Przegląd Filozoficzny – Nowa Seria
R. 25: 2016, Nr 1 (97), ISSN 1230–1493

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Galileo and Contemporary Epistemology. Do we still have something to learn from Galileo's „methodological revolution"?*

Keywords: *G. Galilei, epistemology, idealization*

1. The revolution of ontology

It is a common belief of scientific historiography and philosophical discussion that the application of mathematics to the study of reality was the turning point that transformed „natural philosophy" into „natural science" and then into „mathematical physics". This is precisely the turning point usually attributed to Galileo, with his reliance on the analysis of pure quantitative ratios, of „geometric reasons"; therefore, it is maintained that his greatest contribution to the development of science was «his exemplification of the usefulness and success of the mathematical approach to nature» (Henry 2002: 25). To achieve this result it was necessary to subvert Aristotelism. Galileo accomplished this task by using Plato's ideas that were cleansed of contaminating esotericism, numerology and magic.

Part of the *communis opinio* of the time was the dividing line between Aristotle and Plato on the problem of the use of mathematics (Koyré 1966: 279). In effect, Aristotle and Plato founded their opposing conceptions of science on how to face the gap between matter and geometric figures, i.e.

* Many thanks to Christopher H. Tienken and Ruth Halstead for their help in revising and editing the original text.

nature and mathematics. The former claimed the inapplicability of a perfect tool as geometry to the intrinsically imperfect bodies of nature, both physical and celestial (see Aristotle, *Met.* II (α), 3, 995a, 15–20; *Met.* III(B), 2, 997b, 34–36/998a, 1–6), and this has an obvious echo in Simplicio's arguments (see Galileo 2001: 15). On the other hand, Plato targeted the application of geometry not to the physical nature in which man lives, but only to the perfect world of ideas, considering the issue of the relationship between mathematics and reality in a different way. Starting from the conviction that astronomy cannot be studied because the actual movement of the celestial bodies is imperfect, Plato allots this science to things that «are to be grasped by reason and thought, not by sight» as «this heavenly pattern is to be used as a set of examples or models, as a way of learning about the true patterns» (Plato, *Resp.*, VII, 529d). Geometry is therefore the science of ideal models; indeed, it is the science that enables us to know those ideas on the model of which sensitive bodies are forged (Plato, *Resp.*, VI, 510d-e). According to Plato, mathematics, and the ability to grasp pure, perfect models has a „polemic" function against the senses, that should not be accepted as they *prima facie* appear; otherwise, we would fall into the unmanageable flow of sensations and ever changing appearances, from which we could never extricate ourselves to find the sources of knowledge and the basis of science.

Therefore, there are two ways in which knowledge of the natural world is outlined. First, there is the thought of Aristotle (in astronomy followed by Ptolemy), which somehow inherits Protagoras' loyalty to common sense, to which he attempts to be faithful. Knowledge *par excellence* relies on definitions of the subject-predicate type, the terms of which are obtained by abstraction, conceived as a mere generalization from the sense data, to capture the essence of entities (*eidos*). This procedure ends up being nothing more than the transposition in the reign of the permanent and intelligible of what is obtained by generalization from qualitative common sense. It is precisely this conception of abstraction that is decisive and marks the separation from modern science, just as distinguished scholars such as Ernst Cassirer (1923: 6–26) or Pierre Duhem (1913: 195) have already indicated.

The other route is charted by Plato (subsequently continued by Archimedes and Eratosthenes), who, in opposition to the sense experience, claims that knowledge of the natural world can be only achieved by framing and adjusting it to the ideal models provided by ideas and in a mathematizing perspective. Plato criticizes the empiricist conception, according to which knowledge is „true opinion" (*doxa*) as it assumes that the concepts are *koiná*, derived from the comparison and contrast of sensitive objects, very different from ideas. It is the refusal to conceive of the scientific concept, science, as a result of the generalization of common properties from the experience that marks the separation between Plato and Socrates. Consequently, the valorisation of geometry is carried out as access to ideal entities, that are not „abstracted" from the sensitive forms, but they are the „model" of these (Such 2004: 39–40).

