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A "Galilean Philosopher"? Thomas Hobbes between Aristotelianism and Galilean Science

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Abstract: The conventional portrait of Thomas Hobbes that emerged in twentieth century histories of philosophy is that of the quintessential mechanical philosopher, who openly broke with philosophical tradition (together with René Descartes). Hobbes's scholars depicted a more correct and detailed panorama, by analyzing Hobbes's debt towards Aristotelian and Renaissance traditions, as well as the problematic nature of the epistemological status that Hobbes attributes to natural philosophy. However, Hobbes's connection to modern Galilean science remains problematic. How and in what way did Hobbes take inspiration from Galileo? In this article, I analyze Hobbes's natural philosophy by addressing three topics: (1) his connection with some aspects of seventeenth-century Aristotelianism; (2) differences and analogies between Hobbes's and Galileo's epistemological approaches; and (3) the Galilean foundation of Hobbes's philosophy. Through this analysis I want to show in which sense Hobbes can be properly defined a "Galilean philosopher".

Keywords: Thomas Hobbes; Galileo Galilei; Marin Mersenne; natural philosophy; modern science; Aristotelianism

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1. Introduction: Hobbes's "Aristotelianism" and Conventionalism vs. Galileo's "Realism"?

Among the different topics and problems in the interpretation of Thomas Hobbes's natural philosophy, two have certainly aroused particular interest among scholars: (a) the relationship that ties up Hobbes to Aristotelian philosophy[1] [1–9], and (b) the problem (closely linked to the first point) of the epistemological status that Hobbes attributes to natural philosophy[2] [10,11].

Despite the undoubted influence that Aristotelianism exerted over Hobbes, he always professed his opposition to Scholasticism and, on the contrary, he celebrated his esteem for a thinker considered essentially anti-Aristotelian: Galileo Galilei. As it is well known, in his *De motu, loco et tempore* (or *Anti-White*) (1642–1643), Hobbes describes Galileo as "the greatest philosopher not only of our century, but of all time" [12] (X, 9, p. 178; Eng. Trans. [13], p. 123 modified), and in *De corpore* (1655), he claims that Galileo may be considered the true founder of physics for discovering the principles of the science of motion ([14], I, not pag.; Eng Trans. I, viii). In recent years, the relationship between Hobbes and Galileo—curiously neglected before—has been analyzed in detail and the Galilean legacy present in Hobbes's thought has been adequately valued[3] [8,9,15,16].

However, the comparison between Galileo and Hobbes poses a significant epistemological problem as Galileo's epistemological position seems to be, so to speak, diametrically opposite to Hobbes's. As a matter of fact, Galileo favors a "realist" conception of science, clearly distinguishing the figure of the "mathematical astronomer" from that of the "philosopher astronomer" (*Istoria e dimostrazioni intorno alle macchie solari e loro accidenti* (1612), Letter I, [17], V, p. 102)[4]. If the former can be satisfied by elaborating a purely mathematical and, therefore, conventional, and hypothetical description of the astronomical system, the latter must aim to discover "the true constitution of the universe," which "is,

and is in one way only, true, and impossible to be differently" (*Lettera a Madama Cristina di Lorena, Granduchessa di Toscana* (1615), [17], V, p. 316).

On the contrary, Hobbes clearly states—and does so on several occasions—that in the field of natural philosophy, the researcher must be content with elaborating hypotheses that no empirical evidence can refute[5] [18]. The main Galilean legacy found in Hobbes's philosophy is certainly the mechanistic conception of the universe, which is shared by both philosophers. Nevertheless, if we focus on their different epistemological approaches, it seems that Galileo and Hobbes had a different interpretation of mechanism: Galileo seems to support a "realist" conception of it; while Hobbes seems to consider, at first glance, the mechanistic view of the universe simply as the "most probable" hypothesis. Moreover, Hobbes would appear to be much more Aristotelian than Galileo (at least if we consider the interpretation of Aristotelianism emerged in the so-called School of Padua[6]) [6,19–25].

But is this really the case? Does Hobbes really follow Aristotelianism despite his stance against Aristotelian philosophy? How far does his epistemological position differ from Galileo's alleged "realism"? In this article, I will try to address these questions to show that things are much more complex than they seem: (1) Firstly, I will briefly examine some aspects of Hobbes's relationship with Aristotelianism, through a comparison with the Aristotelian philosopher closest to Hobbes, Marin Mersenne[7] [26]. (2) Secondly, I will examine Galileo's epistemological approach and his view of scientific method to compare them with those of Hobbes. (3) Finally, I will consider the Galilean foundations of Hobbes's philosophy to show in what sense he can properly be defined as a "Galilean philosopher". In doing that, I want to underline how, despite the undoubted differences, Hobbes absorbed and reworked some elements of Galileo's thought.

2. Syllogism, Natural Philosophy, and Skepticism in Hobbes and Mersenne

In his correspondence and in his main works, Hobbes consistently proposes a rather clear epistemological distinction between mathematics and physics, as it emerges from a letter sent by him to Sir Charles Cavendish, dated 1641. Here it is stated that the "mathematicall sciences" are absolutely certain, since they are entirely conventional and based on a "pact and consent among our selves." On the contrary, in the study of "naturall thinges," it is necessary to follow a hypothetical procedure, which allows us to *save the phenomena* (Hobbes to Sir Charles Cavendish, from Paris, [29 January] 8 February 1641, [18]; I, p. 83)[8] [27,28].

Evidently, Hobbes is not original when he proposes this distinction, since it dates back to the late Middle Ages. We find it, for example, in Robert Grosseteste, Roger Bacon and William of Ockham, as Aldo Gargani has already pointed out[9] [1,29]. Indeed, according to Grosseteste, natural philosophy had to keep to the limits of probabilism, while mathematics achieved certain and rigorous knowledge ([30], vol. I, t. II, fo. 10 v). Even Roger Bacon distinguished between mathematics and natural philosophy, but he underlined that the former constituted the primary science from which all other knowledge descended and depended ([31], pars IV, II, 1, vol. I, p. 108). The position defended by Hobbes in the dedicatory letter of *De cive* (1642) ([14], II, p. 137; [32], p. 74), as well as in Chapter 23 of *Anti-White* ([12], XXIII, 1, p. 270) seems to reflect Roger Bacon's aspiration to extend the geometric method to any domain of knowledge[10] [33,34].

