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DAVID PRESTON

Royal Holloway, University of London

Empedocles' Big Break: Pre-Socratic Cosmology and The Big Bounce

This paper endeavours to demonstrate that certain strands of ancient and modern cosmological thought are not as dissimilar as one might initially believe. In doing so, it will examine two accounts of the fundamental nature and origin of the universe – one put forward in the 5th century BCE by the Pre-Socratic Empedocles, and one favoured by a faction of 21st Century CE physical cosmologists. After said parallels are highlighted, there will be some speculation on how Empedocles may have arrived at such conclusions two and a half millennia ago, followed by a defence of him being classified only as an ancient poet.[1]

Keywords: Empedocles, Pre-Socratic cosmology, Big Bounce, Ancient Science

Hands up – who's heard of Empedocles? If the answer is 'not me' then the chances are you've spent your life doing something more productive than scrawling through dusty pages of Diels-Kranz's *Die Fragmente der Vorsokratiker*. If the answer is 'somewhat', you might be a recovering philosopher (or classicist) with a vague memory of a tale about a madman jumping into a volcano interrupting your slumbers as you dosed through a first-year Ancient Philosophy lecture. If your answer is 'but of course, who hasn't?', then – like me – you probably need to get out a little more. Indeed, people like 'us' – by which I mean those who spend their lives studying Pre-Socratic Philosophy – spend much of our time espousing its virtues, relevance, and practicality in relation to 21st centu-

[1] I wish to express my gratitude to Dr Gergő Gellérfi and Dr János Nagyillés (University of Szeged) for their feedback when this paper was presented as a keynote at the *Sapiens Ubique Civis* conference in August 2019. I would also like to thank Dr. Mia Hughes (Imperial College London) for her patience and lucid responses to my countless annoying questions on physical cosmology.

ry thinking, but this often falls on deaf ears—even within academic discussions. Aside from the occasional nod given in the general direction of Plato and Aristotle (and, increasingly, the Stoics), Ancient Philosophy largely continues to be viewed as something perhaps necessary to study as a starting point on a 'History of Ideas' module, but its perceived usefulness and practicality ends around there. Thales, for example, holds the distinction of being classified as the first 'philosopher' due to him challenging the traditional theological narrative with his claim that everything came not from the gods, but from water.[2] Owing to him positing a natural source as the origin of all things, Thales might be seen more as a proto-scientist than a philosopher, something which leads him to be treated as too much of a scientist for the philosophers, but too much of a philosopher for the scientists. This is a sentiment echoed recently by Steven Weinberg, Nobel laureate in Physics, who claims that "the early Greeks had very little in common with today's physicists. Their theories had no bite. Empedocles could speculate about the elements, and Democritus about atoms, but their speculations led to no new information about nature—and certainly to nothing that would allow their theories to be tested. It is better to think of them not as physicists or scientists or even philosophers, but as poets".[3]

It isn't difficult to understand why opinions like those of Weinberg's arise; Pre-Socratic philosophy can be abstract at best and downright bonkers at worst, yet they were grappling with the same problems many philosophers and scientists are today, these being the fundamental nature and origin both of our universe and existence itself. The accessibility of their ideas, however, are often hampered by the dense poetic style they are delivered through, and this might unwittingly cause one to classify them simply as folk or pagan beliefs held by an ancient people which should be handled accordingly – similar to how one might approach Homer's myths of creation or Hesiod's *Theogony*. While such texts might have *historical* value, some mistake their value to be limited purely to this – insights to be gained into the mindset of a people of the

[2] WEINBERG (2015: 15).

[3] Arist. *Metaph.* 1, 983b.

past, but which can have no bearing on or relevance to practical conjectures in philosophy or science.

The following paper, then, will undertake to demonstrate that certain strands of ancient and modern cosmological thought are, in fact, not as dissimilar as might initially be thought. To do this, it will examine two accounts of the fundamental nature and origin of the universe – one put forward in the 5th century BCE by the Pre-Socratic Empedocles, and one favoured by a faction of 21st Century C.E physical cosmologists, this being the 'Big Bounce' model. Here, I must stress that I do not mean to endorse Big Bounce (or for that matter Empedocles) as the most credible of the numerous competing theories currently in dialogue among members of the scientific community; this is something which is rightfully left to our more learned colleagues in physics departments. My aim is more sedate; namely, to highlight some curious parallels between the two theories, offer some light conjecture on how Empedocles may have arrived at such conclusions two and a half millennia ago, and defend him from being classified only as a poet.

What is Big Bounce Theory?

