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What about a Flat Earth? Pierre Gassendi's Reconstructions of Epicurus's Atomic Motion and the Shape of the Earth

Introduction

In line with the tradition of his atomic forefathers Leucippus (cylinder) and Democritus (concave disk), Epicurus maintained that the earth was flat. This probable ('verisimile') conclusion can be distilled from the *Animadversiones in decimum librum Diogenis Laertii* (1649) of the French philosopher and scientist Pierre Gassendi (1592–1655). Lucretius's use of the phrase *orbis terrarum* in two passages from the second book of *De rerum natura* does not undermine this verdict. As Gassendi stressed, the Latin term *orbis* refers to a circle and not to a sphere (*globus*). Hence, the phrase only asserts that the earth that we human observers perceive is terminated by the circle of the horizon.[1] This circle recalls the Greek etymological origin of the term 'horizon': the locution ὁρίζων κύκλος, which denotes the circular line that limits our view.[2] In the chapter 'De globo ipso telluris', included in the posthumous *Syntagma philosophicum* (1658), Gassendi inferred from precisely the same Lucretian passages that Epicurus was especially pleased by the possibility of an 'orbicular' earth ('orbicularem … Terram'). Even if, in this way, Gassendi echoed the terminology from the *Animadversiones*, and although he reiterated that it was likely that the opinions of Leucippus and Democritus had influenced Epicurus's position, it seems that, in the *Syntagma*, he was less clear about the meaning of his terminology and about Epicurus's probable convictions with respect to the earth's shape in general. More specifically, Gassendi no longer offered a clarification of the sense of Lucretius's *orbis*. Likewise, the textual context did not explicitly oppose Epicurus's 'orbicular' earth to a 'globular' earth.[3]

Overall, the Epicurean position on the earth's shape was, and still is, a particularly delicate issue. Even Gassendi, the French philologist and humanist who, throughout his life, attempted to rehabilitate

[1] Pierre Gassendi, *Animadversiones in decimum librum Diogenis Laertii*, Lyon, 1649, pp. 672–4. Gassendi quotes from Lucretius, *De rerum natura*, II.543, 658–9.

[2] F. Montanari, M. Goh, C. Schroeder, G. Nagy and L. Muellner, *The Brill Dictionary of Ancient Greek*, Leiden, 2015, p. 1483.

[3] Pierre Gassendi, *Syntagma philosophicum*, in id., *Opera omnia*, 6 vols, Lyon, 1658, II, p. 4a–b. One might have the impression that, in the *Syntagma* passage, the Latin terms *orbicularis* and *globosus* are similar rather than dissimilar; see, e.g., p. 4b: 'orbicularem, globosamve … Terram'. All translations are mine, unless otherwise indicated.

Epicurus's reputation as well as to translate and delineate his badly preserved works and theories,[4] did not resolve the problem unequivocally. This is not so surprising, however. The ancient sources, as Frederik Bakker recently pointed out, suggest that 'the Epicureans had no firm conviction as to the shape of the earth at all'.[5] Gassendi's not entirely decisive reconstructions, which I mentioned in the previous paragraph, could therefore be seen as the result of the inconclusive nature of the original theory.

To complicate the matter even more, it should be noted that, in a different place and context from the case mentioned above, the shape of the earth played a crucial role in Gassendi's reconsiderations of Epicurean atomism and, in particular, in his reconstructions of Epicurus's account of atomic motion, on which this article will concentrate.[6] At first sight, it could be asked why the issue of the earth's shape entered the discussion on the motion of atoms. Bakker has convincingly argued that Epicurus's (indecisive) ideas on the shape of the earth stood apart from his theory of the natural movement of (indivisible) bodies.[7] Moreover, in Gassendi's *oeuvre*, the unobservable atoms that move through the void constitute a kind of physical matter that tends to differ considerably from the 'concrete bodies' (*res concretae*) that pervade the phenomenal world.[8] Nevertheless, by reading Epicurus through the perspective of Gassendi, I will uncover how the original theory of (natural) atomic motion prompted Gassendi to reconsider and rethink the Epicurean position on the earth's shape and, hence, to insert an issue into Epicurus's account of the motion of atoms which can be regarded as essentially unconnected to it. In particular, we shall see that this insertion was motivated by the meaningful role that Epicurus, as Gassendi remarked, attributed to the human 'observer' in his account of imperceivable atomic

[4] For Gassendi's humanism, see L. S. Joy, *Gassendi the Atomist: Advocate of History in an Age of Science*, Cambridge, 1988.

[5] F. A. Bakker, *Epicurean Meteorology: Sources, Method, Scope and Organization*, Leiden, 2016, pp. 162–263 (162–4, 262). Bakker's conclusions, which are opposed to 'the strong claims in modern studies about the Epicureans' commitment to a flat earth', apply to both Epicurus and his followers. Bakker's argument is directed against, among other authors, J. M. Rist, *Epicurus: An Introduction*, Cambridge, 1972, p. 47; D. J. Furley, 'The Earth in Epicurean and Contemporary Astronomy', in *Epicureismo greco e romano: atti del congresso internazionale, Napoli, 19–26 maggio 1993*, ed. G. Giannantoni and M. Gigante, I, Naples, 1996, pp. 119–25; D. N. Sedley, 'Epicureanism', in *Routledge Encyclopedia of Philosophy*, ed. E. Craig, London, 1998 and 2005, pp. 340–50; and David Konstan, e.g. his article on 'Atomism', in *Oxford Handbook of Epicurus and Epicureanism*, ed. P. Mitsis, Oxford, 2020, pp. 59–80 (74).

[6] The passages which are crucial for the present article can be found in Gassendi, *Animadversiones* (n. 1 above), pp. 211–13, and Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, pp. 274a–275a.

[7] Bakker, *Epicurean Meteorology* (n. 5 above), p. 262. Still, Bakker also accentuates the correlations between natural motion, the cosmological system and the terrestrial shape that have prompted Epicurean scholars to consider Epicurus's atomic motion and his shape of the earth together.

[8] A. LoLordo, 'Epicurean and Galilean Motion in Gassendi's Physics', *Philosophy Compass*, 3, 2008, pp. 301–14; S. Fisher, *Pierre Gassendi's Philosophy and Science: Atomism for Empiricists*, Leiden, 2005, pp. 247–87.

movements. More broadly, the reconstruction of Epicurus and his ideas required important interpretative choices from the (early modern) expositor. Obviously, the 'historical' Epicurus who emerged was Gassendi's Epicurus.

Providing a satisfying reconstruction of the Epicurean theory of atomic motion was not an easy task for Gassendi. For one thing, due to the badly preserved state of Epicurus's philosophical corpus, it was, and still is, hard to offer a reading that exactly represents Epicurus's own thoughts.[9] For another, even if Gassendi found a way to read the original theory – by accentuating Epicurus's human observers – the reading itself generated questions for which he only gradually found novel solutions, as a comparison between the relevant textual evidence will demonstrate. In particular, the reconstruction that Gassendi incorporated in *De atomis* (1636–1637), the thirteenth book of the unpublished manuscript *De vita et doctrina Epicuri*, deviates from the versions that were published later in the *Animadversiones* and *Syntagma philosophicum*. Notably, as this article will underline, the reports on atomic motion that were introduced in the two published works and that almost inevitably included references to the shape of the earth are nearly identical, whereas the accounts of Epicurus's position on the earth's shape, with which I began, differ to a larger extent.

At the same time, the comparative study will show that, in the manuscript as well as in the two published works, Gassendi also provided versions of an alternative to the Epicurean account of atomic movements. As we shall see, for him, the particular value of this 'better' alternative lay in its elimination of the Epicurean swerve. It goes without saying that, in historical and philological terms, these versions were less accurate or faithful to the – rather underdetermined – original.[10] Yet, for Gassendi, that was not really a problem. Indeed, in general, he did not refrain from adapting and purging the aspects of the Epicurean philosophy that could have offended the norms of the seventeenth-century readers. In the cautiously added admonitory remarks that often complete the reconstructions of the original theory, he, for instance, overtly replaced Epicurus's infinite number of uncreated atoms that moved through the

[9] For the diverging philological reconstructions and interpretations of Epicurus's remarks on atomic motion in modern scholarship, see, e.g., D. Konstan, 'Epicurus on "Up" and "Down" ("Letter to Herodotus" § 60)', *Phronesis*, 17, 1972, pp. 269–78, and L. A. B. Wenda, 'Epicurus' Letter to Herodotus: Some Textual Notes', *Harvard Studies in Classical Philology*, 104, 2008, pp. 171–7. In this article, Epicurus's atomic motion will be viewed through the lens of Gassendi.

