Relativistic Persistence*

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1 Introduction

The persistence of ordinary objects is now a staple topic of contemporary metaphysics. Given the interest and industry that the debate has attracted, it is surprising that (contemporary) philosophers have only recently considered in earnest the impact of relativistic physics on the metaphysics of persistence.[1] As we will see, this omission is now well on course to being rectified.

We have two aims in this paper. The first is to provide the reader with a critical guide to this recent work. Much of it investigates whether *endurantism* can be sustained in the context of relativity. Several arguments have been advanced that aim to show that it cannot. We find these unpersuasive, and will add our own criticisms to those we review. Our second aim, which complements the first, is to demarcate the most defensible form of relativistic endurantism (and similarly, of perdurantism). A recurring theme of this paper is that even those philosophers who do worry about relativity have not taken it seriously enough. (Cody Gilmore and, to some extent, Yuri Balashov are exceptions to this general rule.)

Before turning to these two main tasks, we address a worry that we think some will have concerning the legitimacy of the project of articulating a relativistically acceptable version of endurance.

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[1]Yuri Balashov deserves most credit for placing the topic of persistence in relativity on the agenda. For earlier discussions, see Quine (1960, 172), and Smart (1972).

In most contemporary discussions, the perdurance–endurance debate is firmly rooted in a classical (i.e. non-relativistic) world-view. Philosophers who are wary of metaphysical speculation that fails to take science seriously are likely to take a dim view of much of the contemporary debate. But equally they might judge the project of reconstructing relativistic versions of familiar non-relativistic doctrines to be horribly misguided. Should we not start with the relativistic world picture and ask, in that setting and without reference to non-relativistic notions, how things persist? We have a lot of sympathy for such views, but nonetheless think that it is worthwhile to engage with attempts to square the familiar doctrines with relativity. In the case of perdurantism the project is straightforward (although, as we shall see, the right things have not always been said). As for endurantism, consideration of a relativistic version is worthwhile for at least two reasons.

First, the published arguments recently offered against relativistic endurantism do not succeed and it is worth putting on record the true reasons why they fail.

Second, and more significantly, there is at least a *prima facie* tension between the perdurantist account of persisting objects and our experience of such objects. Our basic experiential grasp of the persistence of objects involves the direct perception of persistence in single, temporally extended experiences. It is a commonplace in philosophical discussions of perception that we directly perceive motion, e.g., the motion round the dial of the second hand of a watch. But such perceptions are also direct perceptions of *persistence*; i.e., of the self-same object (the second hand) existing at more than one time. The tension with perdurance consists in the fact that experience does not present this phenomenon as involving numerically distinct temporal parts of the second hand located at different 'times'.[2] This should be clear when one contrasts the phenomenology of the experience of persistence with the way in which experience presents a *spatially* extended object, even one that is perceptually homogeneous, as having numerically distinct spatial parts at different places. To be spatially extended *just is* to have numerically distinct parts at distinct locations; or, at least, that is what experience suggests. A further, perhaps more interesting, contrast is with our auditory perception of words. We hear spoken words as temporally extended, and do so in virtue of hearing their numerically distinct constitutive phonemes as located at different times. It follows that, despite relativity in some sense clearly favoring perdurance, it is worth asking whether there is not some alternative way of conceptualizing persistence that is compatible with relativity *and* does better justice to our experience.[3]

[2]Which is not to say that experience presents this phenomenon as *not* involving numerically distinct temporal parts. This may also be true, but we do not wish to commit ourselves to such a claim here. Thanks to John Hawthorne for pressing this point.

[3]This need not be a version of endurantism, as that is understood in this paper. See Simons (2000) for a non-perdurantist account of the persistence of ordinary objects that might nonetheless be compatible with an ontology that is perdurantist at a more fundamental level.

