WEIGHT IN GREEK ATOMISM

1. Introduction

The *testimonia* concerning weight in early Greek atomism appear to contradict one another. Some reports assert that the atoms do have weight, while others outright deny weight as a property of the atoms. A common solution to this apparent contradiction divides the *testimonia* into two groups. The first group describes atoms within a κόσμος, where they have weight; the second group describes atoms outside of a κόσμος, where they are weightless[1]. Important to advocates of this solution is the δῖνος, or vortex[2]. The vortex, they claim, fulfills a crucial role in the ascription of weight to atoms, and detailed accounts are offered to explain how its rotation and consequent effects reconcile the otherwise conflicting reports.

Despite its endorsement by many notable scholars, I am sympathetic with those who question the tenability of this interpretive solution[3]. Suspicions tend

---

1. D. Furley, The Greek Theory of the Infinite Universe, *Journal of the History of Ideas*, 42, 1981, pp. 571-585, at pp. 572-573 helpfully reminds his reader that the Greek word κόσμος (and compare the Latin *mundus*) refers to a limited, organized system, bounded by the stars. The universe as a whole, by contrast, is referred to by Greek writers as τὸ πᾶν (and compare the Latin phrases *omne quod est, omne immensum* and so forth). For those Greek writers who subscribed to an infinite universe, then, a κόσμος represents the bounded area beyond which begins the rest of the infinite universe. And compare the following lines from Lucretius, *De Rerum Natura,* 1.73-75: *ergo vivida vis animi pervicit et extra processit longe flammantia moenia mundi atque omne immensum peragravit mente animoque*; «And so his mind's might and vigor prevailed, and on he marched far beyond the blazing battlements of the world, in thought and understanding journeying all through the measureless universe» (Smith trans.).

2. On varying conceptions of the vortex in early Greek philosophy, as well as Plato and Aristotle, cf. J. Ferguson, ΔΙΝΟΣ, *Phronesis*, 16, 1971, pp. 97-115. On the vortex's rotation and consequent effects in Empedoclean physics, cf. S. Tigner, Empedocles's Twirled Ladle and the Vortex-Supported Earth, *Isis*, 65, 1974, pp. 432-447.

3. Proponents include: C. Bailey, *The Greek Atomists and Epicurus*, Oxford, Clarendon Press, 1928, pp. 128-132 and pp. 144-146; J. Burnet, *Early Greek Philosophy*, 4th edn., London, Adam & Charles Black, 1930, pp. 341-346; W. K. C. Guthrie, *A History of Greek Philosophy*, vol. 2, Cambridge, Cambridge University Press, 1965, pp. 400-404; G. S. Kirk, J.

to center on its appropriation of Aristotelian cosmological notions or its reading of particular *testimonia*. While I share such suspicions, my primary concern is different. If the common interpretive solution is correct, then we appear committed to the claim that the atoms themselves can undergo a *significant* change. Of course, and in a sense, the atoms can undergo changes. For instance, an atom's present trajectory can change if it collides with another atom. But when this happens, the atom itself does not change; its size and shape are not altered. And it is clear from the *testimonia* that an atom's weight is dependent upon its size. But if an atom's size cannot change, then how can its weight change? It would seem that it cannot. Yet this is just what the above interpretive solution contends: if an atom is within a κόσμος, then it has weight; if it is outside of a κόσμος, then it is weightless.

    In what follows, I shall put pressure on the common interpretive solution by focusing chiefly on one of the *testimonia* –report 1.3.18 from the first–century BCE doxographer Aëtius. This report is crucial to the above interpretive solution for two reasons. First, it apparently denies weight as a property of the atoms. And second, it supposedly describes the atoms when they are outside of a κόσμος. Together these aspects of the report contribute to the present interpretive difficulty, which I intend to resolve by reinterpreting the *testimonium*. In Section 2, I review briefly the pertinent *testimonia*. Here I also take up a question important to the present topic: *what kind of property is weight*? Though some scholars contend that weight is described as a *basic* property of the atoms, I will show that weight is in fact described as a *dependent* property. This, in turn, sets up my first engagement with report 1.3.18 from Aëtius. I will argue that the report does not outright deny weight as a property of the atoms. Rather, it denies only that weight is a basic property of the atoms. Then, in Section 3, I turn my attention to the claim that report 1.3.18

E. RAVEN, and M. SCHOFIELD, *The Presocratic Philosophers*, 2nd edn., Cambridge, Cambridge University Press, 1983, pp. 421-423; and cf. C. C. W. TAYLOR, *The Atomists: Leucippus and Democritus*, Toronto, University of Toronto Press, 1999, at pp. 182-183. The interpretation has been challenged chiefly by Furley and D. O'Brien. Cf. D. FURLEY, *op. cit.*; D. FURLEY, *Two Studies in the Greek Atomists*, Princeton, Princeton University Press, 1967; D. FURLEY, Weight and Motion in Democritus' Theory, *Oxford Studies in Ancient Philosophy*, 1, 1983, pp. 193-209; D. O'BRIEN, Heavy and Light in Democritus and Aristotle: Two Conceptions of Change and Identity, *Journal of Hellenic Studies*, 97, 1977, pp. 64-74; D. O'BRIEN, *Theories of Weight in the Ancient World*, vol. 2., Paris, Les Belles Lettres, 1981. For responses to Furley, cf. D. KONSTAN, Problems in Epicurean Physics, *Isis*, 70, 1979, pp. 394-418, at pp. 408-417; and T. O'KEEFE, *Epicurus on Freedom*, Cambridge, Cambridge University Press, 2005, at p. 120, n. 28. D. FURLEY, 1983, *op. cit.*, contains some pointed criticisms of D. O'BRIEN, 1981, *op. cit.*

supposedly describes the atoms when they are outside of a κόσμος. It has been argued that the phrase «τῇ τοῦ βάρους πληγῇ», or «by the impact of weight», in the report refers to the cause of natural motion (i.e., downward and in parallel, straight lines) for Epicurus's atoms. And where this kind of motion occurs, the context is surely outside of a κόσμος. I do not deny that an atom's weight is the cause of that atom's downward motion for Epicurus. However, I shall argue that an atom's weight does not move the atom downward by an impact. As such, the phrase, «by the impact of weight», does not refer to the cause of natural motion for Epicurus's atoms. Consequently, there is no reason to suppose that the report describes the atoms when they are outside of a κόσμος.

Although these are largely negative conclusions, we are not left without a solution to the present interpretive difficulty. It will turn out that, when read correctly, Aëtius 1.3.18 agrees with those reports that describe weight as a dependent property of the atoms. And as for the other conflicting report, itself also from Aëtius, it can be read in a way such that it too agrees with these conclusions. Once our *testimonia* concerning weight in early Greek atomism are examined thoroughly, it is clear that there is no conflict among them.

2. Weight as a dependent property

Let us begin with two reports from Aristotle.

> (1) *De Gen. et Corr.*, 326 a 8: καίτοι βαρύτερόν γε κατὰ τὴν ὑπεροχήν φη-σιν εἶναι Δημόκριτος ἕκαστον τῶν ἀδιαιρέτων.

> (2) *De Cael.,* 309 a 1-2: τοῖς δὲ στερεὰ μᾶλλον ἐνδέχεται λέγειν τὸ μεῖζον εἶναι βαρύτερον αὐτῶν.

> (1) «Democritus says that each of the indivisibles is heavier in proportion to its excess [i.e., size]».

> (2) «[Those who assert that the primary elements are] solids [i.e., bodies] are better able to maintain that the larger are heavier».

The first report is straightforward. It asserts that, according to Democritus, atoms are heavier in proportion to their size. The second report, however, requires some explanation. It appears in an argument against a theory of Plato's from the *Timaeus* (63 c 1 ff.), according to which the primary and indivisible particles are «surfaces». Plato's theory, Aristotle contends, is absurd for supposing that from these surfaces there can be bodies of which the larger are the heavier. However, he continues, «[those who assert that the primary elements are] solids [i.e., bodies] are better able to maintain that the larger

are heavier»[4]. That is, the Atomists. Whatever we might make of Aristotle's argument itself (something that I shall not discuss here), it is sufficient to note that these two reports are in agreement. Atoms, according to Aristotle's testimony, are more or less heavy depending on their size –the larger an atom is, the heavier it will be.

A passage from Theophrastus confirms this interpretation[5].

