

Vibration as an Explanation of Contact and Compound Individuation in Epicurean Physics¹

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Abstract

This paper discusses three important problems of contact and compound individuation in Epicurean physics. Because the whole of Epicurean philosophy is founded on atoms moving and combining in the void, it is important to their framework to understand how atoms and their minima parts can be adjacent to one another and how to account for different sorts of proximity (as Aristotle distinguishes continuity and contiguity). I argue for a novel interpretation of their physics based on the vibration and harmony of atoms in void that has significant advantages over previous interpretations. From the internal movement of atoms, we can account for minimal contact, atomic contact, and compound individuation, while also lending support to the structure of a philosophy founded on atomic movement and composition in the void.²

1 Introductory Remarks

At the foundation of Epicurean philosophy is their atomist physics. From the composition and movement of atoms in void, they present a complete explanation of everything: from an account of our phenomenal experience and conceptual framework, to the development of an epistemology, a psychology, and a social theory, all terminating in the support of their ethical goals. It is no surprise that a proper account of composition and motion of atoms in void is of great significance for supporting the whole of Epicurean philosophy. Yet no interpretation has been given as to how atoms are composed by the partless minima, how atoms compose larger bodies, and how it is that some concatenations of atoms form an individual and others do not.

These three problems of contact and individuation stem from an argument in Aristotle's *Physics VI*.³ Aristotle's difficulty was in seeing how two independent bodies of minimal size, two partless entities, could touch one another adjacently. Either they would touch part-to-part, part-to-whole, or whole-to-whole. The first two possibilities—part-to-part and part-to-whole—are immediately rejected due to the supposition that neither of the entities have parts. The third possibility is rejected because, in order for two things to touch whole-to-whole, it would

¹I would like to thank Claudia Dumitru, Robbie Hirsch, Daniel Kranzelbinder, Simon Shogry, and especially Ben Morison for helpful conversation and insight on this paper.

²All citations that have a name followed by a number, a letter, and a number in parentheses follow the format presented by the editors of the following text: *The Hellenistic Philosophers, Vol 1*, trans. A. A. Long and D. N. Sedley, (Cambridge: Cambridge University Press, 1987).

³Aristotle, *Physics* in *The Complete Works of Aristotle: Volume 1: The Revised Oxford Translation*, edited by Jonathan Barnes, (Princeton: Princeton University Press, 1984), *Phys VI.1*, 231a29-231b6.

require the two entities to be coextensive and so not adjacent. So much for atomism.

We might wonder if Aristotle's problem worked against Epicurean atomism whose atoms are extended simples. Even though they are impenetrable and physically indivisible, constituting the basic matter in nature, their atoms have parts. It seems that atoms could easily be next to one another part-to-part, and the worry would dissolve. However, the constituents of atoms, the *minima*, are themselves partless physical bodies incapable of existing independently of the atoms they compose. Aristotle's argument, then, works well to pose a *problem for minimal contact*: How can a minimum be next to others as a constituent of an atom if not part-to-part, part-to-whole, or whole-to-whole? The worry extends naturally to create a *problem of atomic contact*: How could two atoms in finitely divisible space really touch if the minima on the boundaries of each must touch? And even if we had an answer to these questions, we get a *problem of compound individuation*: What is distinguishing two atoms that link-up and form an individual and two atoms merely in contact?

Epicurus has an answer to the first of these problems for minima that perhaps extends to the second for atoms: Aristotle did not give an exhaustive list of the ways two bodies could be adjacent to one another. We are told that we can see it happening with "the minimum in sensation," the smallest thing we can imagine:

(8) We view these minima in sequence, starting from the first, neither all in the same place nor touching parts with parts, but merely in their own peculiar way providing the measure of magnitudes—more for a larger magnitude, fewer for a smaller one. (Epicurus 9A(7-8))

Closing our eyes and imagining the smallest point we can think of, we can see it group together with others like it not part-to-part, part-to-whole, or whole-to-whole, but "in their own peculiar way." In some sense, it is true that we can imagine the minima grouping together in this peculiar way. Yet there is something dissatisfying about this passage: Too much of Epicurean philosophy rests on making sense of how two minima are in contact, how two atoms are in contact, and when compounds are individuated and when they are not; a peculiarity does not seem like enough to support an entire philosophical system. David Sedley says, "'In their own special way' is the most Epicurus ventures on the matter."⁴ Perhaps he is right, but I will argue otherwise.