Big Bounce Theory came to prominence in scientific literature in the late 1980s, with the term first coined by Priester and Blome in 1987.[4] In the simplest of terms, it provides a solution to the perennial question asked of Big Bang Cosmology, this being 'What happened before the Big Bang?', by proposing that the cosmos came from the collapse of a previous universe. Big Bounce theorists propose that prior to the Big Bang, there was a contracting universe with space-time geometry that otherwise is similar to that of our current expanding universe.[5] As gravitational forces pulled this previous universe inward, it reached a point at which the quantum properties of space-time caused gravity to become repulsive, rather than attractive. "Using quantum modifications of Einstein's cosmological equations, we have shown that in place of a classical Big Bang there is in fact a quantum Bounce," says Abhay Ashtekar, Eberly Professor of Physics at Pennsylvania State University. "We were

[4] BLOME–PRIESTER (1987: 83–89).

[5] ASHTEKAR–PAWLOWSKI–SINGH (2006).

so surprised by the finding that there is another classical, pre-Big Bang universe that we repeated the simulations with different parameter values over several months, but we found that the Big Bounce scenario is robust."[6]

To simplify, according to general relativity the universe was once condensed into a single point (singularity) which was infinitely dense. The expansion of matter from this singularity is what we know as The Big Bang. What causes the matter to 'blow out' is still a matter of conjecture – cause and effect gets murky when dealing with the first moment of time; all that can be determined and needed to be understood for the sake of this paper is that it simply started flying apart. It can also be determined that the reason everything doesn't get 'sucked' back in to the singularity's gravitational pull is due to dark energy, an unexplained force counteracting gravity, which is responsible for accelerating the expansion of the universe.[7]

This helps us understand the universe in its present state – an ever-expanding mass of matter resulting from an infinitely dense singularity. What happens after this continues to be speculated on by theoretical physicists. One such possibility is a 'Big Freeze', which holds that the expansion of the universe will continue forever. The universe will cool as it expands, eventually becoming too cold to sustain life/energy. An alternative proposed by Roger Penrose is conformal cyclic cosmology which suggests that, owing to the expansion of the universe, particles will be separated so far from each other that they will no longer have mass.[8] If there is no mass in the universe, then there can be no time. If there is no time, then there can be no distance. If there is no distance or time, we cannot tell the difference between something infinitely large or infinitely small and so scale is lost – in both the linear and physical sense. In a universe with no scale, there can be no distinction between a

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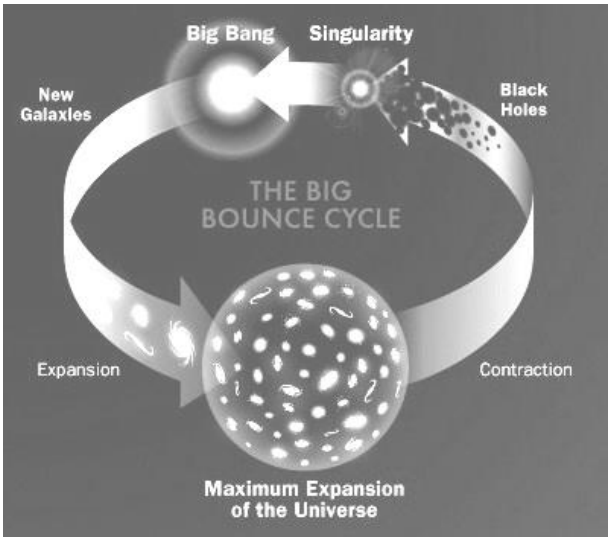
[6] ASHTEKAR–PAWLOWSKI–SINGH (2006).

[7] Though dark energy is responsible for the current acceleration of the universe's expansion, it might not necessarily be responsible for its initial expansion. In the summer of 2020, however, a field which is responsible for both the initial expansion and current expansion was hypothesised in two articles. What we call dark energy would be a manifestation of this field. Cf. ILJIAS et al. (2020) and COOK et al. (2020).

[8] PENROSE (2006: 2759–2762).

huge universe and a tiny one, and so another Big Bang occurs. For my purpose, I wish to draw attention to Big Crunch Theory, which holds that dark energy will decrease over time, leading to the expansion of the universe eventually decelerating. Gravity gains the upper hand in the tug-of-war between the two, and its increasing influence causes the universe to collapse back in on itself. This brings us to the 'Big Bounce' and the view that our current universe was formed from an older collapsing universe, as demonstrated by the graphic below:



The Big Bounce model, then, entails a 'traditional' Big Bang from a singularity, with the expansion (driven by dark energy) forming galaxies. As the expansion continues to a maximum point, the force of dark energy begins to wane, allowing gravity to re-exert its pull causing the universe to contract and collapse back into a singularity, which will eventually result in another Big Bang, before another Big Crunch, and then another Big Bang etc. This cycle is infinite and in turn allows for infinite previous incarnations of our universe. Once again, it should be reiterated here that this paper does not aim to promote the virtues of Big Bounce over competing theories, nor is its author's opinion on the matter in any way relevant. Nor is it needed to dwell further on the intricacies or complexities of the theory—all that is needed here is for the reader to now have a general sketch of Big Bounce Theory to compare against Empedocles' system. With this in mind, I turn to Empedocles.

