEN 98, series No. II, Box 39, Folder 776. The first text, which is entitled *The Character of Galilei's Inductive Method*, consists of 23 pages of which some are typewritten, while the second—entitled *The Platonic Character of the Science of Galileo*—is 16 pages long and is numbered from page 15 to page 30. Both manuscripts have no date, but since several passages partially reproduce what Cassirer published on Galilei, then it seemed more than likely to date these two manuscripts to 1942. And indeed, as many scholars of Cassirer's works are well aware, he had in 1942 printed an essay entitled *Galileo: A New Science and a New Spirit* (1942), which appeared in "The American Scholar," vol. 12, no. 1, pp. 5–19. Furthermore, Cassirer mentions a text by Leo Olschki that appeared that year: "The same view of the absolute originality, of the fundamentally new character of the method of Galilei is maintained and defended in a paper of Olschki *The Scientific Personality of Galilei*, that has been published a few months ago in the "Bulletin of the History of Medicine," XII (2) (Cassirer 1942a, p. 3b).

These two short unpublished writings by Cassirer are remarkable both for their conciseness, as well as for their expository clarity—a trait typical of most of the texts for the lectures Cassirer gave to his students during his "forced" exile. In the first manuscript, the philosopher of symbolic forms outlines the basic features of the Galilean method, coming to appropriately distinguish the empiricism postulated by the Pisan scientist from the conceptual perspectives of thinkers such as Francis Bacon or John Stuart Mill. Having done so, in the second manuscript Cassirer reviews those aspects that, in his view, make Galilei a Platonist, even if original and marked by a resumption not so much of Platonic metaphysical questions, but of the theory of knowledge which can be drawn—in the first place—from the dialogue *Menon*.

Interesting, in this regard, is the comparison engaged by Cassirer with the hermeneutical remarks of Burtt, Edward W. Strong (1936) and Randall Jr. While Burtt had emphasized neo-Pythagorean and neo-Platonic influences, Strong denied such links altogether, while Randall Jr.—for his part—traced Galilean speculation back to a purely Aristotelian background. Before analyzing, albeit briefly, the contents of Cassirer's hermeneutical proposal, however, it must be made clear to readers that the unpublished texts shown here, like the rest of his posthumous production, require a reading in synopsis with what he published during his lifetime, which is why in this contribution the famous essays on Galilei by Cassirer published while he was alive will be considered.

2. PRELIMINARY QUESTIONS

Cassirer's thesis of Galilei's Platonism originates from his articulated *Begriffsbildung*, in which the shift from the Aristotelian concept of substance to the mathematical concept of function is central. The breaking point with Aristotelian physics arises, primarily, from the Stagirite's distrust of mathematics and geometry. But this should certainly not be surprising, since Aristotle considered the concept-formation to be essentially based on the theoretical procedure of abstraction, whose *raison d'être*—as expressed in his *Categories*—lies in the difference between primary and secondary substances:

> “Substance, in the truest and primary and most definite sense of the word, is that which is neither predicable of a subject nor present in a subject; for instance, the individual man or horse. But in a secondary sense those things are called substances within which, as species, the primary substances are included; also those which, as genera, include the species. For instance, the individual man is included in the species ‘man,’ and the genus to which the species belongs is ‘animal;’ these, therefore—that is to say, the species ‘man’ and the genus ‘animal’—are termed secondary substances” (Aristotle, 1967, 2a, pp. 12–21).

So, according to the classical doctrine, the process of concept-formation turns out to be the result of an operation consisting, for example, in the isolation of a property common to several individual objects, which then ends in the formation of a class of individuals possessing a given property. It seems clear that this process of concept-formation did not make possible the application of mathematics to the flat and imperfect phenomenal datum, given that the Aristotelian theory of concept formation presupposes the existence of autonomous substances (cf. Lofts, 2000, p. 37). From this it follows, as Philip Merlan has argued, that nature according to Aristotle, is not, in its large part, susceptible to mathematical (quantitative) consideration and therefore “the concept of a mathematical physics is absent from Aristotle’s thought” (Merlan, 1953, p. 68). After all, the concepts forged by the Stagirite and to which he turns his attention are certainly not Platonic forms or mathematical idealities, but rather the concept-genres of descriptive and classificatory natural science. Based on a rather heterodox interpretation, according to Cassirer the gravity-center of Aristotelian thought “is to be sought in the *biology* of Aristotle, in his theory of organic life” (Cassirer, 2022, p. 282). On the other hand, the main philosophical and scientific interests of the young Aristotle were directed toward organic life; Aristotle looks at reality with the eyes of the biologist interested in grasping the laws of development of organic life. It is with this that the famous Aristotelian rejection of the philosophy of mathematics of the Platonic Academy is also explained, since the forms Aristotle speaks about do not correspond to the abstract and geometrical forms proposed by Plato, but to actual living forms. Plato considered mathematics the privileged way to access the world of ideas, while Aristotle did not consider it possible to apply it to sensible discreteness.