Nevertheless, because of the hypothetical status Hobbes attributes to natural philosophy, his position could also be compared to that of the exponents of the so-called "mixed" or "constructive" skepticism, according to the definition coined by Richard H. Popkin, in his *History of Skepticism*[11] [35]. Indeed, Hobbes's scholar Arrigo Pacchi identified a convergence between Hobbes's hypothetical approach and that of Mersenne and Pierre Gassendi, figures that Popkin considered as two pillars of "mitigated skepticism"[12] [3]. On the contrary, Gargani disagreed with Pacchi, since he found a fundamental opposition between the epistemological positions of Galileo, Descartes, and Hobbes, on the one hand, and those of Mersenne and Gassendi, on the other. According to Gargani, for the former mechanism truly described the real constitution of the universe—since it represented a

means of reducing the sensitive qualities of the bodies to their objective and mathematically quantifiable elements—while for Mersenne and Gassendi, it represented only a descriptive and hypothetical model ([1], pp. 176–182). The interpretations of Pacchi and Gargani can both be considered correct, since they relate to two different aspects of Hobbes's scientific and philosophical thought. However, to understand the true worth of Hobbes's hypothetical attitude to science, it is important to carefully examine and compare his position with that of Mersenne. It is precisely this analysis that allows us to shed light on the level of certainty that any scientific discourse can reach.

Mersenne's position—according to which we can speak of real knowledge only when we master the proper foundations of a certain discipline—is shared by Gassendi (*Syntagma*, [36] I, pp. 122b–123a. See also ibid., 95a–95b)[13] [37,38] and by Hobbes too, who, in his *Anti-White*, models the distinction between *compositive* and *resolutive* methods on the dichotomy that separates certain knowledge, specific to mathematical knowledge, and the probabilism of natural philosophy ([12], XXX, 10, pp. 352–353). At the same time, as far as it concerns the origin and the source of all our experience, Hobbes shares Aristotle's empiricist approach[14], maintaining in *The Elements of Law* (1640) ([39], I, ii, § 2, p. 3), as well as in *Anti-White*, that it is "sufficiently accepted and familiar that there is nothing in the human intellect that was not previously in the sense" ([12], XXX, 3, p. 349, Eng. Trans., p. 364). This position recalls in fact the words of the "sceptic", one of the three characters of Mersenne's work, *La Vérité des Sciences* (1625) ([40], p. 149). In this text, Mersenne stated that the senses were the "couriers" and the "messengers" of reason, but, on the other hand, he also affirmed that it is not true that "the intellect does not know but that which comes through the external senses", because "it knows that air exists and a thousand other things that the senses cannot perceive" (ibid.).

If we compare this passage with a letter sent by Hobbes to William Cavendish of Newcastle in October 1636, significant analogies emerge. Hobbes emphasized the difficulty of empirically verifying phenomena such as *air* and *spirits*, which are for the most part exempt from direct observation[15] [18]. Therefore, in this case, we are forced to use a method based on demonstrative, deductive and aprioristic reasoning only, and to produce simple probable hypotheses around these phenomena. Hobbes explains this clearly in the incipit of *Tractatus Opticus II* (1640–1642). Here, he asserts that the conclusions reached in mathematics are certain because of the conventional and aprioristic character of this discipline, which is structured as a logical system, a priori, and deductive ([41], I, § 1, fo. 193 r, p. 147). On the contrary, in the field of natural philosophy, we can only produce hypotheses or assumptions (*hypothesis sive suppositio*). This idea would seem close to that held by Gassendi in his *Syntagma*, who emphasizes the need to stick to elaborating plausible hypotheses in the field of natural philosophy (*Syntagma*, [36], I, pp. 286a–286b)[16] [42] but we must follow Hobbes's argument, because an important element will emerge.

In his *Tractatus Opticus II*, Hobbes writes that when we conduct research upon an event that appears to our senses—what we usually call a phenomenon—we assume the existence of motions that are its efficient cause. However, it is possible that completely different motions produce effects that are, in fact, very similar. In this case, therefore, it happens that from an erroneous hypothesis is produced a demonstration that is completely correct from the formal point of view, but based on incorrect principles ([41], I, § 1, fo. 193 r, p. 147). Nonetheless, according to Hobbes, we should ask the natural philosopher for nothing more than to formulate plausible hypotheses, and this is not negligible (*Neque vero hoc parum est*). Indeed, if we can explain phenomena and uncover their possible causes, we can also master the effects of nature. This Baconian echo, also present in *Leviathan*, clearly indicates that according to Hobbes the goal of natural philosophy is to acquire a knowledge which allows us to master and modify nature for the benefit of humanity ([43], Chapter 5, pp. 74–75). There is, however, another important aspect that should not be overlooked; Hobbes recommends that hypotheses must be formulated about events perceptible to the senses, that is, about empirically observable phenomena[17] [44]. This implies that for Hobbes—despite the hypothetical connotations he attributes to scientific

research—empirical observation must necessarily be a fundamental part of science. This idea is reaffirmed in Hobbes's subsequent works, starting from his *Anti-White*.

However, in his *Objections* to Descartes's *Meditations*, as well as in *Anti-White*, and in *Leviathan*, Hobbes maintains a syllogistic conception of philosophy, describing it—in Chapter 16 of *Anti-White*—"as a faithful, correct and accurate nomenclature of things" ([12], XIV, 1, pp. 201–202. See also [12], XXX, 17, p. 357).

How might one reconcile this syllogistic conception of philosophy with Hobbes's hypothetical approach to natural philosophy? To answer this question, it is first of all necessary to investigate Hobbes's idea of syllogism, which was influenced by what Mersenne wrote on the same topic. Furthermore, it is important to also consider the foundations of Hobbes's gnoseology, which have their roots in his empiricist approach.