[10] Note that, in the surviving remnants, Epicurus does not explicitly argue for the atomic swerve, which Lucretius invoked in *De rerum natura* by using the term *clinamen*. See Rist, *Epicurus* (n. 5 above), pp. 8, 48. Nevertheless, even though modern scholars have held different opinions on the precise relation between Epicurus's theories and the developments of his followers, Rist, as well as Bakker, have asserted that the atomic declination was an integral part of Epicurus's own physics. See ibid., and Bakker, *Epicurean Meteorology* (n. 5 above), pp. 3, 215. This was also Gassendi's point of view; for his general belief that the Epicureans remained close to the theories of Epicurus himself, see the remarks in his biographical work, *De vita et moribus Epicuri* (1647), which can be found in Pierre Gassendi, *Miscellanea*, in id., *Opera omnia* (n. 3 above), V, pp. 186b–187a.

infinite void with a Christianized version in which God created a finite number of indivisible particles that composed the finite world. Even without primarily focusing on this important religious dimension, however, it will become clear that Gassendi, in the case of the atomic movements, not only presented *his* historical Epicurus, but also relied on his wide-ranging, erudite knowledge in order to support a better alternative.

The Manuscript *De vita et doctrina Epicuri*

As a starting point, I will examine the thirteenth book of the unpublished manuscript *De vita et doctrina Epicuri*. In general, there are considerable textual overlaps between this manuscript and the published *Animadversiones* and *Syntagma philosophicum*. Still, as I shall illustrate, significant differences now and then occur. The thirteenth book, *De atomis*, which can be consulted in the Bibliothèque municipale de Tours, was written in the years 1636 and 1637.[11] It is divided into eight chapters, in which Gassendi considers different aspects of the ancient atomic theory. Most attention is paid to the Epicurean version. For the purposes of this article, it will suffice to concentrate on the last chapter, which is entitled 'De multiplici motu atomorum'.[12]

In this part, Gassendi distinguishes between the natural and the reflexive motion of the atoms, respectively denoting the cases in which an indivisible particle moves freely or collides. According to Epicurus, as Gassendi notes, the former can be further divided into two *species*: perpendicular movement and declination. For the term 'perpendicular', I refer here to Gassendi's *ad perpendiculum*, which, in its turn, is the Latin substitute for Epicurus's κατὰ στάθμην, as mentioned in Pseudo-Plutarch's *The Doctrines of the Philosophers*.[13]

In order to establish the meaning of the term in this context, it should be noted that the Greek and Latin locutions are rooted in practical situations. Both the Greek στάθμη and the Latin *perpendiculum* can refer to the plumb line, the instrument by means of which humans observe the straight lines caused by gravity. That the perpendicular movement of the Epicurean atoms is rectilinear is confirmed by Roman reformulations of Epicurus's philosophy. In the eighth chapter of Gassendi's *De atomis*, one can find several relevant quotations from Lucretius's *De rerum natura* as well as from *De finibus bonorum et malorum* and *De fato* of Cicero, who, as Gassendi underlines, interprets κατὰ στάθμην as *ad lineam*.[14] Further, that the perpendicular movement is related to the lines of gravity is

[11] R. Pintard, *La Mothe Le Vayer, Gassendi, Guy Patin: études de bibliographie et de critique suivies de textes inédits de Guy Patin*, Paris, 1943, p. 42; O. R. Bloch, *La Philosophie de Gassendi: nominalisme, matérialisme et métaphysique*, The Hague, 1971, pp. XXIX–XXX.

[12] The eighth chapter covers fols 188^{v}–192^{v} of the Tours MS 709 – the number refers to the shelf mark.

[13] Pierre Gassendi, *De vita et doctrina Epicuri*, MS Tours, Bibliothèque municipale, 709, 1636–1637, fol. 189^{r}; Pseudo-Plutarch, *Placita philosophorum*, I.23.

[14] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fols 189^{r}–190^{r}, 191^{v}.

also confirmed by the manuscript text. Indeed, Gassendi indicates that this motion is due to the *gravitas* (or *pondus*), which he takes, in the case of the atoms, to be an internal motive principle.[15] In conclusion, the first *species* of natural atomic motion is rectilinear and depends on the *gravitas* of the indivisibles. As we shall see, for Gassendi, these two features are sufficient tools to complete the picture of the (naturally) moving atoms.

In the Epicurean system, nevertheless, this is not the case. Indeed, Gassendi already remarked that there were two *species* of natural atomic motion for Epicurus. By inserting a quotation from Lucretius, he further reveals the ancient point of view.[16] Lucretius's Latin verses demonstrate that, due to their *gravitas* (or *pondus*), which determines the perpendicular motion, the Epicurean indivisibles move downwards or *deorsum* through the (infinite) void. In order to connect the imperceivable and the concretely observable, Lucretius analogically refers to falling raindrops. According to their perpendicular movement, all atoms would fall downwards through the void, like raindrops. Consequently, no atomic collisions and, hence, no generation, would occur.[17] For that reason – and in order to avoid determinism – Epicurus (and Lucretius) introduced an element of contingency in their system: the declination or swerve of the atoms.[18] Without this natural declination, all the indivisible constituents of the world would fall *deorsum* in one, parallel-linear way, as do raindrops. In this sense, *deorsum* designates a single direction and is opposed to the single direction *sursum*, both of which extend to infinity.[19] To sum up, in the ancient atomic theory, as presented by Gassendi, *deorsum* and *sursum* are absolute directions and fit into a parallel-linear conception of perpendicular atomic movement that is supported by references to the concretely observable, that is, falling raindrops. With respect to these concrete bodies, however, it will be important to keep in mind that, for Gassendi, they

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[15] Ibid., fol. 188^{v}.

[16] Lucretius, *De rerum natura*, II.217–24; Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fol. 189^{r}.

[17] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fol. 189^{r}. Implicit in Gassendi's account here is the idea that all Epicurus's and Lucretius's atoms fall equally fast downwards in the void. See, e.g., T. O'Keefe, *Epicureanism*, London and New York, 2014, p. 26.

[18] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fols 189^{r}–189^{v}. In this article, I will mainly concentrate on Gassendi's disapproval of the declination theory in the limited context of atomic motion. For a discussion of the swerve with respect to Gassendi's ethics of the free human being, see L. T. Sarasohn, *Gassendi's Ethics: Freedom in a Mechanistic Universe*, Ithaca NY, 1996, pp. 136–41. See also C. H. Lüthy and C. Palmerino, 'Conceptual and Historical Reflections on Chance (and Related Concepts)', in *The Challenge of Chance*, ed. K. Landsman and E. van Wolde, Cham, 2016, pp. 9–47 (21–3). See also n. 10 above. For additional analyses of the swerve in modern Epicurean scholarship, see, e.g., P. J. Bicknell, 'Why Atoms Had to Swerve: An Exploration in Epicurean Physics', *Proceedings of the Boston Area Colloquium in Ancient Philosophy*, 6, 1990, pp. 241–76; D. Konstan, 'Commentary on Bicknell', *Proceedings of the Boston Area Colloquium in Ancient Philosophy*, 6, 1990, pp. 277–88; J. S. Purinton, 'Epicurus on 'Free Volition' and the Atomic Swerve', *Phronesis*, 44, 1999, pp. 253–99.

[19] Bakker, *Epicurean Meteorology* (n. 5 above), p. 216.

only apparently and approximately fall in a parallel-linear way. For now, it should be stressed that the Epicurean system could only work if the perpendicular movement of the smallest particles was combined with a natural atomic declination.

