**ABSTRACT.** In his *Letters on the motion impressed by a moving mover*, Gassendi offers a theory of the motion of composite bodies that closely follows Galileo’s. Elsewhere, he describes the motion of individual atoms in very different terms: individual atoms are always in motion, even when the body that contains them is at rest; atomic motion is discontinuous although the motion of composite bodies is at least apparently continuous; and atomic motion is grounded in an intrinsic *vis motrix*, motive power, while composite bodies simply persist in their state of motion or rest in the absence of outside intereference. Gassendi does not make much effort to explain how his accounts of atomic and composite motion fit together, and it’s difficult to see how they could possible be integrated. My goal is to explain, given this difficulty, why he accepted both the Galilean theory of the motion of composite bodies and the Epicurean theory of atomic motion.

**KEYWORDS:** atoms, continuity, Galileo, Gassendi, heliocentrism, motion

**Copernicus, Epicurus, Galileo, and Gassendi**

Antonia LoLordo (lolordo@virginia.edu)

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In his *Letters on the motion impressed by a moving mover*, Gassendi offers a theory of the motion of composite bodies that closely follows Galileo’s. Elsewhere, he describes the motion of individual atoms in very different terms: individual atoms are always in motion, even when the body that contains them is at rest; atomic motion is discontinuous although the motion of composite bodies is at least apparently continuous; and atomic motion is grounded in an intrinsic *vis motrix*, motive power, while composite bodies simply persist in their state of motion or rest in the absence of outside intereference. Gassendi does not make much effort to explain how his accounts of atomic and composite motion fit together, and it’s difficult to see how they could possible be integrated. My goal is to explain, given this difficulty, why he accepted both the Galilean theory of the motion of composite bodies and the Epicurean theory of atomic motion.

**I**

In August 1625, Gassendi wrote the first of several enthusiastic letters to Galileo. He enclosed a copy of his recently-published *Exercitationes paradoxicae adversus Aristoteleos* (*Exercises in the form of paradoxes against the Aristotelians*)*,* described some of his observations of sunspots,[[1]](#footnote-1) and told Galileo:

I have embraced your Copernican opinion in astronomy with so much intellectual pleasure that … my mind, unfettered and free, wanders through the immense spaces as if the chains of the common world system have been broken off (6.4b).

Some further correspondence about observational astronomy followed soon after (6.10a–11b, 6.36b–37a). Galileo sent Gassendi a copy of the *Starry Messenger*, along with a telescope, via his patron Peiresc.[[2]](#footnote-2) Gassendi seems to have kept this telescope for the rest of his life; at any rate, his will gives instructions on what to do with ‘Galileo’s morocco leather telescope’.[[3]](#footnote-3)

In March 1632, Gassendi sent Galileo a copy of his *Mercurius in sole visus*, which recorded the 1631 transit of Mercury across the sun (6.45b). The transit of Mercury had been predicted by Kepler, and Gassendi’s observation – generally considered to be the first observation of a transit of Mercury – thus constituted empirical evidence in favor of heliocentrism.

That November, Gassendi wrote to Galileo again, saying that he had just read the *Dialogue Concerning the Two Chief World Systems*, which Galileo had sent via their mutual friend ÉlieDiodati, and praising both the book itself and Galileo’s ‘genius’ (6.53b).[[4]](#footnote-4) On April 30, 1633, Gassendi’s friend, the astronomer Ismail Boulliau, informed him that Galileo was in Rome, where he was supposed to respond to the Inquisition (6.411b-12a).

A few weeks later, in a letter to Tommaso Campanella,[[5]](#footnote-5) Gassendi explained:

[F]rom a recent long letter from Galileo, I have learned that he will soon be in Rome, where he has been summoned. This is astonishing, since he has published nothing without approval. But it is not for us to know these great things … (6.56b).

This mixes sympathy with caution in a manner that is characteristic of Gassendi.

It is not clear precisely when news of Galileo’s condemnation reached Gassendi. He seems to have been unsure of exactly what was happening for quite a while. But in December 1633, he wrote to Peiresc – who had tried to intercede on Galileo’s behalf [[6]](#footnote-6)– thanking him for sending news of Galileo’s situation and explaining: “I would happily write [Galileo] a note, but I don’t know how to begin; everything about this is so touchy …”.[[7]](#footnote-7)

In January 1634 Gassendi wrote to Galileo again:

Great expectation keeps me waiting (o great glory of our age) for news of what has happened to you. For although ignorant rumor has been spread repeatedly, nevertheless, I hardly trust it until the matter has been seen clearly (6.66b).