In his *La Verité des Sciences*, Mersenne—against the instances of skepticism—defended the use of syllogism as a correct means of reasoning ([40], p. 199). In Hobbes too, syllogism is of capital importance, but the English philosopher emphasizes that reasoning, as a rational process, has no connection with existing reality, because it consists only in a calculation of universal names: "philosophy is the science of general theorems, or of all universals to do with material of any kind, the truth of which can be demonstrated by natural reason" ([12], I, 1, p. 105). In other words, correct philosophical reasoning is just a syllogism devoid of any paralogisms. Hence, "reason is nothing but the faculty of syllogising, reasoning being merely a continuous linking of propositions, or their gathering under one head, or, to put it more briefly, the calculation of names" ([12], XXX, 22, p. 358, Eng. trans. [13], p. 377). To this syllogistic conception of philosophy, Hobbes links—exactly like Mersenne, in *La Vérité des Sciences*—a rigorously geometric method and insists on the notion of demonstration, specific to geometry, but which can be applied in every branch of knowledge ([12], I, 1, pp. 105–106).

Regarding the process of acquiring knowledge, Mersenne recommended the application of the *compositive-resolutive* method (proper to the Aristotelian tradition), in which he identified "two ways to learn the sciences (. . .) because analysis leads us so admirably from the summit of each science to the first principles, and the very simple elements, and the way of composition, (. . .) leads us so perfectly, and so certainly, from the first principles of sciences to their perfection . . . " ([40], p. 203). Mersenne's account of *compositio-resolutio* presents important similarities with that proposed by Hobbes in *Anti-White*, Chapter 30:

> If the progression indeed proceeds from the imagination of the cause to the imagination of the effect, and thus towards the goal (which is always the final effect), the mind's discourse is called *composition*, σύνθεσις; if, on the other hand, it proceeds from effect to cause and then to premises, it is called *resolution*, ἀνάλυσις. Both of these are called *reminiscence* (Lat.: *reminiscentia*). (. . .) If every time we imagine an end, the imagination followed the same order of means, proceeding from the cause to the effect, this very reminiscence of means suited to an end would be called art, and, conversely, if it proceeded from the effect to the cause, it would be called science of causes ([12], XXX, 10, pp. 352–353, Eng. trans. [13], pp. 368–369, modified).

The topic represents an evolution in Hobbes's thought and in *De corpore* he modifies his position, further proposing a joint application of the *compositio* and the *resolutio*. However, it is important to investigate Hobbes's gnoseology more deeply. In Chapter 7 of *Anti-White*, he reaffirms what he had already maintained in the *Elements*, namely that all our knowledge can have no other origin than sensory perception, and it is only through the perception of changes in the world surrounding us that we can study natural phenomena:

> So, it seems that the research method can be only one, namely that which begins from the variety of phantasies or images that are produced by the real things that act on the sense organs. Without these images, a stone or a man could [indifferently] investigate anything. Therefore, we say unchanged the things which appear in the same way as before, and changed the others. The mutation

> of things consists in this, that if the organs of sense remain unchanged, the same things nevertheless do not produce the same *species* or image in the mind. It therefore consists in some adventitious motion in the parts of the object ([12], VII, 1, pp. 145–146, my translation).

This passage presents some salient elements of Hobbesian gnoseology, but also tells us something important about its epistemological approach. In fact, Hobbes introduces an apparently extemporaneous comparison with the *stone*, arguing that, without the senses, we would be in the same condition as a stone, unable to have any interaction with natural phenomena. This comparison seems in itself anodyne and banal, but in fact it hides an important reference. This passage, indeed, echoes a similar passage of Michel de Montaigne's *Essays*, where the French author states that the senses "are our Masters" and that we could not have any knowledge without them. Montaigne writes that: "After all, we would have no more knowledge than a *stone* if we did not know that there exist sound, smell, light, taste, measure weight, softness, hardness, roughness, colour, sheen, breadth, depth. They form the foundations and principles on which our knowledge is built" ([45] II, xii, pp. 587–588 A/B, my italic). It is not coincidental that Hobbes refers here, as well as in other passages of the same work, to Montaigne[18] [46,47]. He is aware of the importance of Montaigne's reflections on the topic of gnoseology, since—through his rediscovery and enhancement of ancient skepticism—Montaigne has brought back the problems and challenges that skepticism poses to every theory of knowledge and, more generally, to philosophy itself. As it is well known, Mersenne had embarked on a sort of battle against radical skepticism, admitting the plausibility and applicability of a moderate form of skepticism (see [48]). According to some scholars, Hobbes himself had also been "recruited" by Mersenne in his fight against extreme Pyrrhonism (see [49]). However, Hobbes evidently feels the need to go directly to the source and confront the modern skepticism of which Montaigne was the greatest interpreter. In the quoted passage, Hobbes argues in fact that the empirical world must always be the starting point, but also the arrival point, of every speculation on nature, since it is precisely the comparison with empirical data that gives solidity and foundation to our cogitations. Not surprisingly, in Chapter 26 of *Anti-White*—despite his appreciation of the a priori and syllogistic dimension of geometry—he states that "for someone to prove that something exists, there is need of the senses, or experience" ([12], XXVI, 2, p. 309; Eng. trans. [13], p. 305). In fact, "even so, the demonstration is not thus established" (Ibid.)[19] because our senses are inevitably potentially deceptive, and yet, we have no choice but to trust them to study nature.

As is well known, the idea of a direct, sensitive knowledge of the natural world is one of the cornerstones of Galileo's natural philosophy. Indeed, on the one hand, Galileo evokes the image of the book of nature, arguing that in order to decipher it, it is necessary to know the mathematical language in which it is written (See Galilei, *Il saggiatore*, [17], VI, 232)[20] [15,50]. On the other hand, however, the Italian scientist continually insists on the need to know this book of nature through the senses.

How do these two ways of knowledge interact? And, moreover, what influence did Galileo's epistemological approach have on Hobbes? To answer these questions, it is necessary to briefly analyze Galileo's conception of scientific enquiry and his epistemological approach, to compare it with Hobbes's.