> (3) *De Sens.*, 61: βαρὺ μὲν οὖν καὶ κοῦφον τῷ μεγέθει διαιρεῖ Δημόκριτος. εἰ γὰρ διακριθῇ ἔνθεν ἕκαστον, εἰ καὶ κατὰ σχῆμα διαφέροι διαφέρει, σταθμὸν ἂν ἐπὶ μεγέθει τὴν φύσιν ἔχειν.

> (3) «Democritus distinguishes heavy and light according to size; for if they were separated from one another individually, whatever their differences in shape, they would have weight dependent on their size».

As with (1) and (2), here too is it reported that an atom's weight is dependent upon its size. We have, then, three passages that describe weight as a property of the atoms, and explain the difference between heavier atoms and lighter atoms as due to their size.

At this point it is worth asking: *what kind of property is weight*? Some scholars contend that the testimony of Aristotle and Theophrastus describes weight as a basic property of the atoms[6]. By basic property, I mean a property that is *explanatorily primary*. This may be made clear if we look again at reports (1)-(3). Aristotle writes of heaviness as a product of an atom's size (literally *excess*, ὑπεροχή), such that a greater size results in a heavier atom. And Theophrastus writes that, whatever the differences in shape between individual atoms, an atom's weight is dependent on (ἐπί) its size. In each report, then, we find that a difference in weight between individual atoms is explained by a difference in size. As such, size is a property of the atoms in virtue of which some other property, and variations among particular

---

4. H. CHERNISS, *Aristotle's criticism of Presocratic philosophy*, Baltimore, Johns Hopkins Press, 1935, at p. 211, n. 253, and W. K. C. GUTHRIE, *op. cit.*, p. 403, n. 2, argue that αὐτῶν in (2) refers to compound bodies. But D. O'BRIEN, 1977, *op. cit.*, p. 65, and D. FURLEY, 1983, *op. cit.*, p. 93, note rightly that this reading ruins the antithesis: τῶν δὲ συνθέτων. It must be the case, then, that αὐτῶν in (2) refers to the primary and indivisible particles.

5. For an alternative rendering of this passage, cf. J. MCDIARMID, *De Sensibus*, 61-62: Democritus' Theory of Weight, *Classical Philology*, 55, 1960, pp. 28-30. But cf. D. O'BRIEN, 1977, *op. cit.*, p. 66 and D. O'BRIEN, 1981, *op. cit.*, pp. 116-125, for criticisms of McDiarmid's rendering. O'Brien's criticisms seem convincing.

6. See, for instance, D. FURLEY, 1976, *op. cit.*, p. 81. Although Furley himself does not use the term «basic» –he describes weight as a «primary, irreducible property of the atoms»– his description is in-line with what follows.

instantiations of that property, is both present and explained. It is in this sense that size is explanatorily primary and, therefore, a basic property of the atoms. Since an atom's weight is not explanatorily primary, it is not a basic property of the atoms. Rather, and in accordance with what has been seen so far, weight is a dependent property of the atoms[7].

We should not be concerned that, on this reading, an atom's weight might become explanatorily primary if we shift our focus from individual atoms to atomic aggregates. After report (2), Aristotle continues by noting that the weight of atomic aggregates is not dependent solely on their bulk (ὄγκος). Rather, an atomic aggregate's weight is dependent upon both its bulk and the amount of void imprisoned (ἐμπεριλαμβάνω) within the aggregate itself. As a result, for any atomic aggregate, its weight is determined by the ratio of solid to void, such that a change in this ratio yields a change in its weight. And this is so too for relative weights between two (or more) atomic aggregates. Consider, for instance, a situation in which there are two atomic aggregates, and each aggregate is composed of an equal number of equally-sized, solid parts. Suppose also that one of the aggregates is heavier than the other aggregate. What accounts for this difference in weight? According to the atomists, the greater amount of void imprisoned within one of the atomic aggregates; a greater amount of void makes it lighter than the other aggregate (*De Cael.*, 309 a 8-10). Now consider a similar case, in which there are two atomic aggregates, and each aggregate is composed of an equal number of solid parts. Suppose too that both atomic aggregates imprison an equal amount of void, yet one aggregate is heavier than the other aggregate. In this case, the difference in weight must be explained by one atomic aggregate's possessing a greater bulk –its solid parts are, collectively, greater in size– than the other aggregate (*De Cael.*, 309 a 12-15)[8]. As such, even when our focus shifts from individual atoms to atomic aggregates, size (alongside void) retains its explanatory primacy. And an atomic aggregate's weight, when considered either by itself or relative to another atomic aggregate, also remains a dependent property.

Let us return to the *testimonia*. The next report is preserved by the first-century BCE doxographer Aëtius. Here is the report in full.

(4) 1.3.18 (= pseudo-Plutarch, 1.3.18): Ἐπίκουρος Νεοκλέους Ἀθηναῖος κατὰ Δημόκριτον φιλοσοφήσας ἔφη τὰς ἀρχὰς τῶν ὄντων σώματα λόγῳ θεωρητά, ἀμέτοχα κενοῦ, ἀγένητα ἀδιάφθαρτα, οὔτε θραυσθῆναι δυνά-

_____

7. D. KONSTAN, *op. cit.*, p. 410, arrives at the same conclusion. And both C. BAILEY, *op. cit.*, p. 129 (cf. pp. 131-132), and J. BURNET, *op. cit.*, p. 342, seem to regard weight as a dependent property of the atoms. See also D. O'BRIEN, 1981, *op. cit.*, pp. 233-238.

8. A similar explanation of these two situations is found at *DRN*, 1.358-369, where Lucretius points to differences in weight between macroscopic objects as evidence for the existence of void.

μενα οὔτε διάπλασιν ἐκ τῶν μερῶν λαβεῖν οὔτε ἀλλοιωθῆναι· εἶναι δὲ αὐτὰ λόγῳ θεωρητά· ταῦτα μέντοι κινεῖσθαι ἐν τῷ κενῷ καὶ διὰ τοῦ κενοῦ· εἶναι δὲ καὶ αὐτὸ τὸ κενὸν ἄπειρον καὶ τὰ σώματα ἄπειρα· συμβεβηκέναι δὲ τοῖς σώμασι τρία ταῦτα, σχῆμα μέγεθος βάρος. Δημόκριτος μὲν γὰρ ἔλεγε δύο, μέγεθός τε καὶ σχῆμα ὁ δὲ Ἐπίκουρος τούτοις καὶ τρίτον βάρος προσέθηκεν· ἀνάγκη γάρ, φησί, κινεῖσθαι τὰ σώματα τῇ τοῦ βάρους πληγῇ· ἐπεὶ οὐ κινηθήσεται. εἶναι δὲ τὰ σχήματα τῶν ἀτόμων ἀπερίληπτα, οὐκ ἄπειρα. μὴ γὰρ εἶναι μήτ᾽ ἀγκιστροειδεῖς μήτε τριανοειδεῖς μήτε κρικοειδεῖς· ταῦτα γὰρ τὰ σχήματα εὔθραυστά ἐστιν, αἱ δὲ ἄτομοι ἀπαθεῖς ἄθραυστοι. ἴδια δὲ ἔχειν σχήματα λόγῳ θεωρητά. καὶ εἴρηται ἄτομος οὐχ ὅτι ἐστὶν ἐλαχίστη, ἀλλ᾽ ὅτι οὐ δύναται τμηθῆναι, ἀπαθὴς οὖσα καὶ ἀμέτοχος κενοῦ·

(4) «Epicurus of Athens, the son of Neokles, who philosophized in accordance with Democritus said that the principles of existing things are bodies that can be contemplated by reason, which have no share of void, are ungenerated, imperishable, neither able to be broken nor to be reshaped in respect of their parts, nor susceptible to alteration. And these are contemplated by reason. But these move in the void and through the void. Both the void itself is infinite and the bodies are infinite. *The properties of the bodies are these three: shape, size and weight. Democritus, on the one hand, said there are two: size and shape; and on the other hand, Epicurus added to these a third, weight. For it is necessary, he said, that the bodies be moved by the impact of weight. Or else they would not move.* And the shapes of the atoms are ungraspable, but not infinite. For they are not hook-shaped or trident-shaped, or ring-shaped. For these shapes are easily broken, but the atoms are free from affection and unbreakable. They have their own shapes that can be contemplated by reason. And it is called an "atom" not because it is smallest, but because it cannot be cut, being free from affection and having no share of void»[9].