Empedocles of Acragas (c490 BCE-c440 BCE)[9]

Like the other Pre-Socratics, determining anything we can be certain about Empedocles' life is tricky business, since most of what we know of his life is written by later doxographers and is embellished accordingly. We are however, blessed to have more in Empedocles' own hand than we do any other Pre-Socratic. The ancient doxographers credited a variety of works to him, but his extant fragments can all be ascribed to two poems: *Purifications* and *On Nature* – the former dealing with religious speculations and the latter physical.[10] From these fragments we can determine he was a native of Acragas,[11] beloved to Pausanias,[12] and viewed himself as intellectually superior and godlike to his fellow Sicilians, who he felt spent much of their life in a dream-like state rather than focussed on truth.[13] At times, he seems more shaman than philosopher, with tales of him bringing people back from the dead and wearing gold diadems and bronze sandals abound.[14] Perhaps most memorable, however, are the stories surrounding his death. While the finer details differ in the varying accounts, the common narrative involves him leaping into Mt. Etna to demonstrate his divinity.[15]

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[9] All fragments cited follow the DIELS-KRANZ. All are cited in English using MCKIRAHAN and CURD's 2011 translation..

[10] The tradition that these are in fact two separate poems rather than part of one whole longer piece has been repeatedly challenged in recent centuries. Since this is only tangentially relevant to the discussion at hand, I choose to omit any discussion on it here. Instead, I direct the curious reader to Catherine OSBOURNE's (1987: 27–50) thorough analysis of the problem.

[11] DK 31B112.

[12] DK 31B1; *cf.* B5.

[13] Cf. DK 31B113, B2, B112.

[14] DK 31A1.

[15] *Ibid.;* Heraclides claims Empedocles simply disappeared during the night after a divine voice accompanied by a bright light was heard calling him from the sky. Hippobotus claims that after bringing a woman back from the dead, he went to Mt. Etna and jumped in to confirm what people were saying about him – that he was a god. Lucian's account in the *Icaromenippus* has a more satirical twist; rather than being consumed by the flames, Empedocles was carried to the moon by an eruption where he apparently lives to this day.

Parmenides v. Empedocles

Absurd tales aside, Empedocles' position in the Western philosophical canon is justified by him being the first to posit on idea of an *element* in his response to Parmenides of Elea's monism. Parmenides had argued that the first principle underpinning existence (i.e. what exists or 'what-is') is a single, unified, unchanging, unmoving, eternal whole.[16] It must be single, as for it to be otherwise there must be a point where it is punctuated by 'what-is-not' or non-existence. Non-existence, however, cannot exist, thus rendering such an idea absurd. Nor can it change, as to do so would involve it changing into something it currently is not, but since 'what-is' encompasses all that exists, it can not change into something it is not, as this would require it to change into 'what-is-not', but since 'what-is-not' can not exist, 'what-is' cannot change into it, as something cannot change into something non-existent, only into something that exists or 'is'. It is the same logic that renders 'what-is' unmoving, as to move would require it to move into something 'what-is-not', yet one can't move to a non-existing location, nor can be there space where nothing (including space itself) exists. Finally, its eternality is necessitated by the thought that for 'what-is' to come into being, it would necessarily have to come from 'what-is-not'. Existence arising from sheer non-existence, however, is also absurd; as Lear reminds Cordelia: "Nothing can come of nothing"[17]. Since it can not have been generated, nor can it die – only things which come into existence can cease to be; for something to end it must first begin. While logical, such a system makes a mess of our everyday worldview; subscribing to a system which questions the reality of anything involving plurality, change, time, etc. seems a little too counter-intuitive to be feasible.

The Roots

While Empedocles agreed with Parmenides on the eternality of 'what-is' and the impossibility of 'what-is' arising from 'what-is-not',[18] he took issue with the monistic nature ascribed to it by Parmenides. Rather than

[16] Cf. DK 28B8.

[17] *King Lear* I, i, 92.

[18] Cf. DK 31B8, B12, B13, B7.

it being a single substance, Empedocles argued that existence could be reduced to four core elements or 'roots':[19]

- Earth (also referred to as Hera).
- Water (also referred to Sea/Rain/Nestis).
- Air (also referred to as Zeus/Aither).
- Fire (also referred to as Sun/Hades/Aidoneus/Hephaestus).

Everything in existence for Empedocles consists of a particular compound of these elements. This allows for change, as an entity is created when some or all of the elements mix together and is destroyed when the mixture is dissolved, with the elements then rearranged into different new compounds.[20] The roots, however, are eternal, and cannot be further reduced beyond themselves or destroyed.[21] All are equally important and, like Parmenides' One, never came into being nor will cease to be. Empedocles describes the creation of the Earth to exemplify his cosmogony:

> "Earth came together by chance in about equal quantity to these, Hephaestus and rain and all-shining Aithēr, anchored in the perfect harbors of Cypris, either a bit more or a bit less of it among more of them. From them blood came into being and other forms of flesh."[22]

Similarly, bone is two parts water and four fire mixed inside the earth:

> "Pleasant earth in her well-made crucibles obtained two parts of bright Nestis out of the eight, and four of Hephaestus, and white bones came into being"[23]

When a human 'dies', then, their physical being is not obliterated, merely the elements forming its compound dissolve and move on to a different place in the cosmos.[24] Empedocles gives allegorical titles to the roots

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[19] DK 31A33, B6.
[20] DK 31B21: 315–21.
[21] DK 31B17: 261
[22] DK31B98.
[23] DK 31B96.
[24] DK 31B17: 231.