3. Galileo's Epistemological Approach, and Its Influence on Hobbes

For a long time, historiography on Galileo concentrated on the debate dedicated to his "Platonism", and the widespread acceptance of Alexandre Koyré's thesis obscured the feature of scientific realism present in Galileo's thought [51]. In the second half of the twentieth century, however, Galileo's scholars showed the limits and partiality of Koyré's interpretation[21] [52–57], also underlining Galileo proximity to some elements of Aristotelian philosophy[22] [20,22]. Nevertheless, it is important to emphasize that Galileo departs significantly from both the Platonism of the sixteenth century and the School of

Padua (see [58]) and, as Maurice Clavelin pointed out, "there are many texts in which Galileo affirms an unequivocal realism" ([59]; p. 29 note).

This idea recurs throughout almost all of Galileo's writings, in his *Copernican Letters* (Galilei, *Lettera a Madama Cristina di Lorena, Granduchessa di Toscana* (1615) [17], V, p. 316), and especially in the *Dialogue*, where he expresses the same idea in a particularly significant passage in which he distinguishes knowledge in the field of humanities from scientific knowledge:

> If what we are discussing were a point of law or of the humanities, in which neither true nor false exists, one might trust in subtlety of mind and readiness of tongue and in the greater experience of the writers, and expect him who excelled in those things to make his reasoning most plausible, and one might judge it to be the best. But in the *natural sciences*, whose conclusions are *true* and *necessary* and have nothing to do with human will. One must take care not to place oneself in the defense of error; for here a thousand Demostheneses and a thousand Aristotles would be left in the lurch by every mediocre wit who happened to hit upon the truth for himself (*Dialogo sopra i due massimi sistemi*, [17], VII, p. 78, Eng. trans. [60], pp. 53–54, my italic).

According to Galileo, in natural sciences the conclusions to which we arrive are true and necessary, and are not subject to any error or doubt. He seems to apply the same epistemological criteria to natural philosophy that some late medieval philosophers and the exponents of the Aristotelian School of Padua had attributed to mathematics. As he states in a very famous passage from *The Assayer*, Galileo is convinced that nature is a book and that to know it, it is necessary to learn the characters in which this book is written, that is, *mathematics* (*Il Saggiatore*, [17], VI, p. 232). Mathematics is the basis of Galilean mechanism: it allows, in fact, to apply objective measures to the natural world and to analyze it through the physical laws of motion, which are mathematically expressed, too. According to Galileo, moreover, the universe was written directly by God in mathematical characters, and we can potentially reach an absolutely certain knowledge of it, comparable in this respect to that of its Creator (*Lettera a Madama Cristina di Lorena,* [17], V, p. 316).

However, one might wonder what is the method that, according to the Pisan scientist and philosopher, allows us to acquire this knowledge of the natural world? Galileo tackles this topic several times in his works and argues that the methodology of scientific research must be based on two fundamental pillars, namely the "sensible experiences" and the "necessary demonstrations" (ibid.) [17].

With the expression "sensible experiences" Galileo refers to two things: (a) the empirical observations that underlie the hypotheses we elaborate on the natural world; and (b) the empirical experiments that allow us to ascertain whether our scientific assumptions about this natural world are correct. The notion of "necessary demonstrations", instead, is linked to the "rationalist" aspect of Galileo's thought. With this wording, Galileo denotes the mathematical demonstrations, which are in fact necessary, because they are based on an a priori formal logical-deductive structure, that guarantees them a status of certainty and consequential necessity.

But how do "sensible experiences" and necessary mathematical demonstrations combine? Is there a pre-eminence of the empirical element, or of the rationalist one in Galileo?

It is very difficult to give a univocal answer to these questions, because sometimes Galileo seems to stress the necessity and pre-eminence of theoretical, rational, and mathematical processing[23] [17]; but in other places, on the contrary, he affirms that "among the safe ways to pursue truth is the putting of experience before any reasoning" (Galileo to Fortunio Liceti, 15 September 1640, [18], XVIII, p. 24, Eng. trans. [61], p. 409).

This opposition reaches a dialectical synthesis in the *Dialogue*, where Salviati—the spokesman of Galileo's opinions—expresses his opposition to the apriorism of Simplicio (the Aristotelian character). Simplicio affirmed that Aristotle developed his demonstrations essentially a priori, but Salviati felt the need to correct his interlocutor and reiterates the importance of empirical analysis, which is linked to the "resolutive method":

> What you refer to is the method he uses in writing his doctrine, but I do not believe it to be that with which he (i.e., Aristotle) investigated it. Rather, I think it certain that he first obtained it by means of the senses, experiments, and observations, to assure himself as much as possible of his conclusions. Afterward he sought means to make them demonstrable. That is what is done for the most part in the demonstrative sciences; this comes about because when the conclusion is true, one may by making use of analytical methods hit upon some proposition which is already demonstrated, or arrive at some axiomatic principle; but if the conclusion is false, one can go on forever without ever finding any known truth—if indeed one does not encounter some impossibility or manifest absurdity (Galilei, *Dialogo sopra i due massimi sistemi del mondo*, [17], VII, p. 75. Eng. trans. [60], p. 50).

Ultimately, Galileo argues that comparison with the empirical data must always be the yardstick for evaluating the correctness of our hypotheses and demonstrations, but at the same time, he underlines that an absolutely certain knowledge of the natural world is possible only through the application of mathematics to the book of nature.

Galileo is, however, also well aware that it is not possible to always obtain absolutely certain empirical confirmations of our hypotheses. This is particularly true for what concerns stars and planetary motions, areas of investigation in which it is difficult to make accurate observations, and it is even impossible to carry out empirical experiments.

