Ancient Atomism and Cosmogony

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How should we treat the cosmogonies of the early ancient Greek philosophers? Much work has been done in showing how these cosmogonies differ from creation myths and how they relate to philosophical issues such as change, persistence through change and matter theory. Here, using Leucippus and Democritus as examples, I try to show that interesting light can be shed on these cosmogonies by looking at them in relation to perennial problems in cosmogony and perennial types of solutions to these problems. Ancients and moderns have formulated both in different ways, but there are significant structural similarities. To understand ancient cosmogonies, we need to understand how these perennial problems were perceived, and what types of solutions were available. We then need to analyse how the basic ontological and aetiological principles of their systems lead them to choose certain types of solution over others.

It is generally understood that the early ancient atomists, Leucippus and Democritus reacted to the arguments of Parmenides.[1] They attempted to re-assert plurality and change, and the possibility of cosmogony.[2] They posited a multiplicity of atoms, in a sense asserted the existence of non-being by supposing the existence of a void, and theorised change as the motion, coming together and separation of the changeless atoms. There is an important principle though, which they apply in several different contexts. Simplicius tells us that:

> Leucippus supposed there to be an unlimited number of atoms that are always in motion and have an unlimited number of shapes on the grounds that nothing is such rather than such (*dia to meden mallon toiouton e toiouton einai*) (Physics 28, 8).

Parmenides' argument led to the conclusion that what exists is one and is spherical. There is no real question of its size, at least in relation to anything else.[3] If there are to be multiple things though, what are their shapes? Here the early atomists assert

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2 Furley, 1967:79 ff.

3 Parmenides Fr. 8.

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that there are no preferred shapes, and so with an unlimited number of atoms there are an unlimited number of shapes. If we accept that Leucippus and Democritus postulated any size of atom (as opposed to Epicurus, who specifically limits atoms to very small sizes),[4] then the *ou mallon* principle may have been applied to the sizes of atoms as well. Allowing for the possibility of huge atoms may not have been an oversight, corrected by Epicurus, as is generally thought, but an integral part of early atomist thought. The *ou mallon* principle is also significant in relation to one of the challenges to cosmogony that Parmenides provides. He asks quite generally:

> What birth will you seek for it? In what way, from what source did it grow? I will not allow you to think or say from not being, for it is not to be thought or said that it is not; and what necessity would have driven it later rather than sooner, beginning from nothing, to grow? (Fr. 8, 6–10).

Parmenides does not discuss place in the same manner, but one can easily see how his sufficient reason argument could be extended to where a kosmos is generated as well, given the requisite assumptions about space. How do Leucippus and Democritus react to these issues? The first stage of early atomist cosmogony is vortex formation:

> Leucippus holds that the whole is unlimited... part of it is full, and part void... from these unlimited kosmoi come to be and are dissolved into these again. The kosmoi are generated in this manner — by "cutting off from the unlimited" many bodies of all shapes move in a great void, where they are crowded together and produce a single vortex, where colliding with each other and circulating in all manner of ways, they separate out like to like (Diogenes Laertius IX, 31).

According to Aristotle, Leucippus and Democritus viewed the formation of a vortex as a matter of chance:

> There are some who make chance the reason for the heaven and all of the kosmoi. For from chance arose the vortex and the motion which by separation brought the universe into a state of order (Physics II/4, 196a24 ff.).

There is ample evidence in the doxographical tradition to support this attribution of chance.[5] There is a difficulty though, in that Leucippus says:

> Nothing happens at random, but everything for a reason and by necessity.

One can resolve the apparent contradiction here in two ways. Perhaps Leucippus and Democritus say something happens by chance when actually they mean it oc-

[4] See Dionysius, ap. Eusebium P.E. xiv, 23, 3.