(e.g. Nestis, Hera, Aidoneus), and while this hints at their vitality, it may even suggest their ability to create consciousness.[25] While the elements are responsible for forming compounds, Empedocles also posits two opposing forces in an eternal tug-of-war as the energy which causes the roots to move about in the first place. These are 'Love' (also referred to as Aphrodite, Cypris, or Harmony) and 'Strife' (also referred to as Anger, Wrath, or Discord), the former named so for its unifying nature, the latter for its destructive. Under the influence of Love, the roots are 'glued' and 'fitted' together, while under Strife they are torn apart.[26] To equate this to something more relatable, here we might think about the roles of gravity and dark energy in modern physical cosmology. Despite his allegory of Love and Strife as two painters being able to paint anything imaginable with only four pigments suggesting otherwise,[27] it should be noted that this merely serves to aid the digestion of his theory to his contemporary audience; Love and Strife are mechanical forces, rather than sentient beings in conscious battle with each other.[28]

Empedocles' Cosmology:

> "I will tell a double story. For at one time they grew to be only one out of many, but at another they grew apart to be many out of one."[29]

For present purposes, Empedocles' cosmology is best mapped out in stages which follow a Big-Bounce-like model.

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[25] DK 31A33, B6.

[26] DK 31B96.

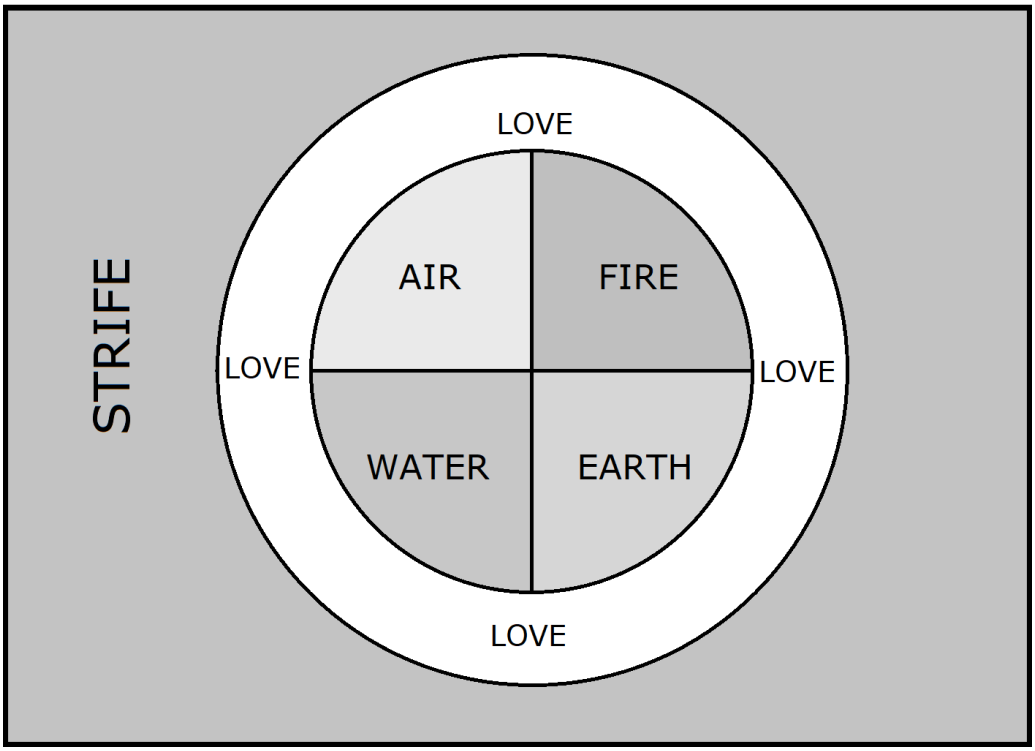
[27] DK 32B23.

[28] Empedocles is rather ambiguous on the existence of metaphysical deities. At times, he follows Parmenides (DK 28B1) and the epic poets by claiming his message is not his own, but one which is being channelled through him by a god (B23). Elsewhere in B23, he claims that "trees and men and women, and beasts and birds and fishes nurtured in water, and long-lived gods highest in honors" are formed from the roots mixing, which would imply that there is nothing beyond his universe. In a fragment discussing the transmigration of the soul (DK 31B115), however, he implies that the punishment for murder – wandering the earth for thousands of years in thousands of different incarnations – is "an ancient decree of the gods". Whether one can be redeemed and achieve communion with these gods, however, remains unclear.