Galileo's ability to unite the perfection of mathematical tools with sensitive discreteness was the turning point; he avoided both the passive acceptance of sensory data in its qualitative richness as the Aristotelian school tradition, and the flight to the Hyperuranium in search of a perfection unattainable in this world, typical of the Platonic tradition. However Galileo picks up on the Platonic approach to mathematical tools, on condition of abandoning the initiatic and soteriological function of mathematics, thanks to the mediation of the Archimedean lesson (Dollo 2003; 2003b), implicitly recovering the scientific Hellenistic method (Russo 1996: 301); and on condition of disposing of the ontology of the perfect and ideal forms separate from the natural world in favour of a new ontology in which the mundane reality has its own autonomy and full intelligibility. Nature, freed from any mysterious entity and occult connection, shall be investigated *iuxta propria principia* and only regarding those aspects that could justify the utilization of mathematical tools. So Galileo believed there was a radical contrast and incompatibility between „the knowledge of the great book of nature written in mathematical characters" and the philosophical contemplation of ideas for which the initiatic use of mathematics was intended in the neo-platonic approach (Galileo 2008: 183). Now, «Mathematics, which for the ancient Greeks was irrelevant to the science of nature, insofar as mathematics concerns what is unchanging and the science of nature that which changes, has become nature's own language» (Macbeth 2014: 117).

However, Galileo's idea of nature as a mathematical book – as stated in the famous passage of *The Assayer* (Galileo 2008: 183) – cannot be conceived of as a kind of mathematical Platonism, that in some ways would group him with many mathematicians and philosophers that even in the twentieth century argued that the very nature of reality was made up of logical forms (beginning with Frege and Russell and finishing with Gödel). In my opinion, Galileo made this assimilation only as a methodical pace so as to justify the use of mathematics, not because he actually believed that the essence of reality was composed of geometric shapes: *if* you want to learn about nature, *then* you have to use the language of mathematics.

The metaphysical assumptions made by Galileo do not lie here. They rely on a necessary further preliminary move: freeing nature from all its accidents, simplifying it, reducing it to the bone, resigning oneself to the inability to grasp the world in its entirety and in all its forms and lush manifestations. For example, it is possible, by taking the decision to simplify the concept of „change", to decide to consider only the spatial „movement" of a body taken in its mere physical materiality, without worrying about its quality or its essence (Galilei 2008: 101). In effect, the hard core of the new Galilean metaphysics lies in the distinction between *primary* and *secondary* qualities, thanks to which a „corporeal substance or material" is reduced to shape, dimension, position, temporal collocation, motion or rest, contacts with other bodies and quantity; instead, tastes, odors, colors etc. «are nothing but empty names» (Galilei 2008: 185–187). Furthermore, knowledge through the senses is justified by a clear acceptation of Democritus' atomism (Galileo 2008: 188). In keeping with his vision of science, «primary qualities for Galileo were simply those qualities which are susceptible of being handled by mathematical and geometrical formulae» (Martinez 1974: 160). It follows that we must just limit ourselves «to gain information about some [...] properties», since the true essence of the earth and the fire or the sun and moon can be grasped only by intellection «when we reach the state of blessedness, not before» (Galilei 2008: 102).

This preventive *simplification* of the world allows the researcher to make a kind of ontological categorization and ordering of things in the natural world, claiming a series of aspects and properties as irrelevant to the scientific understanding of it: Galileo's metaphysical assumptions influence this simplification. The knowledge of the physical world is now conceived of in the context of a mechanistic and deterministic worldview, supported by Galileo even when it leads to false explanations (such as the theory of the tides) and that in later times has been strongly criticized (see e.g. Capra 1996: 17–35). On these basic assumptions, Galileo was regarded as the founder of a new «influential metaphysics» (Watkins 1958), which is summarized by the term „reductionism" and connotes the entire scientific enterprise of modernity (see e.g. Rifkin 2009; Capra & Luisi 2014; etc.). This „reductionism" also affects the type of explanation of natural phenomena with the elimination of all that is not attributable to the motion of material bodies and their interactions (from the change to the spatial movement, from the four Aristotelian causes to the only efficient cause) (Heisenberg 1984: 59–60). Clearly, all this leads to a drastic reduction of the complexity of reality and therefore to the sacrifice of diversity, that is, not taking into account certain aspects of reality that are deemed to be inessential. Therefore, we can say that at the beginning of the seventeenth century with Galileo, and then with Newton, the idea of simplicity continually reaffirms its presence over time and has ramifications to this day (Giordano 2013: 91). The fact that this „simplified" vision of the world is seen as a specific marker of modern science is also evident by the fact that in the epistemology of the twentieth century, it underlies one of the two basic requirements for scientific explanation, as classically canonized by Carl G. Hempel (1966: 47–49) in his „deductive-nomological model": the „explanatory relevance".

