Investigating the Historical Development of the Concept of Matter: Controversies About/In Ancient Atomism

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Abstract
This paper investigates the historical development of the concept of matter and the controversies surrounding it in antiquity when natural philosophers first speculated about the constitution of the physical world. By focusing in the controversy between the ancient Greek atomists who attributed all physical phenomena to atoms and their motion in the void and Aristotle for whom matter is linked by definition to a process of change, the paper intervenes in the current debate about the position of ancient atomism in the history of science. Our conclusions underline the distinctly speculative character of the ancient controversy over the atoms and the void and on this basis modern science cannot be considered a by-product of ancient philosophy. And reversely, ancient, or early modern philosophy cannot be reduced into what is now science considered to be. Both the terms 'science' and 'philosophy' bear distinct significations and should be considered as such in history and philosophy informed science curricula.

Introduction

It has been argued that the role of the history of Atomism should be a basic component in all science curricula. Recent discussions on Atomism and its history in school textbooks and curricula can be found in Rodriguez & Niaz (2002, 2004), Justi & Gilbert (2000), Izquerdo-Aymerich & Adúriz-Bravo (2009). However, science educators should consider that the History of Atomism and its position in the History of Science is still a matter of debate.
Recently, Alan Chalmers[1] (2009) published a book in which he surveys the history of atomism from Democritus to the twentieth century, examining the varying contexts in which science has been practiced.
In this book, Chalmers sees modern atomic theory as the recent legacy of experimental science as it emerged in the 17th century rather than a tradition of speculative philosophy dating back to Democritus and extending to seventeenth-century mechanical philosophy and beyond.
Chalmers believes that a distinction between philosophical metaphysics and experimental philosophy emerged, and was made explicit, in the seventeenth century. His book intends to demonstrate that we learn much about science by recognizing the way in which, by the beginning of the twentieth century, a general atomic theory of matter that was experimentally supported had come about in a way that owed little to the philosophical versions of atomism that had origins in Ancient Greece.
Towards the end of his book, Chalmers writes:

> "The atoms invoked by Ancient Greeks such as Democritus and Epicurus and by seventeenth-century mechanical philosophers such as Gassendi and Boyle were construed as the ultimate and unchanging components of material reality. Twentieth-century atoms are nothing like those envisaged in these philosophical traditions and they and their properties

[1] Alan Chalmers is one of the key figures in the international community of the philosophy of science. His book *What is this thing called Science* is considered as the standard textbook for every student entering the field. The book has been translated in French, German, Spanish, Italian, Portuguese, Dutch, Greek, Norwegian, Danish, Polish, Estonian, Latvian, Japanese, Chinese, Korean and Indonesian, Turkish and Iranian.

> were discovered by experiment rather than philosophical analysis. The modern atom has an internal structure, most importantly an electron structure. Electrons have a charge as well as a mass, electrons have a half-integral spin, a quantum mechanical notion having no classical correlate. Such properties are far from anything envisaged by Democritus and Boyle and cannot be reconciled with the notions of reality and intelligibility that informed their theories." (Chalmers 2009, p. 262).

Chalmer's key theme was stated eleven years earlier in an article titled "Retracing the Ancient Steps to Atomic Theory". This article opens with the claim that:

> "In an article published recently in this journal, Sotirios A. Sakkopoulos and Evagelos G. Vitoratos [vol.5 no.3, 1996] observe that teachers of today can with benefit to their students, retrace the ancient steps to atomic theory. I agree with them, but for reasons that are diametrically opposed to theirs. Sakkopoulos and Vitoratos apparently see a study of the history of atomism to be valuable to the extent that arguments introduced in atomic theories of the past have their analogues in modern atomic theory. Consequently, an appreciation of the historical arguments is seen as illuminating contemporary theory. By contrast, I claim that a study of past atomic theory can serve to illustrate some features of contemporary science because of the significant differences between the two. Versions of atomism prior to Dalton, were philosophical rather than scientific theories, and appreciating the difference between the two tells us something important about science." (Chalmers, 1998, p. 69).

More of Chalmer's argument is presented in the conclusion of the article where he writes that:

> "Whilst it is true to observe that the modern list of properties [of the atom] is different from, and lengthier than, that of Democritus, there is more to it than that. The modern properties are scientific properties, attributed to particles for reasons that stem from within science itself. They were not, and could not have been, anticipated by any philosophy. The properties ascribed to atoms by the philosophers, from Democritus to Boyle, had their origins in common sense and were attributed to atoms for philosophical reasons prior to and independent of scientific research." (Chalmers 1998, p. 82).

It is obvious that for Chalmers, atomism as a philosophical theory of the composition of bodies, an ontological position, had little, if anything, to do with the development of modern scientific practice.

Chalmers' positions have been critically discussed by M. R. Matthews (2009) in a book review published *in the monthly Newsletter of the IHPST Group.*

Matthews criticizes Chalmers on two themes that are central to science education: first, the role of atomism in the history of science, which is basic in all science curricula and second, the issue of realism and instrumentalism in philosophy of science insisting that the overarching question that Chalmers' book deals with is the proper understanding of the role of philosophy and metaphysics in the history and current practice of science.

Matthews recognizes that for Chalmers, theory-guided experimentation is the *differentia* of modern scientific atomism, and this is why there is a break between the tradition of philosophical atomism and the origin of scientific, experimental atomism.

However, he defends the importance of ancient Greek atomism for modern scientific atomism on the basis of the continuity of the materialist programme initiated by the Greek atomists Democritus and Epicurus, who inspired the Roman poet Lucretius to write the poem *De Rerum Natura-The Nature of Things* in the middle of the first century B.C.E. The poem was the only full expression of classical materialism to survive the ancient world. Then, for a millennium and a half, Greco-Roman materialism disappeared from European civilization, driven underground by Christianity or more precisely by the Christian adaptation of the Aristotelian hylomorphic anti-atomism, tentatively resurfacing in seventeenth-century England and France in the writings of Francis Bacon and Pierre Gassendi[2].

[2] Interestingly enough though, Chalmers does draw attention to the atomistic element of Aristotelianism, namely its belief in a natural minima or corpuscles. Aristotle held that matter could be divided downwards into smaller and

In the light of this debate, in this paper we will examine more closely the philosophical import of the early atomism, by relating Leucippus' and Democritus' theory to the chief tenets of the Eleatic school of thought. We will also try to ascertain what ramifications did the Eleatic conception of being have for the philosophical projects of Plato and Aristotle. This flashback to the ancient Greek philosophy can help us better evaluate the particularity of early atomism, and its potential relevance to present-day science education.

