coming searches with the large FAST radio telescope (similar to the late Arecibo one but larger, with its 500-m diameter), which started in 2019. The program, which consists of looking at individual exoplanets near 1 GHz with a multibeam system, is described.

I will stop here, and congratulate the HAPP Centre and IOP for making available for free to a large (I hope) community a variety of good and interesting papers.

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Epicureanism and Scientific Debates: Antiquity and Late Reception. Volume 1. Language, Medicine, Meteorology, edited by Francesca Masi, Pierre-Marie Morel and Francesco Verde (Leuven, Leuven University Press, 2023). Pp. vi + 341. ISBN 978-94-6270-373-5 (hardback), 160 × 240 mm, Euro 90.

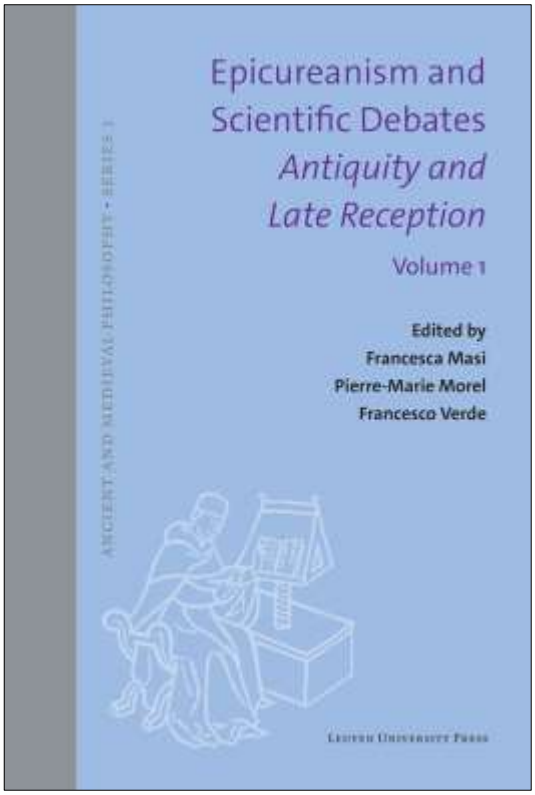
Epicureanism and Scientific Debates: European Tradition and its Ancient Reception. Volume 2. Epistemology and Ethics, edited by Francesca Masi, Pierre-Marie Morel and Francesco Verde (Leuven, Leuven University Press, 2024). Pp. viii + 270. ISBN 978-94-6270-437-4 (hardback), 160 × 240 mm, Euro 90.

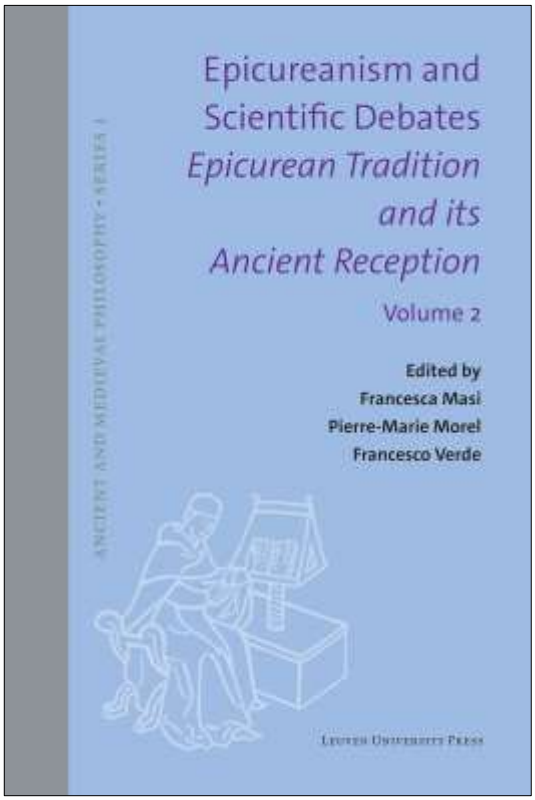
Epicurus is perhaps best-known at second hand, as the philosopher who was most influential on Lucretius, author of *De rerum natura* (*The Nature of Things*). Both of these great thinkers from ancient Greece believed that nature was comprised of atoms and the void, topics at the heart of modern physics. These two volumes, written at the highest scholarly level, explore both the ancient and late reception of Epicureanism. The first volume has more of direct interest to historians of astronomy, but both deliver major insights that will set a new standard in the study of this ancient philosophy.