However, we must not confuse the epistemic level with the ontological one. Galileo said decisively that *if* science is to be done (and hence enable us to predict the phenomena of the natural world), *then* it must take as its privileged objects those objects that have physical size; however, this methodological assumption does not in itself imply a belief that the world as a whole is made only by mass and motion, following exact mathematically laws, and that nothing else in it should count; namely, that the science – *now and forever* – has to cover *only* the variables and phenomena by Galileo indicated as the only ones that can be treated mathematically. Galileo did not think the world was made up of mathematical entities (i.e. it is „platonic"), but simply considered that the physical world – and that alone – can be fully grasped by magnitudes and bodies as he conceived; that is, he thought that the only possible science of the *natural* world is material and comprises sizes, masses, movements in mechanical interaction, tractable in idealized and mathematically simple models.

However, the picture of the world built by Galileo was eventually accepted by science (with few exceptions) in a full metaphysical sense, bypassing the distinction between the epistemic and ontological planes and then imagining the *objects of* science (i.e., mass, motion and so on), as the *actual substance of* the world, its *ultimate* essence. That is the picture that took root with the so-called „classical science", and only with the scientific revolutions of the early twentieth century was it possible to challenge this framework.

Galileo built his new methodology on this basis.

2. The revolution of methodology

Simplification alone is not sufficient without a second move: simplified nature must now be radically *modified* to make geometric calculations applicable. In order to do this we no longer have to deal with rough, imperfect or soft spheres and surfaces, as done by an empirical investigation based upon common sense, but replace them with ideal spheres, perfectly smooth bodies, absolutely uniform motions. Therefore, we must develop concepts that cannot be the simple abstraction from experience, capturing its common properties, but rather constitute a counterfactual creation, in opposition to the everyday experience. In Galileo's views, science cannot consist in the simple registration and generalization of the phenomena, in all specialities of their unfolding, but should aim to capture the process in its pure form, free from random influences. As Amos Funkenstein (1986: 75) argued in his illuminating book, «The strength and novelty of seventeenth-century science, both theoretical and experimental, was in its capacity to take things out of context and analyze their relations in ideal isolation. It was a new form of abstraction, or generalization; and it was recognized by many who employed it as new, as the source of the advantage of the new science of nature over the old».

Nothing is more indicative of the breakthrough made by Galileo than the dispute between Simplicio and mathematical Salviati (impersonating the Italian scientist in the *Dialogue* and in the *Discourses*) (see Galileo 2001: 240–241). In contrast to the obstinacy shown by Simplicio with his adherence to the surface of the material world, the mathematician-geometer Galileo operated a kind of „bleeding" of reality, stripping its flesh. Because only by creating fictitious and ideals entities, and then going down from these, through experimentation and approximation, to the „roughness" of the experience, can mathematics and reality be joined.

This is the argument *ex suppositione* by Galileo defended in letters to P. Carcavy (in 1637) and G.B. Baliani (in 1639) (see Galilei 1964, I: 962), and which he presents in his most mature work, the *Dialogues Concerning two New Sciences*, responding to objections of the same tenor made by Simplicio. William A. Wallace (1981) was one of the first to underline the importance of this method *ex suppositione*. Discussing motion, Galileo admits that the conclusions demonstrated in the abstract are „altered" in the concrete; however, by appealing to the authority of Archimedes he justifies the unrealistic assumptions made by him *ex suppositione* both for the low incidence that they have in the calculation, and because the necessary corrections may be introduced to ensure that the calculations approximate the behaviour of real bodies. Only by proceeding through „poetic fictions" (such as assuming a perfectly circular motion that is always „equal", i.e. uniform) and through the creation of fictitious physical systems is it possible to do science (Galilei 1914: 252). Therefore, the argument *ex suppositione* involves creating unrealistic physical models, built by taking values and properties not empirically accountable and clearly counterfactuals, as happens when the motion of a projectile is studied (Galilei 1914: 250).