He recommended the serenity that, he said, is typical of Galileo. But he still did not seem to believe that things were all that serious. At any rate, he expressed the hope that Galileo might send him some new lenses for his telescope, since, he says, none as good can be found in Venice, Paris, or Amsterdam. Later that year, Galileo did.[[8]](#footnote-8)

 After this, Gassendi continued to correspond with Galileo from time to time. For instance, when Galileo lost sight in one eye, Gassendi tried to comfort him by telling him that we can only see out of one eye at a time anyhow. In case this was not much help, he also shared his sadness about the recent death of his friend and patron Peiresc (6.94a–5a). None of these letters mention Copernicanism, Galileo’s condemnation, or anything about the science of motion.

**II**

 In 1640 Gassendi wrote two *Epistolae de motu impresso par motore translato* (*Letters on the motion impressed by a moving mover*)[[9]](#footnote-9) that played an important role in spurring debate about the Galilean science of motion in France.[[10]](#footnote-10) The letters paraphrased a great deal of material from Galileo’s *Two Chief World Systems*, together with some material from *Two New Sciences.* Gassendi also added a fair amount of new material of his own, which was intended to buttress the Galilean science of motion by explaining its underlying physical causes. This explanation ultimately led Gassendi to make some drastic modifications to the Galilean science of motion. These modifications did not, however, affect what we call Galilean relativity and what Gassendi refers to as Galileo’s “theorem that *if the body we stand on is moving, everything about motion and moving things will occur and appear to us just as if the body were at rest”* (*De motu* 1.1; 3.478a)*.*[[11]](#footnote-11)

 Gassendi’s theory of the motion of composite bodies describes their motion in mathematical terms. He does not have anything that can really be called a *theory* of the motion of atoms, and he never offers quantitative description of the motion of atoms. However, he does make some remarks about how atoms move that are roughly Epicurean in inspiration. These remarks make it extremely puzzling how the motion of composite bodies is supposed to relate to the motion of their atomic components. One would expect Gassendi to say that atoms and the bodies they compose move in the same way, following the same rules. But this is not his view. Instead, he holds that there are three major differences between atomic motion and the motion of composite bodies:

1. Composite bodies can either be at rest or in motion, but the atoms that compose them are always in motion.
2. Composite bodies persist in their state of motion or rest in the absence of outside intervention because there is no reason for that state to change. (This is, of course, an ancestor of the notion of inertial motion.) Atoms also persist in their state of motion and rest, but the reason is very different: atoms have an essential *vis motrix* that is always realized in motion.
3. Atoms move in leaps – in intervals of motion that are interspersed with intervals of rest – while the bodies they compose appear to move continuously. This continuity may be only apparent. Nevertheless, it explains why the motion of composite bodies is open to mathematical description, while the motion of atoms is not.

Gassendi does not make much effort to explain how his roughly Galilean theory of the motion of composite bodies fits with his roughly Epicurean view of the motion of atoms. And indeed, it is difficult to see how the two accounts could possibly be integrated. Given this difficulty, why did Gassendi accept them both?

**III**

 The answer is relatively straightforward in the case of the Galilean theory, for Gassendi’s interest in the Galilean science of motion was primarily motivated by the belief that Galilean relativity is necessary to defend Copernicanism. Gassendi was committed to Copernicanism from very early on. As we have seen, in his 1625 letter to Galileo he described himself as a Copernican. And in the preface to the *Exercitationes,* published a year earlier, he said that in Book IV of that work, “rest will be brought to the fixed stars and the sun: but motion will be given to the earth, as if it is one of the planets” (3.102, no columns).[[12]](#footnote-12)

 Gassendi’s Copernicanism was not quite this explicit in any of his later work, but it stayed fairly close to the surface. Copernicanism faced two main objections: that the Bible says that the earth does not move, and that if the earth really *were* moving then everything on it would fly off into space. Gassendi’s *De motu* is intended to overcome the second objection by showing “the idiocy of the argument, commonly alleged in support of the earth’s rest, from the motion of projectiles” (*De motu* 2.13, 3.519a). He is careful to state that he is not trying to combat this ‘idiotic argument’ in order to defend Copernicanism:

I did this, not to assert that the earth moves, but, from love of truth, to suggest that its rest should be established on firmer reasons. Do not demand that I communicate these reasons to you, as if you think I have some: if I had any, I would give them willingly. Indeed, certain men – first of all our Morin – have come up with some arguments for the earth’s rest, with great ingenuity. However, I always see some problem with those arguments, and hence it always comes down to this: that I revere the decree in which a number of cardinals are said to have approved the earth’s rest. For although the Copernicans think that the passages in holy Scripture that attribute standstill and rest to the Earth and motion to the Sun should be explained as being about the appearances[[13]](#footnote-13) … those passages are explained differently by men who, it is agreed, are of great authority in the Church. Because of this, I stand apart from the Copernicans, and on this occasion do not feel ashamed to make my intellect a captive. This is not because I think that it is an article of faith, for (as far as I know) it is not … but because the judgment of the Copernicans should be considered a pre-existing judgment that cannot be of great weight among the faithful (*De motu* 2.13; 3.519b).

