

Lucretius on the Size of the Sun

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Scientists do not currently know how big the sun is. In fact, in a certain sense, the size of the sun cannot even be known. Rebecca Boyle: “[T]he task of determining the sun’s size is trickier than it might seem because the sun is a roiling ball of plasma with no surface. It’s also constantly spewing gas and radiation and magnetism, so the diameter of its ‘disk’ is constantly fluctuating. But it’s easier to measure during an eclipse.”¹ That last sentence adverts to the unprecedented, elaborate, high-effort undertaking to measure the sun’s diameter during the August 2017 total solar eclipse (see further International Occultation Timing Association 2017). Granted, the uncertainty about the sun’s size in twenty-first-century astronomy concerns a scale and precision well beyond the everyday considerations of nonspecialists. The mainstream community of solar-system scholars would agree unanimously and with a high degree of certainty that the sun is larger – much, much larger – than, say, a soccer ball or a human foot.

No such consensus is to be found in the astronomical-astrological thinking of the Hellenistic philosophers and their immediate Greek and Roman successors.² As with many concepts fundamental to a modern scientific understanding of the universe, the size of the sun was already a matter of speculation in some ancient philosophy. By the first century BC, however, one school was generally perceived to be an outlier on the question: the Epicureans. It was their contention that the sun is the size that it appears to be, a tenet that provoked the derision of their rivals in philosophy and astronomy, and one that on first view may seem baldly

* In a chapter that considers the continued difficulties people have grappling with the sun, it’s worth recalling the hit They Might Be Giants song “Why Does the Sun Shine?” (1994), whose subtitle and first line went, “the Sun is a mass of incandescent gas.” Well, no, it’s not. TMBG released a palinode many years later, “Why Does the Sun Really Shine?” (2009), whose subtitle and first line goes, “the Sun is a miasma of incandescent plasma.”

¹ Boyle: 2017. ² So Barnes: 1989, 31 n. 11; Bailey: 1947, 3.1408.

preposterous. The sun is indeed, after all, much larger than a soccer ball or a human foot; and as Jonathan Barnes shows, ancient astronomers' calculations of the sun's magnitude, even if inaccurate "by at least a factor of 15," were nevertheless "of *roughly* the right order of magnitude."³ Yet despite many disagreements on orthodoxy and heterodoxy in virtually every field of inquiry, the Epicureans and their critics were in agreement that Epicureans believe the sun to be more or less the size it appears.

This chapter advances a threefold argument. [1] Despite the acrimonious mockery of Epicurus' opponents, his and his followers' claims about the size of the sun mean, as a few modern scholars have suggested, that estimation of the sun's magnitude requires careful evaluation and judgment based on data offered by the senses, including but not limited to sight. [2] The presentation of this issue in Lucretius' *On the Nature of Things* (5.564–613), which scholars have treated as an afterthought although it in fact innovates on Epicurus in the explicit discussion of the sun's heat, uses complicated subordination to underscore stylistically that claims about the sun's size are critically dependent on *sensus* and judgments based thereupon, thus issuing a didactic challenge to the Lucretian speaker's addressee. [3] The assertion that the sun is the size it appears became an Epicurean shibboleth, so to speak – a statement prompting reactions that distinguish Epicureans from non-Epicureans, the *cognoscenti* from the *ignoramuses*. I begin by surveying the relevant sources and then considering ancient and modern responses to the Epicurean position. I next proceed to stylistic analysis of the passage in Lucretius and finally connect it to the broader didactic program of *On the Nature of Things*.⁴

The Texts

Epicurus' surviving discussion of the size of the sun appears early in his *Letter to Pythocles* (DL 10.91):

τὸ δὲ μέγεθος ἡλίου τε καὶ τῶν λοιπῶν ἀστρῶν κατὰ μὲν τὸ πρὸς ἡμᾶς τηλικούτον ἐστὶν ἡλίκον φαίνεται. κατὰ δὲ τὸ καθ' αὐτὸ ἦτοι μείζον τοῦ ὀρωμένου ἢ μικρῶ ἔλαττον ἢ τηλικούτον τυγχάνει. οὕτω γὰρ καὶ τὰ παρ' ἡμῖν πυρὰ ἐξ ἀποστήματος θεωρούμενα κατὰ τὴν αἴσθησιν θεωρεῖται.

And the size of the sun and the other stars, in respect to our position, is as big as it appears. But in respect to its own position indeed it happens to be

³ Barnes: 1989, 30; emphasis preserved.

⁴ For the text of Lucretius, which will henceforth be cited as *DRN*, I use Bailey: 1947. All translations are my own. I owe thanks to Sergio Yona and Amy "Not Nathan" Lather.

bigger than what is seen or a little smaller or the same size. For so also fires near us, when seen at a distance, are seen in accordance with perception.⁵

On a preliminary, *prima facie* reading of these lines, Epicurus evidently makes a distinction between the size of the sun “relative to us” (κατὰ τὸ πρὸς ἡμᾶς) and its absolute size or its size “relative to itself” (κατὰ τὸ καθ’ αὐτό). David Furley explicates this distinction as “presumably mean[ing] no more than that we have to infer its size from its apparent size.”⁶ In the former frame of reference, the sun’s magnitude is firmly correlated to the function of our senses (τηλικοῦτόν ἐστιν ἡλικὸν φαίνεται). In the latter, the sun’s absolute size is not stated absolutely, but rather characterized in comparison to its size as we adjudge it based on our sense-perception (μεῖζον τοῦ ὀρωμένου ἢ μικρῶ ἕλαττον ἢ τηλικοῦτον).