In this paper, I will discuss another passage where the Epicureans are concerned with problems of contact, but in this passage they venture much farther than to say that the minima are in contact in their own peculiar way. In understanding better the vibration and harmony of atoms, I will develop a novel interpretation of Epicurean physics. A number of important differences between my interpretation and standard interpretations will become apparent. I introduce solidity as a new source of atomic motion, I argue that there is no transference of energy or non-directional motion among atoms, I show that in addition to directional influences there are vibrational influences among

⁴David Sedley, "Hellenistic physics and metaphysics" in *Cambridge History of Hellenistic Philosophy*, (Cambridge: CUP, 2008) 375.

atoms, I discuss in detail what the conservation principles include and don't include, and I argue that motion does much of the explanatory work in Epicurean philosophy, among other new interpretations.

The paper is broken up into two sections. First, I discuss the shortcomings to the most natural solution to the problems of contact, which states that atoms and minima are next to one another when they occupy adjacent, discrete locations. I show how this solution fails to interpretative incompatibilities with the Epicurean physical system. The Epicureans define discrete space through minimal contact. Not only would it be circular to then define contact through discrete space, but it would fail to give an explanation using atoms, the most fundamental objects in their philosophical framework.

In the second section, I present my novel solution to the problems of contact and compound individuation. Atoms are in contact when their vibrations interact with one another. Minima on the edges of atoms are in contact residually from this and minima inside the atoms are in contact when their vibrations form a perfect harmony. Finally, atoms form an individual when their vibrations harmonize. Atoms are merely in contact when their vibrations do not harmonize. The solution to atomic contact shares interesting similarities to contemporary solutions to contact that invoke fields. I hope my interpretation will not only help us understand how the Epicureans were thinking of contact, but will also help us understand other parts of their physics of motion and of compound individuation, give us a better confidence in their foundations for the whole of their philosophical program, and most of all demonstrate just how complicated, interesting, and elegant Epicurean philosophy is.

2 Part 1: Against the Natural Solution

The Epicurean physical picture is founded on the basic idea that all the world is fully explained by the qualities and behaviors of atoms and void. Atoms are fundamental, extended bodies that are physically indivisible and indestructible. They are those things that never come into or go out of existence, unlike the larger phenomenal things they compose. The partless constituents of atoms are the minima. They are physical components of the atoms that cannot exist outside of the atom they are a part of. Because of the minima, space, time, and motion are discrete. The void, an "intangible substance," is that which is empty of body or that which is occupied by body; it lacks the resistance of touch and provides both location for body to be in and space for body to move.⁵

Given that Epicurean philosophy is founded on the idea that atoms compose and move in the void and because composition requires some understanding of contact, Aristotle's worry is significant. Contact seems to require having parts and even though atoms have parts, how are their partless minima on their extremities in contact? We might think that the Epicureans can solve Aristotle's problems of contact with discrete space. Bodies can be fully separated, occupying discrete and adjacent locations. Nothing is between them. And yet, overlap isn't necessary for contact. In this section, I will discuss the pitfalls of

⁵Sextus Empiricus 5D.

this natural solution.

2.1 The shortcomings of the natural solution

The main argument of this section is that we cannot simply say that bodies are in contact when they occupy discrete, adjacent locations because the discrete grid on nature is defined by minima in contact, the disjoint sequence of partless entities. That would be circular. We would be defining minima contact in terms of the discrete space which is defined by minima contact. I will explain two further worries: (i) atoms are explanatorily prior to minima, not the other way around as the natural solution suggests, and (ii) in studying the case of traversal, we see that properties of the atom (like motion) are treated as explanatory prior to properties of space, (like discreteness).

2.1.1 Minima define discrete space

Consider the following: “We view the minima in *sequence*, starting from the first, neither all in the same place nor touching parts with parts but merely in their own peculiar way *providing the measure of magnitudes—more* for a larger magnitude, *fewer* for a smaller one.”⁶ And then just a few lines later, “We must also think of the minimum uncompounded limits as *providing* out of themselves in the first instance *the measure of length* for both greater and smaller magnitudes.”⁷ The emphasized phrases suggests that minima contact defines magnitude. A minimum is a physical unit. When minima are in sequence, or in contact, with other minima, they supply us with a notion of distance.

Some think that minima are merely conceptual, non-physical entities for the Epicureans. This is not supported by the text. Lucretius says that a minimum is “partless and of a minimal nature,” and never could be “separated by itself, since its very existence is as a part of something else: it is one part, the first, and is followed by similar parts in sequence, one after another.”⁸ The minima are partless by *nature*. *It’s very existence is as a part*. The minima are not merely conceptual. If they were then it would seem that the grid would define them as a part of an atom. Yet, the grid is *not* introduced to generate minima. Minima are physical and by their nature of being partless, define magnitudes when in sequence.