In this „new mental habit" lies the rationale of scientific revolution, i.e. «the willingness to accept counterfactual states as asymptotically approachable limiting cases of reality. The implicitly employed principle of inertia describes such a limiting case [...]» (Funkenstein 2005: 54). Of course, Simplicio argues against this way of proceeding, stating that the assumptions made by Galileo are all impossible (such as a horizontal plane «which slopes neither up nor down», the straight motion, etc.) and cannot be observed in reality, as «the motion cannot remain uniform through any distance»; or he does not see how «it is possible to avoid the resistance of the medium which must destroy the uniformity of the horizontal motion and change the law of acceleration of falling bodies». So these admissions «render it highly improbable that result derived from such unreliable hypotheses should hold true in practice» (Galilei 1914: 251). However, Galileo does not see these objections as an impediment to his approach, and he answers the questions posed by Simplicio, both observing that the instances and the contingencies of reality do not influence strongly the conclusions drawn via the deductions, and maintaining that it is possible to introduce the necessary adjustments to take into account the real conditions expunged thanks to the assumptions made *ex suppositione* (Galilei 1914: 251). Therefore, it is not necessary that Galileo assume the hypothesis as true (as in Finocchiaro 1980: 139), but in fact, he starts from the awareness of its falsity.

In short, 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 (Russo 2004: 75), 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 (Such 2004b: 11–36).

This Galilean procedure has been framed in a vision of science in which the concept of idealization carries out a central role, aimed «not simply to escape from the intractable irregularity of the real world into the intelligible order of Form, but to make use of this order in an attempt to grasp the real world from which the idealization takes its origin» (McMullin 1985: 248). Weisberg (2007) also maintains that «Galilean idealization» is intended to «the goal of simplifying theories in order to make them computationally tractable» and so it has largely a pragmatic justification: «theorists idealize for reasons of computational tractability». In effect – as Weisberg himself admits – the Galilean idealization can be also interpreted as the „minimalist idealization" supported by other scholars (Michael Strevens, Robert Batterman, Stephen Hartmann, Nancy Cartwright), i.e. «the practice of constructing and studying theoretical models that include only the core causal factors which give rise to a phenomenon. [...] a minimalist model contains only those factors that make a difference to the occurrence and essential character of the phenomenon in question». I think that also in Galileo there is the aim to capture the essential factors that are important in order to formulate the mathematical law (see Cartwright 2007: 223).

This attitude is typical of the Poznań School in Poland, that supports an „essentialist approach" to science, influenced by Marx and classical idealism, centered on the concept of idealization, which is the hub around which its methodological approach revolves. The Poznań School, making explicit reference to the Italian scientist since the early 1970s (Such 1973; more recently Nowak 1994; Nowak & Nowakowa 2000), conducted an accurate epistemological analysis of the history of science based on the assumption of counterfactual idealizing hypotheses and their subsequent concretization. So the theoretical construction of science was conceived as a radical modelling of reality, i.e. as its effective „deformation", in contrast to a factualist and descriptivist vision of science, that is rooted in much of the epistemological tradition forged by neo-positivism and essentially accepted even by its critics (e.g., by Popper and Feyerabend) (see Coniglione 2010; Borbone 2011). This kind of idealization is precisely the great methodological innovation of Galileo. It can address scientific problems (Ben-Ari 2005: 3; Falkenburg 2007: 42) making quantitative treatment possible: «no strict mathematical description of phenomena would be possible without idealizing procedures» (Such 2004: 39; see also Palmieri 2005: 345 and *passim*; for an opposite view see Cellucci 2013: 144–145).

But rather than dwell on the methodological and epistemological aspects of this idealizational approach (regarding this, see the texts already mentioned in the quoted books) let us make some further clarifications as to the distinction between simplification and idealization in the thought of Galileo.