The text of Diogenes Laertius includes, between the first and second sentence of this passage, an interpolation with a quotation from elsewhere in Epicurus’ corpus: “So also in the eleventh [book of his] *On Nature*: ‘For if,’ he says, ‘it had lost from its size on account of the distance, it would much more have lost from its bright appearance.’⁷ For there is no other distance for it more suitable for measurement” (τοῦτο καὶ ἐν τῇ ια’ *Περὶ φύσεως*: εἰ γὰρ, φησί, τὸ μέγεθος διὰ τὸ διάστημα ἀπεβεβλήκει, πολλῶ μᾶλλον ἂν τὴν χροάν. ἄλλο γὰρ τούτῳ συμμετρώτερον διάστημα οὐθέν ἐστι). David Sedley explains the final sentence of this quotation as expressing the unique difficulties of measuring the magnitude of the sun: Epicurus “must mean that you cannot get a better vantage point for viewing the sun’s size by moving towards it or away from it. For the size of any terrestrial object . . . one distance is more σύμμετρον than another, because you cannot judge its size if you are too close to it or too far away.”⁸ The sun is too remote – and roughly equally remote from all parts of the world – for us to be able to change our perspective on it. We cannot, therefore, do the necessary perspective-based reasoning about its size with any more certainty anywhere on earth (an issue to which I return below).

In Lucretius’ *DRN*, the same basic doctrine is expanded to a space of about fifty lines (5.564–613), with more extended treatment of the moon (574–584), stars (585–591) and the immense light and heat transmitted

⁵ Similarly Aetius 2.21.5. Late doxographies include a section on the size of the sun, including pseudo-Plutarch, pseudo-Galen, Eusebius, Stobaeus and Theodoretus: See Barnes: 1989, 31 and 31 n. 9; Diels: 1879, 351–352. For a philological analysis of *Letter to Pythocles* 91, including consideration of textual issues and the interpolation of later scholia, see Verde: 2016.

⁶ Furley: 1999, 429; similarly Bailey: 1947, 3.1409 n. 1; Asmis: 1984, 155 and 2009, 98 and 98 n. 23.

⁷ I translate χροά here as “bright appearance” on the recommendation of Algra: 2000, 184 n. 76.

⁸ Sedley: 1976, 49; *contra* Asmis: 1984, 314 n. 66.

by the sun (592–613). The opening of the passage is focused most directly on the matter of the sun’s magnitude (564–573):

nec nimio solis maior rota nec minor ardor
 esse potest, nostris quam sensibus esse videtur.
 nam quibus e spatiis cumque ignes lumina possunt
 adicere et calidum membris adflare vaporem,
 nil illa his intervallis de corpore libant
 flammaram, nil ad speciem est contractior ignis.
 proinde, calor quoniam solis lumenque profusum⁹
 perveniunt nostros ad sensus et loca fulgent,
 forma quoque hinc solis debet filumque videri,
 nil adeo ut possis plus aut minus addere vere.

The sun’s wheel cannot be too much bigger, nor its heat too much lesser, than it is perceived to be by our senses. Because fires—from whatever distances they can send out light and blow hot air upon our limbs—lose nothing from the body of their flames because of these distances, the fire is no more tapered to the sight. Since therefore the sun’s heat and poured-out light make it all the way to our senses and make places shine, so also the shape and contour ought to be perceived from down here in such a way that you could not truly attribute more or less to it.

Epicurus’ basic claim is echoed in the first two lines of this passage of Lucretius. The distinction that Epicurus makes explicitly between τὸ πρὸς ἡμᾶς and τὸ καθ’ αὐτό is implicit in the Lucretian *perveniunt nostros ad sensus* (571) and *hinc . . . debet . . . videri* (572). And the Lucretius-*ego*¹⁰ amplifies the analogy to include earthly fires (a point reprised at lines 586–589, cited and translated below).

A key addition to the Lucretian treatment of this question is the emphasis on the sun’s heat. Epicurus’ appeals in his *Letter to Pythocles*, not simply to sight (θεωρούμενα, θεωρεῖται) but to perception generally, (φαίνεται, κατὰ τὴν αἴσθησιν) implicitly include the non-visual perception of heat produced by the sun. In *DRN*, the point is made explicit and important to the process of determining the sun’s size. The visual presentation of the sun, its “wheel” (*rota*), is correlated with its “heat” (*ardor*) in the passage’s opening line (564). Similarly, the light and heat of terrestrial fires are closely linked (*ignes lumina possunt | adicere et calidum membris*

⁹ Bailey: 1947, 1.460 follows Marullus in moving this line (573 in the manuscripts) to the position I print here (570).

¹⁰ In this paper I use the terms “Lucretian speaker” and “Lucretius-*ego*” rather than “Lucretius” to describe what the text’s speaker does and says: See Gellar-Goad: 2020 (Chapter 1).

adflare vaporem, 566–567). A few lines later the heat and light of the sun again form a naturally conjoined pair (*calor . . . solis lumenque*, 570).