Sure enough, the modern reader may find it hard to see how those distant philosophical speculations could be relevant to the instruction in scientific understanding, unless they would somehow be reckoned as forming the introductory part of historical narratives leading to our present. It is usual to treat the past both as the background which explains our own history *and* as the prelude to an unavoidable and necessary course, as the part preceding and preparing for the principal matter: the achievements of our culture, which are thus, in one way or another, vindicated at the outset. The key point raised by Chalmers here is that science educators should be weaned away from that habit. Natural philosophy is not simply the immature form of modern natural science. Leucippus should not be portrayed as the progenitor of Dalton. And it is perhaps still more significant the fact that the same stricture holds also for Leibniz, Newton or Boyle.

Leibniz' structural theory of matter, for example, does indeed necessitate an explicit and direct conjunction of physics and metaphysics and an incessant regression from the knowledge of facts to the knowledge of general laws and universal principles, rendering possible the representation of natural phenomena as determined by unobservable causes underlying them, which are accessible to reason (see Hassing 2003). The spatial world of bodies is conceived as a set of phenomenal relations among substances the reality of which is assigned to an ultimate ontological order, of metaphysical points or monads. Physics virtually rests upon metaphysics: "although all the particular phenomena of [corporeal] nature can be explained mathematically or mechanically by those who understand them, it nevertheless appears more and more that the general principles of corporeal mechanical nature itself are metaphysical rather than geometrical, belonging to forms or indivisible natures functioning as causes of the <matter or extension> rather than to corporeal or extended mass" (Leibniz 1988, p. 61).

Not less reminiscent of the linking of physics with metaphysics is Newton's appeal to the 'analogy of nature', through which he justified his assumption that the imperceptible indivisible particles possess the same qualities as the perceptible large-scale bodies: extension, hardness, impenetrability, mobility and inertia. Maxwell, many years later, dismissed the dogma of the impenetrability of matter, the opinion, shared by both Leibniz and Newton, "that two bodies cannot co-exist in the same place", as "vulgar". "This opinion is deduced from our experience of the behavior of bodies of sensible size, but we have no experimental evidence that two atoms may not sometimes coincide" (Maxwell 1890, p. 448). Why should the microcosm be analogous to the macrocosm? Molecular forces, on the contrary, seem to act differently from the forces acting within the domain of sensible experience. But this does not imply that the knowledge of molecular dynamics involves any new kind of philosophical speculation on that unknown substratum of bodies hitherto called 'matter'. In the science of dynamics, 'matter' means no more than 'mass', a certain quantitative value which can be specified for each particular body and each particular portion of a body[3]. The view that the concept of matter is redundant, since it designates a metaphysical 'substance' or substratum, was later championed by Mach, and upheld also by some of the founding fathers of quantum mechanics, such as Bohr, Heisenberg and Pauli. Yet, as Karl Popper once remarked "the wonderful theories of these great physicists are the result of attempts to understand the structure of the physical world, and to criticize the outcome of these attempts". The metaphysical speculations on the structure of matter, discussed and

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smaller pieces till a physical limit was reached. But he is careful to insist that these minima were not Democritean atoms and they did not require a void; they were just minimum parts of the whole, and had properties of the whole.

[3] Our succinct account of Maxwell's theses on the problem of impenetrability and the concept of matter is based on the analysis of Harman 1988, pp. 175-208.

criticized from the classical antiquity to the early modernity, were inspired by the same wish to understand the world, and motivated by the same hope for a better life:

> Thus their own physical theories may well be contrasted with what these physicists, and other positivists, try to tell us today: that we cannot, in principle, hope ever to understand anything about the structure of matter: that the theory of matter must forever remain the private affair of the expert, the specialist – a mystery shrouded in technicalities, in mathematical techniques, and in 'semantics': that science is nothing but an instrument, void of any philosophical or theoretical interest, and only of 'technological' or 'pragmatic' or 'operational' significance. I do not believe a word of this post-rationalist doctrine (Popper 1992, pp. 20-21).

Neither do we. Instruction in science should denote something more than building effective technical skills. Doing science cannot be reduced into the ability of suitably handling a set of formalisms. In the very region of post-classical, highly formalized physics, the persistent problem of interpreting quantum mechanics has already stimulated interest in some, seemingly impertinent (in natural science proper), metaphysical and ontological questions, bringing Kant's, Hume's, Aristotle's, Plato's, or even Parmenides' and Democritus', conceptions of reality, and of the knowability of reality, back into play, (see Aerts 1981; Piron 1983; Bohm & Hiley 1993; Verelst & Coecke 1999; de Ronde & Christiaens (eds.) 2010). Maxwell himself, in his inaugural address at Marischal College, Aberdeen, in 1856, told his audience that "those who have raised objections to the engrossing pursuit of physical science have done so on the ground of the supposed effects of exact science in making the mind unfitted to receive truths which it cannot comprehend", but quite the opposite is the case: "it is the peculiar function of physical science to lead us to the confines of the incomprehensible" (Maxwell 1990, p. 427). It is for this reason that we think it worth trying to carry further Chalmers' point: not only to stress the difference between the early and the modern atomisms, but also to explore that which is different, and incomprehensible as such.

Responding to the Eleatic challenge

The early Atomists developed their theory responding to problems posed by the Eleatic school, such as Parmenides' distinction between truth and appearance, Zeno's paradoxes concerning the divisibility, and Melissus' denial of the reality of the void (Curd 2004, p. 215).
Melissus, in a fragment preserved by Simplicius in his commentary on Aristotle's *Physics*, had declared that what-is can only be full:

> For what is empty is nothing, and of course what is nothing cannot be. Nor does it move. For it cannot give way anywhere, but is full. For if it were empty, it would give way into the empty part. But since it is not empty it has nowhere to give way …
> And we must make this the criterion of full and not full: if something yields or is penetrated, it is not full. But if it neither yields nor is penetrated, it is full.
> Hence it is necessary that it is full if it is not empty. Hence if it is full it does not move[4].