[29] DK 31B17: 248–249.

Stage One – Love in domination (life not possible).[30]

"But I shall return to that path of songs that I recounted before, drawing off this account from another one. When Strife had reached the furthest depth of the vortex, and Love comes to be in the middle of the *kosmos*, at this point all these things come together to be one single thing, not at once, but willingly combining, different ones from different places."[31]



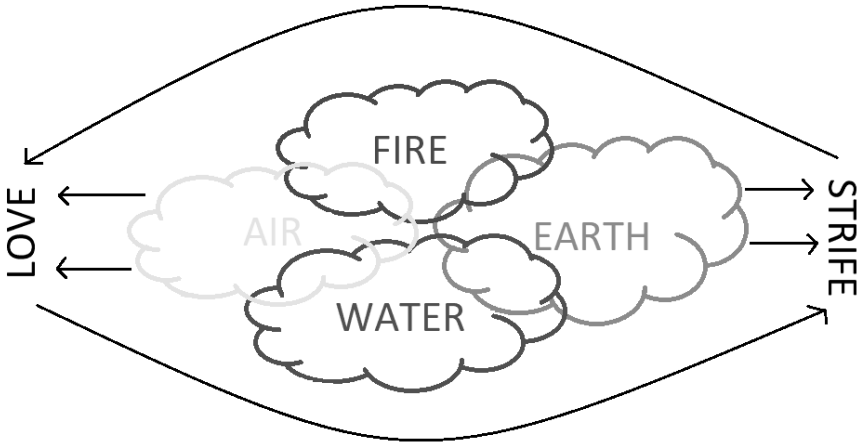
Here we have the stage where Love is in complete domination. The roots are enclosed and unified under its complete influence. Strife is pushed to the extremities. Since there is no tension between the two forces, the elements cannot mix to form compounds. Thus, a cosmogony is not possible. In terms of Big Bounce theory, this would be the singularity of the Big Bang. Eventually, Strife begins to regain some control

[30] As the cycle is infinite, there is obviously no 'beginning', 'first stage', or point in the cycle which supersedes the others in importance. In terms of Empedocles, my choosing to start here is trivial, and I only do so for ease of comprehension.
[31] DK 31B35.

and exert its force on the elements, loosening the hold and causing the elements to seep out.

Stage Two – Contention between Love and Strife (Life Possible)

> "As when painters decorate votive offerings— men through cunning well taught in their skill— who when they take the many-colored pigments in their hands, mixing in harmony more of these and less of those, out of them they produce shapes similar to all things, creating trees and men and women and beasts and birds and fishes nurtured in water and long-lived gods highest in honors. So let not deception compel your mind (phrēn) to believe that there is from anywhere else a source of mortal things, all the endless numbers of things that have come to be manifest, but know these things distinctly, having heard the story from a god."

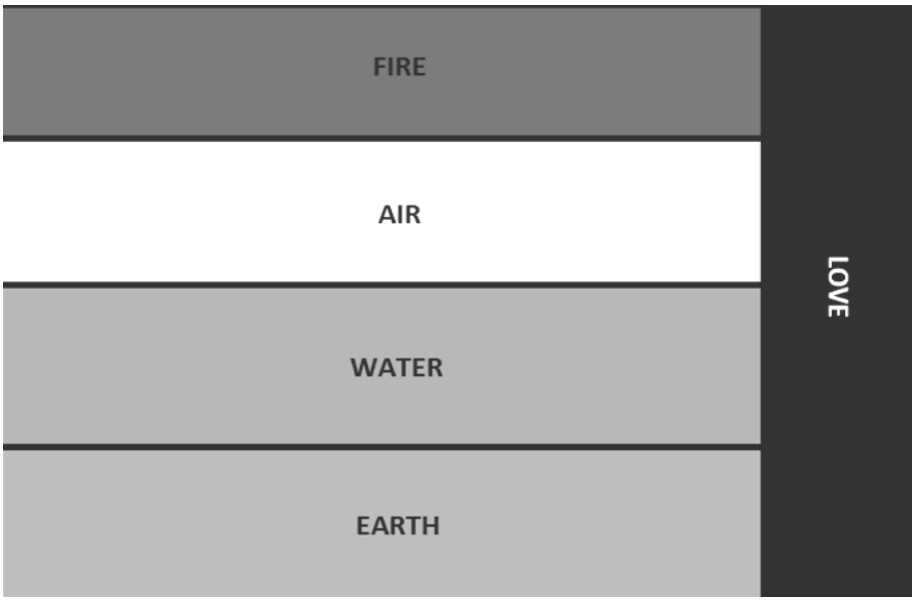


Here we have the following stage. The influences of Love and Strife on the elements are in full contention. This tension between the two – Love pulling one way and Strife the other – allows the roots to mix with each other to form "all things",[32] from celestial bodies to life. Empedocles' system suggests that we are currently in this stage of the cosmological process.