The Lucretian speaker next asserts that the moon is no bigger than it appears (5.575–578) because objects viewed at a distance (on which see my discussion below) become blurred in appearance before they seem to become smaller (579–581); to the extent that the moon has a “clear appearance” (*clara species*, 582), it must be the size it appears (581–584). Furley assumes that this means that the moon has a “razor sharp” outline and therefore is about a foot in diameter.¹¹ In line with my interpretation below of the Lucretian position on the size of the sun, I am less confident than Furley. The full moon’s outline to viewers on earth – although it seems like a perfect circle – is not in fact razor sharp, since during a total solar eclipse the perceptible “diamond ring” effect is produced by the filtering of the last vestiges of sunlight through the mountains and valleys on the moon’s surface.¹²

After covering the moon and stars, the Lucretian speaker returns to the topic of the sun and reassures us that we need not wonder how “this sun of such small size could be able to send out so much light . . . and infuse all things with warm air” (*tantulus ille queat tantum sol mittere lumen, | . . . | . . . et calido perfundat cuncta vapore*, 591, 593). The standard of comparison for *tantulus* is not expressed in the text, and I follow Kiempe Algra’s interpretation, namely, that the sun is small when compared to the size of the cosmos.¹³ Throughout the explanation that follows (*DRN* 5.594–613), the Lucretius-*ego* uses a variety of terms to denote the sun’s heat: *vapor*, *ardor*, *fervor* and *aestus* (in the compound *aestifer*). This lexical richness runs parallel to the multiplicity of Lucretian terms for atoms (*primordia*, *principia*, *semina* etc.). In the case of the atoms, James Warren argues that the “range of terms . . . express[es] the importance of atoms by noting the various roles they play.”¹⁴ Similarly here, I suggest, the range of terms for solar warmth underscores the importance of heat regarding the puzzle of the size of the sun.

¹¹ Furley: 1996, 125.

¹² See, e.g., Thomas: 2017 and, for the original scholarly explanation, Baily: 1836. Also Romeo: 1979, 18. At any rate, Romeo suggests that certainty about the moon’s size is for the Lucretius-*ego* unattainable, because a close-up look (τὸ παρόν) is impossible (12).

¹³ Algra: 2001, 34–35 n. 57. The size of the cosmos is not a settled issue: David Konstan, in a September 2020 conference paper (“Gravity and the Shape and Location of the Earth,” *Epistemology and Meteorology: Epicureanism and Scientific Debates*, SPIN-SPIDER Online Workshop), asserts that Epicurus conceives of a very small cosmos; thanks to David Konstan for sharing a draft of that paper and further observations with me *per litteras*.

¹⁴ Warren: 2007, 22. And see Pope: 2018b for a provocative reading of Lucretian *semina* as particularly sexual and inseminatory.

Finally, a papyrus of Demetrius Lacon addresses the role of distance in perceived brightness of luminescent objects: “Things falling earthwards always look clearer, while further away things [look] less clear” (αἰεὶ τὰ μὲν ἔνυγειον προπείπτοντα [τ]ρανότερα βλέπεται, τὰ δὲ πορρώτερα ἀτ[ρ]ανώτερα, PHerc. 1013, col. 12.4–8). In other words, lights dim with distance. This point is introduced within the context of a discussion about the size of the sun, and indeed the title of this work by Demetrius may have been Περὶ ἡλίου μεγέθους. The papyrus is, of course, fragmentary, and the immediate context of the comment is patchy, but the text’s basic observation points to the fact that, for the sun, magnitude and intensity are crucial unknowns. Without information about how big and bright the sun is near its very surface, one cannot say with certainty, based on its brightness for earthlings, how far away it is; and, conversely, without knowing how far away it is, one cannot with certainty discern its size from its brightness alone.

Ancient and Modern Doxographies

In Cicero’s *On Ends* (1.6.20) we can see a reprise of Epicurus’ assertion in his *Letter to Pythocles*: “He [Epicurus] adjudges it [the sun] to be as big as it appears, or a little bigger or smaller” (*tantum enim esse censet, quantum videtur, uel paulo aut maiorem aut minorem*). This accurate if incomplete doxographical statement is immediately preceded by a claim, unsupported by any actual Epicurean writings (so Barnes: 1989, 32), that Epicurus thinks the sun is the size of a human foot: “To Democritus the sun appears to be large, and he is definitely an educated guy, completely learned in geometry, but to *him* [Epicurus] perhaps a foot’s length” (*sol Democrito magnus videtur, quippe homini erudito in geometriacque perfecto, huic pedalis fortasse*). Cicero’s (mis)representation of Epicurus’ view here is one of the milder takes on the Epicurean position that rival philosophers voiced in antiquity. Bailey adduces additional mockery by Cicero at *Academica* 2.26.82 and notes that “[T]he belief of Epicurus . . . that the sun, moon, and stars are in fact the same or nearly the same size as we see them was ridiculed in antiquity as much as by modern critics.”¹⁵

In fact, it was not Epicurus but Heraclitus (generally well-respected by later ancient philosophers) who, according to Aetius 2.21.4, asserted that the sun was “a human foot’s width” (εὖρος ποδὸς ἀνθρωπέιου). Yet this did not stop the opponents of Epicurean philosophy from regarding as

¹⁵ Bailey: 1947, 3.1407.

absurd Epicurus' claim that the sun is the size it appears. Despite the fact that the Epicureans "were not committed to any particular figure" for the sun's size, the ongoing disputes among Hellenistic philosophical schools were not conducive to honest intellectual debate.¹⁶ Epicurean heterodoxy concerning the size of the sun even came to serve as ammunition for Stoic charges of unmanliness, as Pamela Gordon shows.¹⁷ In the end, the philosophical dissension about the magnitudes of celestial bodies could readily be portrayed as a silly and pointless endeavor altogether, as attested most directly by Lucian's comic dialogue *Icaromenippus*.