The doctrine of ideas does indeed beat a path of a clear scientific-empirical nature, but in the background there still remains the need not to remain anchored in the pure abstract plane exemplified by the generic relationship subsisting between the unity of law and the infinite indeterminacy of the empirical sphere. Rather, it is a matter of fully investigating its intermediate links (τὰ μέτα), that is, the particular laws that give meaning to that relationship which would otherwise remain without scientific value. The world of ideas and the sensible world cannot be thought of except through the relation of participation (μέθεξις), through a movement of up and down without which the very foundation of the doctrine of ideas would lose all meaning and validity. Idea and phenomenon are linked by a relationship that is, so to speak, guaranteed by mathematics, to be understood as the "middle earth" between the intelligible world and the sensible world. It is through the mathematical instrument that reality acquires its precise determinacy, as we can observe in the light of dialogues such as the *Phaedo*, the *Philebus* and the *Timaeus*. Through the medium of mathematics we get, in the perceptible world, a reflection of the idea of the good, since this world participates in the good insofar as it is subject to strict numerical laws. The two worlds admitted by Plato remain, yes, distinct, but at the same time related and part of a "whole" composed of these two dimensions. It is just by denying this background that one runs the serious risk of interpreting Plato's philosophy as an escape from the real world, a one-way trip to the realm of pure theoresis.

It is right these aspects of Platonic thought that, according to Cassirer, Galilei would have inherited, and the pages devoted to the figure of Galilei written by Cassirer represent an original extension, to the sphere of the history of science, of the key-points of Hermann Cohen and Paul Natorp's exegetical proposal on the doctrine of ideas, which is why in Cassirer's eyes the Pisan scientist embodies "the authentic mathematical 'Platonism' in the Renaissance age" (Ferrari, 2021, p. 84). The peculiarity of the historical-theoretical reconstruction of Galilei's work done by Cassirer took its nourishment from the emphasis—that can be found in his early works and from *Substanzbegriff und Funktionsbegriff*—on the methodical-functional valence and hypothetical statute of the Platonic idea. For the Breslau (now Wrocław) philosopher, it is in modern science that the perspective of idealism finds its crowning glory, as it best expresses the productive-constructive character of knowledge. Therefore, the methodological as well as conceptual differences present between Aristotle and Galilei could not be sharper, as Fabio Minazzi correctly states in accordance with Cassirer

> "The starting point is and always remains nature in its immediate concreteness: physics can make abstraction from the single and unrepeatable individuality of a certain natural event, but it can never reach out to a higher plane of abstractness since the concept must instead be able to grasp the 'essence' of a phenomenon by always evaluating it in its concrete natural context. By positing the need for idealization Galileo thus breaks away from the Aristotelian approach and seems to consider, in a more positive way, a Platonic indication" (Minazzi, 1994, p. 267).

Once this essential difference between Plato's *Denkstil* and Aristotle's is established, it seems rather obvious to trace the Galilean conceptual framework back to that found in the Platonic dialogues. On the other hand, it is exactly in the need for a mathematization of the sensible that a good part of historians of science have found the inspiring principle that animated Galilei's scientific work: "the traditional view of Galileo as the father of early modern science is right, because he was the first scientist to realize the idea of a mathematized physics" (Cohen, 1994, p. 78). But before addressing these issues and in order to better understand Cassirer's hermeneutical insights, we need to shed some light by asking two simple questions: Does Galilei's work have a properly scientific value or also a philosophical value? Is it possible to consider the Pisan scientist—philosophically—a Platonist? Only by answering these questions does the long-standing question of Galilei's Platonism acquire a well-defined meaning, at least within the Cassirerian reconstruction.