---

9. Portions of this report are found in Stobaeus, 1.10.14, preserved by Aëtius under the heading Περὶ ἀρχῶν καὶ στοιχείων καὶ τοῦ παντός. I omit the end of the passage, which (and here I agree with H. DIELS, *Doxographi Graeci*, Berlin, de Gruyter, 1879, p. 286, n. 1) seems to be an interpolation. Still, for the sake of completeness, here is the text: ὥστε ἐὰν εἴπῃ ἄτομον, ἄθραυστον λέγει καὶ ἀπαθῆ ἀμέτοχον κενοῦ. ὅτι δέ ἐστιν ἄτομος, σαφές· καὶ γάρ ἐστι στοιχεῖα ἀεὶ ὄντα καὶ ζῷα κενὰ καὶ ἡ μονάς.

There is an oddity in this report that merits a brief comment. Notice that the report describes atomic shapes not as infinite (ἄπειρος), but as ungraspable (ἀπερίληπτος). The early Greek atomists contended that the atoms are of infinitely many shapes, since there is no more reason for them to be one shape rather than another shape (Simp., *In Phys.*, 28.4-27). Epicurus rejected the possibility of infinitely many shapes. But, interestingly, not for the reason given here: that some shapes (e.g., hook-, trident-, or ring-shapes) are easily broken. Instead, Epicurus's rejection of infinitely many atomic shapes proceeds in two steps. First,

Of present interest is the italicized portion of this report. These lines tell us that, for Democritus, size and shape are properties of the atoms, and that later Epicurus added weight as a third property to the atoms. Now there is some question as to how this ought to be understood. On some interpretations, these lines are read as *implicitly* denying that weight is a property –that is, *any* kind of property– of the atoms for Democritus. As such, the *testimonia* are

Epicurus declares that infinitely many atomic shapes entails atoms of infinitely many sizes (*Ad Herod.*, 43). While he does not defend this entailment in *Ad Herodotum*, Lucretius offers a possible defense by appeal to an atom's minimal parts. (It remains an open question whether Epicurus himself defended this entailment by appeal to an atom's minimal parts. His discussion of minimal parts at *Ad Herod.*, 56-59 contains no mention of their use to limit the number of possible atomic shapes. Instead, it is concerned with just those paradoxes involving infinite divisibility propounded by Zeno of Elea.) Consider, for instance, an atom composed of three minimal parts. Once these parts are positioned on top and bottom, swapped left and right, and in short every possible permutation considered, then it is possible to determine what each arrangement of the parts yields with respect to the atom's shape. Consequently, if there are to be additional atomic shapes, there must be additional minimal parts. And this, in turn, entails an increase in an atom's size. As a result, if there are to be infinitely many atomic shapes, so too must there be atoms of infinitely many sizes (*DRN*, 2.478-499). But why should this be rejected? The answer, and so second step, is provided at *Ad Herod.*, 56: while *some* (τινα) variation in the size of atoms will yield better explanations of the events reported by our feelings (πάθη) and sense-perceptions (αἰσθήσεις), the possibility of atoms of *every* (πᾶν) size is not useful (χρήσιμος) for this purpose; and if every size were possible, then we ought to experience visible atoms (ὁρατά ἄτομα). But that is not seen to happen, nor is it possible to conceive of a visible atom. It is possible to flesh out the first of these reasons by again turning to Lucretius. (For this way of interpreting Lucretius's argument, cf. A. A. LONG and D. N. SEDLEY, *The Hellenistic Philosophers*, vol. 2, Cambridge, Cambridge University Press, 1987, §12). The possibility of infinitely many atomic shapes would obliterate the limits that circumscribe all natural phenomena. Take, for example, some phenomenal predicate *F*. However *F* a given thing is, if there were infinitely many atomic shapes, then there would always be a possibility of some atom turning up that would produce something still *F*-er. But, as is revealed by our experiences, there is a limit to how *F* a given thing can be. Therefore, there are finitely many atomic shapes (*DRN*, 2.500-514). The second reason suggests that Epicurus is also concerned with a possibility from earlier atomic systems: *really big* atoms. Democritus, for instance, supposedly put no upper limit on the possible size of atoms –presumably for the same reason that there is no limit on the possible shapes of atoms – with the consequence that an atom could be as large as a κόσμος (STOBAEUS, 1.14.1; EUSEBIUS, *Prae. Evan.*, 14.23.2-3). And Epicurus suggests that such a possibility would allow for atoms that are large enough to be seen (LONG and SEDLEY, *op. cit.*, §12, note rightly that Epicurus's concern here is puzzling, for it does not accord with his theory of perception). But this is unacceptable, for the atoms are necessarily imperceptible. Therefore, there must be a finite number of atomic shapes so as to preclude the possibility of visible atoms. In the light of these reasons, one cannot help but wonder why some atomic shapes would be thought easily broken, and why *this* would be the grounds on which an Epicurean would argue against there existing atoms of infinitely many shapes.

understood as Aristotle and Theophrastus describing weight as a property of the atoms, and Aëtius denying (in this report and the next, which we will see shortly) weight as a property of the atoms[10].

But to read these lines of report (4) as implicitly denying weight as a property of Democritus's atoms is a mistake. Recall the distinction between a basic property and a dependent property introduced above. A basic property of the atoms is one that is explanatorily primary, in the sense that it is a property in virtue of which some other property, and variations among particular instantiations of that property, is both present and explained. Size is a basic property of Democritus's atoms. For it is in virtue of an atom's size that an atom has weight, and a variation in weight between, say, two individual atoms is explained by a variation in their size. Consequently, weight is not a basic property of Democritus's atoms. Rather, it is a dependent property of his atoms.

But the case is more complicated for Epicurus's atoms. When it comes to atomic motion, Democritus contends that the atoms are moved by collisions. Indeed, the atoms are moved by an infinitely long series of collisions (Arist., *De Cael.*, 300 b 8-301 a 11). But Aristotle found this explanation lacking (*Phys.*, 8.1.252 a 32-b 2; cf. *Phys.*, 4.8.215 a 1-13). He criticized Democritus for failing to provide an ἀρχή, or first principle, that explains the unending series of atomic collisions. It would seem that Epicurus was sensitive to Aristotle's criticisms. (Whether or not he knew of them from Aristotle's writings directly is another matter). For his own atomistic physics contains an account of natural atomic motion. The natural motion of the atoms, for Epicurus, is in a privileged direction defined as «downwards» (cf. *Ad Herod.*, 60). And this motion is explained by their weight (*Ad Herod.*, 61; Lucr., *DRN,* 2.217-218). In addition, Epicurus introduces the swerve –a slight shifting to the right or left of one spatial minimum– which enables him to explain the beginning of collisions among atoms, out of which come to be κόσμοι and everything that inhabits them (Lucr., *DRN*, 2.216-224). Notice what has happened here. For Epicurus, the natural motion of the atoms is explained by their *weight*. Weight is now a property in virtue of which some other property –natural motion in a privileged direction defined as «downwards»– is both present and explained. As such, weight is reclassified by Epicurus as a basic property of the atoms.

I suggest, then, that the contrast between Democritus and Epicurus in the

---

10. Cf., for instance, J. Burnet, *op. cit.*, pp. 341-342; G. S. Kirk, J. E. Raven, and M. Schofield, *op. cit.*, p. 422; C. C. W. Taylor, *op. cit.*, p. 179. But see D. O'Brien, *op. cit.*, p. 67, who suggests, as I shall demonstrate, that (4) does not outright deny weight as a property of the atoms. In fact, it should be read in agreement with the evidence of Aristotle and Theophrastus.

italicized portion of report (4) is just this: for Democritus, size and shape are basic properties of the atoms. Later, and in response to Aristotle's criticisms of Democritus, Epicurus reclassifies weight as a basic property of the atoms. For the natural motion of the atoms is both present and explained by their weight. The two concluding sentences support this suggestion: «For it is necessary, he [i.e., Epicurus] said, that the bodies be moved by the impact of weight. Or else they would not move»[11]. Since this portion of report (4) is concerned just with those properties that are basic properties of the atoms, it does not deny –not even implicitly– that weight is a property of Democritus's atoms. Rather, it denies only that weight is a basic property of his atoms. Therefore, it should be read in agreement with the testimony from Aristotle and Theophrastus, where weight is described as a dependent property of the atoms.