Scholars of the modern era have puzzled over the Epicurean position on the size of the sun, with some following the literalist reading that characterizes ancient anti-Epicurean reactions; the preponderance of scholars, however, subscribes to one of a number of alternative accounts of Epicurus' meaning.¹⁸ The older, literal-minded view is represented in lapidary form by Jan Woltjer: *novimus Epicurum et Lucretium eiusmodi absurdas doctrinas probare, ad sensuum auctoritatem provocantes* ("we are aware that Epicurus and Lucretius, arguing from the authority of the senses, proffer absurd teachings of this sort").¹⁹ More nuanced and much more recent is the argument of Elizabeth Asmis on the Lucretian version that "the heavenly bodies, since they appear distinctly, are seen by means of very fine eidola that have suffered very little disturbance in traveling over a vast distance, and that therefore present the size of the heavenly bodies approximately as it is 'in itself.'"²⁰ Furley, meanwhile, holds that Epicurus indeed believes the sun is small and that his insistence on its size is attributable to his adherence to flat-earth theory, the particulars of which would require a diminutive sun.²¹

Yet the matter is more complex than such face-value readings admit. As Barnes points out, "the texts show that, for the Epicureans, the sun was a special case . . . and that the theory of its magnitude was grounded in special considerations."²² One may also recall the problem of being unable to find a more suitable place for "measurement" (συμμετρότερον) of the sun's size based on perspective and distance, a crucial unknown for the resolution of the question. Epicurus' position can as a result be taken to be

¹⁶ Barnes: 1989, 33 and Algra: 2000, 186. ¹⁷ Gordon: 2012, 78.

¹⁸ For a doxography of size-of-the-sun scholarship more focused on the related issues of the sun's distance from the earth and the earth's shape, see Bakker: 2016, 236–239. Overview doxographies are found also in Arrighetti: 1973, 527–528 and Delattre and Pigeaud: 2010, 1089–1099 n. 9.

¹⁹ Woltjer: 1877, 126.

²⁰ Asmis: 1984, 313. Contrast Rudolph: 2011 on the optical theory of Democritus, discussed below.

²¹ Furley: 1996; 1999, 421 and 428–429; Bakker: 2016, 239. ²² Barnes: 1989, 38.

one of *aporia*, an assertion that the sun's size simply cannot be determined to any meaningful degree of accuracy or precision. Hence, Sedley notes that claims about celestial bodies depend entirely on "appearances" (φάσματα), which are themselves derived from "accidents" (συμπτώματα), and so "we cannot assume their perceptible qualities, such as their colours, their relative sizes and their apparent orbits, to be intrinsic to their true natures rather than mere accidental properties."²³ For Epicurus, the size of objects in the sky cannot be resolved by "visual sense-perception alone" (αὐτῆ ἢ ὄψις), but instead must depend on the Epicurean argumentative methods of ἀντιμαρτύρησις and οὐκ ἀντιμαρτύρησις.²⁴

The Epicureans' aporetic stance on celestial dimensions underlies another aspect of their claims about the size of the sun: their opposition to the confident, positivist calculations of astronomers. In part, this Epicurean anti-astronomical sentiment was ideological. Theologically motivated astronomy, such as that espoused by Platonists, ran counter to Epicurus' goal of eliminating superstition.²⁵ Mathematical astronomy as practiced in Cyzicus by Eudoxus and his school, meanwhile, was in Epicurus' opinion "engendered by faulty observations" and "founded on false principles."²⁶ This was, in essence, a methodological dispute, with Epicurus objecting that the mathematical astronomers "based their calculations on arbitrary starting points" and that "contrary to what the astronomers want us to believe, we have no means to determine the size of the sun apart from perception, however unclear its data may be."²⁷ Marco Beretta further suggests that Epicurus was skeptical both of the astronomers' technical capabilities and of their theoretical sophistication when it came to measurements on an atomic scale.²⁸

Algra, in my view correctly, brings in considerations of perspective and field of view to shed light on how the sun can be the size it appears without having to be the size of a human foot: "[E]en berg aan de horizon 'lijkt'

²³ Sedley: 1976, 40, commenting on PHerc. 1042 col. 3.11–end, PHerc. 154 col. 3.1–2. So also Beretta: 2015, 58. Algra: 2001, 15 similarly points to a logical leap lurking behind the small-sun reading of Epicurus.

²⁴ Algra: 2000, 183. Compare Konstan: 2020, 9–10 on the role of φαντασία in Epicurean theory of perception and misperception, with the size of the sun as exemplary case.

²⁵ Barnes: 1989, 41. ²⁶ Sedley: 1976, 36 and 53 respectively.

²⁷ Algra: 2000, 187 n. 88 and 187 respectively.

²⁸ Beretta: 2015, 59; see also *DRN* 4.161–167. Bakker (2016, 258) suggests that the size of the sun was ultimately unimportant to Epicurean philosophers, since otherwise "one would have expected them to take heed of it in other contexts as well, which they did not." Similarly, one might note that Epicurus and Lucretius on the size of the sun do not merit inclusion in Long and Sedley: 1987.

minuscuul in de zin dat hij maar een klein deel van mijn gezichtsveld inneemt. Maar ik kan ook zeggen: ‘dat lijkt mij een grote berg,’ als ik hem vergelijk met andere referentieobjecten” (“a mountain on the horizon ‘looks’ minuscule in the sense that it occupies only a small part of my visual field. But I can also say: ‘That looks like a big mountain to me,’ when I compare it with other reference objects”).²⁹ The difficulty with applying this mountain example to the sun is the lack of such “other reference objects” suitable for putting the sun’s size into perspective. There is, as we have noted, nowhere on earth more σύμμετρον than anywhere else for establishing how big the sun is. Again, an amount of aporia on the question is necessitated.

Francesco Verde endorses Algra’s view, and further adduces the phrase τὸ φάντασμα τὸ ἡλιακόν found in PHerc. 1013 (col. 21.5–6, “the sun’s apparition,” Demetrius Lacon again).³⁰ According to Daniela Taormina, Demetrius “argues that it is the image of the sun that has the size it appears to have,”³¹ not the sun itself. Frederik Bakker adds that “the portion of our field of view that is occupied by the sun . . . is proportional to the ratio of the sun’s size and distance . . . [Thus the Epicureans] refrained from assigning a specific size” to the sun.³² But Bakker comments elsewhere (2016, 258) that the Lucretian speaker’s account of lunar eclipses (*DRN* 5.762–770; cf. Epicurus *Letter to Pythocles* in DL 10.96–97) implies that the sun is larger than the earth. So regardless of the sun’s true size, the Epicureans seem not to have contended seriously that it was so small as twelve inches in diameter.