[5] Simplicius Physics 327, 24 and 330, 14, Themistius Physics 49, 13, Eusebius P.E. XIV, 22, 3, Cicero De Natura Deorum I, 24, 66.

curs by necessity, but the causes are unknown or unknowable to us.[6] Alternatively, perhaps Aristotle calls these chance events because they have no teleological purpose,[7] and the doxographical tradition then follows him, while Leucippus and Democritus consider them necessary events.

The problem with this is that it leaves Leucippus and Democritus with a rather feeble reply to Parmenides' when and where questions. They accept the principle of sufficient reason, but are unable to give any sufficient reason for when and where kosmoi form. Out of necessity from a previous state of distribution and motion of matter in the universe will not do, as Parmenides will simply ask for a sufficient reason for the previous state.

The alternative is to allow Leucippus and Democritus an *ou mallon* reply to the when and where questions, that there are no preferred times or places. One version of this would be that there is necessity outside of the vortices, but there is no reason for when and where vortices form. The second version is more radical in supposing there to be genuine chance events outside the vortices. Aristotle does recognise chance as distinct from necessity in some contexts. He says:

Epicurus (c. 341–271 BC).

> Empedocles says that air is not always separated out upwards but according to chance. He says in his cosmogony "Thus at one time it ran so by chance, but many times it was otherwise" (Physics II/4, 196a20 ff.).

Purposeless necessity would repeat itself. Aristotle contrasts the chance formation of the vortex for the early atomists with the supposed subsequent formation of animals, which he says happens "by nature".[8] This would accord with the evidence of Diogenes Laertius, who says that for Democritus:

> Everything occurs by necessity, the vortex being the cause for the coming into being of all things, and this he calls necessity (IX, 45).

So perhaps outside the vortices there is no (or limited) necessity, and the fragment

6 So Taylor, 1999:191–192, Guthrie, 1965:419, see also Furley, 1987:148 ff., Bailey, 1928:139–143.

7 KRS, 1983:419–420.

8 Aristotle, Physics II/4, 196a25 ff.

we have from Leucippus is missing a context or a qualification. Eusebius certainly attributes random motion to the atoms outside of the vortices for the early atomists and random motion for Epicurus too:

> Those who name the unlimited number of small bodies atoms, and who suppose a void unlimited in extent, say the atoms move by chance in the void. With their disorderly motion they collide with each other... Epicurus and Democritus held this view (Eusebius P.E. XIV, 22, 3).[9]

If there are no preferred places, this would also accord with the evidence of Hippolytus, who says:

> The spaces between kosmoi are not equal, in places there are more and in others less (Eusebius P.E. XIV, 22, 3).

There is a dilemma in cosmogony which can be expressed like this. If the original state of the universe is homogeneous, and it obeys laws which are place invariant, it is then difficult to see how anything interesting will develop in that universe. If the original state of the universe is not homogeneous, we require some further explanation of why the original state is not homogeneous and why it has this particular state as opposed to any other. Modern big bang cosmogony has this problem. If we assume that what expands from the initial state is entirely homogeneous, and that it expands isotropically, then all that will result will be a larger homogeneous universe, which only differs from earlier stages in being less dense and cooler. The modern solution to this difficulty is to invoke quantum mechanics. At an early stage of the universe, quantum effects create slight inhomogeneities in the distribution of matter/energy throughout the universe (the famous "ripples" in space/time). The areas of greater energy density will then act as gravitational attractors. Depending on one's model of cosmic evolution, stars or galaxies will then form around these areas of higher energy density. In reply to the question of why here rather than there, the answer will be that quantum mechanics is fundamentally probabilistic in its nature, and can only give probabilities of energy distribution.

Epicurus certainly adopts this type of solution. If the atoms did not swerve, then they would simply fall in parallel lines and no kosmoi would be formed. I suggest that Leucippus and Democritus also adopt this type of solution. Either there is a random distribution of particles when vortices might form by necessity in some places, or there might be genuinely random motion. In either case there would be no preferred places or times for vortex formation. The *ou mallon* interpretation for when and where vortices form gives the early atomists a consistent and radical reply to Parmenides' use of the principle of sufficient reason.