Unsurprisingly, Gassendi is critical of the generally discredited theory of swerving atoms, which he treats next. In the part on declination, ample space is given to Cicero's disapproving remarks that mainly denounce the inexplicableness of the Epicurean solution.[20] Moreover, Gassendi emphasizes that, despite his own adherence to the (Epicurean) theory that posits the existence of atoms possessing a natural 'impetus' – *dixit* Gassendi – he is not convinced that all indivisible particles have to tend in one and the same direction and that there needs to be declination. Indeed, he continues, atoms that possess an *impetus* that can lead them in any direction whatever explain the natural effects equally well, if not better than Epicurus's swerving particles.[21] In fact, this alternative demands no further reason to account for atomic collisions.

Here, Gassendi seems to give a radical endorsement to a kind of dynamic materialism the causal roots of which are represented by the motive principle of the ultimate particles, for which Gassendi uses various terms, such as *gravitas*, the scholastic natural *impetus* and *vis*.[22] 'Dynamic materialism' implies that the atoms have an *intrinsic* mobility and consequently that there is no need for a divine primary

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[20] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fols 189^{v}–190^{r}. See, e.g., also O'Keefe, *Epicureanism* (n. 17 above), pp. 30–31.

[21] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fol. 190^{r}.

[22] In the beginning of the seventh chapter of *De atomis*, entitled 'De pondere et mobilitate atomorum', Gassendi refers to the atomic motive principle as a *vis*; see ibid., fol. 185^{r}. For a point of view which strongly links Gassendi's atomic *impetus* to the medieval scholastic theory of impetus, see A. Maier, 'The Significance of the Theory of Impetus for Scholastic Natural Philosophy', in *On the Threshold of Exact Science: Selected Writings of Anneliese Maier on Late Medieval Natural Philosophy*, ed. E. Peters, Berlin and Boston, 1982, pp. 76–102 (102). Note that Maier primarily sees a similarity between Gassendi's natural atomic *impetus* and the inexhaustible *impetus* which the 14th-century philosopher Jean Buridan uses in order to account for the motions of the heavens, even though she stresses that, in the case of Gassendi, the *impetus* produces rectilinear motion, whereas Buridan's celestial movements are circular. Importantly, as is exemplified by Gassendi's word choice, his atomic *impetus* is natural. Roughly put, Gassendi does not principally consider atomic *impetus* as an impressed force that accounts for violent motion and that differs from *gravitas*, which accounts for natural downward motion. Quite to the contrary, in Gassendi's own alternative to Epicurus's theory, both terms refer to a principle of natural rectilinear atomic motion. For the history of the impetus theory, see, e.g., also M. Clagett, *The Science of Mechanics in the Middle Ages*, Madison, 1659, pp. 505–40; J. Sarnowsky, 'Concepts of Impetus and the History of Mechanics', in *Mechanics and Natural Philosophy Before the Scientific Revolution*, ed. W. R. Laird and S. Roux, Dordrecht, 2008, pp. 121–45; and M. Van Dyck and I. Malara, 'Renaissance Concept of Impetus', in *Encyclopedia of Renaissance Philosophy*, ed. M. Sgarbi, Cham, 2019. For an account of how the impetus theory was reinterpreted by the young Galileo, see S. Salvia, 'From Archimedean Hydrostatics to Post-Aristotelian Mechanics: Galileo's Early Manuscripts *De Motu Antiquiora* (ca. 1590)', *Physics in Perspective*, 19, 2017, pp. 105–50.

cause.[23] Much scholarly debate has arisen about this notion and its place in Gassendi's system.[24] More broadly, Epicurus's concept of atomic βάρος, which Gassendi translates as *gravitas* or *pondus*, and Gassendi's further developments on it give rise to numerous complex issues. It would, however, be outside the scope of the present article to disentangle these issues here.[25] For my purposes, I consider it sufficient to stress, first, that Gassendi proposes a 'better' alternative to the Epicurean swerve, second, that this is an alternative in which motion *ad perpendiculum* turns into rectilinear atomic motion in general, and third, that this rectilinear motion is caused by an *internal* motive principle. Overall, Gassendi therefore proposes an alternative in which perpendicular motion should not be regarded as a subcategory but as a synonym of natural atomic motion. Nevertheless, he also strives to reconstruct Epicurus's original declination theory. He does so by asking (and answering) the following three questions, which are introduced immediately before his own alternative and immediately after his presentation of Cicero's critical comments on the swerve: 'Do all atoms swerve? How should we

[23] For Gassendi's dynamic materialism, see Bloch, *La Philosophie de Gassendi* (n. 11 above), pp. 210–16. It is interesting to note, in addition, that Bloch, by referring to earlier studies of Alexandre Koyré and Bernard Rochot, remarks that Gassendi's own perspective on atomic motion comes close to that of Democritus. In fact, it can be argued that Gassendi's alternative, in which there is no swerve and in which atomic motion takes place in any direction whatever, represents a return to Democritean atomism. Yet, as Bloch highlights, Gassendi's atomism and his understanding of motion are primarily built on the Epicurean idea that weight is an inseparable property of atoms which is responsible for natural atomic motion. Significantly, Gassendi himself maintains that Democritus did not regard weight as an inseparable atomic property. See Gassendi, *Syntagma*, in id. *Opera omnia* (n. 3 above), I, pp. 266b–267a. For the complexity of the notion of atomic weight in Democritus's system, see, e.g., D. O'Brien, *Theories of Weight in the Ancient World: Four Essays on Democritus, Plato and Aristotle. A Study in the Development of Ideas,* I: *Democritus: Weight and Size. An Exercise in the Reconstruction of Early Greek Philosophy*, Paris, 1981, and A. Chalmers, 'Did Democritus Ascribe Weight to Atoms?', *Australasian Journal of Philosophy*, 75, 1997, pp. 279–87.

[24] See M. J. Osler, *Divine Will and the Mechanical Philosophy: Gassendi and Descartes on Contingency and Necessity in the Created World*, Cambridge, 2004, pp. 191–2. See also A. LoLordo, *Pierre Gassendi and the Birth of Early Modern Philosophy*, New York, 2006, pp. 140–44, where LoLordo discusses the weight of Gassendi's atoms, and, especially, p. 144, where she challenges Osler's interpretation by stating that '[t]here is clear conceptual space for holding both that matter is genuinely active and that God must create and concur with material activity'.

[25] Nevertheless, the previous footnotes may give an impression of the various questions and topics, ranging from natural philosophical theories on movement in nature to metaphysical and theological issues about the causal explanation of moving (atomic) matter and God's relation to it, that are relevant to the study of Gassendi's developments with regard to atomic weight and activity.

conceive of such a declination? Is the natural motion of atoms destroyed by this declination?'[26] For the purposes of this article, the answer to the second question is most relevant.

How should we conceive of such a declination? Gassendi offers two solutions. First, it could be possible, he suggests, that all atomic motion is *ex se* perpendicular. Declination would only appear when the perpendicular motions of two (or more) atoms are compared.[27] In other words, Epicurus's swerve would not exist absolutely, given that all atoms would move rectilinearly *ex se*, but only relatively speaking.

The way in which Gassendi substantiates the argument is intriguing. He develops an analogy by which he attempts to illustrate the imperceivable atomic movements. In particular, he connects these movements with the observable downward motion of two stones. According to common opinion ('vulgari sententia'), Gassendi states, both concrete stones are carried *ad perpendiculum* to the centre of the earth. Nevertheless, he continues, you could consider one of the two movements to be the real perpendicular movement. In that case, if you compare the other motion to the newly accepted norm, this second motion will be regarded as a declination, because it inclines towards the trajectory of the stone that is really moving perpendicularly. This inclination results from the fact that the two stones do not move in a strictly parallel way, as both of them tend towards the earth's centre.[28] In other words, Gassendi quite clearly takes it to be common sense here that the earth is spherical.[29]

In this way, Gassendi's analogy implicitly undermines Lucretius's adherence to the declination theory, the indispensability of which Lucretius illustrated by his comparison between the parallel-linear atomic motion and the falling raindrops. In Lucretius's analogy, the concrete raindrops are the equivalent

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[26] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fol. 190^{r}: 'Caeterum, cum ex hisce locis aliqua nos maneant expendenda inferius, Tria quaedam hoc loco adtingenda praesertim sunt. Unum est, an omnes Atomi declinent; Alterum, ut declinatio hujusmodi sit concipienda; tertium, an naturalis motus ponderum per hanc declinationem tollatur.'