In what follows we show how familiar notions of perdurance and endurance should be transformed in the light of relativity, and how relativistic endurantism withstands recent criticisms. Section 2 reviews the standard non-relativistic doctrines and considers what revisions taking relativity seriously requires. The basic elements of relativistically-defensible endurantism and perdurantism are introduced. Section 2 will also enable us to respond to two recent criticisms of relativistic endurantism, one by Yuri Balashov and the other by Steven Hales and Timothy Johnson. These we deal with in Sections 3 and 4 respectively.

Section 2 characterizes endurance as involving the multi-location of objects in spacetime. The exact pattern of this multi-location remains to be explored. In Section 5, we consider Gilmore's discussion of this issue (Gilmore forthcoming). The most natural of the options Gilmore considers can, we argue, be defended against his objections. Our discussion suggests, however, that an alternative point of view is preferable, one that questions the legitimacy of Gilmore's agenda-setting question. This alternative, moreover, provides a useful perspective from which to reject a final argument due to Yuri Balashov. We review this argument in Section 6.

2 Taking relativity seriously

The persistence debate is but one of three central debates in the philosophy of time. In addition to the opposition between endurantists and perdurantists there is also that between *eternalists* and *non-eternalists* and that between *tensers* and *detensers*. In contrast to the persistence debate, whether and how relativity impacts upon these other issues is well-trodden ground.

Eternalism is a doctrine concerning the *ontological* status of times other than the present. Just as we take distant places to be no less real than our immediate spatial locality, so the eternalist holds that all times are ontologically on a par. In contrast, presentists, for example, hold that *only* the present is real.

Tensers share the presentists' belief that the present is special, but they need not agree that it is *ontologically* favored. Non-present times might also exist, with the present somehow being metaphysically special, perhaps because there are *tensed facts*. Facts about which events *are occurring* (present tensed), for example, would pick out as privileged the time at which those events (tenselessly) occur. Tensers take (token) tensed utterances to be made true by such tensed facts. In contrast, the detenser rejects the idea that the present is metaphysically special. All times are on a par, period. And just as token utterances involving indexicals such as "here" and "I" are standardly held to be made true by non-indexical facts, so the detenser asserts that token utterances of tensed sentences are made true by tenseless facts.[4]

[4]For this reason, detenserism is also known as *indexicalism* (*cf.* Merricks 1995, 523).

For some detensers, an utterance at time t of "It is now raining", for example, is (tenselessly) true iff it is (tenselessly) raining at time t. For others, an utterance of "It is now raining" is (tenselessly) true iff it is (tenselessly) raining simultaneous with that utterance.

We take it that relativity rules decisively against both the non-eternalist and the tenser.[5] To quote the title of Savitt (2000), "there's no time like the present (in Minkowski spacetime)." Both presentism and tensed theories of time need an objectively privileged set of subregions of spacetime, each of which can serve as the present as 'time passes' (however *this* is to be interpreted!). Relativistic physics simply does not provide such a set. Faced with this fact, the tenser can choose to regard the relativistic picture of the world as simply incomplete: there are, in addition to the spatiotemporal facts describable in properly relativistic language, facts about what is present.[6] Such a view is clearly logically consistent, but it prompts an immediate question: are these facts observable? If they are, then relativistic physics is empirically inadequate. Some philosophers no doubt believe this. They are likely to see the experiential phenomena associated with the idea that time passes as lying outside the scope of relativity. But we believe that there is no good reason to think that these phenomena cannot be completely explained in (relativistic) tenseless terms. And we take an eternalist tenseless theory of time to be vindicated if the tenser's additional metaphysical facts are unobservable to the extent that even the nature of our temporal experience fails to constitute evidence for them.

