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Common Sense and Relativistic Supercoincidence

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Abstract

Debates about material coincidence tend to start with common-sense intuitions but quickly leave them behind and lead to highly problematic conclusions. Reconciling the latter with common sense is the next stage in the process, which often requires revision of some of the initial beliefs and has been used to adjudicate many rather abstract and technical proposals in the metaphysics of composition and persistence, ranging from natural (constitutionalism) to radical (nihilism).

I have no disagreement with this overall strategy: theories do need to turn abstract at some point, move beyond common sense, and eventually force upon us interesting, novel, and often counterintuitive revisions in our overall conceptual scheme. This applies to all theoretical areas, and contemporary metaphysics is no exception. But while the latter is widely regarded as being quite extreme in this respect, I want to argue that, in one sense, it is not extreme enough. I do it by developing a new case of material coincidence that is initially motivated not by common sense but by physical considerations, and is not susceptible to any of the standard solutions.

One lesson of science is its ability to expand our imagination beyond the limits of common sense. This may have importance for metaphysics too.

1. Traditional Puzzles of Material Coincidence

Debates about material coincidence have a long and venerable history and tend to rely on common-sense intuitions. For example: no two things can occupy the same place at the same time; a part cannot be identical to the whole; things can survive the loss and addition of small parts; nothing can have incompatible properties at a single moment of time. But starting with these common-sense beliefs, the debates leave them behind rather early in the process, leading to highly problematic consequences. The next stage in the process involves revision of one or more initial assumptions in order to accommodate as many of the common-sense intuitions as possible. While some trade-offs are inevitable, our theoretical schemes must eventually remain anchored in common-sense beliefs.

This is how it always works in theoretical domains. We begin by accepting two or more individually plausible beliefs – for example, belief in free will and in determinism – without realizing that they are incompatible. Sometimes it takes quite a bit of theoretical work to put two and two together; but this is also what makes it so interesting and exciting. And when this finally happens we face a difficult choice: reject one of the initial beliefs, or refine them so as to make them compatible after all. Each of these options, in turn, leads to important theoretical developments.

Metaphysical debates about material coincidence are very similar. Suppose a potter takes a lump of clay ('Lump') at t_1 and shapes it into a vase ('Vase') at t_2. One may feel under some pressure to say that there are two distinct objects at t_2, Lump and Vase, which occupy exactly the same region of space and are composed of exactly the same matter. The pressure comes from the observation that Lump and Vase differ at t_2 in that the former, but not the latter, has the historical property *having existed at* t_1 and, therefore, Lump and Vase cannot be identical. Or consider Tibbles the cat who, as a result of some accident, loses its tail and Tib, a part of Tibbles including everything but the tail. Before the accident, Tibbles and Tib are distinct (a part cannot be the whole), so they must continue to be distinct even thereafter (two things cannot become one), thus producing

another famous example of coincident material entities. All along, we rely on the indubitable principles stated two paragraphs above. But when we put them together in a manner suggested in the scenarios, they clash, forcing us to reject or modify at least one of the initial common-sense assumptions.[1]

Doing exactly that has generated a major industry in contemporary analytic metaphysics and has been used to adjudicate many proposals in the ontology of composition and persistence ranging from natural to radical, and sometimes grouped[2] into two categories, *pluralist* and *monist*, depending on whether the existence of two (or more) coincident entities is embraced or resisted.[3] The most natural pluralist proposal is probably *constitutionalism*: acknowledge that Lump and Vase are distinct but fully coincident entities and try to eliminate or downplay the worry about their locational and mereological coincidence by saying that the former *constitutes* the latter without being identical to it.[4] The most radical proposal is *nihilism*: deny the existence of any composite objects, such as Lump, Vase, Tibbles, Tib, and Lumpl,[5] altogether ("no objects – no problem").[6] Other interesting proposals include mereological essentialism, the dominant kinds view, the rejection of the doctrine of arbitrary undetached parts, various relativizing

[1] For more details on how it happens in this case see a very helpful introduction to a volume of classical readings on material constitution (Rea 1997).

[2] Following Fine 2003.

[3] The literature on material coincidence is large. For a collection of earlier classical readings, see Rea 1997. For an illuminating survey and useful bibliography, see Wasserman 2017. Recent developments are also discussed in some detail in Paul 2010 and Sattig 2015: ch. 3.

[4] The constitution view has been defended, among others, by Wiggins 2001, Johnston 1992, Baker 2000, and Thomson 1998.

[5] Lumpl is a lump of clay created at t_1 in the shape of Goliath (say, by putting two pre-carved pieces of clay together) and destroyed at t_2 (Gibbard 1975). Lumpl and Goliath coexist over the same period of time and share all their historical, as well as momentary properties. In fact, they share all their non-modal properties, differing only in such properties as *possibly surviving flattening*. This makes the case different from Lump and Vase and raises additional problems for some popular solutions to the latter.

[6] For an earlier defense of mereological nihilism inspired by the "problem of the many," see Unger 1979.

approaches, four-dimensionalism (the doctrine of temporal parts), as well as more recent hylomorphic, bundle and constituent ontologies.[7]

It is instructive to highlight an interesting difference between the traditional puzzles of coincidence and various exotic cases that figure prominently in the metaphysical debates in close proximity. The latter include discussions of extended simples and gunk, objects with non-standard topology, sophisticated time travel scenarios, and proposals to cut the intuitive links between the mereological structure of material objects and the mereological structure of the regions of space or spacetime in which the former are located.[8] The combinatorial inspiration behind such cases tends to move the discussion beyond the boundaries of physical possibility, often landing one in uncharted waters. One may feel uncertain about the significance of such cases precisely for that reason. The putative cases of material coincidence, on the other hand, are quite different. They portray situations that are familiar, non-exotic, indeed highly realistic: cats, unfortunately, do lose tails, and potters create vases every day. The facts about them lie in plain view. The recherché part comes from the subsequent theorizing about such cases. Ordinary folk may be initially sensitive to the principle that no two things can occupy the same place at the same time ("Can I walk through a wall?") but "are taken by complete surprise when

[7] On mereological essentialism, see Chisholm 1976 and Van Cleve 1986. On the dominant kinds view, see Burke 1994. On the rejection of the doctrine of arbitrary undetached parts, see van Inwagen 1981. On four-dimensionalism, see Lewis 1983 and Sider 2001. On hylomorphic, bundle and constituent ontologies, see Fine 2008, Paul 2006, and Sattig 2015. Each of these views is motivated by separate considerations, and none was intended to deal exclusively with the coincidence puzzles. In the discussion below I abstract from the more recent developments and focus instead on the earlier approaches, as my primary concern is not to adjudicate among the many currently available solutions to the familiar puzzles but to emphasize the unique nature of the new puzzle developed in sections 2–5 and its resistance to any of the traditional approaches.