The last report is also from Aëtius. It reads,

(5) 1.14.6 (= Stobaeus 1.14.6): Δημόκριτος τὰ πρῶτά φησι σώματα, ταῦτα δ' ἢ τὰ ναστά, βάρος μὲν οὐκ ἔχειν, κινεῖσθαι δὲ κατ' ἀλληλοτυπίαν ἐν τῷ ἀπείρῳ.

(5) «Democritus said that the primary bodies (those he called the solids) had no weight, but were moved by mutual impact in the infinite [i.e., void]».

Here there is an explicit denial of weight as a property of the atoms: Democritus said that the atoms had *no* weight, but were moved by mutual impact in the infinite. So, there appears to be a conflict in the *testimonia*. There are three reports that describe weight as a dependent property of the atoms, one report that should be read in agreement with them, and one report that appears to outright deny weight as a property of the atoms.

But here too a reconciling interpretation is forthcoming. Notice that this report also includes a reference to atomic motion. Above I noted that Democritus's atoms do *not* have a natural motion. Instead, they are moved by an infinitely long series of collisions. But Epicurus's atoms *do* have a natural motion, and this motion is both present and explained by their weight. With this in mind, I submit that report (5) should be interpreted in the following way:

«Democritus said that the primary bodies (those he called the solids) had no weight [sc. as a cause of atomic motion], but were moved by mutual impact in the infinite [i.e., void]».

---

11. It will turn out that, however an atom's weight moves the atom downward, it is not by an impact. I address this matter in Section 3.

On this interpretation, report (5) does not outright deny weight as a property of Democritus's atoms. Instead, it denies only that weight has any connection with atomic motion. Here report (5) agrees with the italicized portion of report (4). There the contrast between Democritus and Epicurus should, I argued, be understood in the light of Epicurus's response to Aristotle's criticisms of Democritean atomism. Democritus did not provide an ἀρχή that explains the unending series of collisions between the atoms. And to this Aristotle objected. Epicurus, it would seem, sought to meet Aristotle's requirement by providing an ἀρχή. He begins by reclassifying weight as a basic property of the atoms. Consequently, weight becomes a property in virtue of which some other property –natural motion in a privileged direction defined as «downwards»– is both present and explained. Then Epicurus introduces the swerve, which enables him to explain the beginning of collisions among atoms. Of significance at present is the connection made by Epicurus between weight and natural atomic motion. For it is here that there is an agreement between report (5) and the italicized portion of report (4). Weight is not a cause of atomic motion for Democritean atoms; they are moved all and only by collisions. For this reason, weight is a dependent property of his atoms. But weight is a cause of atomic motion for Epicurean atoms. For the natural motion of the atoms in a privileged direction defined as «downwards» is explained by their weight. Recall too the concluding sentences from the italicized portion of report (4): «For it is necessary, he [i.e., Epicurus] said, that the bodies be moved by the impact of weight. Or else they would not move». For Epicurus, then, weight gains explanatory primacy. Consequently, it becomes a basic property of his atoms. Therefore, just as report (4) may be read in agreement with the testimony of Aristotle and Theophrastus, so too, I contend, should report (5) be read in agreement with their testimony.

Let us now take stock. In response to an apparent conflict in the *testimonia* concerning weight in early Greek atomism, a common interpretive solution divides the *testimonia* into two groups. Those *testimonia* that describe weight as a property of the atoms, they claim, also describe the atoms when they are within a κόσμος. And those *testimonia* that deny weight as a property of the atoms, they claim, also describe the atoms when they are outside of a κόσμος. That is, within a κόσμος, the atoms have weight; outside of a κόσμος, the atoms are weightless. But this cannot be correct. For according Aristotle's and Theophrastus's testimony, an atom's weight is dependent upon its size. Now insofar as size is a property of the atoms, because all atoms have some size, and an atom's weight is dependent upon its size, it follows that all atoms have some weight. Weight *must* be a property of the atoms for all atomists, regardless of whether they are within or outside of a κόσμος! But if this is so, then what of those *testimonia* that apparently deny weight as a property of the atoms? I began by distinguishing two kinds of properties: a basic property and a dependent property. A basic property is one that is explanatorily primary, in the sense that it is a property in virtue of which some other property, and

variations among particular instantiations of that property, is both present and explained. Size is a basic property of the atoms, while for Democritus weight is a dependent property. But for Epicurus weight becomes a basic property. The natural motions of the atoms is explained by –and only by– their weight. Weight becomes a cause of atomic motion. And *this* is of the utmost significance. For I argued that the two reports from Aëtius, which apparently deny weight as a property of Democritus's atoms, *in fact* deny only that weight is a basic property of Democritus's atoms and that weight has any connection to atomic motion. The second point is the crux of my argument. But it is confirmed by Aristotle's criticisms of Democritean atomism, and Epicurus's subsequent modifications in his own atomistic physics. As a result, Aëtius's testimony may now be read in agreement with the testimony from Aristotle and Theophrastus. Consequently, there is no conflict in the *testimonia* concerning weight in early Greek atomism.

3. Cosmic and Extra-Cosmic States

The interpretation and arguments offered in the previous section challenge those who would accept that Aëtius's testimony denies weight as a property of Leucippus's and Democritus's atoms. But this is only one part of what supports the common interpretive solution. According to some scholars, report (4) describes the atoms when they are outside of a κόσμος. If this is correct, then the apparent conflict in the *testimonia* can be reconciled in the following way: when the atoms are *within* a κόσμος, what I will henceforth refer to as a *cosmic* state, the atoms have weight. This accounts for the testimony of Aristotle and Theophrastus. However, when the atoms are *outside* of a κόσμος, what I will henceforth refer to as an *extra-cosmic* state, the atoms are weightless. And this accounts for the testimony of Aëtius. So, insofar as the testimony of Aristotle and Theophrastus and the testimony of Aëtius describe the atoms in different states, there is no conflict between them. Provided, that is, that there is some reason for *why* atoms in a cosmic state should have weight, while atoms in an extra-cosmic state should be weightless. In this section, I will argue that those reasons marshaled in support of reading report (4) as describing the atoms in an extra-cosmic state cannot withstand scrutiny. As such, there is no more reason to suppose that report (4) describes the atoms in an extra-cosmic state than in a cosmic state[12].

---

12. In Section 4, I shall address why someone might maintain that it is only in a cosmic state that the atoms have weight. And there I will show why it would be wrong to maintain such a position.

Our attention will be focused once more on the italicized portion of report (4). For the sake of convenience, here it is again:

συμβεβηκέναι δὲ τοῖς σώμασι τρία ταῦτα, σχῆμα μέγεθος βάρος. Δημό-κριτος μὲν γὰρ ἔλεγε δύο, μέγεθός τε καὶ σχῆμα, ὁ δὲ Ἐπίκουρος τούτοις καὶ τρίτον βάρος προσέθηκεν· ἀνάγκη γάρ, φησί, κινεῖσθαι τὰ σώμα-τα τῇ τοῦ βάρους πληγῇ· ἐπεὶ οὐ κινηθήσεται.

«The properties of the bodies are these three: shape, size and weight. Democritus, on the one hand, said there are two: size and shape; and on the other hand, Epicurus added to these a third, weight. For it is necessary, he said, that the bodies be moved by the impact of weight. Or else they would not move».

After contrasting Democritus with Epicurus, who, as I argued in the previous section, reclassified weight as a basic property of the atoms, the report concludes, «for it is necessary, he said, for the bodies to be moved by the impact of weight. Or else they would not move». This comment, some claim, describes the atoms in an extra-cosmic state because invites comparison with Epicurus's remarks on the movement of atoms prior to any collisions. Prior to any collisions, the atoms fall downward in parallel, straight lines. And where the atoms fall downward in parallel, straight lines, the context is surely an extra-cosmic state. If this is correct, then there is still some support for the common interpretive solution.

To motivate such a comparison, proponents of this reading begin with a reference to the following report from Simplicius, *In Phys.*, 42.10-11:

Δημόκριτος φύσει ἀκίνητα λέγων τὰ ἄτομα πληγῇ κινεῖσθαί φησιν.

«Democritus said that the atoms are by nature immobile and are moved by an impact».