The next stage in early atomist cosmogony is a separating out from the vortex,

[9] See also Furley, 1989:77 ff.

according to a like to like principle. Sextus Empiricus tells us that:

> Democritus bases his argument on both animate and inanimate things. For animals, he says, congregate with animals of the same kind — doves with doves, cranes with cranes, and so with the other irrational animals. Similarly in the case of inanimate things, as we can see from seeds that are being riddled and from pebbles on the sea-shore. For in the one case the whirling of the sieve separately arranges lentils with lentils, barley with barley, wheat with wheat; and in the other case, by the motion of the waves, oval pebbles are forced into the same place as oval pebbles, and round pebbles as round as pebbles.[10]

There is not an attractive force here which brings like things together, as they are only sorted together when a vortex is in operation. The atomist kosmoi are all different:

> There are innumerable worlds which differ in size. In some worlds there is no sun and moon, in others they are larger than in our world, and in others more numerous... There are some worlds devoid of living creatures or plants or any moisture (Hippolytus, Refutation of all Heresies I, 12).

In relation to such non-teleological accounts, Plato says:

> Each being moved by chance, according to the power each has, they somehow fell together in a fitting and harmonious manner, hot with cold or dry with moist or hard with soft, all of the forced blendings happening by the mixing of opposites according to chance. In this way and by these means the heavens and all that pertains to them have come into being and all of the animals and plants, all of the seasons having been created from these things, not by intelligence, they say, nor by some god nor some skill, but as we say, through nature and chance (Laws 889b).

One important point in Plato's critique here is that the production of a kosmos requires unlike things to be blended. A like to like principle, such as that of the early atomists might explain how like things come together, but cannot explain how unlike things come together in a fitting and harmonious manner.

One perennial problem in cosmogony, in modern terms, is: can the laws of physics alone give an adequate explanation of the origins of our universe, if we suppose there to be only one universe? The ancient version of this is whether it is plausible that our kosmos could be generated solely by chance and necessity from a primordial disorganised state. The modern version of this question relates to the values of the fundamental constants. There is nothing which determines or explains these values. Yet in order that the universe can produce the conditions for life, they have to fall within very stringent limits.[11]

There are two typical options here, the canonical forms being originated by

[10] Democritus Fr. 164.

[11] The usual figure quoted here is accuracy to 1 in 1050.

Plato on the one hand and the early atomists on the other. One can suppose there to be some sort of organising principle which brings the kosmos together. Plato had his craftsman god generating the kosmos out of a chaos, and doing so in the best manner possible. The Milesians tended to have some form of steering or organisational principle inherent in nature, the most conspicuous example here being Anaximander.[12]

The other possibility was to suppose that there was not one kosmos, but many kosmoi. If there are many of these, or indeed an unlimited number, and they are different from each other, then the chances of a kosmos like ours forming solely by chance and necessity are considerably enhanced. The clearest statement of principle along these lines is by Lucretius:

> So many primordial particles, in a multitude of ways have been propelled by their own weight and impacts for an infinite amount of time, and have made trial of all things their union could produce, it is hardly surprising if they have come into arrangements and patterns of motion like those repeated by this world (De Rerum Natura, 5, 186–194).

All of these ancient ideas find modern correlates. There are those who suppose that the values of the fundamental constants are set, either by something inherent in the universe or by some benevolent power extrinsic to the universe. There are modern theories both of an infinite number of co-existent universes, with different values for the fundamental constants and of a single universe which expands, collapses and randomly resets the fundamental constants and then expands and collapses again.