The three editors of these books have brought the combined intellect of 22 additional scholars to bear on the great issues explored here. Francesa Masi, is Associate Professor in the History of Ancient Philosophy at University Ca' Foscari in Venice; Pierre-Marie Morel is Professor of Ancient Philosophy at the University of Paris 1, Panthéon-Sorbonne; and Francesco Verde is Associate Professor in the History of Ancient Philosophy at Sapienza University in Rome.

The stakes here are high:

The very foundations of modern science, which is rooted in Epicurean philosophy, disproves historiographical attempts to reduce Epicureanism





to ethics … it's theoretical core and the only possible paths to achieve it lie in the knowledge and study of nature. (Volume 2, page 8)

One can see here the animating principle that saw the creation of the Royal Society in England, and other national scientific societies that proliferated in the seventeenth and eighteenth centuries.

Ethics features in the first chapter of Volume 1, where Julie Giovacchini (French National Centre for Scientific Research) writes:

> The epicurean theory of language is based on ethical, political, and pedagogical purposes that are not always explicit. (page 15).

Epicurus had to create new language in order "To frame the cardinal questions pertaining to physics, anthropology, noetics, and epistemology …" Thus, scholars meet with a host of words for the first time, some of which either had, or later developed, layers of meaning. Clearly understanding what was meant can also be obscured by the use of modern English words in any translation, so much of what is presented here gives the reader (whether a novice or an expert) a deep insight into Epicurean philosophy. As the author explains,

> … meaning is always contextualized and the important thing is not to fix a meaning in itself but a meaning in relation to other meanings. (page 31).

This rather esoteric notion becomes important quite quickly for any student of Epicureanism. In a chapter on language theory and scientific terminology, Masi confronts us with a dualism that is often ignored. She looks at the word 'atom', the plural of which "…clearly refers to individual atoms." (page 54). However,

> … the plural term can also be used to refer to the elements of an aggregate as a whole. The two meanings are different. In the former case, the term refers to unmodifiable entities endowed with a single type of movement. In the latter, the word refers to modifiable atomic relations characterized by more varied motions of collision. This, perhaps, is why the philosopher felt the need to distinguish the two meanings of the term and to refer them to the correct objective counterparts, so as to avoid misunderstandings, or, worse, distortions of his doctrine on the part of his opponents. (page 54).

Going beyond physics, "Epicurus believes that mental states depend on atomic interrelationships." (page 54). Bound up in this is another polysemic word, *physis*, not be conflated with the modern word physics. It is used

> … as a synonym for the original atomic constitution … with which the human being is endowed from birth. Yet *physis* is a term very dear to Epicurus, who also uses it in a much more generic sense, to refer to any substance or to the essence of a thing. (page 55).

Careful attention to Masi's chapter is essential for an understanding of what follows. Epicurus' definition of cosmos is found in a chapter by Dino DeSanctis (University of Tuscia). It reads, in part,

> A world is an enclosure in the sky enclosing stars and earth and everything appearing in it, containing a section cut off from the limitless expanse and terminating at an outer limit either thin or thick. (page 72).

In a section relating to the cosmos, Epicurus coins a word "… of particular charm …" that, used meteorologically, means a watery downpour. (page 75). But here

> … it is not a simple aqueous precipitation but an atomic effluvium with which Epicurus seems to indicate the agile, almost liquid movement of the atoms that disperse and travel in infinity. (page 75).

Yet another innovative term identified by De Sanctis appears only as a lunar term, meaning interposition or occultation. It first occurs in a section devoted to the Moon's phases, where three possibilities are mooted:

> … waning of the moon and again its waxing would be able to come about both by its own body turning round, and similarly by configurations of air, and yet again by interpositions, and in all the ways the appearances around us proclaim for producing this visible shape. (page 77).