[32] DK 13B23.

Stage Three – Strife in Domination (Life not possible)

"Under Strife they are all apart and have separate forms."[33]

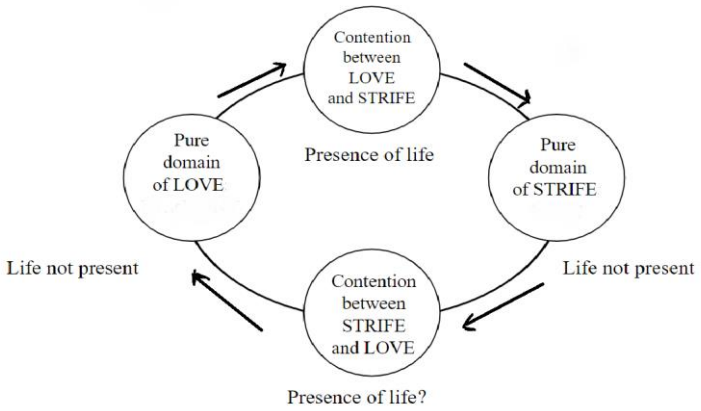


At this stage of the cycle, Strife is in complete domination. Love this time is banished to the extremities. The elements have completely separated from each other, and, being unable to mix, life is not possible. In terms of Big Bounce, this would be equivalent to maximum expansion.

Stage Four - Love begins to exert influence resulting in another contention:

> "And these never cease continually interchanging, at one time all coming together into one by Love and at another each being borne apart by the hatred of Strife. Thus in that they have learned to grow to be one out of many and in that they again spring apart as many when the one grows apart, in that way they come to be, and their life is not lasting, but in that they never cease interchanging continually, in this way they are always unchanging in a cycle."[34]

[33] DK 31B20: 314.
[34] DK 31 B17: 232-236; cf. B36.



After Love has brought the elements back into contention, the former process happens in reverse, similar to a Big Crunch, before reverting back to Stage One and repeating the cycle *ad infinitum*. Whether or not life is present or possible during Stage Four is contested and will be discussed shortly, but for the moment it should be noted that Empedocles believes we are in Stage Two. In short, he views the constant clamour among humans combined with their obsession with eating meat as a sign that Strife is gaining control (though whether meat eating and warring are a symptom or cause of this remains unclear).[35] For Empedocles, then, the history of the universe consists only a quarter of the cycle in the above graphic – from the domain of Love on the left to the contention in the top centre. A full cycle represents the birth and death of the universe. If 'Love' is swapped out for 'Gravity' and 'Strife' for 'Dark Energy',[36] Empedocles' system maps on to the structure of Big Bounce Theory with surprising ease. Both follow a pattern of expansion and collapse facilitated by opposing forces. Both require a contention between the two to necessitate life, with life being absent when there is a gross imbalance of influence. Both posit that we are roughly a quarterway through the cycle, and both allow for the cycle to be infinite.

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[35] Cf. DK 31B121, B124, B136.

[36] Or, more precisely, the hypothetical field that could be responsible for dark energy, which drives the expansion phases of the Big Bounce model. Cf. fn. 7 above.

Cosmogony – Double or Single?

Empedocles hints at the possibility of a cosmogony occurring during Stage Four when he tells us that "double is the generation of mortal things, and double their decline. For the coming together of all things gives birth to one [namely, generation and decline] and destroys it, and the other is nurtured and flies away when they grow apart again."[37] To even begin to fathom, however, how such a 'reverse-cosmogony' could unfold seems absurd, and ultimately leads to bar-stool speculation on Benjamin Button-like scenarios. The problem arises from our attempting to grapple with the 2nd Law of Thermodynamics, which holds that the total entropy (measured disorder) of an isolated system can only increase or stay the same over time. This is the only law in physics that is not reversible and that distinguishes past from future – if you watch a video of cup smashing, you'll know from the increase or decrease in entropy if the video is playing in reverse or not as opposed to, say, a video of a pendulum (in which entropy would stay the same). This also fits well with Big Bang cosmology – we can see entropy increase as the universe expands. It is when we flip this model and look at a Big Crunch scenario that we begin to see some problems, as speculating on any form of order arising in such a scenario would violate the 2nd Law. Stephen Hawking, however, proposed that in the Big Crunch the 2nd Law would reverse, with entropy decreasing and negentropy increasing.[38] This increase in order makes the possibility of a cosmogony during the process less incredible and may lend at least some credence towards Empedocles' hinting of one during the 'crunch' stage of his cycle.

Concluding thoughts

Classifying the Pre-Socratics as nothing more than poets, Weinberg chastises them for their lack of faith in empirical evidence, claiming that 'today we test our speculations about nature by using proposed theories to draw more or less precise conclusions that can be tested by observation. This did not occur to the early Greeks, or to many of their successors, for a very simple reason: they had never seen it done…their speculations led to no new information about nature — and certainly to nothing that would allow

[37] DK 31B17: 232-23.

