

Aristotle on Atomism

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Two kinds of atomism emerged in the philosophy of the Presocratics. One kind was devised as a response to Parmenides and involved indivisible physical atoms. The other kind emerged in response to Zeno's paradoxes and involved indivisible magnitudes that served as a barrier to the infinite division that led to those paradoxes. I argue, contrary to a range of positions to be found in the literature that Aristotle was aware of the distinction between the two kinds of atomism, did not attribute an atomism involving indivisible magnitudes to Democritus, and countered the two kinds of atomism with distinct kinds of arguments.

1. Introduction

There are two kinds of atomism that emerged in Ancient Greece. One kind, involving physical atoms, arose in response to the denial of change by Parmenides. The other kind, involving indivisible magnitudes, arose in response to Zeno's paradoxes. Our main source of information on the atomism formulated by Leucippus and Democritus, to which I will refer simply as "Democritean atomism", is Aristotle. There are conflicting views in the literature concerning the nature of the atomism that Aristotle attributed to Leucippus and Democritus and, consequently, on what Aristotle's critique of atomism involved. David Furley (1967:79–101) is of the view that Aristotle attributes to Democritus two distinct brands of atomism, as Epicurus unambiguously came to do in the century after Aristotle. G. S. Kirk, J. E. Raven and M. Schofield (1999:415) claim that Furley has read more into the text than is justified. Jonathan Barnes (1996:352–60) argues that Aristotle's commentaries are consistent with Democritus defending only physical atomism. Richard Sorabji (1983:354–7) explains the fact that Furley and Barnes can both find grounds for their views in Aristotle on the assumption that Aristotle did not in fact clearly distinguish between the two kinds of atomism with the consequence that there are ambiguities in his characterization and critique of Democritus.

I attempt to clarify the situation in this article. I take issue with the way the distinction between the two kinds of indivisibility, possessed by physical atoms and indivisible magnitudes respectively, has been characterized in the literature and try to do better. I argue that Aristotle did appreciate the distinction between the two kinds

of atomism and the corresponding two notions of divisibility. I also suggest that the grounds for assuming that Aristotle represents Democritus as having invoked indivisible magnitudes are weak. Aristotle had considerable admiration for Democritus's theory. His reasons for rejecting it were quite different from his reasons for rejecting indivisible magnitudes and their deployment in combating Zeno's paradoxes.

2. Physical Atomism as a Response to Parmenides

Parmenides famously denied the possibility of any kind of change. On his account, the world is a homogeneous, motionless, unchanging spherical extent of "being". This is so because the existence of non-being is regarded as an absurdity, so there is nothing to divide one portion of being from another.¹ Leucippus and Democritus avoided the Parmenidean conclusion by allowing for the existence of non-being in the form of the void. The void exists where being is absent. Small pieces of being, called atoms, are miniature Parmenidean worlds insofar as they are homogeneous, contain no non-being and are unchangeable. However, they differ from the Parmenidean world insofar as they have a variety of shapes and sizes and are capable of motion through the void. Atoms move in the void and sometimes collide with other atoms. Because of their intricate shapes, colliding atoms sometimes combine together by becoming interlocked, with hooks engaging with eyes or some such thing. It is in this way that the macroscopic materials of our experience, and indeed the world itself, comes to be formed. Continuity through change is explained by the persistence of unchanging atoms, whilst change comes about as the result of the motions and rearrangements of atoms.

The atoms involved in this response to Parmenides are physical atoms. They are slabs of being with a definite shape and size that can move, collide and become interlocked with other slabs of being. These atoms are unchangeable in the sense that they cannot be divided or distorted in any way. They are physical atoms that cannot be physically divided.

3. Atomism as a Response to Zeno

Zeno proposed four paradoxes designed to challenge the idea that motion is possible. Before I can reach the door of the room I have to get half way to the door. Once I have done so I have to bisect the remaining distance and so on for an infinite number of bisections. I cannot reach the door because it is impossible to execute an infinite number of tasks. In fact, my motion to the door cannot even get started because however small the first part of my motion might be, traversing it will involve an infinite number of bisection. There are three related paradoxes, involving Achilles' failure to catch the tortoise in a race in which he has given the tortoise a start; a moving arrow, which, in occupying an extension of space equal to its length at any instant, does not differ from a stationary arrow; and two rows of carriages moving in opposite directions past a stationary row, designed to show that the moving carriages are moving at

¹ For a detailed reconstruction of Parmenides' argument see Barnes (1996:155–230).

two speeds at the same time depending on whether the speed is determined relative to the stationary or other moving carriages. (This latter paradox is rather easily solved by invoking a notion of relative velocity available to the Ancients, unless space itself is assumed to be made up of indivisible magnitudes.) A fifth paradox is what I will refer to as the paradox of division. Suppose an object is infinitely divisible and suppose it has been infinitely divided. Do the infinite number of parts resulting have a finite size or don't they? If they have zero size then they will yield zero size when recombined. If they have finite size then the infinite number of parts will yield infinite size when recombined. In neither case can the original finite sized whole be recovered.