Simplicius says that the Epicureans “say that motion, magnitude and time have partless constituents,” “for if it were laid down that the object moving over the whole magnitude moves over these too, they would turn out to be divisible.”⁹ The text here seems to suggest that the traversal of the partless bodies leads to the divisibility of motion, magnitude, and time into partless units. The Epicureans do not think that space is endowed with a grid for which we can define the minima. Instead, minima are introduced as physically partless things, which then define discreteness. Space doesn’t itself come prepackaged with the grid. Recall, that the void is merely defined as intangible substance.

⁶Epicurus 9A(8), my emphasis.

⁷Epicurus 9A(10), my emphasis.

⁸Lucretius 9C(1).

⁹Simplicius 11G.

The Epicureans defined motion, magnitude, and time as discrete by referencing the partlessness of the minima in contact and by describing their motion through space.

2.1.2 Atoms are explanatorily prior to minima

If I am right that minima contact define discrete space, it would be circular then to define contact through discrete space. But is there a way to separate the problems of atomic and minima contact? Atoms are in contact by being in discrete, adjacent locations, which is defined by minima contact, and minima contact is defined by being in contact “in their own peculiar way.” Two problems: we don’t want to rest an entire philosophy on a peculiarity and minima aren’t more fundamental than atoms. Atoms are more fundamental than minima.

Why do the Epicureans claim that everything is explained by *atoms* and void instead of *minima* and void? After all, minima are the parts of atoms, composing them and providing them magnitude. Why not start with minima to get atoms and then work up from there? Just because something is physically smaller does not mean it is explanatorily prior. The Epicureans explicitly suggest that the minima— while able to do some explanatory work—have major explanatory shortcomings. The minima owe many of their properties to the atoms they compose. They cannot move except derivatively to atomic movement. They cannot exist except by being everlastingly uncompounded with other minima in the atom they are a part. They cannot traverse distances except incidentally to the traversal to the atom. While minima do immediately define the discrete and finitely divisible space of Epicurean thought, acting as a measure of things, giving us a spatial grid and a staccato time and motion, even acting primarily in the solution to Zeno’s paradox, minima cannot exist or move outside of the atoms for which they are a part. The Epicurean physical texts begin with the simple observation that there is movement in the universe. We are constantly struck by phenomenal evidence that bodies move and combine. In the Epicurean system, which is founded on the belief that everything derives from the movement and composition of basic bodies in void, the minima cannot be the basic explanatory matter because they fail to move or compose on their own.

This may suggest that we should in fact give a solution in terms of atomic contact. We cannot simply state that atoms are part-to-part because we must disambiguate the case where their extremities overlap, which is impossible in the Epicurean system given body is impenetrable, with the case of being in discrete, adjacent locations. We give our first condition on a solution: A solution should explain contact through some property of *atoms* and not the minima. Minima contact should be derivative of atomic contact.

2.1.3 The case study of traversal and why the problem of contact should be similarly solved by the *motion* of atoms

Let’s look now at the case of traversal. The Epicureans think that minima *cannot themselves* traverse a distance because they are partless and could never be in transition from one place to another. Atoms *can themselves* traverse a distance because they have parts and can be in transition from some place to another.

The minima traverse distances incidentally to the traversal and movement of the atoms.

The key feature of the explanation is the *movement* of the atom. The atom passes through a place as its various parts successively take up that place. It moves through a place to get to another. Transitioning is first and foremost about the *movement* of the atom. Minima traverse incidentally to this atomic movement. Because minima will be jumping in staccato to the next place during the traversal of the atom from one place to another, we define discrete space and know that the atom's traversal was across a discrete distance, solving Zeno's paradox. Starting with the *motion* of the atom from place to place, we define transition, which then lends to defining traversal. Only then do we get minimal traversal, and finally discrete space and a solution to Zeno's paradox. We do not reference discrete space or minima in describing the atomic traversal. We only describe the *motion* of the atom.