One aspect brought out by a comparison between Plato and the ancient atomists is that their principles of explanation guide their views on the origins of many aspects of the world. So with Plato, we find that he rejects the multiplicity of shapes and sizes of atoms postulated by Leucippus and Democritus, and supposes there to be two basic triangles from which he then constructs his geometrical atomism. These two triangles are of course the best available.[13] Plato rejects a multiplicity of accidental kosmoi in favour of one well designed kosmos.[14] Plato also rejects zoogony by a multiplicity of accidents leading to viable species (as with Empedocles) in favour of intelligently designed species.[15] We know little of the zoogony of Leucippus and Democritus, but later atomists such as Leucretius accepted Empedoclean ideas on species forming by chance after a multiplicity of accidents. Aristotle is consistent in rejecting cosmogony, zoogony and the formation of the elements in favour of a world that has always been as it is now.

One of the significant cosmological debates of the twentieth century was be-

[12] Aristotle, Physics III/4, 203b7ff., arguably Anaximander as well, Aetius 1, 3, 4.

[13] Plato, Timaeus 53d.

[14] Plato, Timaeus 30c.

[15] Plato, Timaeus 41b ff.

tween steady state (SS) cosmology and big bang (BB) cosmology. BB cosmology, as is well known, argues that there is a determinate beginning to the universe and that it evolves over time. SS cosmology argued that there was no beginning to the universe, and that matter was continually being created. The universe was expanding in both theories, becoming less dense in BB but retaining a constant density due to continual matter production in SS. SS was considered observationally and theoretically superior to BB, until the results of several crucial experiments went the way of BB cosmology. One of the issues at stake here was whether the generation of matter is a one off event, or is occurring all the time. A related question was whether the physics that apply to cosmogony apply all the time, or only while cosmogony is occurring.

The ancient debate of course was not conducted at anything like the same level of physical sophistication, but there was an ancient debate about these issues. The Milesians are rightly praised for making cosmogony a natural process, free from the arbitrary intervention of the gods. In doing so, they made the processes which generate the kosmos as part of the physics of the world about us. So separation from the apeiron goes on for Anaximander, while condensation and rarefaction from air goes on for Anaximenes.[16] One criticism that might be levelled at the Milesians though is that once the kosmos has been formed, the processes that generate it must alter, otherwise the kosmos would lack stability and the apeiron/air would all eventually be converted into the elements. The problem then is that the change in the processes looks arbitrary, and unduly cosmocentric for a physical process, if it changes once the kosmos is fully formed. Empedocles is then interesting in relation to the Milesians in that his principles of love and strife associate the elements into a homogeneous one and dissociate them into a plurality respectively. So on the usual interpretation of Empedocles, love generates a kosmos out of the dissociated elements and then destroys that kosmos by creating the one, while strife generates a kosmos out of the complete association of the elements and then destroys it by generating a total dissociation of the elements. For the first time the kosmos is a by product of physical processes, which do not alter either in nature or intensity once a kosmos has been formed.

With the early atomists the processes which generate kosmoi are ongoing. There is no end to instances of "separation from the unlimited" which form the vortices which bring kosmoi together. The physical processes seem indifferent to the fate of kosmoi. Hippolytus tells us that:

> Some are growing, some are in their prime, some declining, some are coming to be and others failing. They are destroyed by falling into each other (Refutation of all Heresies I, 12).

There is nothing in the early atomists to suggest that there is any change in any

[16] I assume here that neither Anaximander nor Anaximenes believed in multiple co-existent worlds.

physical process when a kosmos comes into existence, and certainly cosmogony is not a singular occurrence. There is no question of matter production for the ancient atomists as the atoms are eternal

There is a related issue here, which is was also a matter of contention between SS and BB in the twentieth century. The SS theorists formulated what they called the perfect cosmological principle, which extended the cosmological principle from space to time as well. So for SS cosmology, not only should the kosmos appear the same, on a large scale, from any point of observation (the cosmological principle), it should also appear the same from any point in time (the perfect cosmological principle). If it is correct that the early atomists were the first to hypothesise an unlimited number of co-existent kosmoi, then they would be the first to accord to the cosmological principle. There are no preferred points of observation in the atomist kosmos. Even where the kosmos might have been thought to be unlimited, as in Anaximander, his account of the stability of the earth still has it in the centre.[17] The kosmos of Heraclitus is the same through time, as he says that:

> This kosmos, the same for all, was not made by Gods or men, but has always existed and will always exist. It is an everliving fire, kindling in measures and going out in measures (Fr. 30).