In the opening of the *Discourse on Comets* (1619), through the pen of his student, Mario Guiducci, Galileo maintains that we can argue "not affirmatively, but only *probably* and *dubiously*" and we can produce only "conjectures" about particular astronomical phenomena such as comets (*Discorso delle comete*, [17], VI, p. 47, my italics). In *The Assayer*, Galileo reiterates the doubting, undogmatic nature of his speculations and those of Guiducci, concluding that the researcher of natural phenomena is sometimes precluded from a certain, objective knowledge of reality, and in such cases, must state a mere hypothesis, determining only one of the possible causes of the phenomenon (*Il saggiatore*, [17], VI, p. 279). This topic recurs on the first day of the *Dialogue*, where Galileo writes that we cannot be sure about the real cause that has produced a certain natural phenomenon, because "there are more ways known to us that could produce the same effect, and perhaps others that we do not know of" (*Dialogo sopra i due massimi sistemi del mondo*, [17], VII, 124. Eng. Trans. [60], p. 99). Regarding this idea, an argument made by Sagredo is very interesting. He affirms that he does not know if "herbs or plants or animals similar to ours are propagated on the moon, or that rains and winds and thunderstorms occur there as on the earth; much less that it is inhabited by men" (Ibid., [17], VII, 86). He also confesses his ignorance about the natural processes that can occur over there and, finally, he recognizes that:

> (. . .) thus, and more so, might it happen that in the moon, separated from us by so much greater an interval and made of materials perhaps much different from those on earth, substances exist and actions occur which are not merely remote from but completely beyond all our imaginings, lacking any resemblance to ours and therefore being entirely unthinkable. For that which we imagine must be either something already seen or a composite of things and parts of things seen at different times; such are sphinxes, sirens, chimeras, centaurs, etc. (Ibid., Eng. trans. [60], p. 61).

In Chapter 7 of *Anti-White*, Hobbes quotes almost literally this argument, also referring to *chimeras* and *monsters*, specifically arguing the difficulty of providing exact, accurate observations in some realms of natural philosophy:

> Therefore, body or *materia prima* can be changed, and its parts moved in innumerable ways; and by means of motion of this sort it can arouse innumerable phantasms (*phantasmata*) in the minds of the percipients. i.e., numerous kinds of images. Granted that is impossible to know what motions the separate particles of the whole world have, it follows that we cannot know how many varieties of things there are and hence *whether or not there are in the heavens bodies like ours*. It

> may be there are; it may be that all the *chimeras* and *monsters of human imagination have their counterparts in the heavens; it also may be that there is not in the heavens any heavy or light object, any man or animal or tree*. As being in fact the things we cannot know at all, because they do not work on our senses from so great a distance ([12], VII, 4, pp. 147–148 Eng. Trans. [13], p. 81, modified)[24].

Hobbes evidently grasped the probabilistic aspect of scientific research, also present in Galileo, and insisted especially on this dimension of natural science. Therefore, despite the due differences, the epistemological approaches of Hobbes and Galileo are not so antithetical, as it might seem at first glance[25] [62,63]. However, there is no doubt that scientific probabilism is much more pronounced in Hobbes than in Galileo. Furthermore, it should be noted that Hobbes, in order to emphasize the probabilistic element of natural philosophy, uses a term that may result problematic: that of *opinion*. The concept of opinion is problematic because with this term Hobbes defines both the hypotheses that we develop in natural philosophy, as well as the unverified (and sometimes irrational) ideas that men form, and which depend mostly on the trust they have towards the source of these ideas.

Already in the *Elements*, Hobbes describes *opinion* as a supposition that is held to be true, either because of defective reasoning, or because of our reliance on the source from which this information comes ([39], I, vi, 6, p. 26). In contrast, knowledge defined as *science*, or "evidence of truth", results "from some beginning or principle of sense" and these principles must be properly linked together to form syllogistic reasoning ([39], I, vi, 4, pp. 25–26). A similar division is repurposed in *Leviathan* ([43], Chapter 7, pp. 98–100), but in this work the discourse becomes more complicated and sophisticated. Indeed, in Chapter 5, Hobbes makes another distinction between *science* and *prudence* ([43], Chapter 5, pp. 72–77), and in Chapter 9, he also differentiates the "knowledge of fact" from logical-consequential knowledge, which is the result of logical-deductive reasoning. "The former is nothing else, but Sense and Memory, and is *Absolute Knowledge*; as when we see a Fact doing, or remember it done; And this is the Knowledge required in a Witnesse. The later is called *Science*; and is *Conditionall*" ([43], Chapter 9, p. 124). Here, Hobbes proposes a radical dichotomy between *history* and *science*, stating that any form of science is necessarily consequential, as a result of rational, logical-deductive knowledge. It is not coincidental, therefore, that in the field of "naturall philosophy" he includes *geometry*, *arithmetique*, *astronomy*, *optiques*, *musique*, and *astrology* too (as a science of "Consequences from the *Influence* of the Starres" [43], Chapter 9, pp. 130–131), those sciences that were defined at that age as "mixed mathematics"[26] [64]. On the contrary, "*Naturall History*,"—"which is the History of such facts, or Effects of Nature" ([43], Chapter 9, p. 124)—is excluded from the realm on natural philosophy.

It is interesting to remark, however, that the Latin version of *Leviathan* (1668) attenuates this dichotomy, insisting rather on the distinction between *natural* and *civil*. There are indeed *natural* philosophy and history (which deal with *natural bodies*), as well as *civil* philosophy and history (whose object are civil or political bodies). Moreover, Hobbes stresses here the joining element that collects natural and political philosophy, and that is the foundation of philosophy itself, the concept of *body*:

> The most general of the subjects of science is body, the two accidents of which are magnitude and motion. So the first thing required of a philosopher on this subject is to say what magnitude is, and what motion is. And this part of philosophy is commonly called "first philosophy" ([43], p. 125, Eng. Trans. by Noel Malcolm).