I argue that the one consistent message the Epicurean sources themselves communicate is that this question, perhaps indeed irresolvable, at the least creates a tug of war between the fundamental basis for knowledge, namely sense-perception, and the chief means of preventing misconceptions, false beliefs and anxiety – i.e., reasoned judgment based on sense-perception. When it comes to the sun, our observational data is sorely limited. And yet it is the only evidence we can access. At the same time, we can no more accept our first impressions of this sense-data as true than we can take Epicurus’ statements in his *Letter to Pythocles* prima facie to mean that he thinks the sun is about as big as his own left foot. Rather, he seems to imply that one must be tentative and judicious in evaluating and hedging our limited information so that we do not reason incorrectly and end up like the fearful, the superstitious and the erotically infatuated.

²⁹ Algra: 2001, 17. ³⁰ Verde: 2017, n. 18. ³¹ Taormina: 2016, 123.

³² Bakker: 2016, 236 n. 184.

Complications in Lucretian Language

I further argue that the Lucretian version of the doctrine on solar magnitude uses language and style to underscore the aporetic Epicurean appeal to the senses. Lucretius' passage brings the crucial concept of heat into the discussion, and it expands Epicurus' analogy to terrestrial fires in a way that both complicates and conditions its applicability to the question of the sun's size. This presentation of the fire analogy, in turn, recalls the Lucretian speaker's examinations of perspective, distance and vision in the opening of Book 4 of *On the Nature of Things* (239–268 and 353–363).

The passage in Lucretius that deals with the size of the sun involves a lot of hedging, since every single sentence is hypotactic. The twelve sentences contained in 5.564–613 average 2.5 subordinate clauses each, with as many as six in one sentence (5.585–591), for an average of three subordinations per five lines of poetry. Categories of subordination include causal, conditional, comparative, temporal, relative, noun clause, result and indirect question. Such pervasive hypotaxis confers an acute mark of contingency upon the message of these lines. The subordination and the contingency are particularly intense in the analogy between celestial and terrestrial fires (5.585–591):

postremo quoscumque vides hinc aetheris ignis;
quandoquidem quoscumque in terris cernimus <ignis>,
dum tremor est³³ clarus dum cernitur ardor eorum,
perparvum quiddam interdum mutare videntur
alteram utram in partem filum, quo longius absunt;
scire licet perquam pauxillo posse minores
esse vel exigua maiores parte brevique.³⁴

Finally whatever fires of the aether you see from down here – inasmuch as whatever fires we see in the lands, so long as their trembling is clear, and their heat is perceived, are indeed sometimes perceived to change their contour little in either direction the further away they are – it is possible to know that they can indeed be only a little smaller or a tad bit bigger.

The sentence begins with a subordinate (relative) clause introduced by *quoscumque*, followed on the next line by a second (circumstantial) and

³³ Here I follow Rouse: 1975, 422, in maintaining the reading *dum tremor est clarus* as opposed to Bailey: 1947, 1.462, who follows Diels in printing *dum tremor <et> clarus*.

³⁴ Bailey: 1947, 1.462, follows Marullus in moving the two final lines (594–595 in the manuscripts) to the position I print here (590–591).

then a third (relative) subordinate clause. The next line brings two further (temporal) subordinate clauses in parataxis with one another. Two lines later there is another relative clause. The main verb does not appear until the penultimate line, only after three verbs and an adjective appealing to our sense-perceptions as observers (*cernimus, cernitur, videntur, clarus*), and that main verb governs a complementary infinitive (*scire*) that itself governs an indirect statement. The overall effect is too contorted and qualified to be taken as a simple declaration of doctrine.

I noted above that the abundance and variety of words for heat in this portion of the poem point to the importance of heat regarding the question of the sun's size, and that by including heat in its presentation of the matter, Lucretius' text appears to innovate on that of Epicurus. Sense-perception is not limited to sight alone, and our sensation of the radiant warmth of the sun (*calor . . . | nostros ad sensus, 5.570–571*) furnishes another kind of data for the reckoning of its size. Its immense heat, despite its profound distance from earth – the extent of this distance is less important than the fact that we can get no significant degree closer to it regardless of how high we climb – attests to the considerable magnitude of the sun. Another Roman-era Epicurean, Diogenes of Oenoanda, similarly appeals to the sun's heat in his refutation of a different misconception about the day star: “[Some people] suspect indeed that the sun is just as low in the sky as it appears, even though it is not just as low in the sky. For if it were just as low, then the earth and all things upon it would have to be burned up” (τὸν γοῦν ἥλιον ὑπολαμβάνουσιν οὕτως εἶναι ταπεινὸν ὥσπερ φαίνεται, μὴ ὄντα οὕτως ταπεινόν. εἰ γὰρ ἦν οὕτως, ἐνπυρίζεσθαι τὴν γῆν ἔδει καὶ τὰ ἐπ' αὐτῆς πάντα πράγματα, fr. 8 Ch). If, as the texts suggest, the sun's heat operates analogously to that of terrestrial fires, then Diogenes' argument here, which is couched as a counterfactual, suggests that the sun has considerable magnitude and heat.