3. Simplification and idealization

First of all, we think it is appropriate to pay due attention to the difference between simplification and idealization, which are sometimes assimilated, in the same way as abstraction and idealization are often assimilated, so that all these are often indicated using the same general label of „simplification", as in McMullin (1985: 248) and Morrison (2005). Jones (2005) distinguishes between abstraction and idealization, but then places both under the common and generic label of simplification. Nowak himself (1994) does not make this distinction, but rather admits (in the wake of an indication made by Hoover 1994: 43–53) a difference between „technical idealization" and „essentialist idealization": the former would be carried out in order to make a given phenomenon tractable mathematically or statistically, while the latter would serve to separate what is essential in it from what is secondary. However, these two types of idealization are both intended as „simplifications" (see Nowak & Nowakowa 2000: 134).

To put it in slightly more formal terms, if the universe of all entities *U* possesses *n* property (at the infinite limit), the classic operation of abstraction consists in the procedure of obtaining from *U* (by omission or by focusing on) a subset A of entities possessing a given property P, that is $A = \{x: P(x)\}$, where it is obvious that the complementary set is constituted by $A' = \{x: \neg P(x)\}$ so that the universe $U = A \cup A'$. To put it more simply, this means that if the set A includes all the entities characterized by possessing a colour, then those with white colour (that is, having the property of „whiteness") have as their complement A' „all things non-white" (and not „black": this would not be the complementary set, but rather the opposite; indeed black and white entities are not the universe U), so that the universe U is the set made up of white and non-white items.

However, in our interpretation of Galileo's procedure, simplification does not consist in this kind of abstraction, but in the fact of not taking the „whiteness" into account at all, so that the entities under investigation by him are neither white nor non-white; in other words, it is incongruous to apply a colour predicate to them, so it does not makes sense to ask what colour they are. While in the first case (one of abstraction) the space of the properties owned by the abstract object is the same as the object from which it has been abstracted, in the second case (the Galilean simplification) this area of properties decreases, so the universe of the entity on which simplification is made is different from the previous one. It is impossible to return to the universe U through a simple union of complementary sets (as we have seen instead is the case for „white things"), because the set of objects obtained for simplification has no complement. As we have already seen, this approach of Galileo can be found throughout his work, such as when he argues for refusing „to attempt the essence", limiting himself to investigating only „some affections" of objects; or when, operating the famous distinction between *primary* and *secondary* qualities, he limits the science to mere knowledge of the primary qualities; and so on.

We have to note that it is not important to eliminate aspects of reality that are considered *secondary* to the study of a given phenomenon, so as to grasp it in the „pure" state; this is what is done with idealization, e.g. it disregards air resistance, friction of a body on the inclined plane and so on (see the many examples of this type of factors in the works of Galileo). In this case, the factors which we know exert some influence on the observed phenomenon are „bracketed" and consequently disregarded because they are judged not to be the essential ones, but they belong to the same ontological furniture of the world admitted by Galileo; only the essential ones are supposed to enable us to achieve a mathematical formulation that is as exact as possible. As we shall see, the difference between simplification and genuine idealizations can be recognized by the fact that while the latter allow a procedure of „concretization" or – as McMullin (1985: 261) says – „de-idealizing", the former, simplification, is absolutely refractory to it: it would be impossible, without introducing a new worldview that would be completely orthogonal to the one established by Galilean science; a vision similar to that from which the Italian scientist freed science.