We might think the case of contact is analogous. Minima *may not themselves* be able to touch part-to-part in discrete space because they are partless. The atoms *can themselves* touch part-to-part because they do have parts. The minima on the edge of the atom will incidentally be in contact due to the contact of the atoms of which they are a part. However, we should note a key difference between the cases. Traversal involves a single atom whereas contact is concerned with the interaction of two atoms. What it is for two atoms to be in contact is for a part of one atom, the extremity, to be touching a part of the other. But, we have to be careful here to disambiguate between cases. What is it for the atoms to be touching part-to-part? It certainly cannot be that there is void between them, that they are overlapping, or because minima are in contact with minima. As with traversal, we couldn't explain transitioning from one place to another by saying that their parts moved to the next place or else atomic traversal would rely on minima traversal, which was assumed to fail independently of an atomic solution. Instead, it was the movement of the atom that explained how the atoms can transition and hence could traverse distances. So too with contact, we need something more to explain what it is to be part-to-part that isn't merely that minima are in contact at extremities of atoms.

3 Part Two: Vibration and Solutions to the Problems of Contact and Compound Individuation

Just as atomic movement explains the traversal of atoms, I will in this section defend a similar solution to contact that primarily concerns the movement of atoms. Atoms are in contact, and there is no void between them, when their internal vibrations interact. We define what it is for atoms to be fully separated and yet not at a distance through the interactions of the internal movements of the atoms. Minima then are in contact incidentally to the internal vibration of the atom. Finally, two atoms become an individual when their vibrations harmonize, when they are in contact in the right way.

3.1 Vibration as a solution to the problem of contact for atoms

We will first look at motion and vibration, the latter of which is primarily introduced to account for atoms being in constant motion. It will become apparent that vibration is also brought up to discuss cases of contact and, as I will argue, solves the problem of contact for atoms.

3.1.1 The Epicurean physical picture of motion and a discussion of vibration

For the Epicureans, motion occurs sometimes with a change in place and sometimes with no change in place. Atoms move between distances and they move in a single spot. The two primary causes of motion that lead to a change in place are atomic weight, manifesting as a tendency to move downward, and collision, which diverts this natural tendency. Later, the swerve was added as another cause of motion, to ensure atomic interaction. The swerve occurs when an atom pivots one minima distance without being the result of weight or collision. We can see that all three of these causes of motion lead to directional changes. After a collision, atoms are diverted from their original path. Weight primarily causes the atom to fall down. The swerve leads to a pivot. In our discussion of vibration below, it will become clear that there is a fourth primary cause of motion. This fourth cause is solidity, which manifests as a constant vibration in atoms. It does not produce a directional component to motion. Note that both weight and solidity are internal to the atom. Below, it will become clearer that there is no *external* influence on an atom's *speed*.

Vibration is a kind of atomic motion. Vibration is introduced for the primary purpose of upholding the Epicurean view that atoms are in constant motion. Consider the following:

- (1) The atoms move continuously for ever, some separating a great distance from each other, others keeping up their vibration on the spot whenever they happen to get trapped by their interlinking or imprisoned by atoms which link up.
 - (2) For the nature of the void brings this about by separating each atom off by itself, since it is unable to lend them any support;
 - (3) and their own solidity causes them as a result of their knocking together to vibrate back, to whatever distance their interlinking allows them to recoil from the knock.
 - (4) There is no beginning to this, because atoms and void are eternal.
- (Epicurus 11A(1-4))¹⁰

It seems as if there is vibration from place to place: atoms can from "their own solidity cause them as a result of their knocking together to vibrate back, to whatever distance their interlinking allows." The atom can vibrate and recoil

¹⁰From an informal discussion with Prof. Benjamin Morison, we concluded with a different translation of (2), which is a bit of a troubling line. The translation is as follows: (2) *For the nature of the void separates each atom out and prepares the way for this, since it is unable to lift, carry, or hold.* I take it that Epicurus was saying, What about the void? The only thing left is for it to offer a precondition for this (vibration) to occur. The only thing that the void could do is be an arena for the movement. It also suggests that because the atom is fully-separated, that no external influence creates this vibrational motion.

from a collision, moving with a change in place. It seems as if there is vibration that is upheld without a change in place: “keeping up their vibration on the spot whenever they happen to get trapped.” But, what does it mean for an atom to vibrate with a change in place or no change in place? Are there two notions of vibration? I will argue they are not different. Atoms always vibrate and always because of their own solidity.