Gassendi’s *De motu* encountered a fair amount of opposition. His most hostile opponent was his old housemate and co-worker, Jean-Baptiste Morin.[[14]](#footnote-14) Morin had already written several anti-Copernican works by that point, and he produced another, *Alae telluris fractae* (*Breaking The Wings of the Earth*) in response to Gassendi. In it, he insisted that Gassendi’s claim that he is not arguing for heliocentrism is disingenuous, and that Gassendi must have known that the Pope had condemned Copernicanism.

Despite Morin’s attack, in his 1646 follow-up, the *Epistolae de proportione qua gravia decidentia accelerantur* (*Letters on the proportion by which heavy falling bodies are accelerated*), Gassendi reiterated his position:

I am a foster-son of the Church and I wholly devote myself to it, so that whatever it condemns, I conclude that that is anathema … I have not heard that the sentence against Galileo was … a Papal decree and hence made general (3.641b).

In the *Institutio astronomica* – written as lectures some time after 1645, when Gassendi became professor of mathematics at the Collège Royal – Gassendi presents an overview of the Tychonic and Copernican systems and repeats that we need not think that the condemnation of Galileo applies to Copernicanism in general:

It is customary to stick to the judgment laid down by the Congregation of Cardinals of the Inquisition, which condemned Galileo’s view of the motion of the earth. But the Orthodox respond (for the Heterodox deal with the matter more briefly) that this opinion was particular, that is, pertinent only to Galileo, since it might take into account particular reasons that applied to Galileo’s view but not to others. They add that this judgment is indeed of great weight, but that nevertheless, it should not necessarily be considered an article of faith (4.60a-b).

And he ends his discussion of the three main world systems in the *Syntagma* in a similar vein:

[I]t seems that the Copernican system is clearer and more elegant. But because there are sacred texts that attribute rest to the earth and motion to the sun – and because it is said that a decree exists that orders texts of this sort to be understood in terms of real rest and motion, not merely apparent rest and motion – it remains the case that the Tychonic system is approved and defended instead, by those who revere such a decree (*Syntagma Physics* 1.1.3, 1.149a).

Gassendi, then, was a life-long Copernican.[[15]](#footnote-15) It is worth noting that aside from the dispute with Morin – who quarreled with a number of people – his commitment to Copernicanism did not cause him any problems. Gassendi was a successful establishment figure: he had powerful patrons like the governor of Provence, he was professor of mathematics at the College Royal, and he received an elaborate state funeral. He understood exactly what you could and could not get away with saying, and wrote accordingly.

**IV**

Gassendi’s defense of the ‘Galilean theorem’ in *De motu* begins by providing what might look like empirical evidence but is really a rhetorical exercise. The basic case he considers is what happens when a ball is dropped from the mast of a sailing ship. To an observer on deck, the ball will appear to fall straight down, landing at the base of the mast. To an observer on shore, the ball will follow a curved trajectory, because it has inherited the motion of the ship. But as well as describing what happens when a ball is dropped from the mast of a ship, Gassendi also describes cases that involve riding on horseback or in a coach. And he invites the reader to perform similar *experimenta* for himself and to observe others performing them.

This demonstration takes many pages. This is, in part, simply because of Gassendi’s rhetorical style. But it also reflects the fact that Gassendi needs to convince the reader of something that it is very easy for 21st century readers to take for granted: that it is irrelevant whether the moved mover is self-moved or moved by some external cause.[[16]](#footnote-16) Hence, it is necessary to discuss both what happens when a ball is thrown in the air by someone walking and what happens when a ball is thrown in the air by someone standing still on a moving ship.

Why, Gassendi asks, do all these *experimenta* give the same result? “The general cause,” he replies, “is that whatever moves impresses its motion on all the things it supports” (*De motu* 1.2, 3.478b). But this is not the end of the story. Gassendi wants to discover the underlying physical explanation of this. He also wants to discover the underlying physical explanation of two more specific rules of motion, which are again due to Galileo:

[T]wo things should be premised, which, among others, are rightly due to the great Galileo. First, that a body descending with its own motion accelerates in such a way that in equal times it goes through ever more spaces, according to the proportion which the odd numbers have among themselves, starting from one … Second, that the path or line which we imagine that a body that has been projected obliquely describes in the air … is parabolic (*De motu* 1.6; 3.483a-b).