Leucippus, the alleged founder of atomism[5], according to the reconstruction of his basic theoretical tenets performed by Aristotle, converted Melissus' denial into an affirmation of the

[4] "(7) οὐδὲ κενεόν ἐστιν οὐδέν· τὸ γὰρ κενεὸν οὐδέν ἐστιν· οὐκ ἂν οὖν εἴη τό γε μηδέν. οὐδὲ κινεῖται· ὑποχωρῆσαι γὰρ οὐκ ἔχει οὐδαμῆι, ἀλλὰ πλέων ἐστιν. εἰ μὲν γὰρ κενεόν ἦν, ὑπεχώρει ἂν εἰς τὶ κενόν· κενοῦ δὲ μὴ ἐόντος οὐκ ἔχει ὅκηι ὑποχωρήσει … (9) κρίσιν δὲ ταύτην χρὴ ποιήσασθαι τοῦ πλέω καὶ τοῦ μὴ πλέω· εἰ μὲν οὖν χωρεῖ τι ἢ εἰσδέχεται, οὐ πλέων· εἰ δὲ μήτε χωρεῖ μήτε εἰσδέχεται, πλέων. (10) ἀνάγκη τοίνυν πλέων εἶναι, εἰ κενὸν μὴ ἔστιν. εἰ τοίνυν πλέων ἐστίν, οὐ κινεῖται", Fr. 30B7, Diels & Kranz 1960, I, pp. 272-273. We have used the English translation given by Richard McKirahan 2010, p. 295.

[5] In fact, we know nothing of Leucippus' life. His successor Democritus overshadowed him in such a degree that Epicurus later denied that any philosopher with the name Leucippus ever existed. The extremely scarce hints we can find in ancient sources concerning his writings may only lead us to the assumption that he may have composed two

void's possibility. His theory was intended to fulfill the need for an explanation of natural phenomena that "would grant to perception what is generally agreed, and would not do away with coming to be or passing away or motion or the plurality of things". Phenomena should be explained as phenomena: their reality should not be altogether discarded as illusionary. So, he agreed both with the Eleatic definition of the void as "what is not" and with the statement that motion is impossible, unless there is void. But he made the choice not to equate what-is-not with non-being. What-is-not, i.e. the void, exists no less than what-is: "both are alike causes of the things that come to be". If motion requires the existence of void, then there must be a place in reality for the void, since in reality, as we perceive it, motion actually takes place. Indeed, what-is, in the strict sense of the term, is completely full. What-is, that other section of reality which is complementary to what-is-not, is a "total plenum". This plenum, however, is not merely one thing. What-is consists of "infinitely many things, invisible because of their small size", which "move in the void". These, infinitely many, things that constitute what there is, which, for Melissus, ought to be "one and all alike"[6], are essentially susceptible to action. "They act and are acted upon as they happen to come into contact, for in that way they are not one, and they generate by being combined and entangled together". Coming to be and passing away are produced respectively by their combinations and their separations. The multiplicity of attributes and substances that we encounter in our reality can be explained by positing an infinity of principles, "as matter of the things that there are", entities "of the same kind", differing from each other in nothing but their shape, position, and arrangement, which move through the void, traversing what-is-not, toward one another, "for it is natural for like to be affected by like", while each of the shapes can be reorganized "into a different complex and so make another state"[7]. Should we take Aristotle's description to the letter, Leucippus asserting "what is granted to perception" came up with the notion of the "atom", of a principle evading perception and nonetheless underlying phenomenal world, being the compact, indestructible core of reality, responsible for whatever we perceive as real.

Another celebrated Eleatic thinker, Zeno, had demonstrated that in reality there can be no motion, or at least, that the way we usually form the impression of motion is logically inconsistent, it may easily be rebutted by evidence brought forward by thinking, by the faculty of reasoning. To have the sense of moving is to have the sense of traversing a finite distance in space. But that which is moving has first to reach the midpoint before reaching the end of the distance to be covered, and the number of midpoints is shown to be infinite. Since space can be infinitely divided by thought, motion in space, as sensed by our bodily organs, is merely an illusion[8]. In another instance, reported by Simplicius, Zeno is said to have proven that what-is can be thought of as just and only one, partless and indivisible, thing. Let's suppose that we are presented with a body known to be divisible, and of a measurable, finite size. If we start cutting it into pieces until the division is complete, then either we reach some parts that remained intact, and are thus uncuttable, or we reach a point where the thing we have just divided disappears. The logical consequence to draw is either that the body the divisibility of which we tested was made up of nothing, since nothing remained after the division, or that it was made up of infinitely small particles, which must be infinite in their number too, and this means that if we put those pieces back together, the aggregate ensued would be a body of infinite size[9]. In either case, our knowledge of its divisibility is illusionary.

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works, the one entitled *Great World-System* and the other *On Mind* (there is also the possibility that the latter was just a portion of the former), see Taylor 1999, p. 157.

[6] "οὕτως οὖν ἀίδιόν ἐστι καὶ ἄπειρον καὶ ἓν καὶ ὅμοιον πᾶν", Fr. 30B7, Diels & Kranz 1960, I, p. 270. Translation by McKirahan 2010, p. 294.

[7] The quotations in this paragraph are from two fragments indicative of Leucippus' theory, preserved by Aristotle (*De Generatione et Corruptione* A.8 325^{a},25-35, Fr 67A7, Diels & Kranz 1960, II, pp. 72-73) and Simplicius (*Physica* 28.4-26 = Fr 67A8, 68A38, Diels & Kranz 1960, II, pp. 73-74, 94). We have used the translation given by Taylor 1999, pp. 71-74. Cf. also the translation of McKirahan 2010, pp. 305-306.

[8] For this argument see McKirahan 2010, pp. 181-184.

[9] Here, we have closely followed the description of Zeno's paradox given by Curd 2004, pp. 173-174.