Vibration is introduced for the primary purpose of accommodating the Epicurean commitment to the claim that “atoms move continuously for ever.”¹¹ The best argument is as follows: “If you think that the primary particles [atoms] can stand still, and can thus initiate motions of things from scratch, you are wandering far from true reasoning.”¹² What could cause the atom to initiate motion from scratch, to begin moving from rest? Either it is the void or an atom. If it is the former, then the void would have causal efficacy, but the void lacks resistance.¹³ Similarly, if an atom were to cause the motion from scratch, something would come from nothing, which is in contradiction with their principles on conservation. We might think that an atom could transfer energy or (non-directional) motion to another atom. However, atoms are always moving at the same speed of supreme swiftness or else slower bodies would traverse distances smaller than a minima when compared to faster bodies.¹⁴ If bodies were able to transfer energy too, then it would be unclear why they couldn’t come to rest, which is an impossibility due to something coming from nothing. So a transference of energy or motion could not help us with this problem. Atoms must be moving even if they are to get “trapped by their interlinking or imprisoned by atoms which link up.”¹⁵ Atoms always move. To deal with cases where atoms do not change place and are trapped by their interlinkings, the Epicureans claim atoms always vibrate.

This argument shows that the atom is always moving, atomic speed cannot vary, and that the cause of the vibrating motion is derived from inside the atom itself. It is in constant motion because nothing could account for starting motion from scratch without a change in the totality of things. Atoms never change speed and are of “supreme swiftness,” are all of “equal velocity,” because the Epicureans do not have conservation rules for energy or motion.¹⁶ Since neither the void nor any other atom has the ability to transfer motion, it is clear that an atom’s vibration is caused from something in the atom itself. Vibration with a change in place and vibration with no change in place are the same vibration, both equally derived from the atom. The only differences there are with respect to vibration are in how atoms interlink with other atoms. Interlinking is a type of contact an atom can have with another.

There are two notions of ‘interlinking’ atoms from the quote: There is one that allows for the atoms of a composite to be separated by void, as in “thin

¹¹Epicurus 11A(1)

¹²Lucretius 11B(1)

¹³The void cannot have causal efficacy since something would come from nothing in contradiction with the three Epicurean principles of conservation.

¹⁴Consider a race between a body moving at 3 minima per moment and another moving at 2 minima per moment.

¹⁵Epicurus 11A(1)

¹⁶Lucretius 11C(3) and Epicurus 11E(4).

air" and "the sun's brilliant light," and one that allows for atoms of a composite to be imprisoned in a *full-blooded* sense, as in those that "form the strong roots of stone, [and] the brute bulk of iron."¹⁷ Atoms must be able to be completely trapped by surrounding atoms. Because contact occurs with no void between the atoms, it would be quite mysterious if it were impossible for an atom to be in contact on all sides. But what do we make of the following quote: "the nature of the void brings this [motion] about by separating each atom off by itself, since it is unable to lend them any support." Being separated off does not mean that there is always void between the atoms. If there were, then there would be void between atoms in collision and contact, which is impossible since the void cannot have causal impact. An atom is *separated off* just in case there is some void or place an atom is colocalized with such that no other atom is colocalized with that same place at the same time. If an atom can be in contact with one atom with no void between them then surely an atom can be imprisoned on all sides.

3.1.2 Contact does not explain or cause vibration, first attempt

In the passage above, vibration is also introduced to account for being trapped by other atoms. In order to argue for this claim, let us look at the most obvious objection to it: the text seems to support the idea that vibration *comes from* contact and not that it *explains* contact or that contact *comes from* vibration. Look at the phrasing, my objector continues. Epicurus says that "*as a result of* their knocking together [the atoms are] to vibrate back" and that atoms keep "up their vibration on the spot *whenever* they happen to get trapped by their interlinking."¹⁸ The causal or explanatory direction is that vibration is *a result of* the contact and not the other way around, and all the worse for my claim.

This reading is mistaken. It misinterprets the passages they allude to and it leads to conclusions incompatible with the rest of Epicurean physics. Consider the first quoted passage above: It is not merely the knocking together that results in a vibration, but "their own solidity causes them as a result of their knocking together to vibrate back."¹⁹ We may read this to mean that it is the atom's own solidity that causes the vibration or we may read this to mean that it is *both* the atom's own solidity and its knocking with another atom that causes the vibration. In either case, there is an internal component to the vibration and it is not merely derived from contact. It seems that what is meant is that it is *only* the atom's solidity that causes the vibration, given a lot of what we have already discussed above. Vibration is caused by something internal to the atom. It couldn't be contact, the void, or an external atom since this would lead to something coming from nothing. The Epicureans both do not have a notion of transference of energy or movement nor can an atom change its motion from its "supreme swiftness."²⁰ The knocking together leads to the 'back' portion of "vibrate back." It is merely directional since collision only results in a change in direction.