Let us specify from the start that it is Cassirer himself who asks such questions and answers them positively in his writings on the Pisan scientist. After all, the influence that Platonism exerted on scientific thought has been grasped with great acumen by Cassirer, who reads the history of modern thought through the lens of a Platonism reshaped in a physical-mathematical key and which he considers central to the development of what the philosopher from Breslau called modern philosophical idealism. For Cassirer, the most relevant aspect of Galilei's Platonism lies in the certainly original and unheard appropriation of the Platonic concept of knowledge. In fact, if a scientist like Kepler was still influenced by the mathematical mysticism of the Pythagoreans, in Galilei there is instead an appropriation of the Platonic concept of knowledge, as Cassirer states in his second unpublished manuscript:

> "The influence of the general metaphysical background of the Neo-Platonic and Neo-Pythagoreans theories of the universe, is clearly to be felt in the work of Kepler. But, to my mind, it was not this side of the problem that became decisive for the development of Galilei's thought. He approaches the problem on a different side, and he looks at it from a different angle. What is of fundamental interest and of fundamental importance for Galilei, is not the Platonic theory of the intelligible world, but the Platonic theory of knowledge, of scientific method and of scientific demonstration" (Cassirer, 1942b, p. 19).

3. A NEW CONCEPT OF TRUTH

Cassirer had already devoted to the first question the dense 1937 essay entitled *Wahrheitsbegriff und Wahrheitsproblem bei Galilei*, in which the Breslau thinker—from the very beginning—speaks of an eminently philosophical value (*eminent philosophische Bedeutung*) of the Galilean work (Cassirer, 2006, p. 51). The entire articulation of Galilei's work does not flatten at all on mere factuality, on the simple discovery and demonstration of new facts. Rather, it is grounded on a new ideal of truth (*auf das neue Wahrheitsideal*), in the light of which he questions the old Aristotelian-scholastic building. The latter, in fact, enters on a collision with the spirit that had animated the Renaissance, characterized by a renewed relationship between man and the cosmos. It was no longer a matter of understanding God's truth as a function of the "inspired Word," but through his work. The study of nature—which condenses into mathematical demonstrations and physical experiment—would thus enable man to gain access to the truth of God. One of the main features of the Renaissance mentality consists in just this empowerment of the self, which is no longer satisfied with mere introspective work culminating in religious conversion, but in a passionate study of the universe and the fervent activity of knowledge. As Lawrence E. Cahoone, the Breslau philosopher seeks to show that Galileo's scientific work reflects a universal Renaissance ideal, not merely physical-mathematical (Cahoone, 1985, p. 274).

For Cassirer, such a spiritual movement develops along an axis that finds its greatest representatives in Nicholas of Cusa, Leonardo da Vinci and Galilei. Nicholas of Cusa had attempted to provide a metaphysical interpretation of the universe, while Leonardo, for example, strives to embrace it by the combined work of contemplation and artistic intuition. But it is only Galilei who becomes the first theoretician of the universe (*wissenschaftlichen Theoretiker des Universums*), due to the fact that he aims to discover "the elementary forces that regulate its construction [*Aufbau*] and to show how they cooperate in it" (Cassirer, 2006, p. 53). For these reasons, Cassirer asserts, Nicholas of Cusa's meaning lies under the sign of the metaphysical concept (*im Zeichen des metaphysischen Begriffs*), Leonardo's in his conception of artistic form (*in seiner Auffassung der künstlerischen Gestalt*), and Galilei's in the thought of law (*im Denken des Gesetzes*).

Yet, it is not to the scientific sphere alone that it is possible to circumscribe the entire personality of Galilei and the historical impact he exerted. Indeed, the philosopher of symbolic forms recalls that Leibniz himself, in mentioning Galilei, placed him among the founders of modern philosophy, and Leonardo Olschki, in his well-known *Geschichte der neusprachlichen wissenschaftliche Literatur* (Olschki, 1919), devotes an entire volume to the literary issues present in Galilei's work. In order to properly understand both the character and the work of Galilei, Cassirer considers it necessary to direct our attention not only to the properly scientific sphere, but instead to the focus of his intellectual activity and thus to his way of research. This, as Cassirer states in the first of the unpublished manuscripts, is condensed in "in his ideal of scientific truth" (Cassirer, 1942a, p. 6). Galilei's fame, as is well known, was initially due to his important scientific achievements, including the discovery of Jupiter's satellites, observations on the phases of

Venus, and so on. But in the long run he could no longer behave as a mere scientist, except that the heliocentric conception he defended and vehemently opposed by the Aristotelian-scholastics implied the need to develop for himself a solid logical armamentarium to defend Copernicus's theses from the attacks of peripatetic philosophy. In this strenuous battle he acted as both a thinker and a scientist, since his research was grounding, as already mentioned, on a new concept of truth.