Here Simplicius reports that, according to Democritus, the atoms have no natural motion, but are moved by an impact. Simplicius's report is significant because it mirrors, but with an important difference, the italicized portion of report (4) from Aëtius.

Aëtius A: ἀνάγκη γάρ, φησί, κινεῖσθαι τὰ σώματα τῇ τοῦ βάρους πληγῇ…

Simplicius A: τὰ ἄτομα πληγῇ κινεῖσθαί φησιν.

Aëtius B: … ἐπεὶ οὐ κινηθήσεται.

Simplicius B: Δημόκριτος φύσει ἀκίνητα λέγων τὰ ἄτομα…

The A portions of each report assert that it is necessary for the atoms to be

moved «by an impact», while the B portions of each report assert that without such an impact the atoms would not (or do not) move. But there is an important difference that provides a valuable clue concerning the context of Aëtius's report: the addition of τοῦ βάρους to the simpler formula τῇ πληγῇ. That is, Democritus's atoms (according to Simplicius) are moved τῇ πληγῇ, or «by an impact», while Epicurus's atoms (according to the report preserved by Aëtius) are moved τῇ τοῦ βάρους πληγῇ, or «by the impact of weight».

That Epicurus's atoms are moved τῇ τοῦ βάρους πληγῇ, it is asserted, recalls *Ad Herodotum*, 61[13]. Here Epicurus writes that each and every atom moves at an equal velocity throughout the void. Heavier and larger atoms do not move faster than lighter and smaller atoms. Moreover, atoms that have been knocked into an upward or sideways trajectory do not move quicker than those that fall downwards because of their individual weights (οὔθ' ἡ ἄνω οὔθ' ἡ εἰς τὸ πλάγιον διὰ τῶν κρούσεων φορά, οὔθ' αἱ κάτω διὰ τῶν βαρῶν). These lines, some maintain, suggest that movement τῇ τοῦ βάρους πληγή, is internal to the atom itself –it is a πληγή from *within* the atom– and is therefore the cause of its downward motion[14]. And this is supported, it is further claimed, by a later line from section 61, which reports that an atom will continue along its current trajectory until ἕως ἀντικόψῃ ἢ ἔξωθεν ἢ ἐκ τοῦ ἰδίου βάρους πρὸς τὴν τοῦ πλήξαντος δύναμιν, «knocked aside either from without or *from its own weight* <reacting> against the force of the atom which struck it» (O'BRIEN, 1981, *op. cit.*, p. 231, n. 1, emphasis in original). The phrase τῇ τοῦ βάρους πληγῇ, then, should be interpreted as referring to the cause (for Epicurus) of an atom's downward motion, in parallel, straight lines and prior to any collisions. And wherever this kind of atomic motion occurs, the context is surely an extra-cosmic state[15].

---

13. A connection between report (4) and *Ad Herodotum*, 61 was first noticed, it seems, in C. BAILEY, *op. cit.*, p. 131 n. 4. However, he does not pursue the implications of such a connection.

14. For instance, in his commentary on *Ad Herodotum*, 61, D. FURLEY, 1967, *op. cit.*, p. 123, seems to endorse such an idea when he writes, «[i]f a falling heavy atom collides with a light atom, then the heavy atom may perhaps be only slightly deflected, or else it may be turned directly about but move upward through only a few space units before its *weight reasserts itself*» (my emphasis). While D. KONSTAN, *op. cit.*, pp. 412-415, is right to challenge Furley on this point, he arrives at the wrong conclusion. I return to this below.

15. D. O'BRIEN, 1981, *op. cit.*, p. 231, also comments on an earlier line in report (4) from Aëtius, which reads ταῦτα μέντοι κινεῖσθαι ἐν τῷ κενῷ καὶ διὰ τοῦ κενοῦ, that «the duplication of the expression seems to me very likely to be a reference to the downward movements of Epicurus's atoms». But he offers no reasons to support this contention. I myself do not understand why the duplication should be thought to make such a reference. For it is certainly correct to say of any atom that it moves, in whatever direction it is presently moving, in the void and through the void.

   The contention central to this argument –that an atom's weight exerts an impact from within the atom itself, that then drives it downwards– is very puzzling. How could this happen?! After all, the atoms are α-τόμον, un-cuttable. Therefore, there are no physical parts of an atom that could, if moved in some way, exert an impact from within the atom and thereby drive it downwards. Fortunately, an explanation for how this event could occur is not needed. For neither do the cited passages from *Ad Herodotum*, 61, nor, for that matter, another report preserved by Aëtius support such a contention. Instead, whenever a striking or an impact is mentioned, it is always between atoms.

   Let us look more closely at the pertinent texts. Here are lines 1-6 of *Ad Herodotum*, 61:

> καὶ μὴν καὶ ἰσοταχεῖς ἀναγκαῖον τὰς ἀτόμους εἶναι, ὅταν διὰ τοῦ κενοῦ εἰσφέρωνται μηθενὸς ἀντικόπτοντος. οὔτε γὰρ τὰ βαρέα θᾶττον οἰσθή-σεται τῶν μικρῶν καὶ κούφων, ὅταν γε δὴ μηδὲν ἀπαντᾷ αὐτοῖς· οὔτε τὰ μικρὰ τῶν μεγάλων, πάντα πόρον σύμμετρον ἔχοντα, ὅταν μηθὲν μηδὲ ἐκείνοις ἀντικόπτῃ· οὔθ᾽ ἡ ἄνω οὔθ᾽ ἡ εἰς τὸ πλάγιον διὰ τῶν κρούσεων φορά, οὔθ᾽ αἱ κάτω διὰ τῶν ἰδίων βαρῶν.

> «Moreover, the atoms must be of equal velocity whenever they travel through the void and nothing collides with them. For neither will the heavy ones move faster than the small light ones, provided nothing runs into them; nor will the small ones move faster than the large ones, through having all their trajectories commensurate with them, at any rate when the large ones are suffering no collision either. Nor will either their upward motion or sideways motion caused by knocks [be quicker], or those downwards [be quicker] because of their individual weights» (LONG and SEDLEY, trans., modified slightly).

It is certainly correct to find here confirmation that an atom's weight is a cause of that atom's downward motion. The last sentence makes that much clear. Notice, though, that it does *not* describe how it is that an atom's own weight causes the atom to fall downwards. Much less, for that matter, does it indicate that such a cause is a kind of impact exerted from within the atom and by its own weight. And though the previous clause mentions a κροῦσις, a striking, smiting or collision, this undoubtedly refers to a striking or collision between two atoms.

   The second section of *Ad Herodotum*, 61, too, does not describe how weight moves the atoms downwards. Here are lines 6-8:

> ἐφ᾽ ὁπόσον γὰρ ἂν κατίσχῃ ἑκάτερον, ἐπὶ τοσοῦτον ἅμα νοήματι τὴν φορὰν σχήσει, ἕως ἀντικόψῃ ἢ ἔξωθεν ἢ ἐκ τοῦ ἰδίου βάρους πρὸς τὴν τοῦ πλήξαντος δύναμιν.

> «For however far along either kind of trajectory [sc. upwards, sideways or downwards] it [i.e., the atom] gets, for that distance it will move as fast as

thought, until it is in collision, either through some external cause or through its own weight in relation to the force *of the impacting body*» (LONG and SEDLEY, trans., my emphasis).

While the genitive participle τοῦ πλήξαντος (of πλήσσω, a cognate of πληγή) is present, the sentence's structure makes clear that the impact is not from within, but is from the outside. In addition, although the sentence draws a contrast (ἢ…ἢ…) between an external cause (ἔξωθεν) and an atom's own weight (ἐκ τοῦ ἰδίου βάρους), which may have lead some scholars to find here support for the contention that a πληγή may refer to a kind of internal impact, this is not the kind of contrast Epicurus has in mind. Rather, the contrast describes the only possible and primary influences for an atom's new trajectory after a collision. That is, an atom's present trajectory is always the result of a collision (ἀντίκοψις) with another atom. But the primary influence on its new trajectory may either be some external force –that is, the force of the impacting body on the atom in question– or the atom's own weight as resistance to the force of the impacting body[16]. So much, then, for these two sections of *Ad Herodotum*, 61.