We do not intend to revisit, here, the historiographical and philosophical debate over Zeno's paradoxes. We need only recall that according to the available evidence, the surviving arguments of Zeno, both these directed against motion and these directed against plurality, were in his own time treated more as metaphysical or ontological arguments, addressing conceptual problems, than as mathematical riddles (see Owen 1957-1958; Vlastos 1967; Hasper 2006a). The impasse towards which he pointed was a conceptual knot faced by any enterprise to speak of what-is by uncritically endorsing the intuitions of common sense: when thought *reflects* actuality, when it mirrors the world, as the latter is being monitored by the senses, then it inevitably yields pairs of contradictory attributes, but if contradictory predicates are predicated of one and the same object, that object cannot *be*[10]. Leucippus and his associate Democritus, moulding a theory of indivisible magnitudes, in which reality is represented as an infinite space -the void- where an infinite number of atoms act and are acted upon, succeeded in showing that the impasse could be unblocked[11]: thinking, not sensing, might quite well explain the alterations testified by the senses without negating them as such, as alterations. Space is infinitely divisible, but this holds true only in the case of the void, only for what-is-not. Atoms, the matter of what-is, are not divisible. They are not so by definition. The knowledge of atoms and void is knowledge acquired through conceptual work: we don't see them; we know what they must be and what they can do after we have situated them within a conceptual constellation. Thought can avoid contradictory predication when it *reflects upon* reality, when it actively reconstructs reality, correcting or even defying common sense, instead of functioning as a faithful mirror. A distinction should be established between what is real and what is actual, what we can think of as being, and what we can perceive as tangibly being there, without however negating the experience of the actual itself: "tangibility ceases to be the criterion of existence, although it remains the touchstone of reality" (Pyle 1995, p. 46).This is why Democritus could declare that atoms and void are "in reality", whereas sweet, bitter, hot, cold, color, all those sensations are "by convention"[12]: the latter pertain to subjective feeling, the former to objective being. And due to Parmenides, the founder of the Eleatic school, Democritus and Leucippus already knew that what thought intends to is that which is out there to be known as real.

Parmenides' bare 'is'

Appealing to audiences familiar with the epic poetry of Homer or Hesiod, Parmenides, had appropriated and transformed epic motifs, themes, and imageries, as well as shamanist thought patterns, in order to develop and to present, by reworking that inherited discursive material, a set of philosophical arguments[13], involving prominently the problem of how true knowledge of what there is can be possible in terms of a quest or journey, undertaken by a mortal being confined

[10] In this sense, Zeno could be credited with the invention of the principle of contradiction, as an ontological principle, though; not as a logical axiom, as it is presently regarded to be. See Hoffman 1964; and Prauss 1966.

[11] David Furley revisiting Aristotle's criticism has pointed out that Leucippus and Democritus considered atoms to be both physically and theoretically divisible, providing thus a response to Zeno's paradoxes (1967, pp. 79-103).

[12] "νόμῳ γλυκὺ καὶ νόμῳ πικρόν, νόμῳ θερμόν, νόμῳ ψυχρόν, νόμῳ χροιή· ἐτεῇ δὲ ἄτομα καὶ κενόν", Fr 68B9, Diels & Kranz 1960, II, p. 139. Translation by Taylor 1999, p. 9.

[13] As for the appropriation of epic and shamanist poetry by Parmenides, see the analysis of Mourelatos 2008, pp. 1-46. Eric Havelock, several years before Mourelatos published his book, had also argued in favor of a similar reading, matching certain images present in Parmenides' poem against devices used by the author of the *Iliad* and the *Odyssey* (Havelock 1958). This interpretation remains controversial. Leonardo Tarán rejects the idea that rooting Parmenides in the epic tradition may cast new light upon his thought: "that tradition had long been dead as a creative force by the time Parmenides wrote, and it is hardly credible that he, born and raised in Southern Italy, could have conceived his philosophy in the very language and meter of the epic". Moreover, "despite the linguistics parallels between Parmenides and Homer, no motif of 'The-Journey' is common to the two" (Tarán 1977, pp. 653-658). Notwithstanding the possible inaccuracies in Mourelatos' and Havelock's interpretation, we think that it fosters an awareness of the distance separating metaphysics, as we, from our present standpoint, understand it, and the inquiry into what-is situated within a quite different, ancient mentality. See also the extensive analysis of Wilkinson on Homer, Parmenides, and the distinction between mythos and logos, 2009, pp. 10-39, 69-79.

within the bounds set by Fate. No matter how much we may try to alleviate the difficulty of operating at such a cultural distance, by insisting that we should treat Parmenides' didactic poem in nearly the same manner as we are used to decode a piece of prose (Diels 1897, p. 7), or even that under its metric form we should recognize "the earliest philosophic text which is preserved with sufficient completeness and continuity to permit us to follow a sustained line of argument" (Kahn 1969, p. 700), any historical reconstruction of Parmenides' philosophy is doomed to raise far more questions than it answers.

We cannot be sure even of what could we specify to be the logical subject of his two fundamental, and complementary to each other, statements: "ἡ μὲν ὅπως ἔστιν τε καὶ ὡς οὐκ ἔστι μὴ εἶναι ... ἡ δ' ὡς οὐκ ἔστιν τε καὶ ὡς χρεών ἐστι μὴ εἶναι" (Fr. 28B2.3-5, Diels & Kranz 1960, I, p. 231). Given the context of these words in the fragment, we may safely assert that the first statement refers to one of the alternative routes of inquiry offered to mortals, the way of reliable conviction or persuasion[14], the proper path to knowledge, the one promising to furnish truth. The second refers to another conceivable way, a trail which no one can actually follow, that of ignorance, of the impossibility of inquiring into anything and knowing anything. And after Karl Reinhardt's work (1916, pp. 32-51) we also know that in Parmenides' text there is an additional, third course, where "what-is" is represented both as being and as not being[15]. This is the beaten path followed by mortals, their attention being constantly riveted on the world as it deceptively appears to them, from which "Kouros", the traveler and first-person narrator of the poem, is warned by the Goddess, who guides him through his ecstatic journey into the Beyond, to stay away. What-is-not (μὴ ἐὸν) cannot be known, thought or spoken of (Fr 28B2.7-8, Fr 28B8.8-9, Diels & Kranz 1960, I, pp. 231, 236) and what appears to be is not what is. But precisely what is that which Parmenides avers that it is? Simon Kastner, presenting in 1835 the first complete edition of Parmenides fragments, translated in Latin, rather literally, the two sentences, as "altera, quod est neque potest non esse … altera, quod non est et quod necesse est non esse"[16] (1835, p. 33). The issue of whether there is a suppressed logical subject, and what would we assume it to be, remained in suspense. And, in fact, still so remains[17].