¹⁷Lucretius 11B(6).

¹⁸Epicurus 11A(1)&(3), my emphasis.

¹⁹Epicurus 11A(3).

²⁰Lucretius 11C(3)

The second quote, that atoms keep “up their vibration on the spot whenever they happen to get trapped by their interlinking,” is misread to suggest vibration comes from contact. Vibration is primarily introduced in this passage to explain what is happening when an atom does not move place. How is it supposed to still be in motion? It vibrates. We are told that atoms vibrate across distances to wherever their interlinking allows. This suggests that not only is it that imprisonment does not cause the vibration but that vibration can even occur without imprisonment. We are also told that “the void brings this [constant motion] about by separating each atom off by itself, since it is unable to lend them any support.”²¹ We saw that this meant that there is always some void that an atom is co-local with such that no other body can at that time be co-local with that same void. That quote includes the phrase “since it [the void] is unable to lend them [the atoms] any support” because it suggests not only that the void cannot lead to the constant motion, but also because the atoms are fully separated off they cannot be given any support by other atoms. The constant motion, the vibration, must occur from inside the atom itself. Not only do these passages my objector quoted not support the reading that contact causes vibration but they also suggest conclusions contrary to the Epicurean system. Vibrations cannot be derived from something external like another atom, the void, or the result of contact.

3.1.3 Solidity causes vibration and a second attempt at showing that contact does not explain of cause vibration

My objector believes that knocking together is what causes vibration. This is a problem for me because knocking together is contact and if I am going to use vibration to explain how atoms are in contact I better not explain vibration as arising from contact. My objector is worried about two things. The first is that the cause of vibration is contact and the second is that solidity couldn't be a cause of vibration. Even if I have shown above that the Epicureans seem to think that knocking together doesn't cause vibration, I haven't yet shown that it is solidity that is the cause. In fact, says my objector, solidity just doesn't seem like the right sort of thing to be a *cause* of motion and since all motion must be caused, the only explanation is that it is a result of contact and collision.

My main goal in this section is to argue against the idea that knocking together causes vibration. As long as I have shown that it isn't contact that causes vibration, I can use vibration to explain contact. I will additionally defend my claim that solidity is the cause of vibration.

There are lone atoms, atoms that have never yet been in contact. Recall that vibration is to *always* occur. Vibration is an eternal state of the atom that ensures that they never stop moving: *given that a situation of imprisonment were to arise*, the atom must still move. Certainly, there are lone atoms, far reaching and isolated in the vast void. Lone atoms still fall in the void due to their weight and still vibrate to ensure that were they imprisoned they would still move.

Does every motion have a cause? If yes, what is the cause of the atom's vibration? It couldn't be the contact because there are lone atoms. Solidity

²¹Epicurus 11A(2).

might seem inadequate because it looks more like a material precondition, like the void is for motion, an explanation of why they vibrate but still not a cause. But then you think that there are uncaused motions or you think that there is something other than the solidity that is the cause. Neither disjunct is a problem for my view. While I do believe that solidity is the *cause* of atomic vibration, I'm fine abandoning the language of causes in favor of the language of explanations or material preconditions. In case we think that there are uncaused motions, that is fine. That's already how I believe we should think of the swerve. My argument is fine in the case of uncaused motion because the important point still is that vibration will define contact. We can still say that the atom itself explains contact since vibration is derivative of the atom. The main points of my view are upheld. Note that it is uncontroversial that the weight of the atom is the cause of the atom's motion of falling down in the void. Solidity and weight are similar. It would be strange to suspect that solidity is not a cause while weight is a cause or that vibration is uncaused but falling in the void is caused. If solidity isn't a cause, the onus is on my objector to give me a story about weight.

The second disjunct is that something other than solidity causes the atom to vibrate. My response is to argue that solidity is the best philosophical and physical option that matches both the Epicurean framework and deviates least from the text. Knocking together cannot cause vibration because of lone atoms. Void cannot cause vibration without causal efficacy. All that is left is the atom or some property of the atom. Solidity is the best option if we vie for a property. Alternatively, we could say *the atom* itself is the cause, not its solidity. Either point is fine for my view.