For further clarity, let me add that the simplification described here might look like what Robert Nola (2004: 356–361) meant by abstraction, but it does not. Abstraction is conceived by Nola as a kind of „clipping" the reality of the factors that are of interest to the individual subject areas: the physicist will be interested in the pendulum mass, length of wire etc., but not in its economic value or who owns it; rather, an economist would be interested in these. He then intends abstraction as an „abstract from", i.e. a „disregard" and claims that it has an epistemic character (we ignore certain properties of an object despite knowing that it has them), whereas the idealization would have, in his view, an ontological character (it is the claim that a certain object does not possess certain properties). Unlike this approach, here we understand abstraction in the classic empiricist sense, as a „take into account", i.e. taking into account the common properties, that actually exist, of a multiplicity of objects. Of course, the two kinds of abstraction procedures are more or less equivalent: „abstracting from" ends up focussing only on those properties that all the scrutinized entities have in common. However, our understanding of abstraction captures the original way in which it has been established since Aristotle. The abstraction of Nola, in our view, is nothing but a weakened simplification compared to Galileo's one that we described, and what might be called „instrumental" or „disciplinary", as it originates from the awareness – clearly present in Galileo – that it is not possible to have a „complete" explanation of nature or of any physical phenomenon, as it is anyway necessary to operate the „cuts" that delimit it as an object not only of a particular scientific discipline, but also of a particular scientific approach to certain phenomena. Moreover, it seems that Nola assumes the possibility that idealization is also made without awareness, since it implies that the scientist does not take into account certain properties of objects or of a physical system, „believing" that these properties are not actually present in them, that is proceeding in the conviction of having to deal with real systems. However, idealization without clear awareness of it – and then the fact that the objects described lack certain properties just because it *has been decided* not to take them into account – not only lacks historical evidence, but would preclude that methodical step well described by Galileo, i.e. the ability to regain the empirical ground and to approach the theoretical model to the experience by introducing the appropriate corrections. Finally, the fact that Nola admits to the possibility of carrying out erroneous abstractions, e.g. excluding certain characteristics that later would turn out to be rather relevant (as happened when the abstraction neglected the reference system in which the bodies move, as later seen with Einstein's special relativity) is admitted in the process of idealization, insofar as it is possible not to include some essential factors among the relevant idealizing assumptions. This is the case of gravity, assumed as a constant by Galileo and so considered to be a realistic factor, and therefore not included within the idealizing assumptions; or the case with so many other factors we do not know about, or that are not consciously considered in the modelling of a physical system but later turn out to be relevant to his explanation. This is precisely one of the ways that science develops according to the theory of „dialectic correspondence" elaborated within the Poznań approach (see e.g. Nowak & Nowakowa 2000: 135–136, 185–194, 251–258; Krajewski 1977; Nowakowa 1994).

Thus, it seems to me clear that the true difference between simplification and idealization is that the former does not admit approximation procedures or concretization for the simple fact that simplifications are not part of the formulation of the law, but are only implicitly or explicitly assumed to constitute the ontology of the world in which idealizations operate. Simplifications constitute a preliminary definition of „furniture of the world" which is the field cultivated by the scientist, who investigates certain types of objects about which it is entirely foolish to ask questions that, as Hempel would say, have no „explanatory relevance" (do not make sense, e.g., asking what influence colour has on the law of free fall). The procedures of idealization assume, then, the preliminary work of simplification.

In a nutshell, *simplification* is an ontological and metaphysical redesign of the world, which is at the basis of a general worldview, and characterizes a large temporal interval; it is the framework within which – to put it in Kuhnian terms – „normal science" is practised, and its break marks the scientific revolution, the birth of a new paradigmatic era; it is this that is Galileo's simplification of the world and *idealization* is its more appropriate methodology. *Abstraction* is the methodological character of Aristotelian science, appropriate for a qualitative worldview; so it is an obsolete conceptual tool, efficient only in a very near to surface knowledge of everyday experience and with a low degree of generalization; its break marks the threshold beyond which the mature science of Physics begins (Nowakowa 1976; Nowak & Nowakowa 2000: 136).

4. Beyond epistemological misunderstandings, finally

The fact that the Galilean approach to science has been undervalued in the epistemological debate of the twentieth century is due to the fact that the latter was too influenced by the so-called standard view. An example is the way in which its opponent Paul K. Feyerabend interprets the work of Galileo. In this case, we see not so much a lack of understanding of the method followed by the Italian scientist, but rather a caricature of it and a criticism leading as a backlash to the suggestion going back to Aristotle and, in an even more radical way, to the denial of those methodical aspects that founded the European rationality in the Greek world and then were incorporated within the scientific revolution. In this framework, the idealizing procedures of Galileo are not seen as the methodological turning point that led to the birth of modern science, but as a kind of perversion of intellect that has separated us from a true knowledge of nature.