[27] Ibid., fol. 190^{v}.

[28] Ibid., fols 190^{v}–191^{r}.

[29] One could argue that the prototypical cosmology that is behind Gassendi's reference to the 'common opinion', is the one that Aristotle developed in *De caelo*. Very briefly put, in this cosmology, as a result of their heaviness, heavy bodies like stones naturally tend downwards towards the centre of the world, which is also the centre of the spherical earth. See, e.g., Bakker, *Epicurean Meteorology* (n. 5 above), pp. 177–9. Gassendi's own account on motion of concrete bodies, as well as his cosmology, considerably differ from the Aristotelian one. For this point, see, for example, LoLordo, *Pierre Gassendi* (n. 24 above), pp. 158–67. It is interesting to note that, according to Gassendi, in the case of concrete bodies such as stones, *gravitas* should be considered as an external attraction caused by material effluvia coming from the earth, and not as an internal principle due to which bodies tend downwards. See, e.g., Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 389a. One can see this as an important illustration of the difference that tends to exist between atoms and concrete bodies in Gassendi's *oeuvre*. See n. 8 above. Despite everything, like Aristotle, Gassendi, of course, maintains that the earth is spherical.

of Gassendi's falling stones. As a result, Lucretius's analogy seems to lead to the position that atomic declination is not absolute. Yet, this was not what Lucretius concluded. Hence, there could be no entire equivalence between his analogy and Gassendi's. Indeed, it is only in Gassendi's version that the spherical shape of the earth excludes the possibility that two falling *res concretae* have a perfectly parallel movement, even if both bodies apparently follow a parallel-linear trajectory.

More generally, Gassendi's analogy accentuates how difficult it was in his view to make a satisfactory connection between the imperceivable atoms and the phenomenal world. Indeed, Gassendi consciously and explicitly underlines that his comparison is not entirely waterproof because of a difference ('discrimen') between the two levels. He signals that, contrary to the concrete stones, which, according to common opinion, tend towards the earth's centre, the atoms have no designated centre towards which they could move in the void universe.[30] In this universe, all atoms move perpendicularly, but, as Gassendi confirms, there are collisions.[31] Hence, these perpendicularly moving atoms do not tend in one and the same direction. There is no single *sursum* or *deorsum*.

In short, Gassendi's first solution is nothing more than his own alternative in Epicurean disguise. For him, this solution, of course, fits perfectly. Yet, for Epicurus, it would have been problematic, as Gassendi was aware. Therefore, he introduces a second solution that aims at offering a historically more accurate answer to the question 'How should we conceive of such a declination?':

> But truly, Epicurus seems to have supposed that there was one single region in the universe from which the atoms were carried perpendicularly ['ad perpendiculum'], namely that region that is upwards to us ['nobis'] who live on this part of the earth ['in hac terrae parte'], in such a way that, when one atom was conceived to fall on the top of the head ['in verticem'], all the others, with movements parallel to this one, were carried either before ['ante'], behind ['pone'], to the right ['ad dextram'] or to the left ['ad sinistram'] and that they did this by falling on the earth, outside of the earth, beyond the world ['Mundum'] and through the infinite. Surely, given this supposition, he [Epicurus] could also understand that certain atoms, varying their direction from the same part, inclined towards others, although with such a small inclination or angle that the course ['ratio'] of the parallel motion varied insensibly. This could indeed be his idea, whether ['Seu'], together with a truly large number of philosophers, he regarded this surface of the earth as a flat surface ['velut planam'], so that he could not easily admit the opposite position of the Antipodes; or that ['seu'], out of the manifold regions of the universe, which correspond to the manifold parts of the earth, he chose one in particular that he understood to be upwards ['sursum'].[32]

[30] Gassendi, *De vita et doctrina Epicuri* (n. 13 above), fol. 191[r].

[31] Ibid..

[32] Ibid.: 'Verum, videtur Epicurus supposuisse unicam Universi plagam, ex qua Atomi ad perpendiculum ferrentur, eam puta, quae nobis in hac terrae parte degentibus sursum est, adeo ut una atomo concepta incidere in verticem,

According to Gassendi, Epicurus thus appears to have posited one single *sursum* (and *deorsum*), as well as an insensibly small, but absolutely real, declination of the atoms that do not follow the parallel-linear path. Furthermore, it seems that the human body functions as a kind of compass that defines the absolute directions and the atomic motion. Here, quite literally, man appears to be the measure of all things. But, how can all human 'observers' have one and the same *sursum* above their head? Or, is only a part of mankind the measure of things? Who are the 'us' ('nobis'), living on *this* part of the earth ('in hac terrae parte')?

It could be suggested that on a flat earth, these puzzling problems that I have raised, but which, as will become clear, Gassendi also wanted to figure out, are solvable. Suppose the terrestrial surface is flat, then, all humans, when raising their head, look in the same direction. Nevertheless, the quoted passage nowhere states that Epicurus officially endorsed a flat-earth theory. In fact, the last sentence seems to indicate that, in the manuscript, Gassendi is undecided on the question. Whether or not Epicurus regarded the earth's surface as being flat ('velut planam'), his theory of atomic motion remained the same.[33] In this way, the manuscript is in line with the recent study of Bakker, according to whom the (ancient) Epicureans did not link their theory of parallel-linear (atomic) motion to a particular terrestrial shape.[34]

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caeterae omnes parallelis ipsi motibus ferrentur seu ante, seu pone, seu ad dextram, seu ad sinistram, idque incidendo in terram, extra terram, & ultra Mundum, & in infinitum. Hoc nimirum supposito intelligere quoque potuit quasdam ex eadem parte varianteis inclinari ad alias, verum tantilla inclinatione, seu angulo adeo exili, ut paralleli motus ratio insensibiliter variaretur. Seu enim hanc terrae superficiem cum Philosophis vere multis velut planam habuerit, adeo ut neque oppositum Antipodum situm facile admiserit; seu ex variis universi plagis, quae varias terrae facies respiciunt, unam quandam adsumpserit, quae sursum intelligeretur; potuit ista sane illi esse mens.'

[33] One could argue that the first option in the passage quoted directly above, in which the Epicurean earth is regarded as being flat, only points to a resemblance between the terrestrial surface and a plane, without entailing that, for Epicurus, the earth really was flat. In this regard, it could be added that, even if Epicurus considered (or experienced) the terrestrial surface 'velut planam', he did not need to be an adherent of a flat-earth theory and could still believe that the earth was, for instance, spherical in reality. Against this argument, however, one might highlight Gassendi's note on the Antipodes. As he underlines, if Epicurus adhered to a 'velut planam' theory, it would be difficult to admit the position and existence of Antipodes, that is, of those people who stand diametrically opposite to us or, more generally, who are the inhabitants of the opposite hemisphere of the earth. This note implies that, in the 'velut planam' option, Epicurus is presented as someone who supported the existence of a genuinely flat terrestrial surface. Moreover, it may be added that the Latin 'velut' is perhaps simply meant as an allusion to the physical height-differences of the terrestrial surface, because of mountains and depressions. For the Greek notion of the Antipodes, see H. Dörrie, 'Antipodes', in *Brill's New Pauly*, ed. H. Cancik, H. Schneider and M. Landfester, http://dx.doi.org/10.1163/1574-9347_bnp_e125250 (accessed: 12 November 2019) and n. 41 below.

[34] See the 'Introduction' above.

It is important to note that many of the topics that we have considered with respect to the manuscript *De atomis* will return in the published works, where Gassendi offers a reconfigured and modified picture of Epicurus's atomic movements. This picture will be examined more closely in the next section.