It is possible for Cassirer to point to the exact place and year of this new *Wahrheitsbegriff*, namely Galilei's letter addressed to Benedetto Castelli (Florence, Dec. 21, 1613). In this letter Galileo asks whether or not the *Bible* has any authority on the knowledge of nature. The way the Pisan scientist answers the question is revelatory, since Holy Scripture can sometimes be subject to the errors "of its interpreters and expositors," whereas nature, on the other hand, «never transgresses the terms of the laws imposed on her» (Galilei, 2005a, pp. 526–527). Cassirer ascribes a decisive significance to this letter of Galilei, to the point of stating that it contains "a new philosophy of science, a new appreciation of the task and the value of scientific thought" (Cassirer, 1942a, p. 7). Galilei knew no other way to prepare the solid ground on which to conduct his struggle in defense of the Copernican system. The importance of the new concept of truth adopted by Galilei encompassed ever broader fields, so that it also invested religion and law. After all, we have seen that nature was understood as the work of God by means of creation *ex nihilo*, with the obvious consequence of giving nature not only a subordinate value but also an absolute gap between it and its creator, if only because the scholastics—referring to Aristotle's *De caelo*—believed that there was no proportion for commensurable and incommensurable magnitudes (Aristotle, 2020, I (A), 7, p. 275a).

This gap, although mitigated by the reflection of Thomas Aquinas, did not prevent the belief that nature and reason were considered subordinate to the purposes of faith and revelation. As Cassirer points out, this opposition was certainly not confined within the perimeter of mere speculative inquiry, since it manifested itself in all other fields of spiritual life, including the evaluation of science, natural philosophy, and moral and political ideas. Even in the Pisan scientist it is possible to find the vehement critique of the so-called doctrine of double truth, according to which on the one hand there is that of revelation and on the other that based on nature and reason. God's revelation is indeed contained both in his words and in his works, but it is what is manifested in the latter that must necessarily prevail. Galilei's purpose, Cassirer points out, was certainly not to challenge the authority of religious thought, but rather to argue that the truth of rational thought has a deeper meaning and origin what is admitted by dogmatic theology. By devaluing the power of reason, theology ended up entrusting the sole guarantee of truth to mere faith, even in fields beyond the spiritual. Conversely, a co-equal relationship between reason and truth does not devalue religious truth but rather consolidates it due to having an exclusive domain reserved for it. However, this new perspective triggered a violent conflict with the Catholic Church (see Findlen-Marcus, 2017, pp. 326–352), according to which this world is only God's work in accordance with his plan, thus deeming illicit even a rational explanation of the universe since this was beyond man's tasks. Instead, as Stephan Otto has remarked,

> "Galileo emphasized several times [...] that the 'reasons,' which govern phenomena in nature, could not be read from these phenomena by mere sensory perception; the spontaneity of the mathematical intellect [*der Spontaneität des mathematischen Verstandes*] was needed to 'discover' such laws" (Otto, 2003, p. 33).

However, Cassirer points out, the emphasis on the empirical character of knowledge can easily lead readers to believe that scientists and thinkers such as Galilei, Bacon or John Stuart Mill are related. In order to understand the difference between Galilean induction and that peculiar to English empiricism, it is sufficient to recall the way in which, for example, Bacon tries to grasp the nature of heat, namely, by collecting all the hot things and deriving by "abstraction" the common note that characterizes them. After all, despite his not too much veiled anti-Aristotelianism, Bacon remains bound as much to the Aristotelian concept of substance as to a purely qualitative and classificatory science, whose method is nothing more than a means of ordering and classifying the elements that make up natural reality. In reference to Galilei, Cassirer prefers to use the term "analytic induction," which he contrasts both with induction in Bacon's sense and John Stuart Mill's inductive logic, also known as *inductio per enumerationem semplicem* (Cassirer, 1942a, p. 14a). The latter is condensed into inference from "particulars to particulars" (Mill, 1843, p. 280), but no induction is able to assure us of the totality of cases, where instead, through a functionalist approach, the law of connection is given at the beginning intended as a fundamental principle and not at any subsequent moment. It is thus that we are able to find the universal not in the totality of individual cases as much as in the individual case itself, within which there must be concealed an element that raises it above its limitation and isolation. In this consists, according to the Breslau philosopher, the so-called *secret of induction*, which "does not begin where we draw a conclusion from several observations regarding all cases, but is already fully contained in the establishment of any individual case" (Cassirer, 2003b, p. 246). Rather, according to Cassirer, it is a matter of transcending the plane of immediate perceptions by appealing to the principles of physics, which in that case serve as means of orientation valid, in the first instance, only hypothetically. This is what the methodical procedure *ex suppositione* used by Galilei consists of, and which he described in a famous letter addressed to P. de Carcavy (Galilei, 2005b, p. 944):[1]