　　There is a later report in Aëtius (= pseudo-Plutarch, 1.12.5) that will help to drive home the point under development. Here is the text:

> Ἐπίκουρος δὲ ἀπερίληπτα εἶναι τὰ σώματα καὶ τὰ πρῶτα δὲ ἁπλᾶ, τὰ δὲ ἐξ ἐκείνων συγκρίματα πάντα βάρος ἔχειν· κινεῖσθαι δὲ τὰ ἄτομα τό-τε μὲν κατὰ στάθμην τότε δὲ κατὰ παρέγκλισιν, τὰ δὲ ἄνω κινούμενα κατὰ πληγὴν καὶ παλμόν.

> «Epicurus said that the bodies are ungraspably many and the primary bodies are simple, and all things compounded of them have weight. And that the atoms sometimes move in a plumbline, and sometimes swerving, and some of them are sent upwards by an impact and vibration».

I only want to point out here that though the word πληγή is present, it again refers to a collision between two atoms. As we have seen in these texts on Epicurean atomic motion, whenever a word is present that denotes a striking, collision or an impact (κροῦσις, ἀντίκοψις or πληγή), it *always* picks out such an event between two atoms and *never* an event that occurs within an atom.

---

16. I am in agreement here with D. KONSTAN, *op. cit.*, p. 413 (and cf. p. 415). In addition, this is sufficient to demonstrate that Furley is wrong when he writes that sometimes an atom, after collision, will move only a few minima in a particular direction before its weight reasserts itself.

Before returning to the phrase τῇ τοῦ βάρους πληγῇ from report (4), there is one more passage that requires consideration. For it has been cited by some scholars in support of the idea that weight exerts a kind of internal impact, which is the cause of an atom's downward motion. It is from Cicero's *De Fato*, 20.46:

> «Declinat», inquit, «atomus». Primum cur? Aliam enim quandam vim motus habebant a Democrito impulsionis quam plagam ille appellat, a te, Epicure, gravitatis et ponderis.

C. Bailey, in a footnote, cites this passage in support of weight exerting an impact from within the atom, which then drives the atom downwards (*op. cit.*, p. 131, n. 4). Unfortunately, he does not offer any argument or commentary to support such an interpretation. However, D. Konstan too finds support for such an idea here and does provide some commentary (*op. cit.*, p. 415). Pointing to the parallel construction of the genitives *gravitatis* and *ponderis* with *impulsionis*, which he reads as dependent on the accusative *plagam*, Konstan contends that *gravitatis* and *ponderis* too must depend on *plagam*. As such, he translates the passage as follows:

> «The atom, says he [Epicurus], swerves. In the first place, why? For they had another kind of power of motion from Democritus, which he calls "the blow of collision," and from you, Epicurus, the blow of heaviness and weight».

But there is good reason to reject this translation and, consequently, its implications for the phrase τῇ τοῦ βάρους πληγῇ. First, recall that neither section of Epicurus's *Ad Herodotum*, 61, nor the later report in Aëtius provide evidence in support of such a translation. That is, one where an atom's own weight exerts a kind of internal impact, which moves the atom downwards. Second, this translation stretches the meaning of *plaga*, the Latin equivalent of the Greek πληγή, so that it now signifies something more general like «force». But this seems unacceptable, for a *plaga*, as with a πληγή, always refers to a striking or impact between two things (cf. LS, s.v. *plaga*, especially §I). Finally, as to the parallel between the genitives *gravitatis* and *ponderis*, and *impulsionis*, it is more natural to read each of them as dependent not on *plagam*, but on *vim*. And this is, I suggest, how H. Rackham understands the passage. He translates it as follows:

> «"The atom does swerve", he says. In the first place what causes the swerve? For the motive force that they will get from Democritus is a different one, a driving force termed by him a "blow"; from you, Epicurus, they will get the force of gravity or weight».

Why is this translation «more natural»? For one, it does not require stretching the meaning of *plagam.* Indeed, «force» is a perfectly natural translation for *vim.* And this, in turn, produces a passage where the downward motion caused by an atom's weight accords with what we have seen in both *Ad Herodotum*, 61 and Aëtius, 1.12.5. Finally, this translation fits better with Cicero's general point. Here Cicero is objecting once again to the atomic swerve (cf. *De Fin.*, 1.19-20). Among other questions raised by Cicero here, one is: *why should Epicurus bother positing such an event in the first place*? It is surely not to account for atomic motion *simpliciter.* For Democritus provided one such explanation: an impact. And Epicurus himself posited another, and altogether different, kind of explanation: the force of gravity or weight. To read *gravitatis* and *ponderis* as dependent on *plagam* makes this passage no longer about causes of atomic motion, but about differences between Democritus and Epicurus on the role of a *plaga* in their respective physical systems. It is hard to see why, at least here, Cicero would be interested in such a topic.

Let me now bring all of this together. It has been suggested that report (4) supports an interpretive solution concerning weight in early Greek atomism where some reports are understood as describing the atoms in an extra-cosmic state. And when the atoms are in an extra-cosmic state, they are weightless. In the previous section, I argued that report (4) denies only that weight is a basic property of the atoms. As such, report (4) can be read in agreement with the testimony of Aristotle and Theophrastus, where weight is described as a dependent property of the atoms. In this section, I have been concerned with the contention that report (4) describes the atoms in an extra-cosmic state. Support for this claim derives from the phrase τῇ τοῦ βάρους πληγῇ, which supposedly refers to the cause of downward motion for Epicurus's atoms. And where atoms fall downwards in parallel, straight lines, the context is surely an extra-cosmic state. But the texts cited to support the phrase τῇ τοῦ βάρους πληγῇ as a description of how an atom's weight moves the atom downwards do not, in fact, do so. If my analysis of these and additional texts is correct, then there is no support for understanding the phrase τῇ τοῦ βάρους πληγῇ as referring to a kind of internal impact exerted by an atom's weight, and so it is not the cause of the downward motion exhibited by Epicurus's atoms prior to the start of collisions. As such, there is no reason to suppose that report (4) describes atoms in an extra-cosmic state any more than it describes atoms in a cosmic state.

4. A Few Loose Ends

The two previous sections present a significant challenge for those who appeal to report (4) in support of the common interpretive solution. At this point, there are a few loose ends that should be tied up.

I mentioned one of these near the beginning of Section 3: dividing the

testimonia into two groups –a group that describes the atoms in a cosmic state, and a group that describes the atoms in an extra-cosmic state– is defensible provided that there is some reason for *why* atoms in a cosmic state should have weight, while atoms in an extra-cosmic state should be weightless.

What evidence is there for why this should be so? Let us begin with the following passage from Simplicius, *In De Cael.*, 569.5-9:

> οἱ γὰρ περὶ Δημόκριτον καὶ ὕστερον Ἐπίκουρος τάς ἀτόμους πάσας ὁμο-
> φυεῖς οὔσας βάρος ἔχειν φασί, τῷ δὲ εἶναί τινα βαρύτερα ἐξωθούμενα τὰ
> κουφότερα ὑπ’ αὐτῶν ὑφιζανόντων ἐπὶ τὸ ἄνω φέρεται, καὶ οὕτω λέγου-
> σιν οὗτοι δοκεῖν τὰ μὲν κοῦφα εἶναι τὰ δὲ βαρέα.

> «The followers of Democritus and later Epicurus say that all atoms are of the same nature and have weight, but because some are heavier, the lighter ones are pushed up as they [i.e., the heavier ones] sink down, thus, they say, it appears that some are light and some heavy».

For ancient philosophers in general, but especially the early Greek philosophers, an important phenomenon to be explained is the twin tendencies of some objects to sink and other objects to rise[17]. The atomists accounted for this phenomenon in part by a theory of ἔκθλιψις, displacement or extrusion. Part of their explanation is contained in the above passage from Simplicius: heavier atoms have the capacity to squeeze out lighter atoms, thereby pushing the lighter atoms upwards. But such a phenomenon can occur only when the atoms have weight. For, as Simplicius writes, it is a difference in weight between atoms that explains why some of them are squeezed out and upwards, while the others sink down.