[8] For surveys of the debates on simples and gunk, see Hudson 2007 and Gilmore 2018. On extended simples, gunk, and objects with non-standard topology, see Hudson 2006 and Parsons 2007. On an interesting use of sophisticated time travel scenarios, see Gilmore 2007. On cutting the intuitive links between the mereological structure of objects and the mereological structure of regions in which they are located, see Saucedo 2011.

the principle is applied to an object and the matter that makes it up; that is clearly not the kind of case they had in the back of their minds when they wanted to accept the principle" (Hirsch 2008: 372). It is fair to say that the proverbial man in the street finds nothing problematic in the stories about Tib and Tibbles, and Lump and Vase, until he is brainwashed by the philosopher into being serious about non-categorical properties – the "various ways that a thing *was*, *will*, *would*, *could*, or *must* be" (Wasserman 2017, §1). One could argue that such features – temporal and historical properties, kind properties, persistence conditions, and other modal properties – are not robust enough to generate widespread ontological anxiety or conflict with Leibniz's Law. It is relatively easy to set them aside. Why should we worry about such allegedly incompatible pairs of properties as *will exist tomorrow* and *will not exist tomorrow* or *had a tail* and *did not have a tail* to the extent that we do about *being square* versus *being round*, *hot* versus *cold*, or *moving right* versus *moving left* (at the same time)? The worry, known as the "grounding problem,"[9] can be put as follows: what is the *current* (or *occurrent*) property of x in virtue of which x will not exist tomorrow?[10]

To a considerable extent, it is this decidedly bleak appearance of ungrounded, free-floating, non-categorical properties that makes them highly susceptible to vicarious treatment generously offered by the counterpart analyses of modal and temporal predication, and by various relativizing strategies.[11] Vicarious problems naturally call for, and may be adequately resolved by, vicarious treatment.

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[9] On the grounding problem see Bennett 2004.

[10] Should "the man in the street" be worried about apparently incompatible aesthetic properties such as *being defective* that could be attributed to Vase but denied to Lump (see Fine 2003)? For the most part I will set the aesthetic properties aside because the new case of coincidence I wish to develop involves only physical properties.

[11] According to the counterpart analysis of modality, Hubert Humphrey has the modal property of possibly winning the US presidential election in 1968 because of the full-blooded existence of someone else – his counterpart in a different possible world – who wins the election there. See Lewis 1971 and Sider 2001: Ch. 5. On the relativizing strategies, see Gibbard 1975, Noonan 1993, and King 2006.

Below I present a new case of material coincidence that is non-vicarious, robust, categorical, non-modal, non-relational, and striking. It is motivated by physical considerations and is not susceptible to any traditional solutions. Thus, in one sense, it is more disciplined than the traditional cases mentioned above – precisely because of its reliance on robust physical properties actually possessed by the objects to which they are attributed. But in another sense, it is more radical, in being not susceptible to any traditional solutions. Because of these features I call it *supercoincidence*. I will conclude, however, by raising some caveats about the case.

One underappreciated lesson of science is its ability to expand our theoretical imagination. This may be important for the metaphysics of material constitution; and for metaphysics more generally. It also raises interesting questions about the relationship among science, philosophy, and common sense. I discuss such questions at various junctures in the development of my case, by comparing and contrasting it with the traditional materials coincidence puzzles.

2. MultiLife

Consider MultiLife (see Fig. 1; the reason for the name will become clear shortly), an object composed of two oscillating point particles of equal mass, moving uniformly towards and away from each other in frame (x,t).[12]

[12] I learned of MultiLife (but not under this name) from Ian Gibson and Oliver Pooley (2006: 194, note 29). A useful way to think of MultiLife is to imagine the particles to be connected by a very light spring and the whole system to be floating freely in space. Note, however, that the springs should be specially designed to ensure the kind of motion depicted in a spacetime diagram in Fig. 2, where the straight boldface line segments represent portions of uniform motion. A normal spring would turn both boldface lines into sine curves – which is not what is intended here.

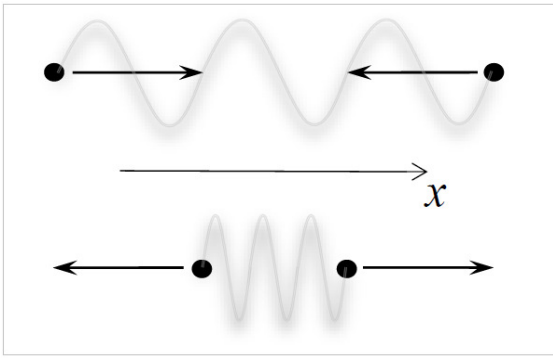

Figure 1. MultiLife.

Fig. 2 is a spacetime diagram of the situation. Which *line* in Minkowski spacetime[13] represents the history of MultiLife? The only physically meaningful candidate would be a line connecting the locations of MultiLife's *center of mass* at different moments of its career. More carefully, such a line must connect the locations of the center of mass of MultiLife determined in a series of reference frames in which MultiLife is "instantaneously at rest." In general, the instantaneous-center-of-mass trajectory of a composite object whose particles are in complex relative motion to each other in a relativistic setting will be rather convoluted, and the procedure for its calculation is far from trivial.[14] Here we can focus on a partial and simplified description of the case. It is obvious that the symmetry line of the whole diagram – the boldfaced vertical line L in Fig. 2 – is a good candidate for the trajectory of MultiLife (i.e. its instantaneous-center-of-mass trajectory). Indeed, MultiLife is instantaneously at rest at any moment in the reference frame (x,t); for example, at t_1, t_2, t_3, etc.

[13] I.e. special relativistic spacetime, which does not support the notion of absolute simultaneity and embodies, instead, an absolute metrical relation between events known as *the interval*, which imposes partial ordering on them.

[14] For a recent philosophically motivated discussion of such a procedure, see Balashov 2012.