3.1.4 Vibration accounts for atomic contact

I have shown that it isn't contact that leads to vibration and that solidity—or the atom itself—is the best candidate for a cause of vibration. We know that vibration, contact, and imprisonment are coincidental. I want to further argue that when the atoms are imprisoned, vibration *accounts* for contact. We know that vibration is a motion in the atom and we know that vibration occurs when atoms are imprisoned or lone. We know that the vibration comes from the atom's own solidity and not from the void or other external atoms. Vibration and contact aren't merely coincidental because we know from later passages that atoms are able to *link up* by harmonizing. Lucretius says, "many [atoms] wander through the great void, which have been rejected by compounds and have also failed to gain admittance anywhere and harmonize their motions."²² Vibration is this harmonizing motion. The reason that we are told in the primary passage that vibration occurs when atoms are imprisoned is because vibration can account not only for constant movement but also for contact. Turn back to the quote: At the end of line 11A(1), we are told that atoms keep up vibration when they are imprisoned by atoms. We are then told that the void fully separates the atoms and that neither the contact from other atoms nor the void can produce this scenario. Something from within the atom produces vibration.

²²Lucretius 11B(6).

Then we are told what that internal cause is: the solidity of the atom. Then we are again shown a connection between vibration and contact. Part of the reason we are taken on a detour from contact and vibration to complete separation of atoms is to say that something internal to the atom allows for atoms to connect up when they are fully separated. The solution to atomic contact is as follows: We know that two atoms are in contact and that there is nothing between them when their vibrations intermingle with one another.

Atoms are in contact when their bodies and their extremities or boundaries are fully separated but they are also not at a distance from one another. There is no void between the atoms, and they are both fully separated and not at a distance, because the vibrations are able to intermingle with one another. Note that there is an influence from one atom to another that isn't the result of coextension. The vibrations intermingle. When the intermingling vibrations harmonize, the atoms link up. When the vibrations intermingle and fail to harmonize, the atoms merely touch. In either case, it seems as if the intermingling vibrations can account for the contact of two atoms, their vibrations are in contact, while maintaining a distance, since they are fully separated off from one another physically.²³

3.2 A helpful analog: fields

To demystify this picture, let us look at some contemporary literature on these problems of contact to help us better understand what the Epicureans might have had in mind. Action at a distance is mysterious. How can something act on something else when they are not touching? Action by contact is also mysterious. How could two things be in contact if not for some overlap?

A contemporary solution to this problem is to introduce the notion of a field. Roughly, fields are regions in which each point in the region is affected by a force. Two magnetic poles repel or attract one another when one is placed in the magnetic field of the other. Objects fall to the ground when they are dropped because they are affected by the force of the Earth's gravitational field.²⁴ Objects don't have to occupy the same place at the same time to be in contact since their fields can interact.²⁵

Certainly, there are still questions and I do not claim that Epicureans had fields in mind. But, it is helpful to see the contemporary analog of the idea I believe the Epicureans did have in mind. Epicureans didn't think there was some *other thing* outside of void and body like field. The vibration is fully a part and derivative of the body. And yet, "[t]he distinction between fields and matter was not drawn sharply when field theory originated."²⁶ At some early stages in their writing, Faraday and Maxwell thought fields were substances.²⁷ Perhaps, primitive field theories conflated the body with the field itself. As I see it, the Epicureans had a similar notion in mind when positing vibration.

²³Different harmonies may be accounted for by varying shapes, the primary source of diversity in the atomic and phenomenal world for Epicureans. Thanks to Simon Shogry for this insight.

²⁴"Field", <https://www.britannica.com/science/field-physics>, 2014.

²⁵Lange, *Philosophy of Physics*, 34-35.

²⁶Lange, *Philosophy of Physics*, 35.

²⁷Substances external to bodies.

There is an internal movement of an atom that can interact with other atoms in such a way as to uphold the idea that the atoms are fully separated off from one another. And this commingling of vibrations in the atoms explains when it is that two atoms have no space between them and are in contact.

3.3 Solutions to the problems of minimal contact and compound individuation

At the beginning of the paper, we worried about Aristotle's problem for atomism: How could two partless things touch if not part-to-part, part-to-whole, or whole-to-whole? We discussed how Aristotle's problem was a problem for Epicurean minima and extended to problems of contact for atoms. The natural solution to the latter of these problems turned out not to work due to interpretative misgivings. In discussing traversal of atoms, we noted that a proper solution to contact would start with a feature of the atoms that did not reference the parts of minima that would then explain atomic contact. Once we had the solution to atomic contact, we decided that it would be best to account for minimal contact by referencing the feature that accounted for contact in atoms, just as in the case of traversal. Finally, features of discrete space would fall out of that solution.