All three explanations rely on gravity in one way or another. For instance, the role of gravity in projectile motion is what links it with Galilean relativity. Gassendi distinguishes two components of projectile motion: a vertical component, whose relation to gravity is obvious, and a horizontal component, which in the cases he is interested in is inherited from the motion of the moved mover. He tries to gain a clearer understanding of this horizontal component by conceiving of a situation in which gravity plays no role, thereby eliminating the vertical component.[[17]](#footnote-17) Thus, he arrives at the conclusion that in the absence of interference, the motion impressed by the moved mover – or by any other source, for that matter – will persist forever:

[Y]ou ask what would happen to that stone which I said could be conceived in empty space if, having been disturbed from rest, it were impelled by some force. I reply that it is likely that it would move equably and without ceasing, and either slowly or quickly, depending on whether a small or great impetus had been impressed. I derive support for this from the equability of the horizontal motion that has already been explained.[[18]](#footnote-18) For it seems that it would not stop except due to the addition of perpendicular motion. Therefore, because there would be no addition of perpendicular motion in that space, in whatever direction the motion started, it would be like horizontal motion, and would not be accelerated or retarded, and so would never cease (*De motu* 1.16; 3.495b).

Thus a body in motion will move “equably and without ceasing”, forever, in the absence of outside interference.

**V**

Now let us consider the physical explanation of the acceleration of bodies in free fall. Here Gassendi starts out by trying to explain the underlying physical causes of the Galilean rule, and ends up modifying the rule significantly – more significantly, perhaps, than he really lets on.

 Since he has rejected the Aristotelian conception of gravity in favor of one on which gravity is an external cause, he needs to determine the nature of that cause. He starts out by itemizing the possibilities:

[A]lthough there are many ways in which an external cause can move something, nevertheless it is well known that they all pertain to two main types, so to speak: impulsion and attraction (*De motu* 1.11; 3.489b).

This, he seems to think, requires no argument. So the cause is either impulsion or attraction or a combination of the two. And really, attraction is just a species of impulsion – “to attract is nothing but to impel something towards oneself with a hooked instrument” (*De motu* 1.17; 3.497a). The hooked instrument in question comes from “the force that belongs to the earth as a whole and is called magnetic” (*De motu* 1.12; 3.491a).[[19]](#footnote-19) The existence of this magnetic force is supposedly demonstrated by the behavior of falling bodies. However, we can only guess at how it operates: “it is not only difficult but even impossible to understand the true way in which the inner nature of things carries out its marvelous operations” (*De motu* 1.14; 3.493a-b). Nevertheless, Gassendi conjectures that the earth emits a tiny stream of particles that hook onto the body and pull it back towards the earth.[[20]](#footnote-20)

 Perhaps because he thinks of attraction as a kind of impulsion, Gassendi describes the acceleration of bodies in free fall in terms of a series of blows. He says that this series of blows is continuous [*continuo*]. But either he is fundamentally confused, as some readers have suspected, or he is just speaking loosely. (Perhaps *continuo* should be translated as *continual* rather than *continuous*.) For on his view, acceleration is not really continuous at all. Rather, it consists of a series of distinct ‘moments’:

[T]he motion or impetus … impressed in the first moment … is not destroyed but perseveres in the second moment, in which another, similar motion or impetus is impressed … and so on; with the result that the impetus continually increases … because of this addition the increase of speed follows the series of natural numbers; namely, in the first moment there is one degree of speed, in the second two, in the third three … (*De motu* 1.17; 3.497a).

Gassendi does not think that the *vis attrahens* of the earth yields the odd number rule by itself: it just gives you the sequence of natural numbers. So there must also be a *second* factor – one that operates at every moment except the first, that is, one that operates constantly once the body is already in free fall. This second force is provided by the air. [[21]](#footnote-21)

This is inelegant, and Gassendi got rid of the *vis impellens* of the air in the 1646 *Epistolae de proportione qua gravia decidentia accelerantur.* There, he explains that he made a mistake when he said that the *vis attrahens* would yield the natural number rule. It actually yields the odd number rule without supplementation.[[22]](#footnote-22) The resulting theory is simpler. But it faces problems of its own, and more or less abandons the attempt to explain the underlying physical causes of Galilean motion.[[23]](#footnote-23)

The mere fact that Gassendi describes acceleration in terms of a series of moments does not show that he thinks of acceleration as discontinuous. Galileo talks about moments too. But the way Gassendi describes these ‘moments’ is noteworthy:

[W]hen I say the first moment, I mean the minimum in which one simple blow is impressed through attraction and a minimum space is traversed by a simple motion (*De motu* 1.18; 3.497b).

Like Gassendian atoms, these minima are extended. I will return to this point in section VII below. But first, let us contrast Gassendi’s account of the motion of composite bodies with his remarks about the motion of atoms.

**VI**

 Gassendi holds, in typical mechanist fashion, that you can explain all physical change in terms of the matter and motion of its component parts – for him, atoms. But despite this theoretical commitment, it is extremely rare for him to offer atomic-level explanation of phenomena. However, there *is* one passage in *De motu* that appeals to the motion of atoms to do explanatory work.[[24]](#footnote-24) In this passage, Gassendi is replying to the objection that he has not explained what keeps projectiles in motion after they have left the projector:

[M]otion is an accident of the following nature: as long as it has a persevering subject and does not encounter anything contrary, it can persevere without the continual action of its cause. And although the internal principles of the moving thing [the atoms] could be said to have not only passive power but even active power, by means of which they continue such motion, nevertheless this power cannot be said to be impressed by the mover but rather aroused by it (*De motu* 1.19; 3.499a).