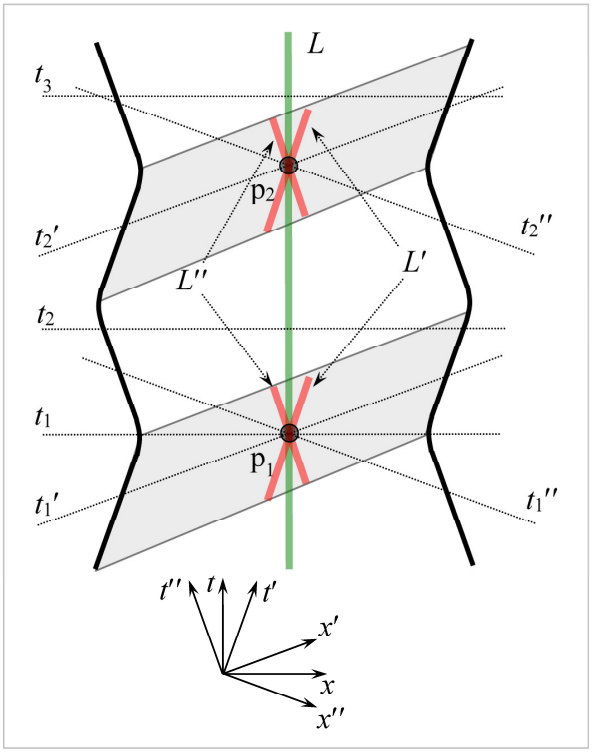

Figure 2. MultiLife is moving left, moving right, and staying at rest at p_1 and p_2. Consider, first, the reference frame (x,t). In this frame, the motion of the two particles is perfectly symmetrical (as in Fig. 1), so the central boldface line, representing the trajectory of the MultiLife's center of mass is "vertical": MultiLife remains at rest in this frame throughout the whole scenario. Consider, next, the reference frame (x',t'), which is co-moving with both particles over the stretches of time in this frame between the two "turning points" on the worldlines of MultiLife's constituents, shown as the shaded areas. A brief explanation is in order. In a typical Minkowski spacetime diagram, a pair of coordinate axes, such as (x',t'), may not look orthogonal to each other, even though they are, in a strict mathematical sense. This has to do with the need to represent non-Euclidean relations characteristic of relativistic spacetime in a Euclidean drawing, such as Fig. 2. In this diagram, moments of time in (x',t') are "at an angle" to moments of time in (x,t); think of such "cross-crossing" of time instants in different frames of reference as a geometrical image of the *relativity of simultaneity*. Now consider t_1', a moment of time in (x',t'). At that moment (focus on the

shaded rectangle), both particles are instantaneously at rest in (x',t'): their worldlines are parallel to the t' axis! Consequently, L' represents their common state of motion at p_1, according to (x',t'). Similarly, L'' in represents the common state of motion of the particles at the same point p_1, according to (x'',t''). The same analysis applies to p_2 and other similar points on MultiLife's trajectory.

Notice, however, that MultiLife is *also* periodically at rest in *two other* reference frames (x',t') and (x'',t'') co-moving with each of the particles and hence, moving relative to each other, and relative to (x,t). At t_1' and t_2', for example, both MultiLife's constituent particles are instantaneously at rest in (x',t') and, therefore, are moving with the same speed and in the same direction in (x,t). This happens over the stretches of time in (x',t') between the two "turning points" on the worldlines of MultiLife's constituents, shown as the shaded areas in Fig. 2. During such a stretch, MultiLife is at rest in (x',t') and, therefore, a line including "oblique" boldfaced fragments (such as L' in Fig. 2), along with some later and earlier fragments of the symmetry line, would also be a suitable candidate for the trajectory of MultiLife. For the same reason, a line including the oppositely oriented "oblique" fragments (such as L'' in Fig. 2), would also be a viable candidate.[15]

Charting a full trajectory of MultiLife comprising the oblique portions need not detract us at this point; we shall return to this task later. For now, we can focus on a simpler question: what is the instantaneous velocity of MultiLife at a single point p_1, which *definitely* belongs to its life career?[16] Is MultiLife moving "right," or "left," or staying at rest, at p_1? It seems that it is doing all three things. But a single object cannot be involved in three

[15] An even more striking two-particle case was briefly discussed by Maudlin (2002: 203–4). If the particles have suitably scaled hyperbolic trajectories in Minkowski spacetime then their center of mass at the common focal point of these trajectories is instantaneously at rest in *all* inertial frames of reference. Thanks to Gordon Belot for pointing me to this discussion.

[16] Because it belongs to all three different trajectories of MultiLife's center of mass, described above.

incompatible states of motion[17] at any moment of its career. Should we say that we are dealing here with *three* coincident objects (call them MovingRight, MovingLeft, and AtRest) composed of the same particles?

This result (which will be further developed in section 5) appears troubling. The trouble at this point may be summarized by saying that, on the face of it, MultiLife has three incompatible properties (i.e. instantaneous velocities) at p_1 that are: (i) robust, (ii) non-modal, and (iii) prima facie non-relational. This brings out a striking contrast between MultiLife and the traditional cases of alleged material coincidence. MultiLife's properties at p_1 – *moving left*, *moving right*, and *staying at rest* – are robust because they are not merely historical, "free-floating" or otherwise vicariously grounded properties. Instead they are respectable physical properties. They are non-modal for obvious reasons. And they are prima facie non-relational in the sense that the conflict between them cannot be easily resolved by relativizing them to different indices. The three mutually incompatible states of motion of MultiLife at p_1 are represented in a *single* reference frame (x,t) in Fig. 2. Perhaps one could say that they are relativized to the *same* index, that is, (x,t). This makes them as troubling as *tall for a basketball player* and *short for a basketball player* and very different from *tall for a philosopher* and *short for a basketball player*, or *being well made for a lump* and *not being well made for a vase*.[18]

[17] In the spirit of mechanics, here and below we treat the state of rest as a state of motion with zero velocity.

[18] The last two are modeled after paradigm aesthetic properties whose importance for the coincidence problems was emphasized by Kit Fine (2003). For further discussion, see King 2006 and Fine 2006. I hasten to note that the unsophisticated and unsuccessful relativization of the state of motion of MultiLife to reference frames mentioned in the text does not exhaust all the relativizing options available to those (i.e. the monists) who wish to deny coincidence in this case. I consider a more sophisticated and promising (but still unsuccessful) strategy in section 4.

3. Some Details

Let us pause and reflect on several important aspects of the MultiLife case. The problem with it arose essentially from our desire to draw a spacetime trajectory of a simple composite object taken as a whole. We know everything there is to know about the motion of the object's constituent particles over their lifetime (let us assume). We want to know what the whole object does at various moments of its lifetime. Surprisingly, there is no unique answer to this question, because more than one spacetime trajectory is eligible to represent the career of our composite system in spacetime. This result is grounded in rather peculiar properties of relativistic spacetime. The remarks below are intended to put the result in sharper focus and highlight the factors primarily responsible for it.