"It is not surprising," writes De Sanctis,

> … that Epicurus consistently plays, so to speak, with this noun always about the moon, perhaps because it seems to be suitable to express visually the behaviour of this astral body in the sky, including its aspects that most attract the interest of man when he observes it. (page 77).

Most famously, Lucretius wrote of an infinity of worlds.

> For, since the totality of space out beyond the ramparts of our world is infinite, my mind seeks the explanation of what exists in those boundless tracts which the intelligence is eager to probe and into which the mind can freely and spontaneously project itself in flight. (page 126).

This line, which has inspired generations of scholars and scientists, comes in a chapter by Chiara Rover (University of Hamburg). In the first book of Lucretius' poem, Epicurus is named as "… the first to burst the bolts and bars of nature's gates." (page 126). Lucretius was led to the infinite worlds concept through an inference by analogy. For him, everything belongs to a particular class composed of innumerable specimens. "The same holds true for the sun, the moon and the sky," writes Rover, "of which there must necessarily be other specimens elsewhere: the same laws apply to the cosmos and to the entities that inhabit it." (page 127). What Rover explicates in her chapter is that phenomena, if carefully selected, "… are able to provide a correct and cogent view, enabling us to *see the invisible*." (page 128; her italics). Thus, the truth of the infinity of worlds is revealed by analogy, similar to how the corporeity of atoms is revealed to man. For Lucretius, this *animi iactus/ iniectus* attains "… the status of fully-fledged criterion of truth." (page 129). It actually becomes the fourth criterion of truth, and it reveals "… the meticulousness of Lucretius' terminological choices." Rover says Lucretius is not betraying the doctrine of Epicurus by introducing this fourth criterion.

> Rather, he possibly sought to standardize its vocabulary, by reserving the term *animi iactus/iniectus* for cases in which it took on the meaning of criterion of truth in the full sense. (page 129).

As is apparent by now, this is not a typical collection of random papers by a suite of scholars. Rather, each chapter builds on the ones before it, so that they really need to be read sequentially to gain a full understanding of the issues. After some chapters on medicine, the astronomically-oriented text resumes with a chapter entitled Gravity and the Shape and Location of the Earth, by David Konstan (New York University). Like Lucretius, Epicurus resorted to analogy in his study on the size of the sun and stars, which relates to the size of the cosmos itself. He used the visual appearance of fires, which are only visible within certain limits. "If the analogy is to apply to heavenly bodies, which to the naked eye are either small, as in the case of the sun, or tiny, as with the dimmer stars, then they cannot be very far away." (page 214) Thus, writes Konstan, the maximum size of the cosmos is "relatively modest, and all the stars are contained within it." (page 214). But this refers only to the cosmos we can perceive; Epicurus is open to the existence of others. "The termination of our particular cosmos is imperceptible, not because it is very far away but simply because the circumference is rarefied or in some other way transparent." (page 214)

The problem of gravity, Konstan states, also has a bearing on the size of the cosmos. Unlike other scholars, he identifies three phases in the formation of the cosmos in the work of Lucretius, and he also says (contra established scholarship) the Lucretian origins of the cosmos do not contradict those of Epicurus. In the first phase, heavy earth atoms gather in the middle of the cosmos. Once in that area,

> … they extrude the lighter atoms, and so they end up at the bottom relative to them. In the words of Lucretius 'The more they came together, entangled with one another, the more they drove out those [bodies] which produced the sea, stars, sun, moon, and the walls of the great cosmos.' (page 219).

In the final phase, the lighter elements then spread out:

> Thus the light and diffusive ether, when its elements had condensed, was set round and enclosed on all sides and, diffused widely in every direction, enclosed all other things in its eager embrace. (page 219).