Given what has come earlier*,* the reader expects Gassendi to say that the projectile doesn’t *need* active power to keep moving – that it will just keep moving, “equably and without ceasing”, unless there is some outside interference. But instead, he claims that composite bodies persist in motion in virtue of the active power of their component atoms. This implies that atoms have active power and that when a composite body is moved by something else, the mover does not *impress* active power on the atoms in the body moved, but merely *arouses* [*excito*]the active power they already have.

 Atomic active power or *vis motrix* is, for Gassendi, the source of all activity in the material world. This suggests that *vis motrix* is not the mere capacity for motion but something more like a genuine force, something that produces or gives rise to motion. So does his claim that bodies persist in their motion in virtue of their *vis motrix* unless there is some outside interference.

Gassendi’s descriptions of *vis motrix* are somewhat vague:

Gravity, or Weight … is nothing other than a natural and internal faculty or power, by means of which Atoms can move and stir [*cieo*] *per se.* Or better, nothing other than an inborn, innate, native, propensity for motion that cannot be lost, and a propulsion or impetus from within (*Syntagma, Physics* 1.3.7; 1.273b).

A propensity to motion sounds like mere potential.[[25]](#footnote-25) But a propulsion or impetus – or, as Gassendi adds elsewhere, an impulse [*impulsio*](*Syntagma, Physics* 1.3.6; 1.266b) – sound actual.

 *Vis motrix* is one of the three essential properties of atoms (*Syntagma, Physics* 1.3.7; 1.273b). The others are size and shape. Since the size and shape in question are *determinate* sizes and shapes – not just the determinable, possession of size and shape in general – it is natural to think that he is talking about determinate *vis motrix* too. So it is essential to atoms to possess a certain amount of *vis motrix*, where *vis motrix* is not mere movability but actual impetus.

This implies that atoms are always in motion. Consider the following passage:

[A]ll motive power which is in composite things is from the Atoms. At least, I observe, since the innate power of atoms is not produced when a thing begins to move but merely acquires liberty . . . as much impetus constantly perserveres in things as was in them from the beginning. From this it follows that however much one atom which impacts another impels it, by the same amount it is repelled from it, and so impetus neither increases or decreases. But, on account of the compensation that occurred, impetus remains always the same, and the same motion perseveres, as long as it is through free space and without resistance. For this reason also, when composite bodies impel and repel each other in turn … either equal forces meet and both sides retain the same motion, or unequal forces meet and, because of the compensation, the same motion perseveres in them taken together. From which it follows in turn that because atoms in composite bodies preserves their motive power or impetus, there can be no absolute rest (*Syntagma, Physics* 1.5.2; 1.343b).

This starts out sounding like a general conservation principle: the total quantity of impetus in the world is conserved. But it is the last move in the passage that is significant for us. Gassendi infers from the premise that atoms in composites preserve their motive power to the conclusion that there can be no absolute rest. This inference only makes sense if a thing with motive power cannot be at rest. So Gassendi must think that things with motive power are always in motion.

 This is a rather strange view. Francois Bernier, one of Gassendi’s earliest and most careful readers, comments in his 7-volume *Abridgement of the Philosophy of Gassendi:*

There is not a single Atom, they [Gassendi and his followers] add, that is not in continual and eternal [*inamissible*] motion, and motion that is very fast and unalterable. But on what foundation is advanced a thing so hard to believe, and so contrary to that which we see in other bodies (2.434)?

Moreover, if atoms are always in motion, how can bodies be at rest?

Gassendi explains that “the cause of deviation and slowness in composite things comes from nowhere else but the repercussion and multiple repression of those same atoms” (*Syntagma, Physics* 1.6.4; 1.385a). Hence,

[T]he principle by which all things in nature, or all composite bodies, move seems to arise from the innate motion of atoms: either from the atoms that the moving body consists in, in cases where a body moves by itself or *per se*, or from the atoms that the mover consists in, in cases where a body is moved by another body which is itself, while it moves, in some sense moved *a se.* For as long as the atoms in some body are agitated in various ways, if some atoms that are more mobile and unimpeded than others conspire amongst themselves to elicit a force in some direction, then they propel the whole body in that direction (*Syntagma, Physics* 1.5.1; 1.338a).