> "I argue *ex suppositione*, figuring a motion toward a point, which starting from stillness goes accelerating, growing its velocity with the same proportion with which time grows: and of this such motion I conclusively demonstrate many accidents; I then add, that if experience showed that such accidents were found to occur in the motion of naturally descending graves, we might without error affirm this to be the very motion that was defined and supposed by me; when not, my demonstrations, fabricated over my supposition, lost nothing of its force and conclusiveness; so that as nothing judges the conclusions demonstrated by Archimedes about the spiral to be found in mobile nature that in that manner spirally moves."

The content of this letter summarizes in an exemplary way the Galilean method, to which the fundamental contribution of mathematics must be added. After all, it is in this aspect that Galilei's peculiar Platonism lies, namely in the extension of the Platonic concept of knowledge to the physical realm through the application of mathematics, as Archimedes did in studying the "spiral lines" and whose example he always kept in mind (see Dollo, 2003, pp. 23–62).

4. THE FUNDAMENTAL CHARACTERS OF GALILEO'S PLATONISM

Let us begin immediately by stating that for the philosopher of Breslau, Platonism in Galileo is not only evident but also determinant; however, it is a matter of carefully specifying its characteristics in order to overcome the vagueness that the label "Platonism" necessarily carries with it. Right at the beginning of the essay in question, Cassirer points out how in the history of philosophy we come across, in fact, skeptical Platonism, the Neo-Platonism of Plotinus, the religious Platonism of St. Augustine, the logical Platonism of Scotus Eriugena and the medieval realists, the Platonism of Ficino, Malebranche and the Cambridge Platonists, as well as the romantic Platonism of Schelling. So, Cassirer states unequivocally, the mere fact of discussing a supposed Platonism of Galilei "seems at first sight to be a very great paradox. If we look at the first principles of Platonism, we find them to be in a flagrant contradiction to all the scientific ideals of Galileo" (Cassirer, 1942a, p. 15). That the Pisan scientist himself admired Plato and felt indebted to his philosophical system is an unquestioned fact, as too his inclination towards the Athenian thinker in the split generated between Platonism and

[1] On Galilei's method of *ex supposition* see also Wallace (1974, pp. 79–104).

Aristotelianism during the Renaissance. In this regard it is worth mentioning Galilei's response to the *Philosophical Exercises* of the peripatetic Antonio Rocco, which reads as follows:

> "which of two ways of philosophizing walks is more accurately, either your pure and simple physical good, or mine spiced with some sprinkling of Mathematics, and at the same time consider, who more judiciously discoursed, either Plato in saying that without Mathematics one could not learn Philosophy, or Aristotle in touching the same Plato for being too learned in Geometry" (Galilei, 1811, p. 343).

If by "Platonism" one simply means an appreciation for formal structures of a mathematical nature, then there would be no difficulty whatsoever in considering Galilei a Platonist *tout court*. After all, Koyré himself—analogously to Cassirer—had peremptorily stated the following: "I have just called Galileo a Platonist. And I believe that nobody will doubt that he is one" (Koyré, 1943, p. 425). We certainly do not intend to question the opinion of the French scholar, but we must nevertheless underline the excessive vagueness of the equation Platonism=mathematicism. And in fact, despite the so clear correspondence between Galilei and such mathematical Platonism, several scholars nevertheless raised strong doubts about this supposed Platonism of Galilei. Such doubts, in Cassirer's opinion, were due to the almost paradoxical nature of Galilei's Platonism, never previously supported in the history of philosophy and science. The Pisan scientist, moreover, had not simply become a spokesperson for traditional Platonism, nor had he embraced the Platonism that circulated in the Renaissance and in the Florentine Academy. Galilei's Platonism, according to Cassirer, was so unheard that it almost seemed like a *contradictio in adiecto*; in fact, for the philosopher from Breslau, Galilei's Platonism could not be traced back to a more or less clear form of abstract metaphysics but was instead transferred to the field of physics; so, it was a physical Platonism. However, was not it Plato himself who stated in *Timaeus* that the discussion about sensible things can at most provide us with a plausible, probable, and approximate discussion? For the Athenian philosopher the search for truth and certainty in the context of becoming—and therefore of δόξα—was a chimera since Platonic philosophy is based on the assumption according to which "we cannot speak of a science of nature in the same sense as there is a science of Mathematics" (Cassirer, 1942a, p. 15).