The unifying element of philosophy must be identified in the notion of *body*, and in the two accidents to which it is subject: *magnitude* and *motion*. For Hobbes, all philosophy boils down to these principles, objective, mechanistic, and, as we will see, profoundly Galilean. Yet, an epistemological problem remains: to which domain does *physics* belong then? Indeed, in *Leviathan*, Hobbes places it in the sphere of natural philosophy, but he summarily defines it, as the science of "Consequences from *Qualities*" ([43], p. 130). The definition of physics is instead much more accurate in *De corpore*, Chapter 25, where Hobbes

describes it as "the science" that "hath its principles in the appearances of nature, and endeth in the attaining of some knowledge of natural causes" (*De corpore*, XXV, 1, [14], I, p. 335; Eng. Trans. [27], I, p. 388). In this chapter Hobbes insists—just like Galileo before him—on the importance of applying the *resolutive* method in the field of physics, and this suggests how it can be properly included in the field of philosophy. The chain of causes, in fact, is always the same, whether one proceeds from causes to effects (with the *compositive* method), or, in reverse, from effects to causes (with the *resolutive* method).

However, the most comprehensive answer that Hobbes has provided on this subject can be found, in my opinion, in *De homine* (1658). In Chapter 10, he refers, in "Ockhamist" tones, to the hypothetical feature of our speculations on the natural world, but argues that even in this context it is possible to produce *demonstrations*. Yet, "this kind of demonstration is called *a posteriori*, and its science, *physics*".

And since one cannot proceed in reasoning about natural things that are brought about by motion from the effects to the causes, without a knowledge of those things that follow from that kind of motion; and since one cannot proceed to the consequences of motions without a knowledge of quantity, which is geometry; nothing can be demonstrated by physics without something also being demonstrated a priori. Therefore physics (I mean true physics), that depends on geometry, is usually numbered among the mixed mathematics (*De homine*, X, 5, [14], II, p. 93, Eng. Trans. [65], p. 42).

Hobbes does not assert the need to apply only an aprioristic research method in the field of natural philosophy. Rather, he underlines that it is sometimes impossible to find the causes of certain phenomena, which are inaccessible to the eye of the investigator[27] [10]. However, we must also remember that in "natural things", that is to say, those things "that are brought about by motion", it is impossible to use a posteriori reasoning, "without a knowledge of those things that follow from that kind of motion". At the same time, one cannot arrive at the knowledge of the consequences of these motions without mastering the science of quantities, namely *geometry*. Therefore, Hobbes always considers necessary the a priori demonstration, that is to say the mathematical-geometric demonstration, because it is impossible to master the great variety of motions without the science, which measures sizes and figures. In other words, he maintains that physics must necessarily be based on the geometrization of nature, namely the research method based on mathematics, which has in Galileo its master and its founder. Indeed, it is not coincidental, that in Hobbes's thought the foundations and objects of geometry and physics largely coincide: the objects of philosophy are exclusively bodies (*De corpore*, I, 8, [14], I, p. 9), and the principles of which Hobbes calls first philosophy exactly reside in the motions of these bodies (ibid., VI, 5, [14], I, p. 62)[28].

Hobbes thus seems to hold to Galilean positions with regard to the geometrization of the world and the application of mathematics to nature. However, it remains to be seen how Hobbes believes to apply geometry to physics. Why and how are physical entities measurable? This question evidently calls into question Hobbes's mechanistic conception of the world and, therefore, his conception of philosophy in general. What status does Hobbes attribute to his mechanism? Is it itself a hypothesis, or does it have certain, metaphysical foundations? To address this question, it is necessary to examine the basis of his mechanistic conception of the world, starting from the first principles that—according to Hobbes—rule nature, and, consequently, also our knowledge of it. From this investigation we can understand how and in what way Hobbes can properly be defined as a "Galilean philosopher".

4. Hobbes's Galilean First Philosophy

In his *Das Erkenntnisproblem in der Philosophie und Wissenschaft der Neueren Zeit* (The problem of knowledge in modern philosophy and science) (1906–1920), Ernst Cassirer highlighted the problematic nature of Hobbes's mechanistic materialism. Indeed, according to Cassirer, the hypothetical epistemological position Hobbes holds regarding natural philosophy inevitably leads to a reduction of the scope of his materialism, which cannot

be defined as properly "metaphysical" ([66], II, p. 46 ff.). This topic was taken up and discussed again[29] [11,67,68], but to correctly address this problem it is opportune to analyse the principles that, according to Hobbes, are the foundation of the empirical world. In fact, Hobbes repeatedly proposes a form of radical materialism that reaches its peak in his Objections to Descartes, with the corporatization of the mind (*Objectiones*, Objectio IV, [3], V, p. 258)[30]. However, this materialism must be reconciled with a phenomenal approach, according to which the existence of substance itself can be inferred only through rational conjecture.

In *De corpore*, Hobbes solves this dichotomy, by developing a correlation between the concept of *phantasma* (*De corpore*, XXV, 9, [14], I, pp. 325–327) and a particular theory of the *accident* (Ibid., VIII, 2, [14], I, pp. 91–92). On the one hand, he deprives the sensitive qualities of the bodies of any ontological reality, describing them exclusively as the *phantasmata* of the subject, and, on the other hand, by defining the accident as "*concipiendi corporis modum*" ([14], I, p. 92), he identifies in fact the concepts of *accident* and *phantasm*. Paganini emphasized the influence of modern skeptical tradition—especially of Mersenne and Gassendi—in Hobbes's development of phenomenalism[31] [16,69]. However, Hobbes's speculation compared to Mersenne's, has a greater theoretical development of the first, fundamental principles of philosophy. Indeed, in his account of accidents, Hobbes distinguishes between accidents that can be born and perish independently from the body's existence, and those without which the body could not even be conceived (and not even exist), such as *extension* and *figure* (*De corpore*, VIII, 3, [14], I, pp. 92–93)[32] [70].

In defining the "essential" accidents of the bodies, without which the body cannot even be perceived, Hobbes evidently had an illustrious predecessor, whom he follows: Galileo. In *The Assayer*, Galileo maintained that only certain qualities could be considered "essential" to the bodies; others are "mere names" and have a purely subjective dimension. He also specified that these elements are: "shapes, numbers, and slow or rapid movements" (*Il Saggiatore*, [17], VI, p. 350).