And again,

On the third property of atoms, that is, weight, or the innate and internal as it were compulsion or mobility, seems to depend all motive power that is in composite bodies. For although atoms have been bound fast and detained in bodies, nevertheless … they do not lose their mobility but incessantly strive. And they strain and bustleto break out, either many in the same direction or some in one direction and others in another. And because of this, the motion is in whatever direction there was the most striving and impetus. For this reason, the motive power that is in any composite body owes its origin to the atoms, and is not really distinct from their weight or impetus (*Syntagma, Physics* 1.6.3; 1.384b).

When a composite body is at rest, then, its component atoms are moving – apparently in a locked pattern of vibration. That pattern can be disturbed by a collision with another body that results in a new pattern of vibration. This new pattern in turn makes the composite move in a straight line at a uniform speed until it encounters further disturbance.

 Gassendi’s account of atomic motion shows that his embrace of the Galilean science of motion is extremely limited. Given his account, no force or motion can really be transmitted in collision.[[26]](#footnote-26) Moreover, not only is acceleration in free fall discontinuous: *all* acceleration must be discontinuous. For if the speed of a composite changes only when its texture – that is, the arrangement of its atomic components – is disturbed by impact, then all change in speed must be instantaneous.

There is an even more fundamental limitation as well. Given Gassendi’s atomism, there is no real reason for all bodies to obey the same laws of motion. What happens in collision is determined by the change in texture, and there is no reason for all textures to be affected by impact in the same way. The Galilean science of matter explains why we can treat all bodies mathematically in the same way; Gassendi’s atomism, in contrast, makes this mysterious. But from Gassendi’s point of view, Galileo’s theory has a gap as well: it does not explain the underlying physical causes of motion, something his own account does very well at.

**VII**

 One last aspect of Gassendi’s sketch of atomic motion is worth looking at. On his view, atomic motion is discontinuous, because space, time, and motion are composed of extended indivisibles. We saw a hint of this in *De motu,* where Gassendi referred to “the minimum in which one simple blow is impressed through attraction and a minimum space is traversed by a simple motion” (*De motu* 1.18; 3.497b). This might strike you as odd: if space and time are composed of minima, then mathematical descriptions of the world cannot be exactly true. But this, in fact, is precisely what Gassendi wants:

[M]athematical indivisibility and the infinity of parts in the continuum do not exist in reality, but are a hypothesis of the mathematicians, and thus it is not appropriate to argue in physics from things which are not found in nature (*Syntagma, Physics* 1.5.1; 1.341b).

Gassendi returns to the suggestion that space and time are composed of minima in the *Syntagma*, in an attempt to explain how all different speeds are possible when atomic motion is – as he says elsewhere – *pernicissimus* (*Syntagma, Physics* 1.6.4;1.385a):

[M]ight I add that slowness arises from the intermixture of rest? Indeed, we conceive that the light of the sun at midday is the maximum, and then various degrees of light all the way down to pure darkness are created by the intermixture of fewer or more shadows. In just the same way, it seems, it can be said that the motion by which atoms are carried through the void … is the fastest possible motion, and every degree of speed which is between that and pure rest derives from the intermixture of fewer or more particles of rest … And so, when there are two moving bodies, one of which is moving twice as fast as the other, we should conceive that, in two individual moments in which the faster body moves, the slower body moves only in one, and is at rest in the other … And do not object that motion of this sort will thus not be continuous: although it will not be continuous in itself, nevertheless it will be continuous to the senses (*Syntagma, Physics* 15.1; 1.341b).

This comes from a discussion of Zeno’s paradoxes in the section ‘Quid motus, an non detur’. Gassendi does not take the question of whether motion exists seriously: it is evident in experience, and one cannot even deny that there is motion without a motion of the tongue (*Syntagma, Physics* 1.5.1; 1.340b). However, he does take seriously Zeno’s argument that “there would be no motion if motion itself, like place and time, were not composed of indivisibles” (*Syntagma, Physics* 1.51; 1.340b).

 Bloch 1971, 226 argues that this is a passing suggestion that does not represent Gassendi’s considered view. For, he argues, the discussion of *minima* of space, time, and motion is confined to a single section of the *Syntagma*. It is introduced somewhat tentatively, as a response to a localized problem. And Gassendi does not mention spatial *minima* in the long section of the *Syntagma* specifically about the nature of space. Hence, Bloch concludes, the introduction of minima is *ad hoc* and should not be taken too seriously.

Messeri 1985, 74ff and Palmerino 2011, 320ff dispute this. They argue that the discontinuity of space, time, and motion fits well with what Gassendi says elsewhere – including what he says in *De motu.*[[27]](#footnote-27) Moreover, they argue, although Gassendi does not develop his suggestions about minima in any detail, he doesn’t give a competing account of the structure of space and time either.