The *Animadversiones* and the *Syntagma philosophicum*

As I have already mentioned in the 'Introduction', the reports on Epicurus's (perpendicular) atomic motion that are included in the *Animadversiones* (1649) and the *Syntagma philosophicum* (1658) are very similar.[35] In fact, the main differences between the two reports result from the respective purposes of the works and from the influence that these goals had on the adopted structures and formulations. In the *Animadversiones*, Gassendi provides a Latin translation of the tenth book of Diogenes Laërtius's *Lives and Opinions of Eminent Philosophers*, which is dedicated to Epicurus and his philosophy. The translation is complemented by an ample commentary, which includes Gassendi's philological observations on the original text as well as his extensive interpretations. The aim of the *Syntagma*, in which many of these interpretations reappear, is to disseminate Gassendi's own philosophy. Nevertheless, even if philological concerns and line-by-line comments on Laërtius's *Lives* are absent from this posthumous work, it nevertheless remains a humanist amalgam of different theories and traditions. Indeed, Gassendi's own philosophy can only be fully captured through the lens of his personally (re)constructed and carefully moulded history of philosophy, which took its final shape in the *Syntagma*.[36]

Contrary to the vast similarities between the reports on atomic motion in the *Animadversiones* and the *Syntagma*, there are substantial differences in this case between the manuscript, on the one hand, and the two published works, on the other. First, I wish to indicate briefly Gassendi's structural rearrangements. In the *Animadversiones* and the *Syntagma*, the two interpretations that functioned in the manuscript as answers to the second question on the atomic swerve ('How should we conceive of such a declination?') are reused in a modified way, as we shall see, and now supplement Gassendi's discussion of the perpendicular movement of atoms. At the same time, they now also anticipate the subsequent paragraphs in which the swerve and Cicero's critical remarks about it are considered, but in which the three manuscript questions are no longer addressed. In other words, whereas, in the manuscript, Gassendi's interpretations were presented within the section on Epicurus's (problematic) declination, they occupy a more autonomous position before this section in the structure of the published works. In the following pages, I will explore these interpretations in their modified, published version.

[35] Gassendi, *Animadversiones* (n. 1 above), pp. 211–13; Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, pp. 274a–275a. In the *Syntagma*, the report is part of the book 'De materiali principio rerum'.

[36] For Gassendi's history of philosophy, see Joy, *Gassendi the Atomist* (n. 4 above).

After having distinguished, just as in the manuscript *De atomis*, between the natural and reflexive motion of the atoms and having again quoted Lucretius's verses which, among other things, contain the analogy of the falling raindrops, Gassendi explicitly notes in the published works that Epicurus's perpendicular movement is not related to any centre. Indeed, he asserts that Epicurus's universe is infinite and acentric. Instead, atomic motion is perpendicular with respect to the two unbounded – an infinite universe has no upper and lower boundaries – directions *sursum* and *deorsum*, as atoms move in an unlimited manner from the former to the latter.[37] Then follows a passage in which Gassendi proposes a particularly interesting interpretation of these two Latin notions:

> And it would certainly be easy to surmise that this was Epicurus's estimation: that any direction whatever from which the atom came needed to be regarded as upwards ['sursum'] and any direction whatever to which it tended as downwards ['deorsum']. That is to say, with respect for instance to us and our position, that not only the direction above the top of our head would be called upwards, if the atom came from that side, and the direction below our feet, to which it tended, downwards, but that the direction below our feet would also be called upwards, if the atom came from that side, and the direction above our head downwards, if the atom went off in that direction. Likewise, if the atom came from the east, then this direction would be called upwards, and the opposite direction, the west, downwards. Conversely, the west would be called upwards, if the movement originated from there, and the east downwards, if the movement was in that direction, and so on. I say that this could, indeed, be surmised. But truly, if this had been Epicurus's idea, he would not have needed to dream up declinatory motion, since the atoms would have been self-sufficient to bump into each other.[38]

In this passage, Gassendi revises several elements that were already included in the manuscript *De atomis*. In particular, he takes up again, in a modified form, the first solution (his own alternative)

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[37] Gassendi, *Animadversiones* (n. 1 above), p. 212; Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 274a.

[38] Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 274b: 'Ac pronum quidem foret reputare eam fuisse Epicuro mentem, ut existemaverit quamlibet regionem esse habendam sursum, e qua veniret Atomus; quamlibet deorsum, in quam tenderet; hoc est, ut facta v.c. ad nos situmque nostrum comparatione, non modo regio supra verticem diceretur sursum si Atomus accederet illeinc, & regio proinde infra pedes, in quam tenderet, diceretur deorsum; sed regio etiam, quae nobis infra pedes, diceretur sursum, si illeinc Atomus adventaret, & regio quae nobis supra caput, deorsum, si in illam abscederet: Ac pari modo si adveniret ex ortu, tunc regio illa diceretur sursum, & quae opposita ex occasu, deorsum; ac vice versa ista sursum, si ab ea esset motus; illa deorsum, si in eam esset, atque ita de caeteris. Reputari quidem, inquam, istud posset; verum, si ipsi illa mens fuisset, nihil sane fuisset necesse declinationis motum somniare; quando Atomi fuissent satis sibi invicem alias occursurae.' Note that the *Animadversiones*, pp. 212–13, include exactly the same words, except that the passage there has a slightly different beginning ('Et cogitari quidem posset eam fuisse Epicuro mentem') and contains the verb *cogitare* instead of *reputare*.

offered in the manuscript to the second question about the atomic swerve. Again, as the last sentence of the passage indicates, what fits for Gassendi does not necessarily fit for Epicurus. Yet, as Gassendi stresses, it would have been better if his Greek forebear had endorsed this interpretation as well, because, in that case, the world would have been spared Epicurus's illusive dreams about declination. In general, in the published works, the way in which Gassendi interprets the terms *sursum* and *deorsum* provides an explicit opportunity to omit the theory of declination without dismissing the Epicurean vocabulary.[39]

Let me now delve more deeply into the ingredients of the solution quoted above. The passage essentially implies that the notions *sursum* and *deorsum* are mere labels that can be variously assigned. They are entirely relative. But, to what are they relative? In a letter to his patron Louis-Emmanuel de Valois, written in 1642, Gassendi attempts to clarify the Epicurean *sursum* and *deorsum* by linking them to Plato's point of view. For both Epicurus and Plato, he signals, the two notions are meaningful only if they are considered with respect to the position of an animal.[40]

In the letter, Gassendi draws on a passage from the *Timaeus* where Plato highlights that a point can be considered both as upwards and downwards, depending on the position of the observer, and where he uses the term ἀντίπους ('antipode') in order to exemplify this relativistic idea.[41] This Platonic conception also appears elsewhere in Gassendi's writings. In the book 'De universo et mundo' of the *Syntagma*, Gassendi explicitly refers to the *Timaeus* and affirms that, even if the Platonic spherical universe (*Universum*) or world (*Mundus*) has a centre and extremities, Plato regarded the clusters *supremum* ('highest'), *superius* ('higher'), *sursum* ('upwards') and *infimum* ('lowest'), *inferius* ('lower'), *deorsum* ('downwards') as denominations or metonymies ('denominationes') closely linked to the parts of the human body ('comparate ad Hominis parteis').[42] The animal from the letter to Valois is thus most commonly a human being. This is also the case in Gassendi's *De motu impresso a motore translato* (1642), which consists of two letters in which Gassendi investigates and elaborates on Galileo's theories of motion.[43] It is in the second letter that Plato's idea is brought into play by

[39] For the possible Democritean aspects of Gassendi's (published) alternative, see n. 23 above.

[40] Gassendi, *Epistolae*, in id., *Opera omnia* (n. 3 above), VI, p. 158b.

[41] Plato, *Timaeus*, 62^{c}–63^{a}. See also Dörrie, 'Antipodes' (n. 33 above), where he remarks that the term was coined by Plato in the passage in question. According to Christine Garwood, however, the term was coined by Pythagoras; see C. Garwood, *Flat Earth: The History of an Infamous Idea*, London, 2007, p. 23, where she also briefly discusses the theological debates about the Antipodes. The confusion seems to arise from the accounts in Diogenes Laërtius, *Lives and Opinions of Eminent Philosophers*, III.24, where Laërtius recalls the claim that Plato was the first philosopher to use the term, and VIII.26, where the term is incorporated in the discussion of Pythagoras's philosophy. This ambivalence did not remain unnoticed in Gassendi's works; see Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), II, p. 13b.

[42] Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 136b.