It is furthermore remarkable that the Lucretian section on how the sun is able to fill the earth with warmth (5.590–613) is drenched in water imagery (*rigando, 594; perfundat, 595; largifluum fontem, 598; confluit and profluat, 601*) and is analogized to a spring irrigating a field (*nonne vides etiam quam late parvus aquai | prata riget fons interdum campisque redundet?*, “also, don't you see how widely a little source of water sometimes irrigates the meadows and streams over the fields?,” 602–603). This paradoxical parallelism draws the reader's attention to the thermal properties of the sun and reminds us once more that appearance and actuality are not one and the same. Furthermore, it emphasizes, by opposition, the immediately preceding analogy of stars in the sky to fires on earth.

That previous analogy (5.585–591), which the Lucretian speaker uses to illustrate the principle that cosmic bodies are more or less the size they appear, likewise (as we have just seen) participates in the passage's stylistic and semantic complications. To begin with, the speaker's claim about fires is false if one takes it to mean that fires do not diminish in size with distance. Fires do, in fact, appear to get smaller as one gets farther away from them. Accordingly, it has been attractive to interpret the claim to mean that fires do not appear to get smaller when viewed at a great distance, up until the point that they disappear entirely. This is the argument of both Bailey and Sedley with reference to lights on land as viewed from across a body of water: That they do not appear to get smaller the farther away one gets from them.³⁵

This line of reasoning is, in my judgment, flawed for two reasons. First, inasmuch as their evidence is anecdotal and experiential in nature, my own *sensus* does not match the *sensus* of Bailey or Sedley. When I carefully studied city lights growing distant while flying home from a conference, I found a sense-experience analogous not to Sedley's description of distant fires but rather to Sedley's description of distant structures: "[H]ouses seen from an aeroplane 'appear' smaller than they are in the sense that they fill a smaller area of our visual field than usual. It is quite another thing for a house to appear smaller than it is in the sense that we are deceived into believing it to be smaller than it is."³⁶ Perhaps lights viewed at a distance are simply more difficult to size up with the imprecision of the naked eye. At any rate, the conflict between individual perceptions in this type of situation suggests either an error in judgment based on sense-data, or else that the sensory experiences may not be generalizable, and thus that this interpretation of the Lucretian analogy is incomplete.

The second, more pressing problem is that Bailey's and Sedley's explanations omit the inclusion by the Lucretius-*ego* of the continued perception of the heat as well as the light of fires as a principal condition for the analogy's validity (*dum cernitur ardor eorum*, 5.587; Algra: 2001, 15 and 17, uniquely includes the warmth criterion). The text requires it to be a both/and condition with regard to perceptible light and heat together, and in such a situation the distant-lights hypotheses of Bailey and Sedley are

³⁵ Bailey: 1947, 3.1409; Sedley: 1976, 50.

³⁶ Sedley: 1976, 51. Similarly, my own experience with shading my eyes from the sun conflicts with Furley's (1999, 429) comments on the matter: "[W]hen we see a mountain in the distance, it is so small that it can be blocked from sight by the extent of a hand; yet we know, from a close look, that it is enormous. In the case of the sun, the effect is not the same, because the sun is a light, and lights behave differently."

inadequate to account for the syntactical nuances. Matters are complicated further still by the readily observable phenomenon that heat and light dissipate at vastly different distances, and the intensity of the fire affects the transmission of its heat and the character of its light. Even when both light and heat are sensible, the point is still, as Algra notes, that “de grootte *in principe* nog goed kunnen *schatten*” (“*in principle*, the size can still be estimated well”).³⁷

In the end, readers of *DRN* 5.564–613 are left with a question: Given what we know about fires on earth, how big indeed would the sun have to be in order to seem big enough to have such phosphorescent and thermal action at such a distance? For a caution on the limits of the analogy to earthly fires, we need only look to Asmis’ point that the Lucretius-*ego* “seems to have held that in most cases there is a difference in presentation between an object and another that resembles it.”³⁸ In principle, the lingering question can be answered only if we can accurately assert the distance between us and the sun – a measurement that was, for Epicurus and his school, unfathomable, given the limits of their empirical science. Once again, the Epicurean/Lucretian position ultimately seems to be one of reasoned aporia.

Size of the Sun as Didactic Challenge

Getting to this state of reasoned aporia is no simple task, as my ruminations above indicate. The text of *DRN* presents what can be taken on a simple surface reading to mean that the sun is the size of a soccer ball, a claim that may strike ancient and modern readers alike as patently ridiculous. I suggest that the complication and the seemingly questionable wording are part of the point of the passage, a call for us to apply our Epicurean philosophical and critical thinking to a knotty problem. In this respect, the Lucretian presentation of the size of the sun can be compared to the role of hunting imagery throughout the poem (Whitlatch: 2014) or the final-exam interpretation of the plague scene at the poem’s end (e.g., Clay: 1983, 257–266). Each of the three constitutes a didactic challenge to the reader, whose successful progression through the Lucretian narrator’s didactic plot entails solving the riddle it presents.