We specified the movement of an atom from place to place to define traversal. We then noted how the minima moved incidentally to this movement. Since the minima move in staccato, jumping from one place to the next, we define a discrete space and solve Zeno's paradox. Similarly for contact, we have just defined contact of atoms by the internal movements of the connected atoms: atoms are in contact when their vibrations interact with one another. We want now to solve the problem for minimal contact in a way that helps us get clear just exactly how minima—in their own peculiar way—are in sequence.

I will argue that minima are touching because of the solidity of the atom. The solidity of an atom causes an internal vibration. The minima vibrate in perfect harmony with one another and, as such, are everlastingly stuck together. Recall that atoms are "not composed by assembling these [minima] but rather gaining their strength through being everlastingly un-compounded."²⁸ Notice first that this explicitly states that the minima do not come together to form atoms. The atoms have always been the way they are. They neither are composed nor are separated. They are "everlastingly un-compounded." Recall that minima cannot move or traverse distances on their own. They gain motion and traversal incidentally by being a part of an atom. The minima would not be able to explain phenomenal movement, let alone explain the motion of the atoms or be the support of the rest of the Epicurean philosophical system. Similarly for contact, the atom is always in motion; it is always vibrating because of its own solidity. The solidity is an emergent property from the everlasting compounded nature of the atom and minima. And because the atom is vibrating, the minima too are vibrating. And because they are vibrating, just as two atoms are in contact when they vibrate, so too are the minima in contact because of their perfectly harmonious vibrations.

²⁸Lucretius 9C(2).

One of the pitfalls of the natural solution to the problem of atomic contact is in its inability to distinguish between cases where atoms come together to form an individual and cases where atoms are merely in contact. Why am I a compound individual but my body and the chair are merely in contact? Consider the following quote from Lucretius: “many wander through the great void, which have been rejected by compounds and have also failed to gain admittance anywhere and harmonize their motions.”²⁹ When the vibrations of a group of atoms harmonize, they come together into a unit. What is meant by an atom being given “admittance” is that an atom is a part of a compound individual and not merely in contact with the other atoms. It is clear that there is some kind of “harmonious motion” occurring when atoms are given “admittance.” This motion is best understood as vibration, as opposed to falling, swerve, or collision.³⁰

4 Conclusion

The whole structure of Epicurean philosophy is designed to serve its ethics. It aims to disprove the possibility of a soul’s survival after death, refute the prospect of judgment, punishment, and reward in the afterlife, devalue the importance of human behavior to the gods, and ultimately alleviate physical and mental anguish. It seeks to support the enjoyment of pleasures and defend the value of friendship to gain peace of mind. And at the foundation of the Epicurean system is their atomistic physics. From the composition and movement of atoms in void, we get an explanation of everything: from an account of our phenomenal experiences and conceptual framework, to the development of an epistemology, a psychology, and a social theory, all terminating in the support of their ethical goals.

It is clear that a proper account of composition and motion of atoms in void is of great significance to support the foundation of Epicurean philosophy. Yet no proper interpretation had been given as to how atoms are composed by the partless minima, how atoms compose larger bodies, and how it is that some concatenations of atoms form an individual and some do not. I hope to have shown in this paper how atoms are to be in contact, by the interactions of their vibrations. From the solidity and internal movement of the atoms, I have shown how we can even respond to Aristotle’s challenge for minima and get clear on the vague formulation of how minima are in contact in their own peculiar way. Finally, I have shown how atoms that link-up form an individual when they harmonize and how atoms merely touch when their vibrations fail to harmonize.

²⁹(Lucretius 11B(4-6))

³⁰Note the striking similarities between the Epicurean solutions and Aristotle’s. For Aristotle’s solution, bodies *A* and *B* are in contact (contiguous) just in case the (appropriate) extremities of *A* and *B* overlap. For the Epicureans, bodies *A* and *B* are in contact just in case *A* and *B*’s vibrating motions interact. Contact is explained by some further relation *R* in both cases. For Aristotle, it is the notion of surfaces or extremities overlapping. For the Epicureans, it is the notion of the interaction of the bodies’ vibrations. Note the differences: (i) the relation is the same for minima and atoms for the Epicureans and different for surfaces and body for Aristotle and (ii) the explanation is from surfaces to bodies, micro to macro, for Aristotle while for the Epicureans, the explanation is from atoms to minima, macro to micro.

This account of Epicurean physics aids not only in our understanding of contact, location, and other related notions, but lends support to a philosophical system founded on the movement and composition of atoms in void. Most of all, I hope to have shown throughout the paper that the Epicurean physical system was well-reasoned, thoroughly interconnected, and deeply elegant.