[43] In the letters *De motu*, Gassendi examines elements from both Galileo's *Dialogo* (1632) and his *Discorsi* (1638). Among other things, in these letters, Gassendi extensively explicates and defends Galileo's concept of relativity;

Gassendi.[44] There, he points out that the eastern part of the world ('pars mundi oriens') can be left ('sinistra') or right ('dextra') according to the position of the observer's body.[45] Likewise, he states, if we take the position of our Antipodes, what was *supremum* will be *infimum*, given that it will now be below our feet.

Overall, in the Platonic conception, a spherical earth is the norm. The existence of Antipodes, for instance, is not easily admitted on a flat earth.[46] Besides, according to both Plato and Epicurus, human (or animal) perception defines the notions *sursum* and *deorsum*.[47] That Gassendi refers to 'us and our position' in the passage quoted from the *Animadversiones* and the *Syntagma* is, however, noteworthy; for it contains Gassendi's modified, *first* answer to the (manuscript) question 'How should we conceive of such a declination?', which is the answer that corresponds to his alternative to Epicurus's atomic motion. Yet, in the manuscript, the idea that the human body functions as a compass emerges from the *second* solution, that is, the reconstruction that aims to suit Epicurus's own theory. In other words, the reference to 'us and our position' in the passage from the published works bears witness to an attempt by Gassendi to expand the idea of the human compass to his alternative solution. Accordingly, one can interpret this introduction of the human observer as a strategic attempt to underline the 'Epicurus-like' nature of the solution. In this reformulated alternative, however, Epicurus's human compass – the observer's body – is replaced by a (horizontal) astronomical coordinate system that harmonizes better with Gassendi's remarks in the letters *De motu*. Indeed, whereas Epicurus, in the text quoted from Gassendi's *De atomis*, states that atoms could fall to the right or to the left, Gassendi writes that they could come from the east and from the west.

Nevertheless, despite the above-mentioned (Platonic) relativity claims that lie behind Gassendi's interpretation, the quoted passage at the same time marks its independence from these views. In fact, in this case, Gassendi is working on an entirely different level. In Plato's *Timaeus*, as the French humanist stresses, the universe and the world coincide and are both finite.[48] Gassendi's *Mundus* in the

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he challenges the standard arguments against a moving earth, without explicitly endorsing, as he is careful to underline, the Copernican (and Galilean) world system; and he tries to add a causal framework to Galileo's odd number law of falling bodies in order to corroborate its validity.

[44] Gassendi, *Opuscula philosophica*, in id., *Opera omnia* (n. 3 above), III, p. 507b.

[45] In this respect, Aristotle, *De caelo*, $284^{b}6$–$286^{a}2$, can be seen as another important text in the background.

[46] See, e.g., n. 33 above.

[47] Similarly, on the first day of Galileo's *Dialogo* (1632), Sagredo, one of the three interlocutors, declares that the two notions *sursum* and *deorsum* 'are applicable only to the actual world, and imply it to be not only constructed, but already inhabited by us': Galileo Galilei, *Dialogue Concerning the Two Chief World Systems – Ptolemaic & Copernican*, transl. S. Drake, 2nd edn, Berkeley, 1967, p. 16; Galileo Galilei, *Dialogo sopra i due massimi sistemi del mondo Tolemaico e Copernicano*, in id., *Le opere*, Edizione nazionale, Florence, 1890–1909, VII, p. 40.

[48] Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 136b.

De motu also has a centre and extremities.[49] By contrast, the Epicurean atoms move through an infinite void universe.

Still, Gassendi's alternative goes further than Epicurus's view as well. As Gassendi's discussion in the manuscript *De atomis* already showed, Epicurus's *sursum* and *deorsum* were of a single and absolute nature. This point generated questions about the puzzling role of the human observer. Furthermore, it led scholars to the conclusion that the void space of Epicurus and Lucretius was anisotropic rather than isotropic.[50] In Gassendi's own alternative, by contrast, the empty and infinite space has, in itself, no single 'upwards', 'downwards', 'before', 'behind', 'from the right', 'from the left' or 'middle'.

In this way, Gassendi's conception of space corresponds to the point of view of Cleomedes, a representative of Stoic philosophy, who is quoted in the book 'De universo et mundo' of the *Syntagma*.[51] This connection should not come as too much of a surprise. According to Edward Grant, the Stoic cosmology and, in particular, the idea that the finite, spherical cosmos is surrounded by an infinite, three-dimensional void had an important influence on the early modern developments in thinking about space.[52] Further, modern scholarship has already established that Gassendi's conception of an infinite, isotropic void space, which, as I argue, constitutes the background to the atomic movements in the reformulated alternative, results from the erudite combination of a wide range of sources. Apart from the Epicurean and Stoic legacies, Gassendi's notion of space, which is often seen as a further step towards Isaac Newton's ideas on absolute space, benefited, for example, from scholastic and contemporary insights as well. It would, however, take too long to uncover the entire genealogy of Gassendi's conception of space.[53] I will therefore return to the analysis of Gassendi's modified alternative to Epicurean atomic motion that can be found in the *Animadversiones* and the *Syntagma philosophicum*.

In Gassendi's isotropic void space, the labels *sursum* and *deorsum* are not relative to humans and their bodies, nor do they refer to the directions of an astronomical coordinate system. As the passage

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[49] Gassendi, *Opuscula philosophica*, in id., *Opera omnia* (n. 3 above), III, p. 507b. Galileo, in his turn, seems to have remained undecided on the issue of the infiniteness of the world and the universe, given mankind's epistemological limits. See, e.g., A. Koyré, *From the Closed World to the Infinite Universe*, Baltimore, 1957, pp. 95–9.

[50] D. M. Miller, *Representing Space in the Scientific Revolution*, Cambridge, 2016, pp. 14–15.

[51] Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 137a.

[52] E. Grant, *Much Ado about Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution*, Cambridge, 1981, p. 183.

[53] For more detailed accounts of Gassendi's conception of space and its historical foundations, see ibid., pp. 206–15; Bloch, *La Philosophie de Gassendi* (n. 11 above), pp. 172–201; D. Bellis, 'Imaginary Spaces and Cosmological Issues in Gassendi's Philosophy', in *Space, Imagination and the Cosmos from Antiquity to the Early Modern Period*, ed. F. A. Bakker, D. Bellis and C. Palmerino, Cham, 2018, pp. 233–60.

quoted from the published works illustrates, they are determined by the movement of the atoms, the physical, but nonconcrete, bodies that traverse this empty space. In this abstract case, humans can only label directions depending on the motion of the indivisibles. If an atom moves in an unlimited manner from A to B, A will always be the unbounded direction *sursum* and B always the unbounded direction *deorsum*. Conversely, if an atom moves in an unlimited manner from B to A, B will always be the direction *sursum* and A always the direction *deorsum*. This holds true not only for A and B, but also for C, D, E and so forth. Furthermore, it holds true for all possible 'observers', whose position is in fact irrelevant. Hence, in this isotropic space, the shape of the earth is of no importance at all. There are no differences between observers on a flat, a spherical, a cylindrical, a conical or an irregularly shaped earth. As Bakker indicated, the ancient Epicureans also thought that the earth's shape and natural (atomic) motion were completely different questions. According to Epicurus and Lucretius, however, all naturally moving atoms would follow a strictly parallel-linear path from A to B, if there were no declination.

In sum, Gassendi's first interpretation in the published works, which is founded on his own alternative from *De atomis*, entails that perpendicularly moving atoms are carried forward linearly. Natural atomic motion *ad perpendiculum* becomes a synonym of natural rectilinear atomic motion in general. These atomic movements can still be regarded as directed towards a *deorsum*. This *deorsum* does not, however, depend on the position of human beings, but on the (diverse) movements of the indivisible particles themselves and, specifically, on their (diverse) orientations. In this way, *deorsum* becomes a ubiquitous label and 'we', the human observers, can act as labellers only *pro forma*. In other words, just as in the manuscript analogy between the atoms and the two falling stones, perpendicularly moving indivisibles are carried forward (recti)linearly by their proper motive principle, variously called *gravitas*, *impetus* or *vis*, which does not steer all of them in one single direction, in contrast to the objects falling on earth, which, due to their *gravitas*, tend towards one particular centre, according to common opinion.[54] Moreover, provided that the atoms move only from A to B, Gassendi's first solution could also be suitable for Epicurus and Lucretius.