The reduction of bodies' secondary qualities to the action of motion on the sense organs of the perceiver is evidently present in Hobbes's works as well, starting from the *Elements*, and also in the nearly coeval *Tractatus Opticus I* (See [39], I, ii, § 4, p. 4; Ibid., § 10, p. 7; Id., *TO I*, [14], V, pp. 220–221). The question is returned to in *Anti-White*, where Hobbes proposes an analysis of the concepts of *body* and *accident*:

> There being two classes of things, one of which Aristotle called tò 3n, i.e., *ens*, and the other tò eînai, that is *esse*, we cannot conceive of a passage from the first, i.e., *ens*, to *non-ens*. Hence, as every philosopher believes, the entities (*entia*) do not, by reason of a natural or ordinary virtue, decay absolutely (. . .). Hence there can be created and there can perish completely not the entities (*entia*) themselves but the acts, forms and accidents which distinguished them from other beings ([12], XXXV, 1, pp. 387–388; Eng. Trans. [13], p. 422, modified, my italics).

According to Hobbes, the body must be conceived as "that which has dimensions or which occupies an imaginary space" ([12], XXVII, 1, p. 312), and this idea is inextricably linked to that of *matter*. Indeed, he considers body and matter as "names of the same thing, but interpreted in different ways. When considered *simpliciter*, an object that exists is termed *body*, but when considered as capable of assuming a new form or a new figure is called *matter*" (ibid., my italics). However, matter, that has no determination of its own, is defined by certain attributes or particular characteristics: the *accidents*, the second type of elements that Aristotle mentioned, distinguishing between entity (*ens*) and being (*esse*). This latter kind of conceptual reality is fundamental because it is what allows us to conceive the singular entities: the bodies, with their determination. However, "accidents, essences, and forms, (corporeity excluded) are produced and perish every day" (ibid.) and they are, therefore, the transient properties of the one matter. In fact, in *Anti-White*, Hobbes seems to restrain the entirety of the primary qualities of bodies as conceived by Galileo into a single quality: corporeity. However, in a draft of *De corpore* from about 1644, he develops a more

complex solution to the problem, by proposing a distinction between two very different kinds of accidents:

> Aristotle's definition (*Accidens inest in subjecto non tamquam pars sic tamen ut sine subjecti interitu abesse potest*[33]) is right save that some accidents may not be from the body without the destruction thereof, for a body cannot be conceived without *extension* and *figure*. Other accidents which are not common to all bodies but proper to some as rest, motion, colour, hardness etc. do continually perish, others succeeding, so as the body never perishes (*De Principiis* (National Library of Wales, Ms. 5297), Appendix II, in [12], p. 452, my italics).

Hobbes affirms that only matter persists despite any modification, or even destruction, to which a body is subject and, according to Aristotelian philosophical tradition, this matter is called *first matter* (ibid.)[34]. Accidents are not truly contained in bodies; however, the mutation, or change, of a body is evidently determined by the existence or absence of certain accidents. Indeed, there are some accidents that cannot be removed through a process of abstraction, without simultaneously conceiving the body's destruction. These accidents, that Hobbes identified as being completely inseparable from the body, are *extension* and *figure*: two of the qualities that Galileo gave in *The Assayer* as essential qualities of bodies.

The relationship that Hobbes establishes between the concept of body and the two accidents of extension and figure is fundamental to his philosophy. Indeed, these accidents, determine the existence of the bodies and allow the application of an essential concept of Hobbes's mechanistic conception of the universe: the concept of *cause*, which serves as a bridge between the universe of perception and phenomena, and the material reality that populates the natural world[35] [71].

Moreover, already in Chapter 27 of *Anti-White*, Hobbes makes the notions of *entity* and *body* coincide, writing that "*ens* is everything that occupies space, or which can be measured as to length, breadth, and depth. From this definition it appears that entity (*ens*), and body are the same thing (. . .) body is that which has dimensions, or which occupy an imaginary space" ([12], XXVII, 1, 312, Eng. Trans. [13], p. 311 modified, my italics). This definition of the body as such that can take up an imaginary space—which returns in Chapter 8 of *De corpore* (*De corpore*, VIII, 1 ff., [14], I, p. 90 ff)—is evidently very important. The condition of the object that occupies an imagined space is what makes the body itself thinkable, because this is what allows it to be distinguished from the first matter, and therefore serves as a *principium individuationis*. Moreover, "the extension of a body is the same thing with the magnitude of it, or that which some call real space" and "this magnitude does not depend upon our cogitation, as imaginary space doth; for this is an effect of our imagination, but magnitude is the cause of it; this is an accident of the mind, that of a body existing out of the mind" (VIII, 4, [14], I, p. 93, Eng. Trans. [27], I, 105).

This statement has a fundamental significance in Hobbes's philosophy, since it explains quite clearly two things: (1) on the one hand, it lets us understand that Hobbes's mechanism applies to an external reality, outside of us, which is material and does not depend at all from our mind; and (2) on the other hand, it also allows us to understand that our thoughts, or *phantasmata*, about the external world, are produced mechanically, and they therefore have a real equivalent in the world. All this is possible, however, only thanks to the existence of some fundamental accidents that: (a) allow the existence of bodies; (b) determine the notion of the body in general; and (c) allow us to think the bodies themselves. Hobbes was able to apply these philosophical concepts thanks to the work of Galileo who, before him, had conceived the existence of objective and primary qualities of the bodies. Galileo shaped a mechanistic image of the universe, which was inherited by Hobbes, and which had a great fortune in seventeenth-century natural philosophy. This is, I claim, the reason Hobbes celebrates Galileo as the greatest philosopher of all time, and which allows us to define him properly as a "Galilean philosopher".

5. Conclusions: Galileo, Hobbes and Early Modern Mechanical Philosophy

As we have seen, the three topics analyzed in this article: (1) Hobbes's interpretation of Aristotelian method; (2) the comparison between Galileo's and Hobbes's epistemological approaches; and (3) the foundations of Hobbes's first philosophy, all lead us to remark on the deep influence exercised by Galileo on Hobbes's thought.