I side with Messeri and Palmerino. So, in effect, does Bernier, although he finds the view silly:

It is ridiculous to imagine that in these different movements there are some intermixed pauses or small moments of rest, and that a slow and a fast motion differ in that there are more pauses in the slow one than the fast one – especially because there is no reason why a ball which, rolling slowly on a billiard table, has been stopped or put at rest, would not remain at rest until some cause that puts it in motion intervenes (Bernier, *Abreg*é2.449-450).

One reason scholars might downplay the suggestion that space, time, and motion are composed of extended minima is that it seems crazy. But what seems crazy, of course, is historically relative. A lot happened to the way people thought about motion between 1640 and 1678, and what seemed crazy in 1678 – let alone what seems crazy in 2014 – need not have seemed crazy in 1640.

 Another reason scholars might downplay the suggestion that space, time, and motion are composed of extended minima is that it is incompatible with the Galilean science of motion. But Gassendi was willing to make some major changes to it in any case. For example, he holds that bodies only follow the odd number rule when falling through air – the opposite of what Galileo thought.[[28]](#footnote-28) And he holds that the effects of gravity should diminish as you move away from the earth, since gravitational rays become more widely spaced the further away from the earth you get.

 Gassendi recognizes that this is incompatible with what Galileo said. But the incompatibility does not bother him. He simply notes that we should not expect to be able to observe the diminishment of *vis attrahens* as we get further from the center of the earth: there is no tower or mountain high enough for this phenomenon to be noticeable (*Syntagma, Physics* 1.5.3; 1.359b). So Gassendi is willing to modify Galileo’s views to make them fit in better with his physics in a number of cases. Why not also modify them to make them compatible with the suggestion that motion at sub-maximum speeds is composed of the intermixture of moments of motion and moments of rest?

**VIII**

 I have explained that Gassendi gives a surprising sketch of the way atoms move, a sketch that does not seem to fit very well with his roughly Galilean account of the motion of composite bodies. Gassendi’s reasons for accepting the Galilean theory are relatively clear. For one thing, Galilean science had an enormous amount of prestige in Gassendi’s intellectual circle, and it would have been a huge obstacle to the acceptance of atomism if it required rejecting the Galilean science of motion. Moreover, Gassendi wanted to defend Copernicanism, and thought he needed Galilean relativity to do so. The rest of the Galilean science of motion came along for the ride.

 Why, then, did he accept the Epicurean theory? Gassendi was already heavily invested in his Epicurus project when he started thinking about Galileo’s science of motion. However, he could easily enough have altered atomism to make atoms move like macroscopic bodies.[[29]](#footnote-29) So why did he choose not to do this?

 One possibility that Gassendi thought that he needed atomic *vis motrix* to guarantee a source of genuine activity in the material world.[[30]](#footnote-30) Another possibility is that he found the notion of continuity so troubling that he could not allow it to be a feature of the material world. One of Gassendi’s main lines of argument for atomism is that if there were no atoms, there could be no bodies: no matter how many unextended points are combined, the result will never be an extended thing. This line of thought applies to space, time, and motion equally well.

 However, I think, neither of these explanations is really the right one. It is quite natural for us to ask how a philosopher’s various views fit together. Indeed, it is often difficult for historians to *stop* asking this question. But in this case, the question may be unhelpful. Gassendi did not set out to produce a system like Descartes’ tree of the sciences. There is no single system of which Gassendi’s comments on Book X of Diogenes Laertius’ *Lives of the Philosophers*, his biography of his patron Peiresc, his observation of the transit of Mercury and his refutation of Herbert of Cherbury’s theory of truth are parts. Nor is there a single system of which the Epicurean theory of atomic motion and the Galilean theory of the motion of composite bodies are parts.