Therefore, if by Platonism we mean this complex concept illustrated by Plato in *Timaeus*, then we must admit that Galilei was never a Platonist. The Athenian philosopher holds a distinction between the intelligible world (ἐπιστήμη) and the sensible world (δόξα), thus making mathematical physics impossible, while Galilei instead takes the opposite path. The Pisan scientist, essentially, transfers to the realm of becoming that ideal of exactness that Plato assigned only to the realm of the intelligible. Cassirer's reasoning is based on the following recognition of Platonic thought: if we can contemplate eternal and necessary truths solely in the world of ideas, then the sensible world, subject to a perennial Heraklitean flux, is reduced to mere semblance, opinion, doxa, and in this sense we cannot find any mathematical perfection in nature. It is for this reason that Galilei, according to Cassirer, transferred the theory of ideas to the field of physics, ensuring that the changing sensible world could become susceptible to a mathematical treatment. It is through this shift that, according to the philosopher from Breslau, the Pisan scientist "can, as a convinced Platonist, venture to transfer the movement itself into the 'realm of ideas'" (Cassirer, 2002, p. 327). But for a better understanding of Galilei's peculiar Platonism, it is worth underlining, albeit briefly, the conceptual impact deriving from Archimedes. This influence, in fact, was somewhat overlooked by Cassirer, while instead, as Coniglione rightly highlighted, the figure of Archimedes proved to be of fundamental importance for Galilei in outlining with ever greater awareness the basis of his method:

> "Galileo is well aware of the method he used; thanks to it, it is possible to apply mathematics to reality, as Archimedes did in studying the 'spiral lines.' This constant reference to the scientist from Syracuse, made several times, mainly where Galileo speaks of the method *ex suppositione*, is particularly significant not only because it is through his mediation that the influence of Platonism can be understood properly, but because in him, as also in the Hellenistic science, there is a clear awareness of this need to work counterfactually with respect to nature, as in the case with the hydrostatic of Archimedes. After all, it is with Archimedes that a methodical procedure was recognized; it would not be too far-fetched to believe that this was a source of inspiration for the same reflections of Galileo" (Coniglione, 2016, p. 129).

At the basis of the Galilean conception of nature there is the idea that alongside a logic of numbers and abstract figures there is also a physical logic. It is true that from the *Phaedo* to subsequent Platonic *Dialogues* we witness a notable effort on Plato's part aimed at bridging the gap between the intelligible world and the sensible world, so in addition to this separation (χωρισμός) there is also the well-known relation of participation (μέθεξις) between phenomena and ideas. However, this χωρισμός is never completely canceled out, thus assuming the role of a barrier that Galilei tries to break down. It is no coincidence, on the other hand, that Plato's *Timaeus* never constituted the authentic source used by Galilei for the development of his concept of truth and knowledge. The Platonic dialogue that most of all captured Galilei's interest was the *Meno* and this is due to the fact that the Pisan scientist sees in it the so-called procedure by way of hypothesis (ἐξ ὑποθέσεως) (Plato, 2002, 86E), from which the method of problematic analysis could be developed. Let us think to the imperative aiming to "save the phenomena" (σῴζειν τὰ φαινόμενα), which Plato had posed to the astronomers of his time, consisting in assuming uniform and perfectly regular motions in order to account for the apparent irregularities of the astral orbits—according to the testimonies of Simplicius present in his commentary on Aristotle's *De caelo* (Simplicius, 1894, p. 488). As Cassirer writes in his second Manuscript on Galilei's Platonism:

> "Which are those circular, uniform, and perfectly regular motions—asks Plato—which, supposing them to be true, account for all the appearances of the movements of the planets? The Platonic question was answered in the spherical theory of Eudoxus and Calippus. For Eudoxus and Calippus the planetary spheres were not what they were for Aristotle. They are not conceived as material of transparent bodies—they are introduced as rational hypotheses by the assumption of which we may make understandable the motion of the celestial bodies. This Platonic method of 'problematic analysis' that had proved its importance and its fertility in the field of Geometry and Astronomy is, in the new science of Galileo, extended to the whole field of Physics" (Cassirer, 1942b, p. 26).