A principal element of the response to the solar challenge is to think about optics and perspective when it comes to figuring out the size of the sun. Contrary to Barnes’ claim that “there is virtually no evidence on how

³⁷ Algra: 2001, 17; emphases mine. ³⁸ Asmis: 1984, 155 n. 29.

the Epicureans understood the perception of size,”³⁹ recent scholarship on perspective in the atomic theory of Democritus gives ample clues for Epicurus’ own thinking, which can in turn be confirmed as Epicurean by examination of relevant passages elsewhere in Lucretius’ *DRN*. Kelli Rudolph’s study of Democritus clarifies the theoretical function of εἶδωλα in the perception of size in relation to distance.⁴⁰ Rudolph also explores the importance of Democritus’ metaphor of wax impressions for his atomic theory of vision: Because “a wax impression is an isomorphic copy of the original, but never an exact replica” (2011, 79), the eidolic-vision theory of Democritus allows for “epistemic uncertainty in the images we see” (80). Since, according to Democritus, sight consists in the physical reception of physical emissions from viewed bodies, the objects so viewed and visions of them should not be considered identical, because the εἶδωλον of the thing is never the thing itself. For Epicurus and his followers who have adopted Democritean atomism and optics, therefore, visual sensation – though it may (inasmuch as it is a sense-perception) be infallible – requires active cognition in order for sensations to be properly related to and with their sources.⁴¹

We can verify that some such theory of vision at a distance is in force in *DRN* by considering passages that deal with perspective in the treatment of simulacra in Book 4. The main description of how we are able to judge distance by sight appears at 4.244–255. In essence, the image emitted by the perceived object to the viewer pushes the intervening “air” (*aer*, 247, 251) past the viewer’s eyes, and the quantity of the air is directly proportional to the distance between viewer and viewed.⁴² That the sun falls into the category of distant objects requiring intentional perspective-taking along these lines is arguably obvious, but is also suggested by the Lucretian speaker’s explanation, shortly thereafter in the same book, of the sun’s blinding power (4.325–328). According to the Lucretius-*ego*, the sun is endowed with great power even though it is shining from on high (*vis magnast ipsius . . . alte*, 326); the sun’s simulacra, therefore, as they travel through air (*aera per purum*, 327, a phrase that looks back to the importance of air in 4.244–255), can strike the eyes heavily enough to

³⁹ Barnes: 1989, 37. ⁴⁰ Rudolph: 2011, 79 figs. 1–2; 2015, 50; *contra* Nightingale: 2015, 56.

⁴¹ For the Epicurean doctrine of the infallibility of sense perceptions see, e.g., DL 10.31–32; Striker: 1977; Taylor: 1980; Asmis: 1984, 152; Vogt: 2016: *passim*, with further bibliography at 155 n. 1.

⁴² This is the “intromission” theory of optics characteristic of the ancient atomists, including Leucippus, Democritus and the Epicureans: See, e.g., Thibodeau: 2016, 133–134 and 138.

harm their atomic compounding.⁴³ From these lines the reader can determine that the sun is not entirely a special case, but is subject to the same air-based perspectival adjustments as are other observable objects.

The image most often cited by scholars examining the Lucretian treatment of perspective is that of the tower seen from far away (4.353–363), which is square but appears at a distance to be round. According to the speaker's explanation for the apparent roundness of the tower's "angle" (*angulus*, 355), "while the simulacra are moving through a lot of air, the air with constant collisions forces it [the angle] to become dull" (*aera per multum quia dum simulacra feruntur, | cogit hebescere eum crebris offensibus aer*, 358–359). As a result, "every angle all at once has escaped our perception" (*suffugit sensum simul angulus omnis*, 360). That the tower appears round does not make it round; that the tower is in reality square does not invalidate our perceiving it as having a round appearance from a distance.⁴⁴ The fact that the Lucretian discussion of the size of the sun invokes readers' sense-perception (with *videtur* at 5.565, *inter alia*) prompts them to think back to the Lucretian discussion of perception at a distance, and to recall from the tower example that data derived from visual perception degrades over distance along with the simulacra themselves. We know intuitively that the sun is farther away than such a tower, and thus we know that we need care in assessing the size of the sun, just as we would in assessing the size (and shape) of a far-off tower.

Finally, there must be perspective-taking on our tactile sensation of warmth as well as on our sight. The heat emitted by a candle, by a bonfire and by a burning building fades away at profoundly different distances – an important piece of evidence in figuring out just how big the sun appears to be. Similarly, the Lucretian speaker's explicit introduction of heat into the Epicurean doctrine on the size of the sun may suggest to readers that they ponder as well the difference in perceived heat transmitted by the sun and the moon, despite the roughly equivalent percentage of the sky they fill – attested by, among other things, the moon's ability to eclipse the sun for terrestrial viewers. Vision alone, it appears, is insufficient for solving the puzzle.

So the implied prompts to remember the role of heat in addition to light, and to apply our understanding of perspective to the question of the size of the sun, amount to another current in the didactic airstream of *DRN*.

⁴³ Pope: 2018a, 207–208, suggests that the lines that follow, 4.329–331, use sexual and ejaculatory imagery in describing the sun's rays.

⁴⁴ Cf. Vogt: 2016, 148.

The Lucretian speaker, rather than merely parroting a ruthlessly ridiculed doctrine, instead pulls his student-readers into the process of inquiry. It becomes the didactic audience's task to receive data from sense-perception, and to use lessons learned earlier in the poem (as about perspective and distance, cf. 4.239–268, 353–363) in making correct rational judgments based upon that sense data. Asmis reminds us that for the Lucretius-*ego* “there is no clash between the judgment of the senses and objective reality, because the type of fact that seems to be in conflict with sense perception does not fall within the province of sense perception at all, but belongs to an entirely distinct domain of reality . . . judged by reason.”⁴⁵ As Demetrius Lacon writes of a related solar question, “the sun does not *appear* stationary, but rather it *is thought* to appear stationary” (ο[ὐ] φαίνεται μ[ε]ν ὁ ἥλιος ἐσ[τ]ηκώς, δοκεῖ δὲ φαίν[ε]σθαι, PHerc. 1013 col. 20.7–9; cited by Barnes: 1989, 35–36 n. 36). Tricky cases such as the size of the sun, where sense data is incomplete, may require suspension of such reasoned judgment, until enough evidence becomes available to evaluate our hypotheses through the process of ἐπιμαρτύρησις, until which point the opinion must remain a προσμῆνον.⁴⁶

In the Epicurean and Lucretian account of reality, the senses themselves are infallible. The Lucretian speaker's assertion that the sun is just as big as it is perceived to be by our senses must therefore also be infallible – just as the perception that the sun is bigger when it is close to the horizon at sunrise and sunset must be infallible, without our having to believe that the sun actually changes sizes dramatically during the day. But our interpretation of what exactly that assertion entails about the sun's actual size is a matter of judgment, and as such is fallible and uncertain indeed. As with the argumentation presented by the Lucretius-*ego* throughout the poem, and as with the gripping, awful plague scene at the end of Book 6, we must be keen-scented, relentless and detached from mundane concerns and fears in order to reckon and judge accurately in cosmic matters.