In classical physics, the trajectory of a composite system is determined by following its center of mass. This is a straightforward task, for the location of the center of mass at any moment of time is determined by the locations of the system's smallest parts at that time via a simple formula.[19] But in special relativity, there is no such notion as "a moment of time"; there are only moments of time in particular frames of reference. What frame should be used in calculating an instantaneous location of the center of mass? Presumably, the *instantaneous rest frame* of the whole body. But to know in which frame the body is "instantaneously at rest" when its constituent particles move relative to each other in complicated ways, one apparently needs to know what trajectory in spacetime represents the motion of the "body as a whole,"[20] and it is unclear that this could be known without knowing the trajectory of the composite body's center of mass. We seem to be in a circle. To make things worse, one cannot simply assume, as is done in classical mechanics, that the frame in which the whole

[19] If the system's smallest parts are discrete masses the radius vector of the center of mass $\mathbf{r}$ at any given time is simply the weighted sum of the radius vectors of the components: $\mathbf{r} = \sum m_i \mathbf{r}_i \,/\, \sum m_i$.

[20] Then the instantaneous frame of the whole body would be defined by the tangent to this trajectory at a given point.

body is at rest automatically coincides with the frame in which the total momentum of the body is zero.[21]

Can the circle be broken in a principled and physically motivated way? Yes. The basic idea in the idealized case of an object such as MultiLife, composed of n non-interacting particles, is to chart the trajectory of the whole object by connecting the locations of its center of mass determined in instantaneous frames in which the total relativistic momentum is zero, and then translate the result to an arbitrary frame by a Lorentz transformation. The circle could thus be broken by identifying an instantaneous zero-momentum frame first. This way of doing it is motivated by the physical significance of zero total momentum frames and their uncontested eligibility to serve as instantaneous rest frames of composite bodies.[22]

But as Fig. 2 clearly shows, a procedure of this sort may fail to yield a unique trajectory of the body. The vertical boldfaced line *as well as* both oblique lines, all intersecting at p_1 and p_2, are equally eligible to represent fragments of such trajectories. Hence a problem.[23]

Confronted with this problem one might attempt to dismiss it as follows. What is the big deal about the state of motion of MultiLife represented by the trajectory of its center of mass? And what does it have to do with material coincidence anyway? The traditional coincidence puzzles originate in, and get their bite from, not only the sameness of matter but the alleged *colocation* of two objects: their exact location at the same region of space or

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[21] See, in this connection, Pryce 1948, who mentions *six* different methods for defining the center of mass of a system of free particles in special relativity.

[22] For details of this procedure, see Balashov 2012. This procedure is similar to Pryce's "proposal (d)" (1948: 63 and §3) developed in a much more technical environment of his article. More recent articles refer to Pryce's "proposal (d)" as the prescription for calculating the location of the "covariant noncanonical Fokker-Pryce center of inertia." See, in this connection, Alba, Lusanna and Pauri (2002), Alba, Crater and Lusanna (2007), Lusanna (2013), and references therein.

[23] The problem is *not* the existence of three different *reference frames* – (x,t), (x',t'), and (x'',t''). The real problem is the existence of three intersecting *boldfaced lines* representing the intuitively incompatible states of motion of a single object *in any chosen frame*. I thank the referee for pressing me to highlight this important difference. I revisit this point in section 4.

spacetime. We wonder, for example, how Lump and Vase can have incompatible (historical or modal) properties *at* their common location. There appears to be no similar worry about MultiLife, where the alleged incompatible properties (viz. *moving right* vs. *staying at rest*) seem to be attributed not to the "real stuff" (i.e. the scattered quantity of matter) of which MultiLife is composed, but to an empty point of spacetime representing its center of mass. This empty point simply does not deserve the title of a *location* of MultiLife, in difference from the Lump and Vase case, where a particular matter-filled region of space is a bona fide location of both objects (if there are two) or a single object (if there is only one). If asked to identify a location of MultiLife one could perhaps refer to a pair of separated matter-filled points, but not to an empty point. Since the incompatible instantaneous velocities are attributed to the latter, but the object is actually located at the former, there is no problem of *co*location and hence no puzzle of material coincidence. Indeed, one could make an excellent *tu quoque* retort to an earlier note about the "vicarious" or "merely relational" nature of the allegedly non-categorical and ungrounded historical and modal properties doing the heavy lifting in the traditional puzzles. The kinematic properties of the center of mass, which do the heavy lifting in the MultiLife case are, if anything, worse and should not be taken seriously.

My response to this, developed below, is that the kinematic properties – such as *moving right* and *staying at rest* – *are* the *real properties* of the composite object(s) in question,[24] and that they *should* be taken seriously. Although such properties are best *represented* by assigning velocities to the objects' centers of mass, the properties so represented are the *actual* properties of the composite material objects located at the corresponding matter-filled regions, and not the properties of empty spacetime points. And they should be taken seriously because they play important roles in physics.

Take the classical laws of motion. Their application to objects consisting of several massive parts crucially involves the notion of the *center of force* (which, of course, is none other than the center of mass) whose kinematics

[24] I.e. of MultiLife, if one denies material coincidence, or of MovingRight and AtRest, if one allows coincidence.

and dynamics embody important physical properties of an object as a whole; for example, acceleration arising in response to a net external force. It is with respect to the *center of balance* (which, again, is none other than the center of mass) that the *rotation* of a body in a complex state of motion is best described in terms of angular momentum, torque and other such parameters. Any textbook in mechanics is filled with problems featuring multiple bodies on inclined and rotating planes, arms, levers and beams, connected by ropes, springs and other links restricting their degrees of freedom in various ways and often requiring the application of Newton's second law, or the conservation of momentum law, to the connected system as a whole, which, in turn, requires the identification of the center of mass of the entire connected system, and also requires working in its rest frame. Indeed, for any realistic object larger than an idealized material point, the '$\mathbf{F}$' of the '$\mathbf{F}=m\mathbf{a}$' refers to the net force acting on the object's center of mass, and the '$\mathbf{a}$' to the latter's acceleration. The same holds true, *mutatis mutandis*, for relativistic mechanics. The concept of the center of mass is central and indispensable to physics. With such credentials, denying it a robust metaphysical status would be inappropriate.[25]

And this status is also needed for other theoretical purposes. If we want to be able to talk meaningfully about composite objects' persistence over time we need a way of tracking their momentary *locations* – the 3D slices of the objects' paths in spacetime. And the only way to track them is to have a spacetime trajectory representing the composite object's career. If we want to *label* such locations – for example, by the *age* of the object – we need the notion of *proper time* for the whole object; and it is not possible to define it without drawing the object's worldline in spacetime.[26] The center of mass

[25] To be sure, not everything that plays an important role in physics is real. For example, the ether and phlogiston, which played important roles in the development of classical electrodynamics and thermodynamics respectively, are not real. This raises a host of hotly contested issues, which are beyond the scope of my discussion here. I will say this much: the metaphysical status of the central concepts of mechanics, such as mass and force, is much more secure than the status of the ether and phlogiston was in their heyday.

[26] See Balashov 2012 for a recent discussion of these issues.

trajectory is the best, indeed the only notion capable of playing these important roles.