On the other hand, when taking planet earth into consideration, the scientist, hypothetically, imagines it as a particle, that is, a body with mass but whose size can in the first instance be neglected; this is due to the fact that the mass of the earth is so small compared to that of the orbit that when analyzing the orbital movement it is possible to consider the earth as a particle. In this case, the judgments of the Aristotelian Averroes should not be surprising who, regarding the astronomy of his time, stated: "the astronomy of our time does not exist; it adapts to the calculation, but does not agree with what exists" (Averroes, 1562, Book XII, comm. 45).

So, it is just the need for the hypothetical method drawn from the *Meno* that allows us to understand Galilei's "Platonism" in a more precise way. This method had led to very important scientific results if we think, in particular, of the famous principle of inertia applied to an evident idealized circumstance that does not occur in reality.[2] In light of the *Meno*'s hypothetical procedure, Cassirer was able to provide illuminating analysis concerning not only Galilei's *modus operandi*, but also the reasons that pushed the Pisan scientist to turn his gaze to Aristotle's great antagonist.[3] But Galilei's interest in the *Meno*, however, should not lead readers to downplay the im-

[2] The bibliography on Galilei and the concept of idealization is now vast. We only point out Leszek Nowak (1995, pp. 111–126) and Francesco Coniglione (2016, pp. 123–140). For a historical and theoretical survey on idealizations in science see (Coniglione, 2004, pp. 59–110).

[3] On the different philosophical options existing between Galilei and Aristotle—in addition to the aforementioned writings of Nowak and Coniglione—see also the great work of Amos Funkenstein (1989).

portance of the *Timaeus* for the development of a mathematical conception of nature. On the other hand, the idea that our concepts—as well as our experience—of external objects are not limited to reproduce mere qualities existing in them remains platonic, since there is always the mediation of the synthetic activity of the intellect, thanks to which the field of perceptive qualities is contrasted with a field of sizes and numbers. Instead, Aristotle's clear rejection of Plato's philosophy of mathematics, at least for the development of modern science, was fatal in many respects. It is no coincidence that one of the Platonic dialogues most mentioned and criticized by Aristotle is just the *Timaeus* and this was probably due to the fact that "Plato dealt here with physical and biological problems, which were dear to him" but, continues Carlos Steel, "notwithstanding his great interest in the *Timaeus*, Aristotle is very critical about its arguments: all his comments are negative" (Steel, 2016, p. 328). In fact, the Stagirite, as the Polish scholar Jan Such pointed out, did not limit his scathing criticisms to the ontological value of ideas, since he also denied "the epistemological value and methodological importance of Plato's ideas as indispensable theoretical means of scientific analysis of empirically existing objects" (Such, 2004, p. 40). Plato, as is known, aims to strip sensible reality of its accidents by assuming the thesis according to which the bodies that constitute the universe are susceptible to a mathematical explanation, in order to overcome a conception of nature of a naively empirical character. But it is precisely on this point that Aristotle reveals his divergence from Plato. In his view, the examination of physical phenomena, to which mathematics is not applied, relies solely on empirical observation. On the contrary, Plato's reliance on immutable forms, on the one hand, would entail an unjustifiable fusion of mathematical science and natural science, and on the other hand, a reduction in the explanatory depth that stems from concrete observation, which is the only approach capable of encompassing the widest range of phenomena. The profound reasons behind the Aristotelian criticism of the great Platonic cosmology of the *Timaeus* lies mainly on the paradoxical nature that a physics of this type assumed in the eyes of the Stagirite. However, as Cassirer reminds us, although Platonic physics—within which all being and all the differences of matter "are resolved and dissolved in purely ideal geometric determinations"—may also seem paradoxical, it is also true

> "that this physics not only was used, in principle, by Descartes at the beginning of modern philosophy, but its fundamental methodical concept also seems to have found a surprising Renaissance in the most modern form of physics, in that general theory of relativity in which ultimately all dynamic determinations can equally be traced back to pure metric determinations" (Cassirer, 2003a, p. 458).