The paradoxes all involve some kind of infinite division and the path to them can be blocked by denying that infinitely divisible continua exist. This leads to our second kind of atomism. It postulates the existence of indivisible magnitudes that set limits to the division of any magnitude, whether a physical magnitude or a magnitude of space or time.

4. Physical Atoms do not Solve Zeno's Paradoxes

Atomism postulating physical atoms is distinct from atomism that postulates indivisible magnitudes. The former type of atomism does not provide a general resolution of Zeno's paradoxes. To see this, imagine I am trying to reach the door by successively bisecting the distance remaining to travel and suppose that I have nearly made it. Suppose I have just one physical atom to go. Then my task has hardly begun. Because before I can pass the physical atom I have to pass half of it, before I can pass half of it I have to pass a quarter of it and so on.

The claim that physical atoms do not help solve Zeno's paradoxes needs a slight qualification. The paradox of division was sometimes interpreted as expressing a worry about the possibility of infinitely divisible matter wearing away to nothing.² Physically indivisible atoms do resolve that worry.

5. Types of Divisibility

Physical atoms do not serve to resolve Zeno's paradoxes because, as my comments in the previous section presupposed, they are divisible. They are divisible in some sense other than physically divisible. There is a need for clarity concerning what this non-physical kind of divisibility is. I do not find the literature adequate in this respect. There, the tendency is to distinguish physical parts of atoms from conceptual or theoretical parts, and to talk of mental division as opposed to physical division. Furley (1967:4) distinguishes between physical division and "theoretical division", where an object is theoretically divisible "if parts can be distinguished within it by the mind". Sorabji (1983:352) makes the distinction in terms of two kinds of barrier to division, physical barriers and conceptual barriers. Andrew Pyle (1995:20) distinguishes

² Aristotle seems to construe the paradox in that way in *Generation and Corruption*, 1, 2, 316b:23–28.

between physical division and division “in thought” and Barnes (1996:353) distinguishes between “division by the axe” and “division by the mind”.

I suggest it is inadequate to pose conceptual parts and mental division as the alternative to physical parts and physical division. Physical atoms do not have physical parts in the sense that no part of an atom can be detached from the remainder. Nevertheless, physical atoms *have* parts in a sense that does not depend on division by the mind. Some physical atoms have protuberances like hooks, distinct from the main body of the atom, that may slot into something like eyes that are the parts of other atoms. A large physical atom might shield a small physical atom from a shower of small physical atoms but a small one cannot shield a large one because *parts* of the larger one will protrude. When one atom moves past another it passes the nearer *parts* before it passes the further ones. Physical atoms have parts. It is inappropriate to call these parts conceptual parts for the reasons I have given. “Geometrical parts” would do nicely if it were not for the fact that continuous magnitudes other than geometrical extensions have parts too, such as time. I propose the term “metrical parts” and will talk of metrical division into metrical parts.

When one physical atom passes another it must pass it part by part. If the atom being passed is continuous it will have an infinite number of metrical parts which will need to be passed. To the extent that the accomplishment of an infinite number of passings poses a problem, Zeno’s paradoxes threaten in a way that is not linked to division by the mind.

As we have seen, one way to block the path to Zeno’s paradoxes is to postulate indivisible magnitudes, or, in my terminology, indivisible metrical parts. Such “atoms” are quite distinct from physical atoms.³ The latter have shape and size as well as being physically indivisible and they need to have such features in order to be able to play the physical role they are meant to play. Metrically indivisible parts presumably all have the same size, the limit of metrical division. It is not clear whether metrically indivisible parts can have a shape and, if they can, what shape.

6. Did Aristotle Distinguish Between Physical and Metrical Division and Physical and Metrical Parts?

The distinction between physical division and what I have called metrical division is not a particularly subtle one and given the subtlety of many of the distinctions that Aristotle was able to make and appreciate, I find it hard to believe that Aristotle was unaware of it. In any case, in one location Aristotle makes the distinction quite explicit (although not using my terminology of course). He does so in *On the Heavens* (306a:30–306b:2) in a context where he is discussing Plato’s view that the properties of the four elements are to be attributed to the shapes of their atoms. The passage reads as follows:

³ Aristotle used the word “atom” (ἄτομο) to refer to indivisible magnitudes and sometimes, but less frequently, to refer to physical atoms.

For any one who wishes to give each element a shape of its own, and makes this the ground of the distinction between the substances, has to attribute to them indivisibility; since division of a pyramid or a sphere must leave somewhere at least a residue that is not a sphere or a pyramid. Either, then, a part of fire is not fire, so that there is a body prior to the element — for every body is either an element or composed of elements — or not every body is divisible.