Size of the Sun as Epicurean Shibboleth

The Epicureans did not believe that the sun was the size of a human foot. They distinguished between the sun's actual size and the size of its appearance, the latter of which was the only magnitude measurable from

⁴⁵ Asmis: 1984, 155.

⁴⁶ So Bailey: 1926, 287–288; Romeo: 1979, 12; Taylor: 2016, 142 n. 20, with Epicurus VS 24, DL 10.34, Sextus Empiricus *Against the Grammarians* 7.211–212 and 215–216.

earth with the technology available. In this matter as almost everywhere else, the Epicureans appealed to the truth of sense-perception – with the important caution that discerning reality from appearance requires perception-based judgment, which itself is not guaranteed to be true. In Lucretius' poem, the discussion of solar magnitude adds more detail to Epicurus' original conception, especially with the introduction of the sun's heat into the passage. Complicated style emphasizes how full of hedges and conditioned claims the Lucretius-*ego* is, and his thorny exposition of the doctrine amounts to a didactic challenge that sends readers elsewhere in his work, to ponder perspective and to hunt down a proper understanding of this aspect of the natural world.

By staking out a stance of *aporia* conditioned by sense-perception and reasoning thereupon, the Epicureans did in fact prove to be less wrong than everyone else. Algra emphasizes that “*all* ancient estimates of the size of the sun, including those put forward by the mathematical astronomers, were false.”⁴⁷ The failing of ancient mathematical science in estimate-making was pervasive since, Geoffrey Lloyd notes, “an important recurrent phenomenon in Greek speculations about nature is a premature or insecurely grounded quantification or mathematicisation.”⁴⁸ Epicurus and his school, in avoiding a concrete statement of the sun's size, avoided being concretely wrong, in contrast to Eudoxus and all the rest. The sun passage in *DRN* pushes the reader towards non-commitment rather than risking such a misjudgment.

In closing I argue that the size of the sun is an Epicurean shibboleth. In Epicurus, in Lucretius and in Demetrius, we see the same nostrum repeated, with progressive elaborations that do not fully clarify the basic precept. The persistence of Epicureans in this formulation is not so much the result of reflexive dogma or pseudo-intellectual obscurantism as it is a passphrase, a litmus test. Think like an Epicurean, and you will figure out that the sun's appearance and the sun itself are two related but distinct things with two different sizes; that you must keep the infallible data of the senses, tactile as well as visual, in proper perspective when making judgments about your perception; and that the available data is insufficient to estimate the sun's magnitude to an acceptable degree of confidence (compare Barnes: 1989, 36). Think that Epicureans believe the sun's diameter is a foot, that they are absurd, and you have exposed yourself as un-Epicurean. The first/second-century AD Stoic doxographer Cleomedes, who as Algra points out “nowhere takes account of the Epicurean principle

⁴⁷ Algra: 2000, 187 n. 88; emphasis preserved. ⁴⁸ Lloyd: 1987, 280.

of multiple explanations,”⁴⁹ likewise fails this test when he mocks Epicurus’ position on the size of the sun.

Thinking like an Epicurean – rather than figuring out the actual size of the sun – is, I suggest, the point of the Lucretian passage on the size of the sun, as it is indeed the fundamental point of Epicurean natural philosophy generally. Constantina Romeo suggests that Epicurus’ moral program of liberating humankind from the fear of death motivates his followers’ ardent defense of his claims on the sun’s size. Since Epicurus presented understanding of the natural and celestial world as essential for a life of ataraxia, “nel momento in cui lo Stoico ritiene di avere dimostrato l’errore di Epicuro nella scienza della natura, sostiene pure che Epicuro non ha dato nessun conforto di fronte alla morte” (“in the moment in which the Stoic [Posidonius] thinks he has shown Epicurus’ mistakes in natural science, he also claims that Epicurus has provided no comfort in the face of death”).⁵⁰ Yet Posidonius has actually failed the test, has misunderstood the stakes of the debate. Precise measurement of the sun’s size is not what is at issue for the Epicureans, and so proof of scientific error does not vitiate Epicurus’ moral philosophy. The Epicureans pushed back so fiercely against their opponents’ (mis)characterizations of Epicurus’ position because of the underlying epistemological and phenomenological principles. It does not matter to Epicurean ethics or to ataraxia whether the size of the sun is known. After all, the Epicureans did not even need to affix a certain size to the sun to accomplish their core epistemological objective: to remove anxiety about divine control over cosmological phenomena.⁵¹ What matters, and the underlying reason for this Epicurean shibboleth, is a readiness to use careful reasoning and good judgment to embrace uncertainty about the nature of things without succumbing to the anxiety-inducing fear of death.

⁴⁹ Algra: 2000, 183. ⁵⁰ Romeo: 1979, 17.

⁵¹ On the Epicurean methodology of offering multiple plausible explanations for natural phenomena in situations where a single correct explanation could not be produced, see especially Hankinson: 2013.