The passage quoted, however, is immediately followed by a second interpretation in which Epicurus's position on the earth's shape is readdressed. Why would Gassendi want to reconnect atomic motion and the shape of the earth? In the manuscript, he had implied that the question of the earth's shape was beside the point. The answer lies in the fact that, in Gassendi's account in *De atomis*, Epicurus's human observer, the 'us', leaves the seventeenth- (and twenty-first-) century interpreter rather puzzled. As my analysis of the second manuscript solution has indicated, the idea that man is the measure of all things and, in particular, of atomic motion and its absolute directions leads to the question of how all human observers on earth can have the same *sursum* above their head. It is clear that the

[54] For a brief discussion of the notions *gravitas* and *impetus*, see n. 22 above. For Gassendi's manuscript remark about 'common opinion', see n. 29 above.

introduction of the observer in Gassendi's reconfigured, first interpretation, that is, his own alternative, is mainly an adroit 'Epicurus-like' manoeuvre that assigns the role of labeller to the human observers, even if their position is in fact irrelevant to the (diverse) movements of the atoms. In the revised, second solution, which aims to be historically more accurate, the question about the human observers receives a more profound answer:

> It seems that he [Epicurus] rather thought about the matter in such a way that, in his opinion, this surface of the earth that we inhabit should be regarded as a flat surface ['quasi planam'][55] and that one should conceive ['concipiendum esse'] of the horizon all around ['totum circum horizontem'] as exactly the same plane ['planum'], spread and continued into the heavens and further into the entire immensity of the universe. Indeed, he seems to have imagined ['imaginatus'] that the weights ['pondera'] that fall downwards ['deorsum'] to us, in Europe, as to others in Asia, Africa and so forth, would not meet (if they are conceived of continuing their movement) in the earth's centre itself, but would avoid each other and would always retain between them a strictly parallel motion, as long as the movement lasts. Accordingly, he seems to imagine ['imaginari'] that the direction that is upwards ['sursum'] to us really is the direction that is upwards with respect to the movement of all the atoms, insofar as all around [us] the [upward] direction is extended above the continued, as already said, plane of the horizon ['horizontis planum'] – everything that moves towards the (infinitely stretched) plane, is said to come from above ['superne'] and everything that tends beyond it, is said to tend lower ['inferius']; and [he seems to imagine] that this is the case if we have conceived this plane in the place where it is, or as translated ['translatum'], or if, parallel to this one, we have adopted another plane far above and beyond the top of our head, or far below and beyond our feet.[56]

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[55] Cf. n. 33 above.

[56] Gassendi, *Animadversiones* (n. 1 above), p. 213; Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 274b: 'Videtur … potius rem sic cogitasse, ut opinatus fuerit, hanc Terrae superficiem, quam incolimus, habendam esse quasi planam, & totum circum horizontem concipiendum esse ut idemmet planum diductum continuatumque & usque in Caelum, & porro in omnem Universi immensitatem. Nempe imaginatus videtur, quae pondera deorsum cadunt tam nobis in Europa, quam aliis in Asia, in Africa, &c. non coitura (si concipiantur motum continuare) in ipso Terrae centro, sed abitura, servato semper motu inter se exquisite parallelo, quandiu motus duraverit. Quare & imaginari ['imaginatus' in *Animadversiones*] videtur, regionem illam quae nobis est sursum, esse eam revera, quae respectu motus Atomorum omnium sursum sit; quatenus circumquaque extenditur supra continuatum, ut iam dictum est, horizontis planum, in quod (infinite protensum) quaecumque adveniunt, advenire superne dicantur, & ultra quod quaecumque tendunt, tendere dicantur inferius; atque id quidem sive id planum isto, quo est loco, conceperimus, sive translatum, aut aliud ipsi parallelum habuerimus supra, supraque, ultra verticem, aut infra, infraque ultra pedes.'

In the passage, Gassendi advances a tightened and elaborate reconstruction of Epicurus's atomic motion and his position on the earth's shape. Even though Gassendi has at this point already made clear that there exists a better alternative, the reconstruction has its proper *raison d'être* in his eyes, since it satisfies his historical and philological concerns, as is demonstrated by the ample references to Epicurus's *Letter to Herodotus* and Lucretius's *De rerum natura* that follow the passage quoted above.[57] In this reconstruction, humans, whom Gassendi considers to be of central importance in Epicurus's theory of atomic motion, but who are abstracted from the isotropic picture in the better interpretation, do matter. After all, one could suggest, the locutions κατὰ στάθμην and *ad perpendiculum*, which mark, as Gassendi explained, the perpendicular movement of atoms, are rooted in concrete and practical situations, given their associations with the plumb line. The use of the Latin *pondera* in the passage is revealing in this regard, for, in this way, the distinction between the concrete bodies and the imperceivable atoms is, as it were, camouflaged.[58] Human observers are given the possibility of positively saying something about or even defining the movements of the unobservable atoms. Of course, Gassendi also adroitly included this idea in his alternative interpretation. Yet, it is only in what he intends as a historically more accurate reconstruction that the position that the human being holds as an observer (on the earth) really matters. So, when Gassendi reconstructs the original perspective and speaks about *pondera*, he takes into account that, according to Epicurus and Lucretius, the motion of the invisible atoms that fall downwards due to their *gravitas* is strongly connected to the (practical) human experience of concrete bodies that fall κατὰ στάθμην due to their βάρος, which, for the ancient Epicureans, derives directly from the βάρος of the atoms.[59] Not entirely surprisingly, therefore, the

[57] Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, pp. 274b–275a. The *Letter to Herodotus* is the first of three letters from Epicurus's own hand that Diogenes Laërtius included in the tenth book of his *Lives*. It presents an epitome of Epicurus's atomist physics. In the *Syntagma*, Gassendi incorporates a part of his Latin translation, including his own in-text clarifications, of this letter (Laërtius, *Lives*, X.60), in order to highlight the resemblance between his reconstruction and the ancient source. The second half of Gassendi's reconstruction, in particular, attempts to capture Epicurus's original phrasing. For the translated section of the *Letter to Herodotus* and Gassendi's philological remarks on it, see also Gassendi, *Animadversiones* (n. 1 above), pp. 45–6, 421. The Greek section in question is confusing and difficult to read and understand, as Gassendi highlights. Accordingly, it has also received much attention by modern scholars; see n. 9 above. See also, e.g., C. Bailey, *The Greek Atomists and Epicurus*, New York, 1964, pp. 311–13; Rist, *Epicurus* (n. 5 above), pp. 47–8; Bakker, *Epicurean Meteorology* (n. 5 above), pp. 215–16. The question of the extent to which Gassendi's reconstruction (dis)satisfies the historical and philological concerns of modern scholarship on Epicurus's atomic motion is beyond the scope of the present article.

[58] Note that Gassendi also used the word *pondus*, in the genitive plural ('ponderum'), when he introduced the three questions on Epicurus's declination in the manuscript. See n. 26 above.

[59] For the connection in Epicurus's theory between the *gravitas* of the atoms and the *gravitas* of the concrete bodies, see Gassendi, *Animadversiones* (n. 1 above), p. 314, and Gassendi, *Opuscula philosophica*, in id., *Opera*

earth's shape enters into play in this reconstruction. In the manuscript, Epicurus's *sursum* was already above the head of the observer who lived on *this* part of the earth. In the published works, it is explicitly above the head of the people in Africa and Asia as well.