Going back to MultiLife, it is, of course, a very simple object consisting of just two particles. One might think it is too "thin" to deserve so much attention. But other more complex symmetric configurations,[27] shown in Fig. 3, generate similar results.

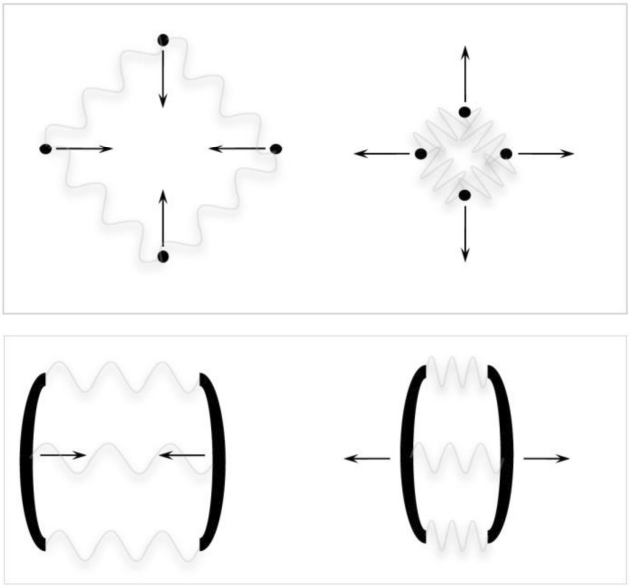

Figure 3. MultiLife variations.

For simplicity, I continue focusing on MultiLife in the sequel.

4. Implications

MultiLife is not easily amenable to any of the traditional non-radical treatments of alleged material coincidence.[28]

[27] Possibly connected by light springs and floating freely in space.

[28] The discussion below is not intended to favor any of the traditional treatments of material coincidence.

Let us begin by setting aside mereological essentialism and the dominant kinds view. These remedies are ineffective because the case of MultiLife does not involve mereological change or kind change.

Consider constitutionalism. The constitutionalist has two options. She could say that there are three objects in the situation – MovingRight, MovingLeft, and AtRest, which are, respectively, moving right, moving left, and staying at rest at p_1. The constitutionalist could insist that one of them constitutes another without being identical to it. But it seems grossly implausible to suggest that something that is moving left or staying at rest can in any way constitute anything moving right. The instantaneous properties of the constitution base and constitution product cannot be so drastically incompatible. The situation here is very different from the sorts of situations that are used by constitutionalists in their support, where the relevant properties of a complex aggregate of matter make it highly eligible to constitute a certain vase, or an animal, or a human person. MovingRight or AtRest, in contrast, are simply ineligible to constitute MovingLeft.

But there is a better constitutionalist response. Let us return to Fig. 2. Intuitively, MultiLife is staying at rest at p_1 *because of* what its constituent particles are doing at t_1; for it is their states of rest at t_1 that are relevant to calculating the instantaneous velocity (i.e. zero) of MultiLife's center of mass at p_1. Similarly, we are led to conclude that MultiLife is moving to the right at p_1 when we focus on what its particles are doing at t_1': both are moving to the right at that moment (look again at the shaded portion of the diagram in Fig. 2). Similarly for moving to the left. Depending on what portions of the constituent particles' trajectories we focus on, we attribute different velocities to MultiLife at p_1. And we focus on different portions of those trajectories because they are cut out by different time hyperplanes in different frames of reference.

This suggests that the constitutionalist should concentrate not on the relation between MovingLeft and AtRest but on the relation between each of the three composite objects and their common *constituent matter* – the two particles, considered at various times in various frames. The constitutionalist could say that the particles *constitute* AtRest at t_1, that the very same particles *constitute* MovingRight at t_1', and also *constitute*

MovingLeft at t_1''. All three composite objects are constituted by the same matter at different times in different frames, and it is those relations of constitution that account for what the three composite objects are doing at the respective times-in-frames.

This is different from what most constitutionalists normally say when dealing with the traditional puzzles of material coincidence. Most of them do not say that the same matter constitutes *both* Lump and Vase; instead they say that Lump constitutes Vase. But some authors do emphasize the availability of *three* entities involved in the situation – Lump, Vase, *and* their common underlying matter – and the need to keep track of them in resolving the puzzles.[29] Far from being implausible then, the above proposal – to say that three differently moving objects are constituted by their common underlying matter at different times-in-frames, without being identical to the matter – looks very reasonable.

But when the case is looked upon this way it becomes clear that one need not be a constitutionalist to avail herself of this obvious relativizing strategy. All one needs to do is relativize *composition* to times-in-frames. One could say that the two particles *compose* AtRest at t_1, MovingRight at t_1', and MovingLeft at t_1''. There is no need to wheel in constitution. And the motivation for relativizing composition to times-in-frames is quite straightforward. In the classical setting, we routinely relativize composition to different moments of absolute time, common to all frames; we say, for example, that certain particles compose Vase at one time and the bust of Napoleon at another. Special relativity brings new and unexpected features to the situation: times are no longer common to frames, and time hyperplanes corresponding to different frames may crisscross, as t_1, t_1', and t_1'' do in Fig. 2. Having appreciated the significance of these new features we may feel the need to adjust our relativization schemes accordingly. And they provide the pluralist with a desired and perhaps non-puzzling strategy in the case of MultiLife.

[29] E.g., Gibbard (1975: 188–189) is careful to distinguish among a *portion* of clay (which may continue to exist when scattered), the *lump* of clay (which cannot survive breaking into pieces), and the *statue*.

Could the monist avail oneself of a similar relativization strategy? The monist must deny the existence of three objects in the situation; instead he should say that a single object has three *compatible* properties relativized to different indices. Could he put this by saying that MultiLife is moving to the left *qua MovingLeft* but not *qua MovingRight*, and then point out that the velocity properties expressed by such sort-relative predicates are not incompatible? For this proposal to work in a way it is expected to work in other cases of material coincidence,[30] *MovingLeft* and *MovingRight* must delineate separate kinds in the way *lump*, *vase*, *animal* and *human person* do. But there is every reason to think that if *MovingLeft*, *MovingRight* (and *AtRest*) demarcate any physically interesting kinds at all, they demarcate the *same* kind of *uniformly moving* object. So, relativizing velocity properties to kinds of moving objects will not help.

But relativization to kinds is not the only available option. Indeed, it may be just as ill-conceived as imposing on the constitutionalist an implausible view (briefly considered and rejected above) that MovingLeft may constitute AtRest. And just as the constitutionalist could, in principle, relativize constitution to times-in-frames,[31] the monist could make similar use of relativizing the *state of motion* of a *single object* (i.e. MultiLife) at an otherwise eligible point to reference frames. In our case this yields an apparently unproblematic verdict that MultiLife at p_1 is at rest *relative to* (x,t), moving right *relative to* (x',t'), and moving left *relative to* (x'',t'').