Whether or not Aristotle has adequately characterized Plato's theory and effectively criticized it need not concern us. What is important is that Aristotle points out that to fulfill the role they need to play in Plato's theory, the triangles and other shapes that constitute his atoms must be indivisible. The reason he gives is that division of them leads to parts of some other shape. He explicitly assumes here that the atoms are indivisible in one sense (analogous if not identical to the sense in which Democritean atoms are physically indivisible) and divisible in another sense which corresponds to what I have termed metrical divisibility.

Aristotle was definitely aware of, and used, a distinction between physical and metrical divisibility. However, the fact that he made the distinction clear in one place does not imply that he did not confuse the issue elsewhere. So I have more work to do to free Aristotle of the charge of not adequately employing the distinction.

7. Aristotle's Response to Zeno

One area in which Aristotle might be accused of not adhering to the distinction is in his discussion and response to Zeno's paradoxes. I agree that Aristotle does not make clear the method of division in his discussion. But this is not a failing because his argument, properly understood, *does not depend on a specification of the method of division*. This needs explaining.

Aristotle appreciated the problems that Zeno posed for the notion of a continuum understood as "that which is divisible into divisibles that are infinitely divisible" (*Physics*, 6, 2, 232b:25).⁴ He argued that it is not possible to construct a continuous magnitude out of indivisibles on the grounds that to do so requires that the indivisibles be laid part to part or edge to edge, an impossibility given that indivisibles lack parts or edges (6, 1, 231a:21 – 231b:5). Nor can indivisible points be laid in succession since, from the definition of a continuum, two indivisible points not coincident will have an infinity of indivisible points in between them (6, 1, 231b:6–14). He argued that moving indivisibles entail indivisible units of time, since if one indivisible passes another in time, t , and time is continuous, then it will pass half that indivisible in half the time, thus dividing the indivisible. Given the consequence that indivisibles of time follow from indivisible spatial magnitudes, Aristotle concluded that this kind of atomism entails that motion must occur in jerks, which he clearly regarded as absurd (6, 1, 231b:19–232a–12). He argued that the present, separating the past and future, cannot have any duration, so that time is not made up of "nows" and he used

⁴ All translations of Aristotle are from McKeon (1968).

this to combat Zeno's arrow paradox (6, 3, 233b:33–234b:9). He also sought to resolve Zeno's other paradoxes of motion. He argued that, although a distance to be traversed can be divided into an infinity of parts by successive bisections the available time can also be so divided, with each distance to be traversed matched by an interval of time, the infinite number of distances and times both having a finite sum (*Physics*, 6, 2, 233a:22–32 and 6, 9, 239b:10–29).

There remains the puzzle of how the passing of an infinite number of spaces or times can be accomplished, whether to reach the door or to catch the tortoise. Aristotle responded to this with a distinction between actual and potential division. Distances and durations, and any other continuous magnitudes, are said by Aristotle to be divisible potentially but not actually (*Physics*, 8, 8, 263a:15–263b:9). The distance separating me from the door is potentially divisible. The halfway point potentially divides it in half. The division can be actualised, by severing or marking the floor, by my passing half-way and then stopping, or by my merely making the division in thought. But, having so halved the distance, the remaining distance remains potentially divisible, and so on, however many halvings are actualised. The (potential) infinite divisibility of continuous magnitudes is not, for Aristotle, relative to some process of division. Further actual division of continuous magnitudes is always possible whatever the process of division because continuous magnitudes *are* infinitely divisible.⁵

Aristotle responds to Zeno's paradoxes of motion by insisting that continuous magnitudes such as lines, although potentially divisible at an infinity of points, are not made up of points and cannot be actually divided at an infinity of points. He further assumes that a line is not divided by continuous motion along it, since the motion, like the space and time it involves, is infinitely divisible. Segments of motion, however small, can be paired off with the times taken for that motion and the distances covered by it. Division at a point will require marking off the point in some way, whether by stopping at, or marking or contemplating it. An infinity of such actual divisions of a continuum is impossible, not because of limitations in our physical or mental resources, but, more fundamentally, because the continuum is infinitely divisible, with points not standing next to point, nor indivisible next to indivisible. In *Generation and Corruption* (I, 2, 317a:1–13) Aristotle applies this kind of reasoning to dissolve Zeno's paradox of division. A continuous entity, as such, is divisible at any point, but it cannot be simultaneously divided everywhere, because a continuous magnitude is not made up of points in the required sense. Hence, the infinite division presupposed in the paradox is impossible.⁶ Once again, the point rests on an analysis of the nature of the continuum and does not require a specification of the method of division.

Aristotle had responses to Zeno's paradoxes that retained the notion of continuous magnitudes, times and motions that avoided appealing to indivisible magnitudes. The fact that he did not specify the method of division should not be taken as evidence

⁵ My interpretation of Aristotle's position is in line with that of Lear (1979–80).