In the published reconstruction, it is thus possible for people all over the world to have one and the same *sursum* above their head. Put differently, in the *Animadversiones* and the *Syntagma philosophicum*, Gassendi makes an effort to answer the puzzling questions that I asked about the manuscript version. In order to solve the manuscript puzzle, Gassendi develops the idea that if all humans are positioned on a flat terrestrial surface, they look in the same direction when raising their head. In this case, the human compass defines the two absolute directions and the parallel-linear atomic movements. As can be seen, the published text makes extensive use of the concept of a plane surface. 'We', the human observers in Europe, are located on a terrestrial plane on which the people in Africa and Asia, who participate in the same parallel-linear system, are imagined to be as well. The extended terrestrial plane in question is closely related to the horizon. The plane of the horizon, about which Gassendi speaks, is moreover easily translated ('translatum') and can even be substituted by another, parallel plane. In general, the passage points out that Epicurus, in his theory of perpendicular atomic motion, not only attributed a crucial role to human observations, but also resolutely exploited his powers of conceiving ('concipiendum esse') and imagining ('imaginatus', 'imaginari'). The observation of the surface on which 'we' stand and of the horizon all around leads to the conception of an infinitely stretched plane. In this respect, it is helpful to recall the etymological origin of the term 'horizon', which I addressed in the 'Introduction'. In particular, it denotes the circle on the terrestrial surface that marks the humanly observed (linear) intersection of earth and sky. All things considered, the plane terrestrial surface is of central importance for Gassendi in his published reconstruction of Epicurus's original perpendicular atomic motion. By contrast to the manuscript *De atomis*, where Gassendi seemed undecided on the question of Epicurus's position on the earth's shape, the reconstruction in the *Animadversiones* and the *Syntagma* primarily represents Epicurus as a flat-earth thinker.

Strictly speaking, however, this reconstruction does not necessarily imply that Epicurus believed that he really lived on a flat earth. One could imagine and conceive of a flat terrestrial surface and see this as an indispensable step in the construction of a theory on 'observable' parallel-linear, perpendicular (atomic) motion, without genuinely supporting a flat-earth theory. In a similar way, early modern authors on mechanics could assume that the perpendicular lines of gravity between objects, or different

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omnia (n. 3 above), III, p. 17b. The latter reference is to a passage from Gassendi's *Philosophiae Epicuri syntagma* (1649), which first served as an appendix to the *Animadversiones* and presented a summary of Epicurus's philosophy. This work should not be confused with the posthumous *Syntagma philosophicum* (1658). Clearly, the connection that Gassendi perceives between Epicurus's atoms and concrete bodies with respect to their βάρος is not maintained in his own view, where the internal motive principle of the atoms is different from the external *gravitas* due to which bodies are attracted towards the earth. See also n. 29 above.

parts of an object, and the centre of the earth were parallel to each other, even though these writers, just like Gassendi in his manuscript example of the two perpendicularly moving stones, generally acknowledged the approximate nature of those parallel lines and believed in a spherical earth. An important illustration of this can be found in the fourth book of Galileo's *Discorsi* (1638), which Gassendi knew well. There, through his spokesman Salviati, Galileo invoked the authority of Archimedes in order to underline that the human scale is so small compared to the size of the (spherical) earth that 'in practice, ... we may consider a minute of arc on a great circle as a straight line, and may regard the perpendiculars let fall from its two extremities as parallel'.[60] A reading could be proposed in which Gassendi's published reconstruction left room for a broader application of such an Archimedean procedure to Epicurus's theory on perpendicular atomic motion, in which the practical side of the parallel and linear observations went together with the imaginative and conceptual assumption of a generally flat terrestrial surface.

There are, however, indications that, in Gassendi's reconstruction, Epicurus's plane terrestrial surface was more than just an assumption and that it was instead pointing towards a genuine belief in a flat earth. On the one hand, in both the *Animadversiones* and the *Syntagma*, Gassendi noted that his account of the Epicurean bodies ('ponderibus') that fell at different places of the earth's surface – such as Europe, Africa and Asia – was in agreement with two verses of Lucretius's *De rerum natura* mocking the idea that everything tended towards the middle and that there were Antipodes.[61] On the other hand, in the *Animadversiones*, Gassendi reiterated the issue of the perpendicularly falling bodies ('res'), which could also refer to falling atoms in Epicurus's theory, at the outset of his discussion of Epicurus's position on the earth's shape, which I briefly considered at the beginning of the 'Introduction'. Interestingly, in this context, Gassendi suggested a close connection between Epicurus's parallel falling of *res* and the probable verdict that he did not regard the earth's form as spherical but rather as a flat surface.[62] In other words, for Gassendi, it was difficult not to consider the issue of Epicurus's position

[60] Galileo Galilei, *Dialogues Concerning Two New Sciences*, transl. H. Crew and A. de Salvio, New York, 1954, p. 251; Galileo Galilei, *Discorsi e dimostrazioni matematiche intorno a due nuove scienze*, in id., *Le opere* (n. 47 above), VIII, pp. 274–5. For the early modern debates on the issue of the parallel lines of gravity, see D. Bertoloni Meli, *Thinking with Objects: The Transformation of Mechanics in the Seventeenth Century*, Baltimore, 2006, pp. 30–32, 101–2 (where Bertoloni Meli discusses the beginning of the fourth book of Galileo's *Discorsi*), 128. See also M. Van Dyck, 'Gravitating Towards Stability: Guidobaldo's Aristotelian-Archimedean Synthesis', *History of Science*, 44, 2006, pp. 373–407, where he independently makes similar points to Bertoloni Meli.

[61] See Gassendi, *Animadversiones* (n. 1 above), p. 213, and Gassendi, *Syntagma*, in id., *Opera omnia* (n. 3 above), I, p. 275a. Gassendi quotes from Lucretius, *De rerum natura*, I.1058–9. For the difficulty of admitting the existence of Antipodes in the case of a flat earth, see n. 33 above.

[62] See Gassendi, *Animadversiones* (n. 1 above), p. 672. It should be noted that the passage on the perpendicularly falling *res* was not repeated in the *Syntagma*, when Gassendi introduced his claim that Epicurus was especially pleased by the possibility of an orbicular earth. This can be seen as an additional indication of the less clear way

on the earth's shape, with which I opened the article, and the issue of Epicurus's perpendicularly moving atoms (or *pondera* in general), which I examined throughout the article, as communicating vessels in the original theory.

Overall, throughout his published and unpublished works, Gassendi was not entirely decisive about Epicurus's position on the earth's shape. Moreover, in the manuscript *De atomis*, he indicated that the unidirectional and parallel-linear rain of atoms constituted the core of the Epicurean theory of perpendicular atomic motion, regardless of the particular shape of the earth. Yet, in his quest for a historically accurate and coherent presentation of the original theory, Gassendi felt compelled to let *his* Epicurus elaborate the concept of an (extended) terrestrial plane of the horizon. Officially, this procedure did not automatically entail that Epicurus believed that he really lived on a flat terrestrial surface, although such a connection was easily made.

Conclusion

In the 'Introduction', I underlined the complexity of the question of Epicurus's position on the earth's shape. I also advanced the idea that this question was detached from the Epicurean theory of natural (atomic) motion. In the course of the article, however, it has become clear that, on several occasions, the earth's shape did emerge in Pierre Gassendi's reconsiderations of the perpendicular and swerving movements of the Epicurean indivisibles. In particular, the position of Epicurus's human observer turned out to be a tough nut to crack. In the manuscript *De atomis*, Gassendi's reconstruction left room for puzzling questions. In the *Animadversiones* and the *Syntagma philosophicum*, Gassendi presented a modified reconstruction that aimed at solving the problems by placing the human observers on an extended terrestrial plane. Still, he himself preferred to deal with the atomic movements in an alternative way. In the isotropic void space, which he eruditely constructed out of a wide range of materials, the imperceivable atoms had a completely different behaviour from, for example, two concrete stones that fell towards the earth. In the isotropic framework, where the position of the human observers on the earth was irrelevant, the *sursum* and *deorsum* of Epicurus and Lucretius were ubiquitous labels that depended on the (diverse) movements of the atoms themselves. Correspondingly, the Epicurean system, in which the perfectly parallel-linear atomic movement required the addition of a natural declination in order to account for the generation of things, was replaced by an alternative in which perpendicular movement, that is, rectilinear movement, was the only natural atomic motion. If Epicurus had himself adopted this alternative, an option that his early modern expositor reluctantly dismissed, then Gassendi would have been relieved of the interpretative troubles and puzzling questions that, as this article has revealed, informed his published reconstruction of Epicurus's atomic motion and shape of the earth.

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in which Gassendi discussed the topic of Epicurus's view of the earth's shape in the chapter 'De globo ipso telluris' in the *Syntagma*. See the 'Introduction' above.