In his works, Feyerabend discusses Galileo at length, reconstructing the argument in order to show how he violates all the inductive canons and rules of rationality established by philosophers of science – by the neo-positivists and above all by his great challenger Karl R. Popper. In fact, Feyerabend outlines the idealizing assumptions made by Galileo, that indeed replace the experience of the Aristotelians with an „unnatural" reality, with its „subversion", literally with «a new kind of experience that is not only more sophisticated but also far more speculative than the experience of Aristotle or of common sense. Speaking paradoxically, but not incorrectly, one may say that Galileo invents an experience that has metaphysical ingredients. It is by means of such an experience that the transition from a geostatic cosmology to the point of view of Copernicus and Kepler is achieved» (Feyerabend 1993: 75–76; see also 1971: 156 and *passim*).

However, Feyerabend's acknowledgement of the application of the idealization method does not go in the direction of its recognition as the genuine procedure of science, which triggered the age of methodological maturity, and therefore enabled us to have a new knowledge of nature, but as proof of the unnaturalness of science, of its systematic deformation and falsification of reality, of its being an intellectual trickery that removes man from true knowledge of the world. In his reading of Galileo, the continuous overlapping of the two levels we saw characterize his revolution is evident: the metaphysical-ontological and the methodological. The deformation procedures of the idealizational method are not distinct from the new worldview that justifies them, so they are inextricably linked to the metaphysical framework that underlies the Galilean design. Consequently, the vision of science to which they lead is radically challenged, to the extent that it replaces the real, true world, in all the multiplicity of its forms, with an artificial, „abstract" world.

This interpretation of Feyerabend emerges more clearly in his principal work, *Against Method*, and in his contemporary or subsequent writings, when the Copernican revolution and its method are treated as a sort of mental illness, to the extent that they turn us away from reality to elaborate mental constructions totally devoid of contact with reality, albeit coherent in themselves (Feyerabend 1983: 363). And in fact, the woodworm that eats away the attempt to catch the „wealth" of experience (either scientific or natural) from within is the process of abstracting, in which Feyerabend also includes what we have defined as idealization: it replaces the richness of nature and the spiritual world with naive models and poor abstractions (1983: 386).

Therefore, Feyerabend ends up supporting a view of nature that is different from that established by science, i.e. that of Greek culture before the advent of the rationalism of the great metaphysical systematisers. After all, the same experience as conceived by Aristotle – so criticized by Galileo – is an attempt to overcome the split between appearance and reality, to give reason to experience in some way, recovering typical instances of archaic tradition – trying to reconcile the abstract schemes of Parmenides and Plato with the richness of everyday experience (1983: 140). The peculiar character of Aristotelian science is, for Feyerabend, based on common sense, the validity of which he defends, which he does not do for modern science.

The merit of Aristotelian science, therefore, is not creating theories that move away from the experience, or that „deform" it, as in the case of the theory of motion; unlike Galileo's science, that simplifies the complexity of nature and creates a non-existent abstract movement, that of Aristotle «comprises all types of change, in living beings as well as in inanimate matter and that agrees with evidence of the most convincing kind» (1978: 146).

In short, Feyerabend's appreciation of Aristotle and the critique of science is based precisely on questioning the „new world" that Galileo had built and that becomes part of the imagination of all modern, „classic" science, i.e. reality understood in a reductionist, mechanical, quantitative, calculable way, from which all the properties that were deemed impossible to treat scientifically had been expunged. But Feyerabend – not distinguishing ontological background and methodological approach – attributes this new worldview only to an idealizational and abstractive process (for him, the two terms are equivalent), without realizing that the latter can generally preserve its validity also in a science no longer anchored to the same metaphysical presuppositions indicated by Galileo. Therefore, the new method, that for Galileo and his followers marked the epistemological break at the sources of modern scientific knowledge, is for Feyerabend the Achilles' heel that affects mankind's cognitive abilities. The inability to frame the Galilean science within the methodological criteria known to him makes Feyerabend blind to the genuine novelty of Galileo and thus pushes him to declare the failure of this type of science in favour of a more complete and authentic knowledge of nature.