[38] HAWKING (1988: 15).

their theories to be tested'.[39] Indeed, both Parmenides and Empedocles do warn us to be judicious of our senses, with Empedocles claiming he arrived at his conclusions via *a priori* reasoning alone.[40] This is a claim, however, I find a little dubious; Empedocles certainly needs and uses empirical evidence to justify his arguments. His claim, for example, that we are venturing into the domain of Strife is based on him comparing what he believed to be the previous 'Golden Age' of the Greek World with the clamour and discord of the age in which he was writing. He saw this increase in entropic events as evidence that Love was losing its power to Strife, something he claims is evident from empirical observation (increase in war, etc.). The growing prevalence of meat-eating is used as further evidence; in the 'Golden Age' (so Empedocles thought) people were satisfied with a simple plant-based diet,[41] whereas in the 5th Century BCE "A father lift[ed] up his own dear son who [had] changed form, and, praying, slaughter[ed] him, committing a great folly.... But he, refusing to hear the cries, slaughter[ed] him and attend[ed] an evil feast in his halls. Likewise a son seizes his father and children their mother, and tearing out their life, devour the dear flesh."[42] Empedocles here supports metempsychosis – a belief common in Pythagorean and Orphic circles at the time – and the idea that one should refrain from eating animals and certain vegetables[43] as they might contain the souls of previously departed humans. While certainly not verifiable through empirical testing, such a theory requires more than a priori reasoning alone (observing different animals and vegetables, etc). His theory of the cosmos being created from the mixing and dissolving of the eternal roots must also have been based on his observations of the world. Consider the death of a person; rather than ceasing to be entirely, the matter of which they are composed dissolves and finds a different place in the world; they are buried in the ground and eventually become food for the worms and nutrients for the soil. The worm becomes food for the bird, the bird becomes food for the fox, and so forth. Empedocles is stating that

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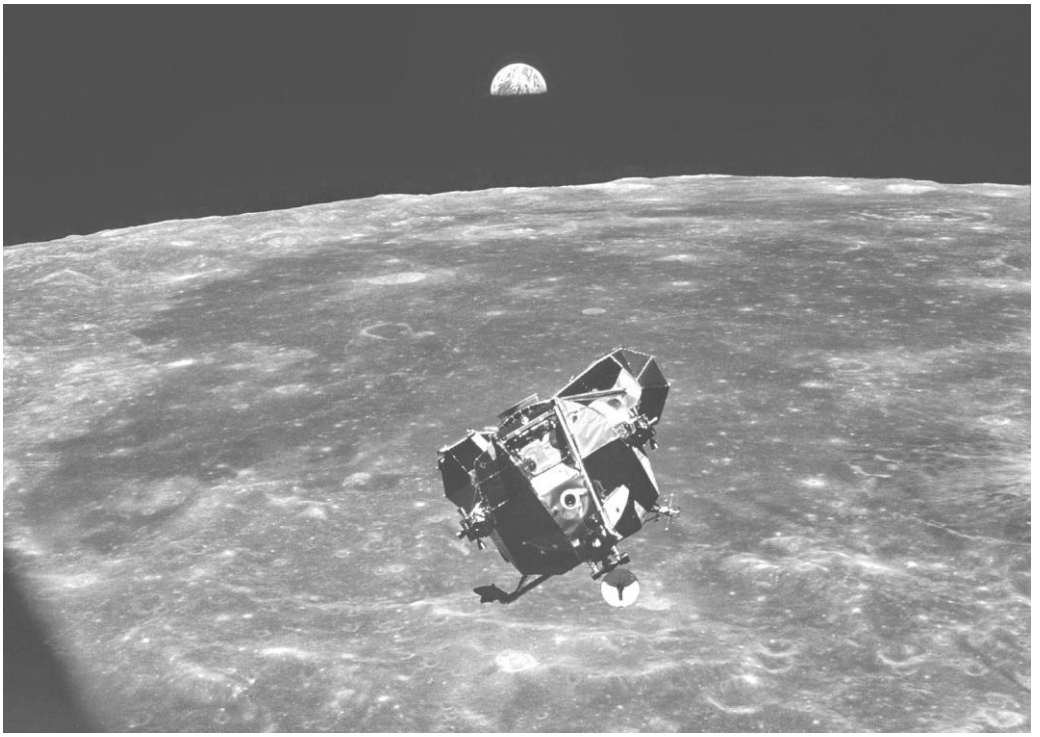
[39] WEINBERG (2015: 15).
[40] Cf. DK 28B7, 31B2, 31B3.
[41] DK 31B128, B30.
[42] DK 31B137.
[43] DK 31B141.

there is nothing present in the universe in its present state that was not present at its beginning, nor will there be at its end which is not present now. One here might be reminded of the below picture taken by Michael Collins of Buzz Aldrin and Neil Armstrong departing the Apollo in the Lander for the moon's surface. The picture is occasionally wheeled out by general interest science magazines/websites which like to point out that Collins is the only person who has ever existed and who ever will exist who is not in the frame of the photo.[44]



Like Empedocles' roots, matter cannot be created or destroyed, and so the materials of which every person who has ever existed (bar Collins) consisted of are still in the frame of the photo in one form or another (or, perhaps, just beyond it on the Apollo itself). Moreover, the materials which will make up every person born in the millennia to come are also in the frame, which again recalls Empedocles:

[44] Most recently in *The Vintage News:*
https://www.thevintagenews.com/2019/05/05/micheal-collins/.