Some scholars interpret these sentences as ontological assertions, while others translate them in a manner that highlights more their metaphysical and epistemological import or even their metalinguistic function. So, following the first, and more traditional, line of interpretation, Parmenides' bare 'is' can be regarded as an existential verb supplied with a noun, or a noun phrase, as its subject, denoting the entity whose existence is being asserted: here, it is averred that something exists. And we may determine what is declared to exist by supposing that our missing subject is 'reality', 'all that exists', 'being'[18], or, in a more recent and elaborate version of that interpretation, "what is there for speaking and thinking of" (Gallop 1984, pp. 8, 61), "whatever we inquire into" (Barnes 1982, p. 128), "what can be talked or thought about" (Owen 1960, p. 95). Another choice is to assume that the verb 'to be' has no subject here at all, either because it is impersonal (Fränkel 1946, p. 169; Tarán 1977, note 30, p. 662) or because it is placed in propositional constructions which serve as premises of a syllogism, as the preliminary steps of an argument intended to progress and to let meanings gradually unfold. At the end of the argumentation process a key concept may come out, as the centre around which all else revolves, and that concept can be plausibly designated as that which 'is'. Once more, there are a few potential candidates to consider for filling this post: 'being' (Mansfeld 1964, p. 90; Tarán 1965, pp. 33, 37; Coxon 1986, pp. 20, 174-175), any subject of enquiry, whatever it may be (Kirk,

[14] "Πειθοῦς ἐστι κέλευθος (Ἀληθείηι γὰρ ὀπηδεῖ)", Fr. 28B2.4, Diels & Kranz 1960, I, p. 231..

[15] Tarán (1965, pp. 59-72), Cordero (1979), and Nehamas (1999, pp. 125-132) still disagree with that view, which has achieved canonical status among contemporary scholars. They think that there is no third path, or that the alleged third path falls into the second: the way of not being and that in which being and not-being are confused are virtually the same.

[16] We could literally translate Karsten's version in English as "the one [way], that is and cannot not be … the other, that is not and necessarily is not being".

[17] For a detailed presentation of the debate from the 1930s to the 2000s, see Cordero 2004, pp. 46-54.

[18] For an account of this interpretation and extensive bibliography see Marcinkowska-Rosól 2010, pp. 45-48.

Raven & Schofield 1983, p. 245) or the verb 'to be' itself, elevated to the status of a concept pointing to the very fact of being (Cordero 2004, pp. 51-52). A third alternative is to settle on a "veridical" reading, translating the Greek verb 'εἶναι' as "to be so", "to be the case" or "to be true", rather than "to exist". Thus, Parmenides' statements could be decoded as expounding a doctrine concerned less with the reality itself than with how could we gain knowledge of what-is, how could we properly think and speak of what is the case (Kahn 1966, 1969). A similar emphasis on the strictly logical aspects of Parmenides' statements is to be found in yet another, fourth line of interpretation, according to which the ἔστιν, in the fragment 28B2, is just an element in an affirmative statement, a copula, performing primarily a logical function. The controversial lines 3 and 5 of the fragment could be, therefore, translated as follows: "the one [way] <which says> that is and that it is not possible not to be … the other [way] <which says> that is not and that it is necessary not to be"[19]. The logical notion of the verb 'to be' can be further stressed by reconstructing Parmenides' statements as answers to the question "What one may say?", as metalinguistic: "Negative judgments are impossible, for they refer to nothing. Positive judgments are possible, but only insofar as they say no more than 'is'". 'To be' is interpreted as fundamentally predicative, as a copula "but with both the subject and the predicate-complement left blank" (Mourelatos 2008, pp. 52, 55). In terms of its grammatical function, the bare 'is' plays the common role of a copula, but logically may function as the 'is' of identity, making thought capable of connecting things and thus establishing identities. 'To be' garners the meaning of 'to be what it is to be'. Parmenides managed to discard the possibility of change and plurality by constructing the following logical formula: "real things, things that are *F* in the strong sense of being what it is to be *F*, cannot change", because "to be what it is to be *F*, to be the nature of *F*, is to be *F* in every way and at all times" (Nehamas, 1999, pp. 133-134).

Parmenides pondering over the possibility of being, over the possibility of knowing what being is, over the possibility of the language conveying the knowledge of being: the debate on the possible logical subject of 'is' reveals the multiplicity of problems that are inherent in any conceptualization of what-is. Perhaps, the most important outcome of Parmenides' effort to conceptualize being is the awareness of the fact that crafting a concept which is meant to correspond to something real is always an interesting problem leading to more, and even more interesting, problems. How could we know something we don't know? And how could we know that we have actually received what we did not hitherto have, that we have come now to know what we knew that we did not know before? In this regard, we may assent to Karl Popper's claim that Parmenides "found himself speaking about the unspeakable" (1998, p. 148). And what's more, he found himself opening up the horizon for thinking what he thought it was unthinkable: differentiation and change in reality. While his central argument, whether seen as chiefly ontological or as chiefly epistemological, succeeded in producing a rupture with the earlier Ionian tradition of cosmological accounts, by reducing all oppositions to the one between being and not being, and by "showing that cosmological explanations amount to the assertion of non-Being" (Tarán 1965, p. 39), nonetheless it was an argument with considerable impact on cosmology itself, representing an attempt to make headway in the direction of a radically revised, rational cosmology, both by setting standards for the rational evaluation of cosmological theories (Curd 2004, p. 125) and by posing new cosmological problems, such as that of the different modalities of being (what Plato and Aristotle later recognized as central to Parmenides' theory, Palmer 2009, p. 44) , and, even more importantly, that of change (Popper 1998, p. 114).

In a way that might seem curious to our eyes, Parmenides monism opened up a horizon befitting for a variety of elaborate pluralisms to emerge. Alan Chalmers observes that Leucippus and Democritus envisaged the portions of being they called atoms to be "themselves miniature Parmenidean worlds that are one and changeless for all the reasons that Parmenides' one, the universe as a whole, was argued to be changeless" (2006, p. 24). Curd tried to prove that the world of Parmenides was not one, in terms of number or of matter. It was one only in terms of

[19] This could be an English version of Guido Calogero's translation: "l' una < che dice > che è e che non è possibile che non sia ... l'altra, < che dice > che non è e che è necessario che non sia" (Calogero 1977, p. 19).

predication: 'to be' something, in the sense of being really what that particular something essentially is: that it had to be one, to cannot not be. Leucippus and Democritus, insisting that the void, despite being defined as what-is-not, is no less real than what-is, not only echo "the Eleatic identification of void with what-is-not, but [they are] also recalling the Eleatic understanding of what it is for something to be … Void must, on their view, qualify as a genuine entity"[20] (Curd 2004, p. 196). In the case of Parmenides, thinking was stretched beyond, and eventually turned against, its own motivation: a theory which was constructed so as to negate coming-to-be fuelled theories explaining coming-to-be, or at least ascribing to coming-to-be the status of a legitimate philosophical problem.