The early atomists though are the first to allow for cosmogony and for the universe to be the same on a large scale through time. This is not so for Empedocles, whose one kosmos undergoes significant changes through time. For the atomists, there are always kosmoi coming into being, and others passing away. They specify no beginning to this process and no end. That there are no preferred places or times of observation for the early atomists is fitting, and might be seen as another application of the *ou mallon* principle.

Leucippus and Democritus then did not merely set up a philosophy which had implications for their view on cosmogony. They actively engaged with serious perennial problems in cosmogony. They engaged not only with Eleatic issues, but also with the Milesians, Heraclitus and Empedocles on issues of whether cosmogony is a singular event, whether the processes that cause a kosmos to form continue unaltered once that kosmos has formed, and whether the large scale structure of the universe alters over time. On these perennial issues they choose a coherent set of possible solutions in line with their basic philosophical positions.

This methodology of examining how perennial problems and solutions in cosmogony were perceived has a broader application to Greek thought on cosmogony from Thales onwards. There are more problems in cosmogony that are relevant to other ancient thinkers, though that of course is a subject for a much broader study than I can attempt here. What I hope to have shown here, using Leucippus and Democritus, is that such a methodology can produce some interesting insights.

[17] Aristotle De Caelo II/13 295b10 ff.

This methodology also has a more specific implication for the study of Parmenides' immediate successors. The early atomists clearly addressed more problems than those set by Parmenides, and that is significant for examining the views of thinkers such as Empedocles and Anaxagoras, who like the early atomists are too often seen as reacting to Parmenides alone. It is also important that the Greeks formulate and discuss many of the issues which are central to cosmogony for the first time. This is not true of any other ancient culture, where we find creation myths and theogonies, but no philosophical or scientific cosmogony. That is a significant component of the case for the Greeks achieving something radically different from their contemporaries.[18]

Bibliography

Aristotle.
Physics. W. D. Ross, Oxford U.P., 1936.
De Caelo. D. J. Allan, Oxford U.P., 1936.
Bailey, 1928
C. Bailey, The Greek Atomists and Epicurus, Russell and Russell, New York.
Diogenes Laertius. Lives. R. D. Hicks, Loeb (Harvard U.P.), 1925.
Epicurus. The Extant Remains. C. E. Bailey, Oxford U.P., 1926.
Furley, 1967
D. J. Furley, Two studies in the Greek Atomists, Princeton U.P.
Cosmic Problems, Cambridge U.P., 1989.
The Greek Cosmologists, Cambridge U.P., 1987.
Gregory, 2000
A. D. Gregory, Plato's Philosophy of Science. Duckworth, London.
Guthrie, 1965
W. K. C. Guthrie, A History of Greek Philosophy, vol. II. Cambridge U.P.
Kirk, Raven and Schofield, 1983
G. S. Kirk, J. E. Raven and M. Schofield, The Presocratic Philosophers, 2nd ed., Cambridge U.P.
Lucretius, De Rerum Natura. W. H. D. Rouse, Loeb (Harvard U.P.), 1975.
Naddaf, 2005

[18] See here my "Ancient Greece and the Origins of Science" in this volume.

G. Naddaf, The Greek Concept of Nature, New York U.P.

Plato. Timaeus, Laws. Opera, 4 vols, J. Burnet, Oxford U.P., 1900–1907.

Simplicius. Simplicii in Aristotelis Physicorum libros quattuor posteriores commentaria. H. Diels, Reimeri Berlin, 1895.

Taylor, 1999

C. C. W. Taylor, The Atomists, Leucippus and Democritus, Phoenix Supplement 36.