However, there is an aspect of Feyerabend's critique that deserves to be taken seriously, although it can affect Galileo only in part, i.e. insofar as the Italian scientist endorsed the Platonist and Aristotelian idea that a *single* theory, with an unambiguous interpretation, should be a snapshot of the world, a faithful picture of reality. This aspect lies in the pluralistic vision of science maintained by Feyerabend, the one that led him to state that: «Historical traditions and theoretical traditions are both traditions in their own right, with their own laws, objects, research products and associated beliefs. Rationalism did not introduce order and wisdom where before there was chaos and ignorance; it introduced a special kind of order, established by special procedures and different from the order and the procedures of historical traditions» (1987: 118).

However, this pluralistic view is precisely what flows naturally from the Galilean conception that sees science as the conscious construction of idealized models of reality. If this approach is released from the underlying Galilean metaphysical vision and is included within a vision of reality and of knowledge in which the conceptualization of man makes „cuts" in the world to build models (mathematical or otherwise) that are operationally effective and manageable, then science can no longer be considered to be a monolithic and unidirectional enterprise, in which scientific theories succeed one another, the next incorporating and generalizing the previous, as is described in the standard conception of scientific change using the so-called „theory of reduction" (see Nagel 1977: 345–407). After all, the great methodology lesson of Galileo consists in the awareness of the need to know *what* to watch and *how* to see; but it must be separated from the naive adoption of reductionism, mechanism and determinism as a unique and universal methodology.

This awareness and the modelling methodology implemented by Galileo make it possible to establish a strong continuity between the classical science and the following one, up to the so-called „science of complexity", without invoking easy paradigmatic revolutions. This is because the knowledge of nature always involves «a series of cognitive choices targeted and active, fruits of a clever agreement between observation data and theoretical tools. Nature is never obvious, nor „already there"» (Licata 2015: 72).

Only in the second half of the last century, with the decline of the neo-positivist conception of scientific theories and the emergence of new theoretical perspectives, did the awareness of the idealized nature of science grow increasingly, especially among the protagonists of those investigations that fostered the „theory of complexity" (see i.e. Mandelbrot 1995: 6–7). The domains of experience which physicists have so far preferred not to talk about – and that Galileo put aside to build his science – can now be fully treated by other idealizational models that make other „cuts" on reality than those of classical science. It is another way to make the idealization, as explained by Prigogine & Stengers (1984: 229).

This is the heart of science identified by Galileo, not the metaphysical vision that underlies it. Scientific knowledge (as indeed *every* kind of knowledge that is not an immediate and mystical adherence to the totality of experience) constructs ideal objects that do not exist in nature as they are created solely for the purpose of applying mathematical equations to them. In short, scientific theories do not speak of nature, but of an idealized model of it: to exchange a model with nature and therefore believe that reality is made up of ideal gases, rigid body and so on would be a serious mistake and an epistemological conceptual confusion. This means swapping the plan of scientific theory for the ontological dimension, our *knowledge* of the real for the real as such. This is not, of course, the mistake made by Galileo in his methodology; indeed it was stated that his uniqueness lies in being able to find a balance between scientific practice and philosophical-methodological self-awareness (Such 2004: 37–38). Therefore, the Galilean aspect to overcome does not lie within his methodology, but concerns the preliminary simplification of the world he made, i.e. believing that the world made by mass and motion is only the legitimate and possible object of natural science, and that it is the only one that can be the subject of a true and reliable human knowledge.

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Abstract

In order to support his new science, Galileo Galilei criticized the Aristotelianism that permeated the science of his time, by endorsing Aristotle's traditional rival, Plato, read through the mediation of Archimedes, another scientist he valued highly. This allowed him to lay the foundations of modern science, breaking with the qualitative science of peripatetic medieval philosophy. To this purpose, he built a new methodology that is justified by a worldview based upon several ontological assumptions that outline an influential metaphysics that are pivotal to science. It is uncertain whether Galileo gave these assumptions the character of a purely methodological and necessary move; anyway, subsequently they deeply marked scientific thought, and particularly influenced scientists and philosophers who were barely aware of the methodological approach of modern science. However, it would be a mistake to transform the assumptions, that are at the basis of Galileo's methodology, into a „true" vision of nature, as this would end up being an obstacle to any scientists who want to follow different scientific paths. In this paper, I analyse how Galileo dealt with this issue, and for this purpose, I start with his critique of the ontology of Aristotle's followers.