However, things are not as simple as they might appear. The first point to note is that the procedure underlying the current approach is very different from, and much more complicated than, a trivial relativization of velocities to frames of reference.

The latter is involved in saying, for example, that a car is moving straight ahead according to one observer, moving left according to another, and moving right according to yet another observer. One could well imagine

[30] See, e.g., Noonan 1993 who invokes an "Abelardian" approach, on which the properties expressed by certain predicates vary according to how the subject is conceptualized.

[31] Even if this gives her no advantage over the foe of constitution who is free to relativize composition to times-in-frames; see above.

this sort of situation when approaching a road intersection. Similarly, MovingRight (let us assume, for a moment, that there is such a distinct object) can be said to be moving to the right at p_1 in reference frame (x,t), but to be at rest at the same point in frame (x',t'). Fig. 2, showing a single fragment of the boldfaced line L' at different angles at p_1 in two different frames, provides a good illustration of this trivial relativity of motion known from elementary physics and common sense.

In contrast, the other – peculiar and non-trivial – relativization recipe suggested as a monist treatment for the MultiLife case requires us to consider not one, but *all three* boldfaced lines, L, L', and L'', which intersect at p_1 and represent three incompatible states of motion of MultiLife at that point. We want to say that all three intersecting lines represent actual states of motion of MultiLife at p_1; but we now want to relativize them to three different reference frames. In other words, we want to say that, at p_1, MultiLife is: (i) at rest *in* (x,t) *relative to* (x,t), (ii) moving right *in* (x,t) *relative to* (x',t'), and (iii) moving left *in* (x,t) *relative to* (x'',t''). That would be similar so saying that the very same car is moving straight ahead according to a given observer, but also moving to the left (and moving to the right) at the very same point, *according to the very same observer*.

The second point to note is that the frames of reference to which the state of motion of MultiLife at p_1 is thus relativized – i.e. (x,t), (x',t'), and (x'',t'') – are not chosen arbitrarily by us (as is done in illustrations of the trivial relativity of velocity) but are *determined* by the actual kinematic histories of the constituents of MultiLife according to a somewhat complicated procedure for identifying the latter's instantaneous rest frames.[32] Fig. 2 suggests that this procedure fails to yield a unique trajectory of MultiLife at p_1; that is why we end up having three intersecting boldfaced lines at this point. The lines, in turn, determine three instantaneous rest frames (i.e. (x,t), (x',t'), and (x'',t'')), to which the instantaneous state of motion of MultiLife at p_1 is then relativized.

The overall result may be summarized as follows: *given* the full trajectories (and nothing else) of the constituents of MultiLife in relativistic

[32] As described in Balashov 2012.

spacetime, three intersecting lines turn out to be equally *eligible* to represent the state of motion of this composite object at their common point of intersection (to repeat: in a *single* frame of reference). In an important sense, the orientation of these three lines (in any single frame of reference) *supervenes* on the kinematic histories of the constituent particles and is *intrinsic* to the composite system.

But it is the orientation of a particular boldfaced line at p_1 that itself determines a corresponding instantaneous rest frame which serves as a *relatum* in the suggested relativization strategy. In fact, such a reference frame could be strictly *defined* in terms of the tangent to the respective boldfaced line at p_1. The net result of the relativizing approach currently under discussion is then somewhat as follows: given the actual motion of MultiLife's constituent particles (and nothing else), the instantaneous state of motion of MultiLife at p_1 is represented by line L relative to L, by line L' relative to L', and by line L'' relative to L''. In other words, MultiLife at p_1 is staying at rest according to L, is moving to the right according to L', and moving to the left according to L''. This may be what it is in fact doing. But the real worry is *how* it manages to do all three things. I am not sure *this* worry is fully addressed by the relativization strategy developed above. Although the whole *triple* of the intersecting lines supervenes on (is wholly determined by) the kinematic histories of MultiLife's constituent particles, it remains troubling to realize that the whole composite object is doing three things at once: moving right, left, and staying at rest. And it does not immediately help to be told that it is moving right relative to the intrinsically determined direction representing its motion to the right, and is staying at rest relative to another intrinsically determined direction representing its state of rest.

I think it is fair to say that common sense, even when extended by traditional metaphysical theorizing, is simply blind to such a possibility. Again, drawing a contrast with the relativization approaches typically deployed to resolve ordinary cases of material coincidence may be helpful here. One could maintain that there is a single material object o at t_2, variously referred to as 'Lump' and 'Vase', which survives flattening *qua Lump* but not *qua Vase*, is valuable or beautiful *qua Vase* but not *qua*

Lump, and so forth.[33] This monistic resolution of the Lump/Vase quandary may or may not be eventually acceptable,[34] but here the allegedly conflicting historical, modal or aesthetic properties are relativized to different kinds grounded, at least in part, in the extrinsic relations *o* bears to other members of the corresponding kinds, to various communities or social conventions, and so on. Quite apart from the contrast[35] between the controversial status of the historical, modal or aesthetic properties involved in such cases and the robust physical properties at work in the MultiLife case, the items responsible for relativizing away the allegedly incompatible properties in the Lump/Vase case (e.g. future histories, possible histories, or social communities) do not emerge from the structure of the composite object in question (i.e. *o*) in a way they do in the MultiLife case; instead they must be brought from without. In other words, they are extrinsic not intrinsic.

In these two respects – the non-categorical nature of the apparently conflicting properties and the extrinsic nature of the relata invoked to explain away the apparent conflict – other popular cases of material coincidence are no different from the Lump/Vase scenario. A curious case that may bear more resemblance to the MultiLife situation was mentioned by Simons (1987: 113–114) and developed by Varzi (2008: §6.2). Consider two English words, 'fallout' and 'outfall', made up of the same letters arranged in a circle. This circular inscription can be read as two different words depending on where one starts. For that matter, consider the famous rabbit/duck drawing, or the letter 'p' drawn on a glass door. The letter could also be taken to read 'q' or 'b' or 'd' instead, depending on the direction from which one looks at it (see Varzi, ibid.). In these examples, a natural inclination is to deny any puzzling coincidence (of two words or pictures, of four letters) and to assert that there is just one inscription, or a single line drawing, which is read differently from different perspectives, or

[33] Proposals along these lines have been developed, among others, by Gibbard 1975, Noonan 1993, and King 2006.

[34] See, in this connection, Fine's (2006) response to King 2006.