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1. These observations were published in his posthumous *Opera Omnia*, where they are included in the *Commentarii de rebus caelestis*. See e.g. 4.232. [↑](#footnote-ref-1)
2. Baumgartner 1988, 175. [↑](#footnote-ref-2)
3. Fleury and Bailhache 1955 includes Gassendi’s will. [↑](#footnote-ref-3)
4. One of the things he praises is Galileo’s recognition of the limits of human understanding: “What is really marvelous is that, when human sagacity cannot proceed further, the candor of your mind is such that you always acknowledge the weakness of our nature in good faith. For however plausible your conjectures may be, nevertheless, for you they are no more than conjectures. And you do not make pretences or allow them, as the common philosophers are accustomed to do. How justly you appraise the value of things!” (6.53b). This is something Gassendi himself emphasized, especially early on, in the *Exercitationes.* [↑](#footnote-ref-4)
5. The other notable feature of Gassendi’s very brief correspondence with Campanella is that Campanella – who spent twenty-seven years in prison – seems to have warned Gassendi to be careful in his handling of Epicureanism. Gassendi replied that he was arguing against the Epicurean view of Providence, as Campanella insisted, and that he always bore in mind what was appropriate for him to say “as a Christian and theologian” (6.54b). [↑](#footnote-ref-5)
6. See the letter from Diodati to Gassendi of 10 November, 1634 (Galileo, *Opere,* 16.153). [↑](#footnote-ref-6)
7. To Peiresc, 28 December 1633 (Galileo, *Opere* 15.368). It is not clear what Peiresc had told Gassendi. [↑](#footnote-ref-7)
8. See the letter from Diodati to Gassendi of 10 November, 1634 (Galileo, *Opere,* 16.153). [↑](#footnote-ref-8)
9. These are reprinted in volume 3 of his *Opera Omnia*. [↑](#footnote-ref-9)
10. See Galluzzi 2000 for a detailed account of this debate – which he calls ‘the second Galileo affaire’ – and Gassendi’s role in it. [↑](#footnote-ref-10)
11. Galileo himself did not call this a theorem. [↑](#footnote-ref-11)
12. Gassendi never wrote anything past Book II. Book III, about physics, was supposed to introduce the void and argue against Aristotelian forms, which he had already attacked in passing in Books I and II. Hence, it does not seem likely that he stopped writing after Book II in order to avoid the issue of Copernicanism. [↑](#footnote-ref-12)
13. Here I have elided several long sentences giving further details of how the Copernicans explain the relevant Biblical passages. [↑](#footnote-ref-13)
14. Bougerel 1970, 9. [↑](#footnote-ref-14)
15. I think this is *clearly* right, but Gassendi’s commitment to Copernicanism is not universally agreed upon. Joy 1987, 102 says that “Gassendi’s considered view of the truth of the Copernican hypothesis was one of mild skepticism”. [↑](#footnote-ref-15)
16. See Palmerino 2004, 139 [↑](#footnote-ref-16)
17. This requires understanding gravity as an external force rather than an intrinsic property of bodies. By this point, Gassendi has already dismissed Aristotelian explanations. He does not even consider the possibility of explanations on which gravity is some *non-*Aristotelian intrinsic property. [↑](#footnote-ref-17)
18. At 3.489a-b. Gassendi gives several reasons, some of which seem to pertain to genuinely horizontal motion and some to motion along the horizon. One involves considering a sphere rolling along a surface, which would accelerate when going down a slope and decelerate when going up, “from which you see that if the sphere is of such a nature that it is accelerated on a decline and retarded on an incline, if it is somewhere that neither inclines nor declines it will be neither accelerated nor retarded but will maintain its course and move indefinitely” (3.489b). [↑](#footnote-ref-18)
19. This, as Gassendi notes, is essentially William Gilbert’s explanation of gravity – one that Galileo himself was sympathetic to. [↑](#footnote-ref-19)
20. See 3.638b for more on the tentative status of this explanation. [↑](#footnote-ref-20)
21. “[T]he air that has been pressed downwards [by the falling body] pushes the surrounding air, and it can only gain the freedom to rise via the space above, which was left open in the meantime. Because of this, the air, springing back, rushes along the sides to the place above and invades that place, which was left empty. And since this invasion cannot happen without the rushing air urging on the stone, in the second moment two new blows are impressed, one from the Earth, which continues to attract the stone, and another from the air, which begins to urge on the stone” (*De motu* 1.18; 3.497b). [↑](#footnote-ref-21)
22. “I did not sufficiently consider that the degree of speed acquired in the first moment remained whole in the second moment, so that it was able to traverse two spaces. I thought of it as if it were only able to traverse one space. Because of this, when I saw that three spaces were traversed in the second moment, I promptly supposed that just as one space was traversed through the degree of speed remaining from the first moment, so two other spaces were traversed through two other degrees of speed that had been acquired in the meantime (*De proportione* 2.12; 3.621b). [↑](#footnote-ref-22)
23. See Palmerino 1999, 2004, and 2008 for more on this. [↑](#footnote-ref-23)
24. At 3.497b he also appeals to the innate motion of atoms as part of an attempt to deconstruct the distinction between natural and violent motion. [↑](#footnote-ref-24)
25. So does *mobilitas*, at e.g. *Syntagma*, *Physics* 1.6.3 (1.384b). [↑](#footnote-ref-25)
26. This has some metaphysical advantages – it allows one to avoid positing the migration of a mode from one substance to another – but I see no reason to think Gassendi had this in mind. [↑](#footnote-ref-26)
27. This is especially significant because *De motu*, unlike the posthumous *Syntagma*, was brought to publication by Gassendi himself. [↑](#footnote-ref-27)
28. At least, he did so in his *De motu*, where he needed the *vis impellens* of the air as well as the *vis attrahens* of the earth to get the odd number rule. The later view of *De proportione* does not seem to have this implication. [↑](#footnote-ref-28)
29. Such an alteration would be nowhere near as drastic as those required to make Epicureanism compatible with Catholicism. [↑](#footnote-ref-29)
30. See LoLordo 2005 for more on this. [↑](#footnote-ref-30)