But weight is not sufficient (or so it sometimes claimed) for the atomists to explain the twin tendencies of some objects to sink and other objects to rise. An appeal to the vortex seems necessary. D. Konstan provides a helpful explanation here[18]. He writes:

> «... I submit that this power of atoms to jostle their lighter neighbors out of the way was precisely the property to which Democritus attached the name weight. We may observe that weight in this sense has nothing whatever to do with tendency of atoms or compound bodies to fall; whenever a group of

---

17. On this point, see D. KONSTAN, *op. cit.*, p. 410.

18. Konstan himself does not endorse the line of reasoning under examination here. I cite him only because he provides a most helpful explanation of the phenomenon under consideration. In addition, it is not clear to me that the vortex is a necessary condition for the phenomenon of ἔκθλιψις. I elaborate on this below.

atoms is moving in a uniform direction and encounters a resisting surface or texture of corpuscles, the heavier (if they are atoms) or the denser (if they are compounds) will force their way further in the given line of progress and displace the lighter. To be sure, this process will only yield the regular contrariety of direction exhibited in the perceived motion of lighter and heavier substances when the random atomic movements are organized into a more or less uniform current, and such a current was assumed by Democritus to arise out of chance turbulences evolving into vortices. That is, the vortex is a necessary condition of the observed phenomena of displacement. But, in the first place, the vortex is not a sufficient condition: it must be supplemented by the power associated with weight. In the second place weight is not even a necessary condition for the formation of the vortex and the tendency of matter to fall. Against the hypothesis that Democritus saw any connection between weight and some privileged direction in the universe, I may add that I see no reason at all to suppose that according to his theory the vortices in different cosmoi necessarily had the same orientation» (*op. cit.*, p. 410).

Let us work through this explanation[19]. The first sentence is, more or less, Simplicius's report concerning the theory of ἔκθλιψις held by Democritus and Epicurus. Now if displacement or extrusion is to explain the twin tendencies of some objects to sink and other objects to rise –a phenomenon that occurs with *observable regularity*– then there must be something else involved that will secure this aspect of the phenomenon. The rotation and consequent effects of a vortex can fulfill such a role. A vortex's rotation produces centripetal force that drags or pulls objects downwards along its vertical axis. Now since the speed of rotation is greater, and so the centripetal force stronger, towards the bottom of the vortex, heavier atoms and denser bodies are pulled further downwards along the vertical axis than lighter atoms and rarer bodies. Consequently, when such lighter atoms and rarer bodies are in the path of these heavier atoms and denser bodies, the latter displace or extrude upwards the former –there is, quite literally, *a squeezing out* (ἔκθλιψις)– along the vertical axis until such objects settle at some higher point in the vortex. So, a vortex's continual rotation produces an environment in which bodies (either atomic or compound) can and will move in a more or less predictable, uniform current within the vortex. And this more or less predictable, uniform current secures that heavier atoms and denser bodies that are being pulled downwards, and so towards the bottom of the vortex, can encounter lighter atoms and rarer bodies. When this occurs, the heavier atoms and denser bodies

---

19. Here I am indebted to S. TIGNER, *op. cit.*, p. 440, and D. KONSTAN, *op. cit.*, p. 410.

will displace the lighter atoms and rarer bodies. In this way, then, an atom's weight in conjunction with the vortex's rotation and consequent effects explain the twin tendencies of some objects to sink and other objects to rise.

We are now in a position to state why some might contend that atoms in a cosmic state should have weight, while atoms in an extra-cosmic state should be weightless. Simplicius's testimony suggests that the phenomenon of ἔκθλιψις can occur only when the atoms have weight. For it is a difference in weight between atoms that explains why some atoms are squeezed out and upwards, while other atoms sink down. But it also necessary (or so it is sometimes claimed) that the phenomenon of ἔκθλιψις can occur only within a vortex. And this is so because an environment suitable for the occurrence of this phenomenon is produced only within a vortex. Given these two contentions, it is not unreasonable to then draw an additional conclusion that it is only within a vortex that the atoms have weight. That is, just as a vortex's rotation and consequent effects produce an environment suitable for occurrences of ἔκθλιψις, so too does a vortex's rotation and consequent effects produce those conditions necessary for the ascription of weight to the atoms.

Even if it is correct to claim that the phenomenon of ἔκθλιψις can occur only within a vortex, though, this will fail as a demonstration for why atoms in a cosmic state should have weight, while atoms in an extra-cosmic state should be weightless. First, there is no need to invoke the vortex as producing those conditions necessary for the ascription of weight to the atoms. According to the interpretation proposed above, an atom's weight is dependent upon that atom's size. And since all atoms have some size, it follows that all atoms have some weight regardless of whether they are in a cosmic state or an extra-cosmic state. Put differently, those conditions necessary for the ascription of weight to the atoms are produced, if you will, *by the atoms themselves*. Second, all that has been explained here is the conditions under which an atom's weight becomes, so to speak, perceivable. Konstan puts the point well when he writes a little later that it is only under certain conditions that an atom's weight can manifest itself –namely, within a vortex and in relation to other atoms– as a single atom, considered in isolation, presents itself only as a geometric form (*op. cit.*, p. 410). But this does not preclude the atoms from in fact having weight; even if it cannot be seen (if you will), this does not entail that it is not there! I submit, then, that appeal to Democritus's use of ἔκθλιψις to explain the twin tendencies of some objects to sink and other objects to rise does not support the contention under consideration. Therefore, there is no reason, *pace* the common interpretive solution, why atoms in a cosmic state should have weight, while atoms in an extra-cosmic state should be weightless.

As a final comment on this matter, allow me to explain why it is not clear to me that the vortex is a necessary condition for the phenomenon of ἔκθλιψις. It seems possible for a stream of atoms or atomic aggregates to be moving through the void, where this movement occurs in an extra-cosmic state, and moving towards them in the opposite direction is another stream of atoms or

atomic aggregates. Now assuming that one of these streams of atoms or atomic aggregates is heavier or denser than the other stream of atoms or atomic aggregates, when they meet the stream of heavier atoms or denser atomic aggregates will displace the stream of lighter atoms or rarer atomic aggregates. There is no reason –at least, none that I can see– for why an event of this sort would not occur at some point in an extra-cosmic state. If so, then it is incorrect to claim that the vortex is a necessary condition for the phenomenon of ἔκθλι-ψις. However, a closely related claim does seem correct: *the vortex is a necessary condition for the phenomenon of* ἔκθλιψις *to occur regularly*. For, as we saw above, the vortex's rotation and consequent effects produce an environment in which bodies (either atomic or compound) can and will move in a more or less predictable, uniform current. And this sort of predictability is required if Democritus is to explain the observable regularity of some objects to sink and other objects to rise. So much, then, for this loose end.

The other loose end concerns (once more) the italicized portion of report (4). Much of the controversy concerning the natural motion of Epicurus's atoms and its connection to an extra-cosmic state could have been avoided, it seems to me, if only it were realized that there was no time at which the atoms actually fell downward in parallel, straight lines. Allow me to explain[20]. Above I stressed the influence that Aristotle's criticisms of Democritean physics had on Epicurus's own atomistic physics. Epicurus reclassifies weight as a basic property of the atoms, and he maintains that atoms swerve. The former modification satisfies Aristotle's demand for an account of natural atomic motion; the latter modification provides an ἀρχή that explains the beginning of collisions among atoms, out of which come to be κόσμοι and everything that inhabits them. But it is a mistake to then infer on the basis of these modifications that there was some time during which the atoms, for Epicurus, in fact fell downwards until a swerve started the unending series of collisions. Epicurus is quite clear that the atoms are, and have always been, in collision with one another at *Ad Herodotum*, 43-44:

κινοῦνταί τε συνεχῶς αἱ ἄτομοι τὸν αἰῶνα, καὶ αἱ μὲν εἰς μακρὰν ἀπ᾽ ἀλλήλων διιστάμεναι, αἱ δὲ αὐτοῦ τὸν παλμὸν ἴσχουσαι, ὅταν τύχωσι τῇ περιπλοκῇ κεκλειμέναι ἢ στεγαζόμεναι παρὰ τῶν πλεκτικῶν. ἥ τε γὰρ τοῦ κενοῦ φύσις ἡ διορίζουσα ἑκάστην αὐτὴν τοῦτο παρασκευάζει, τὴν ὑπέρεισιν οὐχ οἵα τε οὖσα ποιεῖσθαι· ἥ τε στερεότης ἡ ὑπάρχουσα αὐταῖς κατὰ τὴν σύγκρουσιν τὸν ἀποπαλμὸν ποιεῖ, ἐφ᾽ ὁπόσον ἂν ἡ περιπλοκὴ

τὴν ἀποκατάστασιν ἐκ τῆς συγκρούσεως διδῷ. ἀρχὴ δὲ τούτων οὐκ ἔστιν, ἀιδίων τῶν ἀτόμων οὐσῶν καὶ τοῦ κενοῦ.