Hobbes was certainly influenced by ancient and Renaissance Aristotelianism, but he certainly felt closer to Galileo. It is well known that in the dedicatory letter of *De corpore*, he described Galileo as "the first that opened to us the gate of natural philosophy universal", because before him and Harvey "there was nothing certain in natural philosophy but individual experiments, and *natural histories*" ([14], I, not pag.). Hobbes's scholars have often interpreted this eulogy in merely rhetorical terms, neglecting the reason Hobbes gives to support this statement. Moreover, since the time of the important research by Lasswitz and Brandt[36] [67,72], indeed, scholars have focused more on specific aspects of Galileo's influence on Hobbes, and they actually discovered important Galilean legacies in Hobbes's scientific thought. However, the topic of Galileo's influence on the foundations of Hobbes's philosophical system has very rarely been addressed, and even if it has been, often in passing. This is, to some extent, not surprising after all, since even the debate on the figure and the legacy of Galileo is still open.

In recent years, scholarship correctly underlined that the image of Galileo as the champion and the sole founder of modern science is, in large part, a legend. Unfortunately, this realization ended up overshadowing the real contribution Galileo offered to early modern philosophy. Galileo sometimes is (surprisingly) described as extraneous to mechanism[37] [73], but if we focus on Hobbes's interpretation of his work we can correctly understand how, and in which way, Galileo has been read by one of the most important early modern mechanical philosophers.

Why, in the quoted passage of *De corpore*, does Hobbes maintain that Galileo must be considered as the true founder of physics? Because through his work he allowed the application of mathematics to natural phenomena, and, according to Hobbes, thus laid the basis for founding this discipline philosophically. Galileo's work has an even deeper and more important meaning for Hobbes, because his philosophy is entirely founded, as we have seen, on Galilean principles: on the concept of *body* and on those *accidents* that determine it. Recognizing that is fundamental, not only in order to arrive at a correct interpretation of Galileo's influence on Hobbes's philosophy, but because it also offers interesting insights into a correct analysis of Galileo's legacy in early modern philosophy.

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Notes

1 Aldo Gargani identified analogies between Hobbes and some exponents of the sixteenth-century Paduan Aristotelianism, especially Agostino Nifo and Jacopo Zabarella. See [1] (esp. pp. 32–51) esp. 32–51. See also [2] (p. 52 ff.); [3]. In recent years, Hobbes' relationship with Aristotelianism has been investigated in detail. See esp. [4–6] (pp. 184–195); [7,8] (esp. p. 48 ff.); [9].

2 On this topic, see esp. [10,11].

3 See [8,9,15]; and esp. [16].

4 Unless otherwise indicated, all translations are mine.

5 See for example Hobbes to W. Cavendish, Earl of Newcastle, from Paris, 29 July/8 August 1636, [18], I, p. 33.

6 On Paduan Aristotelianism see [20] (pp. 274–403); [21–23]. For a more recent and detailed analysis see [6,24,25].

7 Mersenne is to be considered an atypical Aristotelian philosopher, but he professed himself an epigone of the philosopher of Stagira. On this point see [26].

[8] See also Id., *Six Lessons*, [27] VII, pp. 183–184. See also [28].
[9] See [1], pp. 153–165. On Hobbes and Ockham see esp. [29] (pp. 85–93).
[10] On Hobbes' logic and his deductive method, see [33,34].
[11] See [35], pp. 129–150.
[12] See [3], p. 12 ff., p. 63 ff., and p. 179 ff.
[13] On Gassendi's epistemology see [37], esp. p. 89 ff.; [38].
[14] See Aristotle, *De anima*, III (Γ) 8, 432a. For the Latin expression: "*Nihil est in intellectu quod prius non fuerit in sensu*" see Thomas Aquinas, *Quaestiones disputatae de veritate*, q. 2, art. 3, 19.
[15] Hobbes to William Cavendish, Earl of Newcastle, from Paris, 29 July/8 August 1636, [18], I, p. 33.
[16] However, unlike Hobbes, Gassendi is sceptical about the possibility of founding a demonstrative science "*per causas*." See [42], p. 41 ff., pp. 68–70, p. 117, and p. 173.
[17] On the status of the hypothesis in Hobbes see [44].
[18] See [46], pp. 165-6, pp. 223–224, and 281–282. See also [47].
[19] " . . . for someone rigidly demanding the truth from people who says that Socrates lived or existed will tell them to add: 'Unless we have seen [Socrates's] ghost or spirit', or 'Unless we were asleep, we saw Socrates; so Socrates existed, etc'."
[20] See also [15]. On the topic of the book of nature in early modern philosophy see [50].
[21] See [53–58].
[22] On this topic see esp. [20,22].
[23] See for ex. Galileo to Pietro Carcavy, 5 June 1637, [17], XVII, pp. 90–91, and Galileo to Giovan Battista Baliani, 7 January 1639, [17], XVIII, pp. 12–13.
[24] See also [12], XXIV, 1, p. 289.
[25] Garber especially insisted on this difference. See [62], esp. pp. 107–114. See also [63].
[26] On mixed mathematics see [64].
[27] This point has been underlined by Jesseph. See [10], pp. 146–147.
[28] " . . . *causa enim eorum omnium universalis una, est motus; nam et figuram omnium varietas ex varietate orituur motuum quibus construuntur.*"
[29] The historiography on this topic is of course very broad, and goes from [67] to [68] and [11].
[30] " . . . *mens nihil aliud erit praeterquam motus in partibus quibusdam corporis organici.*"
[31] See [69], esp. 29–31; [16], p. 21 ff.
[32] See [70], esp. p. 75.
[33] *The accident is present in the subject, not however as a part, but rather (in the sense) that without the subject in which it is inherent, it could not be.* Hobbes refers to Aristotle, *Categories*, 1 a, 20–24.
[34] Cf. *Aristotle*, *De generatione et corruptione*, I, 5, 320b; Id., *Metaphysics*, E, 1029b.
[35] See [71].
[36] See [67,72].
[37] See [73], esp. pp. 13–15.

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