Speaking of the knowledge of reality

Aristotle waded into the problem of coming-to-be and passing-away, as Leucippus and Democritus had done before him. But the challenges he had to encounter were different from those of the early Atomists. What he had to overcome was not Parmenides' theory explicitly concerning the possibility of being really something, with all of its various implications, but Plato' theory explicitly concerning the possibility of knowing what something really is, informed as the latter was by Parmenides' theory of being[21].

In some of the platonic dialogues, clear knowledge of reality is presented as coincidental with the knowledge of unchanging ideal objects, of forms. That only what is universal and lasting can be knowable, this was a conviction shared both by Plato and Aristotle. Serious differences, however, arise when we come down to specifics: Plato had described the proper process to attain that end as an operation enforcing seclusion from the sensible world, as an act of recollection, an unconcealment[22] of the real induced by the concealment from the actual. The philosopher, the "lover of wisdom", knowing the world, instead of being engaged in the flux of phenomena, has to become estranged from the sensory entities to be known, the moving shadows of reality that shroud and conceal reality itself, to "look down upon the things which now we suppose to be" and to gaze up "to that which truly is". Only by performing such a leap into a higher and deeper, transcendental we would call it today, grade of being, the philosopher learns to speak, or rather remembers how to speak, the language of truth, which is but the "language of Forms", "passing from a plurality of perceptions to a unity gathered together by reasoning" (Plato 1972, p. 86, *Phaedrus* 249B-C).

This transition from the sensible actuality, the world as a cave with fleeting shadows cast upon its walls, to the intelligible reality, the world as a "symphony of proportion", a "Living Thing which comprehends within itself all intelligible living things" (Plato 2000a, pp. 16-17, *Timaeus* 30C, 32C), is signified as a retrieval of repressed cognitions. Anamnesis is the word denoting soul's reinstatement in the world as it is ideally depicted, as seen by the eye of the mind, which, according to Plato, is the world as it really is, an orderly fabric whose life explains the life of any of its part. Digging up the reality lying under and beyond what sense-organs can capture, the soul is "let by itself to behold objects by themselves" (Plato 1955, p. 48, *Phaedo* 66E1-2), distinct from, and superior to, sensible appearances.

Not that sensuality is totally tossed out as an index of being. Through sense perception we become acquainted with visible things, we even can form true opinions about what sort of thing

[20] Curd discusses atomists' views on the reality of void in pp. 188-206. Cf. the analysis of Dayley 2006.

[21] Nehamas writes that in Plato's "self-predication", in his frequently employed idea "that the *F* itself is *F*, independently of any particular analysis we might give to it", we may discern the import of Parmenides' doctrine of being in "a more fully spelled-out version", 1979, pp. 93, 98.

[22] Martin Heidegger prompts us to remember that the Greek word we use to translate as 'truht' literally means 'unconcealedness'. And he does not neglect to caution against possible retrojections: "It is therefore an idle play with 'word-forms' if we render ἀλήθεια by 'unconcealedness', as has become fashionable recently, but at the same time attribute to the word 'unconcealedness', now meant to replace the word 'truth', a significance which we have merely gleaned from the ordinary later use of the word 'truth' or which offers itself as the outcome of later thinkings', 1992, pp. 11-12.

any entity we perceive is, and we can also embark upon the inquiry into the essential nature of reality by stirring up true opinions about what reality looks like[23]. The task we cannot fulfill, when we restrict ourselves to empirical investigations, is to give a rational account of what a thing essentially is, to figure out causes explaining not its actuality but its reality, establishing its relation to an intelligible object, a form, which is real, non-identical, that is, with its particular sensible instantiations and independent of the mind which thinks of it (the beautiful explaining an actually beautiful thing, as separate both from the instances of beauty and from the minds that come to understand beauty, see McCabe 1999, pp. 62-63). By being something which we can locate, as part of the world wherein we dwell, through our sensory organs, a visible thing participates in being. By not being susceptible, as such, to reasonable ascertainment, it belongs to the province of non-being as well. It is "something" indeed, though only if we take that word literally: a shadowy presence situated between being and non-being, a perishable image uncertainly oscillating in-between, "'knowable' in a sense but not in the full sense; *doxa*, but not *episteme*" (de Vogel 1988, p. 53). Plato's "lover of truth" does not feel any ascetic contempt for sensuality. But he does not feel the slightest desire for the prizes delivered inside the shadow cave of actuality to those who have been proved "quickest at identifying the passing shapes" on the walls or those who had "the best memory for the ones which came earlier or later or simultaneously, and who as a result are best at predicting what was going to come next" (Plato 2000b, p. 222, *The Republic*, 7, 516C-D). He does not envy the cosmologists and the physicists preceding him, and he refuses to enter into dispute with them on how to explain natural phenomena. He chooses a different ground to prosecute his intellectual enterprise, a different jurisdiction over knowledge to assert. Leucippus' atoms are images explaining the world as an image. Plato's regular geometrical solids, composed by indestructible triangles, are intelligible entities explaining an intelligible world[24]. As Aristotle once evaluated the differences between them:

> For Plato is so far from giving the same account as Leucippus that, while both of them declare that the elementary constituents are indivisible and determined of figures, (α) Leucippus holds that the indivisibles are solid, Plato that they are planes, and (β) Leucippus declares that they are determined by an infinite number of figures, Plato by a definite number. It is from these indivisibles that the coming-to-be and dissolutions result: according to Leucippus through the void and through the contact (for it is at the point of contact that each body is divisible); according to Plato, as a result of contact only, for he denies that a void exists (Aristotle 1955, p. 243, [*On Coming-to-Be and Passing-Away*, 325^{b}, 25-34]).

Thinking of the reality of change

Disqualifying sensual experience of concrete individual things as a reliable source of knowledge, and installing a gradation of being which implies a sharp, permanent tension between the sensible and the intelligible, between the fluctuating entities which constitute what actually exists and the non-perishable forms which populate the ideal realm of what has been and what will once more be (after the separation of the soul from the body), Plato's account of how the obstacles barring human access to truth should be removed threatened, so Aristotle thought, to render our efforts to contemplate on, and to probe into, natural reality meaningless, to "abolish the whole study of physics" (Aristotle 1961, I, p. 77, *Metaphysics*, A, 992^{b} 8-9). In his

[23] This is a point emphasized by Bedu-Addo 1983, as for the process of recollection.