> "From these all things that were and are and will be in the future have sprouted: trees and men and women, and beasts and birds and fishes nurtured in water, and long-lived gods highest in honors. For there are just these things, and running through one another they come to have different appearances, for mixture changes them."[45]

Why, then, do we find these parallels between Empedocles and modern cosmology? While the similarities are notable, is it implausible to conjecture that both are using similar methodology? For this, Empedocles' motivations must be revisited. Owing to their proximity, it isn't incredulous to suggest that Empedocles would have been familiar with Parmenidean thought (either directly or indirectly). He agrees with Parmenides on the eternality and indestructability of 'what-is'. He is unable, however, to reconcile Parmenides' monism with his everyday experience of change, plurality and motion; to accept these as anything but given seems too counter-intuitive. Thus, he must create a system which a) allows for the eternality and indestructability of its core fabric and b) allows for change, motion, etc., and c) accounts for the world as we know it. It seems the only available option to Empedocles was to scrap monism in favour of pluralism, which allows for the existence of many things, the interaction of which allows for a cosmology. Based on what he was working from, and the challenges he faced, constructing an eternal cyclical universe comprised of basic elements which account for all things and can be seen in action in our everyday world seems a logical step. The reason he settles for four specific elements is speculative, but it was certainly not arbitrary. Like his Milesian predecessors, it is likely he conducted an empirical investigation using the tools he had at his disposal, through which he concluded that everything could be reduced to one of the four roots, but that the roots could not be reduced any further than themselves. The opposing forces of Love and Strife not only explain the cause of the roots mixing, but also the passage of time.

Owing to this, it seems unfair to disqualify Empedocles as a scientist on the grounds that his theories weren't/couldn't be 'tested'. The problem lies in how we interpret 'test'. Modern physicists test their evidence

[45] DK 31B21.

with the tools they have at their disposal – these not only being a plethora of equipment, but also over a millennium of scientific research and scholarship to work with or compare against. These were tools which Empedocles obviously did not have, but to tax him on this is unfair, as he still had to test his theory against the (albeit in comparison sparse) evidence available to him. To suggest he didn't would be to suggest that he came up with such an intricate system out of the blue, which seems rather incredulous. Caution should also be shown in discounting him owing to the fact that his system can be shown to be false, as the same criticism could be applied to numerous figures in the history of modern physics, and also might imply that current methodologies in physics are unfalsifiable. Yet Empedocles remains resigned to the annals of Pre-Socratic philosophy, where, unless Lucian was correct, he seems doomed to remain.

Bibliography

ASHTEKAR–PAWLOWSKI–SINGH 2006
A. ASHTEKAR – T. PAWLOWSKI – P. SINGH: *Quantum Nature of the Big Bang.* Physics Review Letters 96 (2006). DOI: 10.1103/PhysRevLett.96.141301

BLOME–PRIESTER 1987 H.-J. BLOME – W. PRIESTER: *The problem of the primeval explosion: 'Big bang' or 'big bounce'?* Sterne und Weltraum 26 (1987) 83–89.

COOK et al. 2020 W. G. COOK – I. A. GLUSHCHENKO – A. ILJIAS – F. PRETORIUS – P. J. STEINHARDT: *Supersmoothing through Slow Contraction*. Physics Letters B. 808 (2020). DOI: 10.1016/j.physletb.2020.135690

HAWKING 1988 S. HAWKING: *A Brief History of Time: From the Big Bang Black Holes*. New York 1988.

ILJIAS et al. 2020 A. ILJIAS – W. G. COOK – F. PRETORIUS – P. J. STEINHARDT – E. Y. DAVIES: *Robustness of slow contraction to cosmic initial conditions*. Journal of Cosmology and Astroparticle Physics 8 (2020). DOI: 10.1088/1475-7516/2020/08/030

OSBOURNE 1987 C. OSBOURNE: *Empedocles Recycled.* CQ 37 (1987) 27–50.

PENROSE 2006 R. PENROSE: *Before the Big Bang: An Outrageous New Perspective and its Implications for Particle Physics*. In: Proceedings of the EPAC 2006. Edinburgh 2006, 2759–2762.

WEINBERG 2015 S. WEINBERG: *To Explain the World: The Discovery of Modern Science.* London 2015.