4. CONCLUSION

Although there were those who considered the Platonic *Timaeus* "a brilliant and daring conjecture, a great myth, somewhere between religious, poetic and metaphysical: not at all a book of science» (Bignone, 1973, p. 13), one must not however forget—especially in light of the Platonic reflections of the *Timaeus*—that it is right in the Athenian philosopher that the need for a "great mathematization of the concrete and the sensible" can be found, as the historian of science Abel Rey had also highlighted (Rey, 1939, p. 236). However, one must not forget that according to the Athenian philosopher, mathematics was not aimed merely to the knowledge of the world, since it was also an instrument of elevation of the soul, of spiritual asceticism which allowed the soul to reach the contemplation of ideas; in fact, this is how Proclus interprets it. Moreover, it was not Plato's intention to assign a purely technical status to geometry and mathematical sciences, since they actually had broader purposes. In any case, if we keep in mind the theory of the *Timaeus*, then it appears clear that the elements the Athenian philosopher refers to are not, as Cassirer states,

> "The material ones, whatever they may be, but purely mathematical determinations. If we want to root ourselves in the world of sensible being and sensible changes with thought as such, if we want to 'fix' points of support in that world, then we can never find them in the qualities perceived directly, through which we usually distinguish the 'things' of empirical perception and according to which we usually call one air and the other fire, one water and the other earth" (Cassirer, 2003a, p. 458).

Cassirer's thesis is certainly audacious, and we must proceed with an extreme hermeneutical caution when comparing ancient concepts to modern ones; but, as Paul Friedländer wrote,

> "one must run this risk. For it is senseless, it is even impossible, to study the *Timaeus* with the windows so completely closed that no breath of modern physics is allowed to enter. Today's scientists, in their turn, may enrich their historical background by a critical study of Plato's scientific myth" (Friedländer, 1973, p. 257).

The meaning of the methodical operation made by the Pisan scientist consists not only in the rejection of the naive realism of the Peripatetics, but also in the revival of the Platonic concept of knowledge drawn from the *Meno* and transferred to the field of physics. On the other hand, even in the Platonic perspective the distinction between the eternal movements of the celestial bodies and the changing ones of the sensible world remained firm, but the Pisan scientist—with a remarkable intellectual courage—tried to go beyond Plato although starting from his own presuppositions, thus deleting the gap between pure and applied mathematics. Despite the principle of χοινωνὶα τῶν γενῶν, for the philosopher of symbolic forms—as he himself writes in the monograph *Ziele und Wege der Wirklichkeitserkenntnis* published posthumously in 1999—Plato would still be far from that "harmony" [*Harmonie*] between the mathematician and the empirical to which modern mathematical knowledge of nature tends and which forms one of its fundamental postulates [*grundlegenden Postulate*] (Cassirer, 1999, p. 24). Yet, the "dialectical" nature of Galilei's reasoning does not disappear despite the demolition of that wall between κόσμος αὶστητὸς and κόσμος νὸητος which the Athenian philosopher instead up-holds, albeit not in radical terms. We know that for Plato one can only have an authentically dialectical knowledge of "what-always-is" and that consequently the "knowledge" would lose its strength if we directed it towards the sphere of becoming. As is well-known, for Plato, a knowledge limited to the sphere of the sensible cannot provide us with any true knowledge, since the latter cannot change like empirical phenomena, but must rather remain firm, that is, it must reveal itself as incontrovertible.

This is the form of knowledge that is usually defined in terms of ἐπιστήμη, usually opposed to simple opinion (δὸξα). But with this, contrary to what was claimed by many philosophers and historians, Plato did not intend at all to denigrate empirical reality. On the other hand, the problem does not consist in the appearance of the things perceived by us through the senses or perceptions, but rather in considering mere perception as the only and stable criterion of truth. In the posthumous text *The Relations of Philosophical and Scientific Thought in their Historical Development*—i.e. a long manuscript of the lectures given by Cassirer at the Bedford College in London between 1934 and 1935—he recalls that in *Timaeus* the Athenian philosopher attempts to provide "a description, a sort of theory concerning the origin and constitution of the visible world. But he never did acknowledge to this theory the same degree of certainty as to the true and principal objects of philosophy" (Cassirer, 2020, p. 93). But we also know that Platonic dialectics arises right from mathematics, remaining inextricably linked to it. Galilei does nothing other than adhere to the Platonic conceptual framework, however overcoming the restriction [*Grenzbestimmung*] posed by the Athenian philosopher, i.e., the distinction between the intelligible world and the sensible world.

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ABOUT THE AUTHOR — PhD in Philosophy, Catania University, Dipartimento di Scienze della Formazione, Via Biblioteca, 4, 95124, Catania, Italy.

E-mail: giacomoborboneyahoo.it.