⁶ I endorse the analysis of Aristotle's argument here recently offered by David Sedley (2004), although I resist his assumption that Aristotle is here criticizing a position he attributed to Democritus.

that he did not distinguish between methods of division because his arguments were independent of the method of division.

8. Aristotle's Critique of Atomism

It is beyond the scope of this article to give a detailed account of Aristotle's critique of atomism. My aim is simply to argue that implicit in that critique is an appreciation of the distinction between the two kinds of atomism, one involving physical atoms and the other involving indivisible magnitudes.

In a number of places Aristotle construes Democritean atomism as a response to Parmenides and in those locations it is clear that to play their role in that context those atoms must be changeless bodies with a definite shape and size.⁷ Aristotle clearly regarded this theory of Leucippus and Democritus to be by far the best of those of his predecessors. It was "the most systematic and consistent theory" (*Generation and Corruption*, 324b:36) involving a method that had confronted all the problems (315a:36–315b:1) defended by "arguments appropriate to the subject" (316a:13). Aristotle's problems with the "solids" constituting the atoms in this physical atomism in effect involved the complaint that because they were impassive solids possessing only shape, size and motion they were unable to interact and combine in ways sufficient to account for the range of activity apparent in the world.⁸

Aristotle also argued against the kind of atomism that invokes indivisible magnitudes. Insofar as the arguments for such entities stem from a desire to resolve Zeno's paradoxes, Aristotle's solution of those paradoxes that did not involve giving up on continuity obviated the motivation for introducing indivisible magnitudes. Further, as we have seen, he saw problems with the idea that indivisible magnitudes can be combined into macroscopic entities because, lacking edges, they cannot be laid edge to edge in the required way. He solved the paradox of division by insisting that a continuous body cannot be simultaneously divided at an infinity of points because points are not next to points in the required way.

The two kinds of atomism were combated with different kinds of arguments. The discussion of Zeno's paradoxes in the *Physics* makes no mention of Democritus. Democritus is mentioned in the context of the discussion of infinite division in *Generation and Corruption*. However, it is not clear that Aristotle is attributing the assumption of indivisible magnitudes to Democritus. I find it difficult to reconcile the assumption that he did so with the high regard Aristotle had for Democritus's theory as one that "confronted all the arguments" and with "arguments appropriate to the subject". When, following his detailed discussion of indivisibles in Book 1, Chapter 2, he proceeds, in Book 1 Chapter 8, to discuss atomism involving "indivisible solids", and insists that "we must not now enter upon a detailed study of the consequences" (1, 8, 325b:35). But he has already given a detailed discussion of indivisible

⁷ See, for instance, *Generation and Corruption*, (315a:35–315b:15 and 324a:24–325b:5).

⁸ The main arguments are set out in *Generation and Corruption*, 326a:1–326b:6.

magnitudes in Book 2. This, together with his explicit referral in this place to atoms as “solids”, indicates a clear distinction between physical atoms and indivisibles. Further, the arguments that Aristotle proceeds to offer against physical atoms, summarized by me in the second paragraph of this section, are quite different in kind to those offered against indivisible magnitudes.

9. Conclusion

I have argued that Aristotle did appreciate the distinction between physical atoms and indivisible magnitudes and the differing senses in which they are to be regarded as indivisible. He argued against both kinds of atomism but with quite different kinds of arguments. This is the case whether Aristotle regarded Democritus as having proposed both kinds of atomism or not. I have suggested that the grounds for assuming that Aristotle attributed an advocacy of indivisible magnitudes to Democritus are weak.

Bibliography

- Barnes, 1996
Jonathan Barnes, *The Presocratic Philosophers*. Cambridge: Cambridge University Press.
- Furley, 1967
D. Furley, *Two Studies in Greek Atomism*. Princeton, New Jersey: Princeton University Press.
- Kirk, Raven and Schofield, 1999
G. S. Kirk, J. E. Raven and M. Schofield, *The Presocratic Philosophers*. Cambridge: Cambridge University Press.
- Lear, 1979–80
Jonathan Lear, “Aristotelian Infinity”, *Proceedings of the Aristotelian Society*, 188–210.
- McKeon, 1968
Richard McKeon, *The Basic Works of Aristotle*. New York: Random House.
- Pyle, 1995
Andrew Pyle, *Atomism and its Critics*. Bristol: Thoemmes Press.
- Sedley, 2004
David Sedley, “On *Generation and Corruption*, I. 2”, in F. De Haas and J. Mansfield (eds), *Aristotle: On Generation and Corruption, Book I*. Oxford: Clarendon Press.
- Sorabji, 1983
Richard Sorabji, *Time, Creation and the Continuum*. London: Duckworth.