«The atoms move continuously forever, some separating a great distance from each other, others keeping up their vibration on the spot whenever they happen to get trapped by their interlinking or imprisoned by atoms that link up. For the nature of the void brings this about by separating each atom off by itself, since it is unable to lend them support; and their own solidity causes them as a result of their knocking to vibrate back, to whatever distance their interlinking allows them to recoil from the knock. *There is no beginning to these* [i.e., these sorts of atomic motion, including rebounds], because the atoms and void are eternal» (LONG and SEDLEY trans., modified slightly)

Epicurus's two modifications to Democritean physics are only explanatory ἀρχαί and do not provide a temporal starting-point for either atomic motion or collisions[21].

If there is, then, no point in time during which Epicurus's atoms fell downward in parallel, straight lines, which would require a swerve to start a chain of collisions, and the phrase τῇ τοῦ βάρους πληγῇ does not refer to how an atom's weight causes the atom itself to move downward, then what should be made of the italicized portion of (4)? H. Usener emended the passage, substituting ὁλκῇ for πληγῇ. If such an emendation is accepted, the passage would then read:

Δημόκριτος μὲν γὰρ ἔλεγε δύο, μέγεθός τε καὶ σχῆμα ὁ δὲ Ἐπίκουρος τούτοις καὶ τρίτον βάρος προσέθηκεν· ἀνάγκη γάρ, φησί, κινεῖσθαι τὰ σώματα τῇ τοῦ βάρους ὁλκῇ· ἐπεὶ οὐ κινηθήσεται.

How should the phrase τῇ τοῦ βάρους ὁλκῇ be understood? A ὁλκή denotes «a drawing» or «a dragging» (cf. ἕλκω, literally «to draw» or «to drag»). As such, it is possible to render the phrase τῇ τοῦ βάρους ὁλκῇ in English as, «by the drag of weight».

«Democritus, on the one hand, said there are two: size and shape; and on

---

21. This claim is admittedly controversial, and therefore requires further discussion and defense. For reasons of space, though, I cannot provide such a discussion or defense here. Still, let me offer this much. An immediate concern is the label «explanatory ἀρχαί». What does the downward motion and swerve explain if, at this point in our discussion, they amount of nothing more than dialectical moves available to an Epicurean when confronted with a demand for natural motion and an ἀρχή? I am inclined to see them fulfilling an important, explanatory role in Epicurus's attempt to embrace atomism, while at the same time avoiding a commitment to determinism. In a future article, I plan to investigate this inclination.

the other hand, Epicurus added to these a third, weight. For it is necessary, he said, that the bodies be moved by the drag of weight. Or else they would not move».

This is not the place to argue for the acceptance of such an emendation. However, the above arguments seem to lend some philosophical support to the philological emendation proposed by Usener.

5. Conclusion

The interpretation offered in this article gives primacy to Aristotle's and Theophrastus's testimony. But not simply to their contention that the atoms of Leucippus and Democritus have weight. It stresses, as other commentators have observed, the relationship between an atom's weight and its size. This relationship is stressed in part by my distinguishing between two types of properties: basic properties and dependent properties. The distinction is, perhaps, of the utmost importance. For I wish to resist accepting at face value Aëtius's testimony, but I also wish to avoid discrediting Aëtius's testimony as historically valueless (*pace* O'BRIEN, 1981, *op. cit.*). With this distinction in place, it is possible to read Aëtius's testimony not as outright denying weight as a property of Leucippus's and Democritus's atoms. Rather, the reports deny only that weight has any connection to atomic motion; that weight has the explanatory primacy Epicurus would later grant it in response to Aristotle's criticisms of Democritean atomism.

The relationship between an atom's weight and size described in Aristotle's and Theophrastus's testimony is stressed in another way too, which appeared at the end of Section 2. And this point drives my entire interpretation. According to Aristotle and Theophrastus's testimony, an atom's weight is dependent upon that atom's size. Now insofar as size is a property of the atoms, because all atoms have some size, and an atom's weight is dependent upon its size, it follows that all atoms have some weight. Weight *must* be a property of the atoms for all atomists, regardless of whether they are *within* or *outside* of a κόσμος! To accept the common interpretive solution in light of this point requires far too much. We must accept Aëtius's testimony at face value. And we must reject the very relationship between an atom's weight and its size described in the reports of Aristotle and Theophrastus. For it is not possible to accept this relationship and at the same time maintain that the atoms are weightless when outside of a κόσμος.

Finally, though many of the arguments offered here advance negative conclusions, this does not leave us without a solution to the present interpretive difficulty. With the distinction between basic properties and dependent properties in place, and recognition of the connection between an atom's weight and atomic motion later established by Epicurus, the following results:

there are three reports that describe weight as a property of the atoms, where it is a dependent property; there is one report that should be read in agreement with them, for it denies only that weight is a basic property of Democritus's atoms (*contra* Epicurus); and there is a final report that should also be read in agreement with these four, as it denies only that weight has any connection to atomic motion (*contra* Epicurus). Consequently, there is no conflict among the extant testimonia concerning weight in early Greek atomism[22].

Michael J. Augustin
(Santa Barbara)

ΤΟ ΒΑΡΟΣ ΣΤΟΥΣ ΕΛΛΗΝΕΣ ΑΤΟΜΙΚΟΥΣ

Περίληψη

Οἱ γραπτὲς μαρτυρίες ὅσον ἀφορᾶ τὸ *βάρος* στὸν πρώιμο ἑλληνικὸ ἀτομισμὸ φαίνεται νὰ ἀναιροῦν ἢ μία τὴν ἄλλη. Κάποιες ἀναφορὲς βεβαιώνουν ὅτι τὰ ἄτομα ἔχουν βάρος, ἐνῶ ἄλλες σαφῶς ἀρνοῦνται τὸ βάρος ὡς ἰδιότητα τῶν ἀτόμων. Μία κοινὴ λύση σὲ αὐτὴν τὴν προφανὴ ἀντίφαση διαιρεῖ τὶς μαρτυρίες σὲ δύο ὁμάδες. Ἡ πρώτη ὁμάδα περιγράφει τὰ ἄτομα μέσα σὲ ἕναν κόσμο, ὅπου ἔχουν βάρος· ἡ δεύτερη ὁμάδα περιγράφει τὰ ἄτομα ἔξω ἀπὸ ἕναν κόσμο, ὅπου δὲν ἔχουν βάρος.

Μία μαρτυρία «κλειδί» ποὺ συνεισφέρει σ᾽ αὐτὴν τὴν λύση εἶναι τοῦ Ἀέτιου, 1.3.18. Αὐτὴ ἡ μαρτυρία ἐμφανῶς ἀρνεῖται τὸ βάρος ὡς ἰδιότητα τῶν ἀτόμων καὶ ὑποθετικὰ περιγράφει τὰ ἄτομα ὅταν βρίσκονται ἔξω ἀπὸ τὸν κόσμο. Ἐπιχειρηματολογῶ ἐναντίον αὐτῆς τῆς ἑρμηνευτικῆς λύσης δείχνοντας πρῶτον ὅτι ὁ Ἀέτιος, 1.3.18, δὲν ἀρνεῖται τὸ βάρος ὡς ἰδιότητα τῶν ἀτόμων. Δεύτερον, ἐπιχειρηματολογῶ ὅτι ἡ ἀναφορὰ δὲν περιγράφει τὰ ἄτομα ὅταν βρίσκονται ἔξω ἀπὸ τὸν κόσμο. Μολονότι αὐτὰ εἶναι εὐρέως ἀρνητικὰ συμπεράσματα, ὑποστηρίζω ὅτι δὲν ἀπομείναμε χωρὶς λύση στὴν παροῦσα ἑρμηνευτικὴ δυσκολία. Ἀπὸ τὴ στιγμὴ ποὺ οἱ μαρτυρίες ποὺ ἀφοροῦν τὸ βάρος στὸν πρώιμο ἑλληνικὸ ἀτομισμὸ ἐξετάζονται διεξοδικά, εἶναι σαφὲς ὅτι δὲν ὑπάρχει διαμάχη μεταξύ τους.

Michael J. Augustin
(Μτφρ. Χριστίνα Σινου)