[24] For a detailed discussion of Plato's "elements" and their constituent triangles, see Miller 2003, pp. 163-196. Plano persistently avoided mentioning the early atomists in his dialogues. There is a passage of Diogenes Laertius according to which Aristoxenus, in his "Historical Notes", offers the testimony that Plato wished to burn all the writings of Democritus he could buy, but he was eventually prevented to do so by the Pythagoreans Amyclas and Clinias. Jean Bollack has argued that Plato, contrary to what we may be led to assume by reading that narration, admired Democritus and preferred not to mention his name by virtue of that name's prestige. Rein Ferwerda (1972) tried to find evidence supporting, or refuting, Bollack's theory and after discussing possible Democritean influences on Plato, he concluded that Bollack's interpretation should be accepted.

Metaphysics, Aristotle sums up his judgment of Plato's theory by noting that "although Wisdom is concerned with the cause of visible things", this question has been ignored, since we are left with "no account of the causes from which change arises": in the belief that we are accounting for the substance of the entities which we perceive "we assert the existence of other substances; but as to how the latter are the substances of the former, our explanation is worthless", for 'participation', the word used by Plato to denote the imitation of the forms, "means nothing", is not a genuine explanation, does not tell us the reason why. Philosophy, he fears, has been let to lapse into mathematics, whereas mathematics should be studied only as a means to some other end (1961, I, pp. 75-77, *Metaphysics*, A, 992[a] 24-29, 32-33).

The last sentence in the extract above discloses, we think, one major thrust of Aristotle's criticism against Plato. To be sure, he never differed from his illustrious predecessor so much as it is usually supposed. Lloyd Gerson has attempted, rather compellingly, to show that Neoplatonists did not delude themselves into fancying that Aristotle's project is not openly opposing that of Plato. Both, for example, rejected nominalism and materialism. Aristotle agreed with Plato that "there has to be something", a universal, an intelligible form, "like humanity and whiteness for there to be particular human beings and particular white things". His disagreement had to do with the alleged separation of forms (2005, p. 278). Certainly, Plato's forms are distinct from sensible particulars and properties. But being distinct does not necessarily entail being separate: forms cannot be thought to exist regardless of whether the corresponding sensible particulars exist or not; they are somehow tied with them. Aristotle, regarding forms as universals, argues that if we regard them also as separate, then forms would be both universals and individuals. His claim, however, that forms existing as separate are particulars, whereas they are thought of as being universals too, presupposes one assumption which he actually holds and makes him move a considerable, though not unbridgeable, distance away from Plato. The assumption in question is that universals cannot exist uninstatiated[25], that particular entities are the primary substances, the real instances of intelligible objects, or that only through understanding the particulars can we understand the universals.

Yet, we must underline the fact that the endorsement of that assumption by no means leads to any revival of empiricism, as professed by the earlier cosmologists. By drawing philosophy back into the realm of the sensible world, into actuality, Aristotle assigned himself the task of transcending the limitations of Plato's philosophy without falling back into the old fallacious ways of empiricism. The cosmological tradition of the past could be filtered through a theory of knowledge capable to critically inspect all the dimensions of knowing itself, bringing them prominently into view as actual problems indispensable for any attempt to theorize on nature, and reversely the metaphysical and epistemological traditions of the present could be reterritorialized upon a landscape of actuality traversed not by simulations, but by individual entities invested with their own reality. Aristotle does not draw rough lines of demarcation between the way of truth and the way of seeming. Contrary to that, whenever he is about to come to grips with the complexities of being, or thinking, or speaking, he reconstructs the arguments of the most influential philosophers preceding him. Neither does he set apart actuality from reality. Instead, he introduces a concept of matter as potentiality, as the field of non-actualized possibilities. From now on, change and plurality are problems that thought must not only embrace, as problems relevant to the knowledge of what-is, but also unavoidedly explicate, because their impact on thought itself, on the way thought can articulate its reflective movement as thought of reality, aware of its being non-identical with its object, cannot be repressed any more.

If Parmenides problematized what-is, Aristotle problematized both reality and actuality, going back and discussing seriously "how is it possible for action and passion to occur", when do they occur, why and how (1955, p. 237, *On Coming-to-Be and Passing-Away*, 325[a], 23-26], what account should we give for coming-to-be and passing-away. His criticism against the early

[25] Our short presentation, at this point, is based on Gail Fine's analysis, 1993, pp. 60-61.

atomists brought to the forefront questions involving the intersection of reality and actuality: the question how could we explain motion, what is its cause, or the question how could we understand the possibility of atoms' being, how could we justify the existence of entities which are mathematically divisible and at the same time physically indivisible, insofar as their "ability to be mathematically divided entails the ability to be physically divided, even though the two abilities are very different logically, that is, in terms of their actualization" (Hasper 2006b, p. 124). The first question led Epicurus to modify the early atomic theory providing an explanation for the motion of atoms which employs, along with the principle of collisions, that of the weight of the atoms and the assumption that atoms falling down through the void occasionally and unpredictably swerve from their predetermined course and collide with each other (see O'Keefe 2005, p. 122). The second question triggered detailed discussions and heated debates on the fabric of cosmos for many centuries to follow. Perhaps even more weighing, on the whole development, in particular, of natural philosophy from the late Medieval period up to the 19th century, is a third question addressed by Aristotle, in connection with the problems of motion and divisibility: "how can there be any before and after without the existence of time? Or how can there be any time without the existence of motion?" (Aristotle 1984, p. 130, *Physics*, VIII, 251^b, 10-12). To be in time, to become something and to pass away in time, the real expressed as actual in time, emerged as one of the most vexing problems thought had to tackle ever since. Aristotle's own answer was that time is "just this – number of motion in respect of 'before' and 'after' … not movement, but only movement in so far as it admits of enumeration" (1984, p. 70, *Physics*, IV, 219^b, 2-3), and, indeed, enumeration is possible, because the 'now', the present being of the entity moving, can be posited as the measure of time (Routila 1980, p. 250). Time as a kind of number: how could we conceive Newton or Leibniz theorizing on nature without such a conceptual background?