[35] Noted in sections 1 and 2 above.

from different gestalt states of perception. The respect in which these examples are closer to the MultiLife case and different from the standard coincidence cases has to do with the more straightforward nature of the apparently incompatible features of the mereologically and locationally coincident entities: the difference between 'fallout' and 'outfall', and between the rabbit and the duck, stares us in the face. But the extrinsic nature of the relata called upon to resolve the apparent puzzles in the inscription and drawing cases is even more pronounced than in the Lump/Vase case and their likes: visual perspectives and gestalt states of perception are clearly external to the inscriptions and drawings, and are grounded in factors (psychology of perception, evolutionary history, language learning) that have nothing to do with the internal structure of the coincident entities in question. As noted above, in the MultiLife case the relevant perspectives are, on the contrary, determined by the physical history of the constituents, and the resulting "lines of internal relativization" (to different instantaneous rest frames) are drawn by nature itself. In other words, the three apparently incompatible states of motion are handed to us by the physical world and are not simply brought by different ways of "reading" the situation, as in the 'fallout'/'outfall' or rabbit/duck cases.

Despite these differences, it would be wrong not to emphasize one special aspect of the MultiLife case that could make the relativizing approach attractive, at least initially. It may be true that the three relevant perspectives on the motion of MultiLife emerge "from within" – from the kinematic history of its constituent particles. But once the perspectives have emerged, in the manner depicted in Fig. 2, it becomes clear that the three apparently incompatible *local* states of motion of MultiLife (represented by the intersection of the three boldfaced lines at p_1) are determined by what its constituents do at three *different stages* of their histories, cut out by the crisscrossing time hyperplanes: t_1, t_1', and t_1''. These hyperplanes may be drawn through p_1 "by nature" (i.e. solely determined by the trajectories of the constituent particles and not by any extrinsic factors). But this does not detract from the fact that the three allegedly incompatible states of motion of MultiLife at a certain *single* moment of its career are fully grounded in

what its constituents do at *different* moments of their careers. If so, then relativizing MultiLife's state of motion to such different "doings" might not seem so implausible after all.

On the other hand, this non-local[36] determination of a local state of motion of MultiLife makes the approach which turns on relativizing this state itself inferior to relativizing composition or constitution, considered above on behalf of the pluralist. The point could be supported by putting it in terms of temporal parts. Suppose the three pairs of sections of the trajectories of MultiLife's constituent particles, cut out by t_1, t_1', and t_1'', represent, not just three different stages of motion of these particles, but the states of motion of numerically distinct *entities.* This would considerably enhance the plausibility of relativizing composition (or constitution). It seems rather natural to say that one pair of temporal parts of the two particles compose AtRest, while another, numerically distinct pair of their temporal parts compose MovingRight. In a familiar derivative sense, central to the doctrine of temporal parts, the particles themselves (i.e. the long temporally extended things) could then be said to compose AtRest at t_1, in virtue of having the corresponding temporal parts, and to compose MovingRight at t_1', in virtue of having different temporal parts. It seems much less natural to say that the particles compose just one thing whose states of motion at various times-in-frames must be relativized to complicated items eventually emerging from the extended stretches of the histories of the particles.

To sum up the discussion so far, MultiLife seems to have three incompatible local states of motion at select points of its history. The best pluralist response to a potential coincidence worry is to relativize instantaneous composition to times-in-frames, and thus to different stages (or temporal parts) of the constituent particles. The best monist response (which seems inferior to the pluralist's) is to relativize in a similar way the instantaneous state of motion of a single composite object.

[36] But still *internal* to the composite system; see above.

These treatments may be adequate for the initial problem about the local states of motion of MultiLife at several discrete points of its history. But there is more to the case.

5. Calm and Hectic Lives

We began by raising this question: what is MultiLife doing at a single point p_1, which belongs to its life career? We noted that, on the face of it, it is doing three incompatible things there: moving right, moving left, and staying at rest (see Fig. 2 reproduced below as Fig. 4, with some simplifications). We concluded that this raises a prima facie coincidence problem, to which the pluralist could respond by relativizing instantaneous composition (or constitution) of a composite object to several *different* stretches of the trajectories of its constituent particles (or to their temporal parts). The monist could respond, less plausibly, by relativizing in the same way the instantaneous state of motion of a single object.

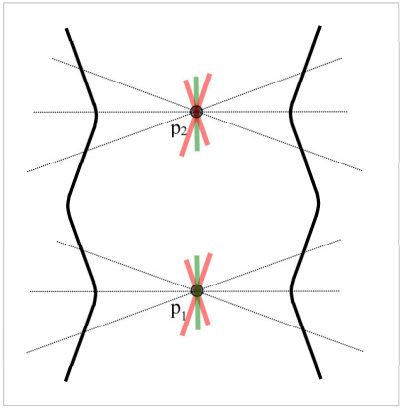

Figure 4. MultiLife is moving left, moving right, and staying at rest at p_1 and p_2.

But eventually we must confront a more intriguing question: what is MultiLife doing *throughout its entire life*? To address this question, we need to connect the stretches of the boldfaced lines intersecting at p_1, p_2, and so

on, to obtain complete continuous trajectories representing MultiLife's total history. One such trajectory is the symmetry line of the whole diagram (Fig. 5a). Other trajectories will include one or more "oblique" boldfaced fragments at p_1, p_2, and so on, continuously merging with the symmetry line (Figs. 5b and 5c). Each continuous selection of vertical and oblique fragments will constitute a possible total history of MultiLife.[37] Every such history is determined by the total histories of MultiLife's constituent particles; just not uniquely.

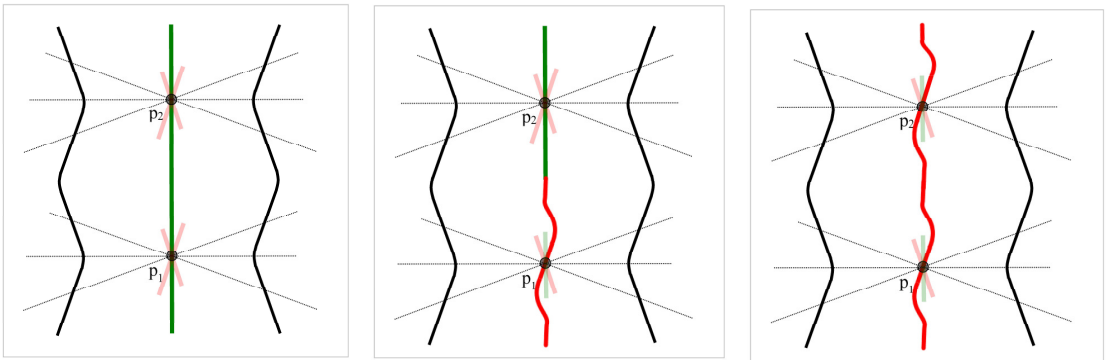

Figure 5. (a) Calm life. (b) and (c) Hectic lives.