"This stage is distinct, and not produced by extrusion as such …" writes Konstan in identifying this phase of cosmic formation (page 219). The Epicurean philosopher Diogenes of Oenoanda reduced

> … the Sun, the Moon, the planets and the fixed constellations to simple conglomerates of material continuously moving around in space … (page 271),

and he is further studied in Volume 2, where Attila Németh (The Research centre for the Humanities, Budapest) devotes a whole chapter to him.

As was apparent in his explanation for the phases of the Moon, Epicurus was not averse to positing multiple explanations for cosmic phenomena. The implications of the

'method of multiple explanations' is tackled head-on by Voula Tsouna (University of California, Santa Barbara). She states this concept of

> … *pollachos tropos* as a proper scientific method probably had its roots in the atomism of Democritus … Aristotle standardly uses the *pollachos tropos* to account for phenomena such as shooting stars. (page 223).

Democritus died in 370 BCE, 100 years before Epicurus died, but Tsouna writes

> Epicurus was more at home in Democritus' mechanistic universe than in the world of Theophrastus [a colleague of Aristotle]. And he proved able to discern the potential of atomism for the purpose of explaining irregularities in nature. (page 226).

Tsouna importantly notes that Epicurus is the first philosopher known to us to argue in favour of *pollachos tropos* and against the use of a single explanation in astronomy and meteorology. Indeed, Epicurus wrote a critique of what astronomers typically did.

> What Eudoxan astronomers do is to construct mental models and base their reasoning on instruments that they construct. But this, Epicurus argues, is wrong. For the indications of the instruments cannot serve as a basis of an analogy with the *meteôra* (celestial phenomena) that we *actually see* in the heavens. (page 230, her italics).

This is because while

> … an instrument is an object whose properties are observable and known, a meteôron is an image whose causes are unobservable and their nature unknowable. (page 230).

Even such a phenomena as the rising and setting of the Sun "… cannot be captured by a single explanation." (page 233). Lucretius follows Epicurus by including multiple explanations of *meteôra* "… in an overarching ethical framework." (page 242).

This approach ultimately led Epicurus to a devastating conclusion. Since astronomers desire the impossible (a single explanation for their observations), they

> … get into a situation that is irrational … and find themselves in conflict with evident facts … And, typically, they become epistemically arrogant, fanatic, or even insane. (page 251).

Quite a denouement with which to end this review! (Perhaps modern research astronomers feeling the first twinges of anxiety should be given a dose of Epicurus to stave off even worse symptoms.) Overall, a remarkable pair of books that plumb the depths of Epicureanism in a variety of disciplines. Essential reading for any historian of astronomy dealing with early cosmological thought.

Each chapter in these important books has self-contained footnotes and references. There are separate indexes for ancient and modern names in both books. There is a typo in Volume 1: "nd" should be "and" (page 67).

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***Attention is Discovery: The Life and Legacy of Astronomer Henrietta Leavitt*, by Anna Von Mertens. (Cambridge, MIT Press, 2024). Pp. 264, ISBN 9780262049382 (hardback), 205 × 260 mm, US$34.95.**

Henrietta Leavitt (1868–1921) worked at Harvard College Observatory after the completion of her academic certification at Radcliffe until the year of her death in 1921. She was one of a team of women, hired by the Observatory Director Edward Pickering, to be one of his 'computers', women who collected data for the benefit of astronomical science. The legacy of the contributions of Leavitt is dealt with deftly by visual artist Anna Von Mertens.

Leavitt, in her particular work, noticed patterns in the variability of luminosity in a class of stars known as Cepheids. This regularity in the period of luminosity, which was later to be called the 'Leavitt Law,' would provide astronomers with an alternate tool, more far-reaching than that of parallax, to determine the distance of stars. Harlow Shapley, successor to Pickering at Harvard Observatory, used Leavitt's research to establish that the Milky Way was much larger than had been originally thought. He determined the extent of our Galaxy was, more correctly, of the order of 100,000 light years across. However, he was not ready to admit to the existence of other galaxies beyond ours.

This volume includes contributions, in words and images, by those with other perspectives. Rebecca Dinerstein Knight, novelist and poet, set the scene for a day in the life of the lady computers in the Brick Building, their place of work. There was a culture of