Between speculations and propositions

The preceding analysis shows that Alan Chalmers is correct in underlining the distinctly speculative character of the ancient controversy over the atoms and the void. He is not correct, however, in presenting as a mark of differentiation, between the ancient speculative and the modern scientific versions of atomism, the fact that some of the properties which the early atomists ascribed to atoms "had their origin in common sense", that their atoms were, in the last analysis, "miniature idealized" colliding stones (Chalmers 2009, pp. 39-40). As we have tried to point out, the concept of the atom and that of the void were the fruits of a deep problematization of common-sense intuitions. Any theory concerning natural phenomena draws on ordinary everyday experience, incorporates, or could be referred back to, intuitions that are part of ordinary experience. What really does make a significant difference is the answer to the question whether the theory under scrutiny transcends common sense, without entirely suppressing it, or idealizes, and thus vindicates, common sense. Leucippus' and Democritus' theory, we think, belongs rather to the first category. As a matter of fact, it was the first ancient Greek theory to be launched with the explicit or, if anything else, recognizable purpose of doing precisely that: moving beyond the limits of ordinary experience, but without negating what ordinary experience confirms. The Parmenidean core distinctions, that between the way of seeming and the way of truth, as well as that between what-is and what-is-not, are nested inside early atomism. "All the perceptible qualities are brought into being, relative to us who perceive them, by the combination of atoms, but by nature nothing is white or black or yellow or red or bitter or sweet [...] People think of things as being white and black and sweet and bitter and all the other qualities of that kind, but in truth 'thing' and 'nothing' is all there is [...] 'thing' being [Democritus'] name for the atoms and 'nothing' for the void"[26]. This testimonium given by Galen of Pergamum illustrates how Parmenides' doctrine of being was converted into the first system of mechanical

[26] Fr 68A49, Diels & Kranz 1960, II, p. 97. Translation by Taylor 1999, pp. 143-144.

materialism, wherein we can trace the origins of a conception of nature which still retains its currency. We owe to Democritus, as Ernst Bloch notes, the definition of nature as a "subject-free objectivity" (Bloch, 1985, p. 83), as an *external* world, lying beyond our perceptual grasp, independent of human agency and visible only to the eyes of the mind. But the surviving fragments and testimonia about Democritus' theory are also highly indicative of the major difficulty that any such endeavor to define nature as stripped of sensible qualities is doomed to go through. The eyes of the mind must somehow correspond or relate to the eyes of the body. Again quoting Galen: "Democritus was aware of this; when he was attacking the appearances with the words 'By convention colour, by convention sweet, by convention bitter, but in reality atoms and void' he made the senses reply to thought as follows: 'Wretched mind, you get your evidence from us, and yet you overthrow us? The overthrow is a fall for you'"[27]. Only by being active thought can penetrate the veil of appearances. In order to remove the traces of the sensible, though, it must also be objective, to detach itself from the body, the locus of sensibility that made thinking possible in the first place. If truth is that which it pursues, then thought should not function as a mirror of the sensible, but still it should function as a mirror of the visible, external world, of what-is independently of any human mediation.

The conceptual vacillation of Democritus between the sensible and the intelligible, which is evident in most of his fragments, either ethical, psychological or epistemological (according to our, late modern classificatory schemes), cannot be resolved because in his theory of knowledge, as is the case with all ancient theories of knowledge, there is no space reserved for the subjective factor, as a crucial, indispensible element in the production of knowledge (Bloch 1985). Knowing is always a kind of seeing, a way of viewing things from a distance; not a kind of working on things, of imitating nature by setting up, controlling, and reproducing definite processes. In this lack of experimentation (which exemplifies the contempt for labour shared by the members of the ruling class in the slave-owning mode of production) lies the difference between early atomism and modern atomism. We agree with Chalmers up to that point. But we believe that this difference separates Democritus from Boyle, too. From the fact that the latter's corpuscularianism was not experimentally tested it does not follow that the philosophical import it had is more comparable with that of Democritus' atomism than with that of 20th century scientific atomism.

Modern science is not a by-product of ancient philosophy. And reversely, ancient, or early modern philosophy should not be reduced into what we now consider science to be. But both the terms 'science' and 'philosophy' bear significations liable to appreciable alterations, as time goes by. If we define science, taking into consideration only its presently dominant form, as a set of institutionalized practices, a standardized way of conducting experiments within the secluded social space of laboratory, coupled with a way of formulating problems within the equally secluded social space of academic training facilities, then Parmenides' and Aristotle's speculations are irremediably alien not only to the modern atomic theory but to any present-day scientific undertaking. If, by contrast, we define science as a tradition of posing interesting questions, testing hypotheses and correcting the unavoidably many mistakes through critical discussion, then those speculations can be seen, or more precisely can be re-appropriated, as part of that tradition. But they should not be represented as the simplistic, elementary versions of the elaborate and specific propositions which are included in the contents of knowledge we presently possess. Chalmers rightly underscores the importance of this difference as far as science education is concerned. The atomisms of the past should be reconstructed and presented as complex theoretical accounts, whose difference from the complex theoretical accounts of late modernity, might cultivate the ability to discern, and criticize, the earmarks of modern scientific experimental culture. Still, we could also add that there is yet another advantage in opening space for the history of early atomism in science education, namely, the awareness that knowing involves a conceptual work, and that between concepts and sensible things a grey zone always

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[27] Fr 68B125, Diels & Kranz 1960, II, p. 168. Translation by Taylor 1999, p. 143.

lurks, of polysemous entities, tentative constructions, projections, vacillations, and unstable associations. The existence of this grey zone is what makes science to be something more than a mirror of reality: an adventure of intervening in the world so as to make it better. We are far away, indeed, from Parmenides. But Parmenides' open question of what is 'to be' is still relevant to the task of defending science as a critical tradition. Should we regard the distance separating our present from that past as an impassable gap, then we should also wonder how much distance have we already traversed, away from what Otto Neurath and his colleagues, back in 1929, envisaged (in Vienna Circle's Manifesto, Neurath 1981): a scientific conception of what-is, a quest of knowing presupposing the collective labour of inquirers and rendering the real possibilities for a better common life objective, actually available to every human being, a genuinely philosophical undertaking within the sciences, which was not intended, though, to be yet another version of philosophy, as we now habitually understand this term, as the science of the sciences or as the clarification of scientific statements.

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