The pluralist could try to summarize the situation by saying that we are dealing here with multiple (infinitely many!) composite objects completely coinciding throughout their entire histories, one of them living a very calm life, the others more or less hectic lives. It is not immediately clear what the monist could say. So let us focus on the pluralist options first. They are not very many, and none of them seems very promising.

Contrast the "global question" (about entire lives) with the earlier "local question" about the state of motion at a single time. The pluralist response to the local question turned on relativizing instantaneous composition or constitution to different times-in-frames. In other words, it turned on relativizing what happens at one point to what happens at more than one

[37] Although the diagrams in Fig. 5 are rather crude sketches and not exact calculations they are intended to be faithful to the essential features of the case.

point. Now that the question is about *entire histories*, this relativizing strategy is unavailable.

Intuitively, the total history of a composite object must be determined by (supervene on) the histories of its parts and the total history of their relations to each other. But in this case, it simply is not (does not). The parts do what they do throughout the lifetime. But there seems to be no fact of the matter about what the whole does throughout its lifetime.

Again, it is useful to compare and contrast the situation with other coincidence puzzles. At this juncture, a good contrast case is that of Lumpl.[38] Lumpl and Goliath are composed of the very same particles throughout their lifetimes. The total physical histories of both composite objects are fully determined by the physical histories of their constituent matter; we know what Lumpl and Goliath are doing: just sitting there, in the sculptor's studio. Arguably, their modal properties are not so determined. They could be taken to be ungrounded primitives, or grounded in multiple *de re* representations, such as possibilia, or in different ways of conceptualizing a single object.[39] This may give the pluralist the requisite resources to distinguish Lumpl and Goliath, and to the monist the resources to resolve the apparent incompatibility of their modal profiles. But one may simply dig in one's heels and refuse to grant a robust status to the non-categorical modal properties in the first place (see section 1). One cannot do so in the MultiLife case. Physical states of motion underwriting the many histories of MultiLife are categorical, non-modal, and robust. This makes the case insusceptible to any of the traditional remedies.

One might feel that the potential of the relativizing strategies is not yet exhausted. Couldn't the diehard pluralist relativizer say that the particles, considered *throughout their histories*, compose (or constitute, if one prefers) CalmLife *relative to a particular sequence of times-in-frames* associated with the vertical boldfaced line in Fig. 5a, and that the very same particles compose a certain HecticLife (one of the infinitely many) *relative to another*

[38] See Gibbard 1975 and note 5.

[39] These strategies have been developed, in rather different ways, by Lewis 1971, Gibbard 1975, Noonan 1993, and Paul 2006.

such sequence associated with one of the zigzagging boldfaced lines (Figs. 5b and 5c)? For that matter, couldn't the diehard monist relativizer say that the particles considered throughout their histories compose a single object, MultiLife, which has one total physical history relative to a corresponding sequence of times-in-frames, and many other histories associated with other such sequences?

Perhaps they could say this. (What else could they say?) But what is "a particular sequence of times-in-frames," which is required to do the heavy lifting in such relativizing strategies? In essence, it is just a sequence of time hyperplanes through the consecutive points on a chosen boldfaced trajectory, drawn at each point orthogonally to the tangent of the trajectory. Any such sequence of hyperplanes is fully determined (in a strict mathematical sense) by the corresponding boldfaced line, and vice versa (modulo parallel transport). The net result of this relativizing approach for the pluralist is then as follows: throughout their total histories, the particles compose (or constitute) the history of CalmLife relative to the history of CalmLife, and they compose the history of a given HecticLife relative to that history, and so forth. The corresponding net result for the monist is this: MultiLife leads a calm life relative to the calm life history (i.e. the vertical line), and it also leads multiple hectic lives relative to the corresponding hectic life histories. This may be what it is in fact doing. But apart from being dangerously close to circular,[40] the above relativizing proposal does not get at the real worry about the case: *how* do the particles taken together manage to do *all these things* at once? Why does the system have these multiple equally eligible histories in the first place? The many boldfaced lines keep staring us in the face even after the relativization.

This leaves us with an option of saying that *nothing* lives any of these drastically different lives, calm or hectic. There are just two particles doing what they do. This amounts to denying metaphysical significance to the boldfaced lines in Figs. 2, 4 and 5.[41] Maybe they do not represent the

[40] Where the circle is very small: the relata (i.e. entire histories) to which the relevant properties are relativized are identical with the properties themselves (i.e. entire histories).

[41] See section 3 above for the physical considerations against such denial.

trajectories of *anything*. Perhaps this is the most reasonable thing to say, in the circumstances. But this is, of course, just good old nihilism.[42]

6. Conclusion

I conclude tentatively that the case of MultiLife is curious and resistant to the standard non-radical treatments of material coincidence.[43]

And to return to the point made at the beginning: we do not encounter anything similar of MultiLife in our ordinary reflections on material coincidence. Common sense, even when extended with the traditional metaphysical tools, seems to be blind to the sheer possibility of MultiLife. It is the physics of the case that opens a rather unexpected dimension in logical space. Consider this contrast: we often say of someone that she has lived many different lives at once: the life of a teacher as well as that of a student; the life of a giver and the life of a taker. One can also be said to have lived both a good and a bad life. But one cannot be said to have spent her entire life in Europe, and also in frequent trips between the Old and the New Worlds. Reconciling this new possibility with common sense may

[42] Some of the referee's comments suggest to me that a version of the problem would arise even if nihilism were true. Even the nihilist would have to say that the particles perform, collectively, three incompatible activities throughout their lifetime.

[43] The qualification is due to residual uncertainty about the status of the simple diagrams such as Figs. 2 and 4, and of the procedure for calculating the trajectories of discrete composite systems from the trajectories of their constituent particles, described in Balashov 2012. Both are rather sketchy, involve various idealizations, and their relation to each other is not so clear. When fully developed, the procedure may establish the existence of an instantaneous center of mass trajectory. But the case of MultiLife also hinges on the non-uniqueness of such a trajectory, which cannot be established by the simple procedure. It is strongly suggested by the physical description of the case in section 2, and by Figs. 2 and 4. But the description and the figures may mask further details. The case may eventually be decided by physics ("empirical metaphysics" at work?). But its very possibility would remain striking even then. Interestingly, the notion of the center of mass of composite bodies in special and general relativity has rarely been discussed by physicists (cf. Pryce 1948). See, however, Alba, Lusanna and Pauri (2002), Alba, Crater and Lusanna (2007), Lusanna (2013) for recent discussions and further references.

require a more drastic revision in our overall conceptual scheme than those that have been forced upon us by the traditional puzzles of material coincidence.[44]

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