What of endurance? The combination of eternalism and a tenseless theory of time falls short, by itself, of ruling this out. Endurance involves persisting objects being wholly present at different times. For tenseless eternalists, therefore, endurance involves persisting objects existing at multiple times by being tenselessly and wholly located at these times. But note that the kernel of tenseless eternalism is that all times are on a par. Since the endurantist is not committed to regarding any time—any particular temporal location of any particular enduring object—as special, endurantism and tenseless eternalism are entirely consistent. Of course anyone who embraces this position must respond to Lewis' (1986, 202–5) problem of temporary intrinsics. The endurantist does so by relativizing property instantiation to times.[7]

One moral of relativity is that there is no privileged present, but since the endurantist need not regard any time as privileged, why need more be said? The answer lies with the reason *why* a relativistic world does not admit a privileged

[5]The issue is (surprisingly) controversial though. What follows is not intended to persuade committed non-eternalist tensers. We are merely clarifying our position, which we take to be that of Saunders (2002).

[6]See e.g. Prior (1970, 247).

[7]We will not rehearse the various different ways to implement this relativization. An overview is found in Haslanger (2003).

present. After all, nothing in Newtonian physics singles out (now!) a particular time as 'the Now', but the tenser will not judge Newtonian physics to be inadequate for that reason. The reason why there is no time like the present in Minkowski spacetime is that, in Minkowski spacetime, *there is no time*. This, we think, is the lesson of relativity that many philosophers have yet to take fully on board. It means, clearly, that our characterization of endurance in terms of *time*-relativized property instantiation by objects multiply located at different *times* must be revised. But so must the characterizations of eternalism and the tenseless theory of time, for these too were stated in terms of times. Without modification, relativity is as inimical to these positions as it is to their rivals.

2.1 Formulating Relativistic Perdurance

The required alteration to eternalism is obvious and trivial. Relativistic eternalism is simply the doctrine that all *regions of spacetime* are on a par, ontologically and metaphysically. It is with many philosophers' attempts to formulate relativistic versions of the other positions that we disagree. The most popular strategy, surely, has been to *frame-relativize*. This, we contend, is fundamentally wrong-headed. A few examples will illustrate our point.

Consider Ted Sider's definition of a temporal part, and his associated definition of four-dimensionalism (perdurantism):

> x is an *instantaneous temporal part* of y at instant $t =_{\text{df}}$ (1) x exists at, but only at, t; and (2) x is a part of y at t; and (3) x overlaps at t everything that is a part of y at t.
>
> ... Four-dimensionalism may then be formulated as the claim that, necessarily, each spatiotemporal object has a temporal part at every moment at which it exists.
>
> This all could be made relativistically acceptable by relativizing the definition of a temporal part to a frame of reference, and then stating four-dimensionalism as the claim that for any chosen frame of reference, every spatiotemporal object has a temporal part at every moment of time at which it exists. (Sider 2001, 59)

Note that there are two temporally relativized notions at play here: parthood-at-a-time and existence-at-a-time. Sider himself prefers an atemporal notion of parthood, and offers alternative definitions in terms of it (2001, 56–60). He chooses to offer definitions in terms of the temporally relativized notion purely because he thinks that this may be the only notion acceptable to his endurantist opponent; he is concerned to state four-dimensionalism in a manner that his opponent must admit is intelligible. Even if we avoid temporally relativized parthood, however,

temporally relativized existence remains, and is crucial to the definitions framed in terms of atemporal parthood.

The 'times' of the definitions simply do not exist in a relativistic world. But what is wrong with Sider's response: replace them with the times of inertial frames?[8] A number of things.

First, an ambiguity in the frame-relativized definition needs to be clarified. Is it taken to be a frame-relative matter what temporal parts the object has? (*Relative to frame F* the object has one set of temporal parts each existing at, and only at, a time in F; relative to frame F' it has *another* set, and so on.) Or is the idea that the object has *all* of these temporal parts quite independently of whether we consider things from the point of view of some particular frame of reference?[9]

It is perhaps obvious that the second of these proposals was intended, but it is nonetheless worth stating explicitly what is wrong with the first. It seeks to attach a metaphysical weight to frames of reference that they simply do not carry. Inertial frames of reference (or, more accurately, spacetime coordinate systems adapted to them) are no more than the spatiotemporal analogues of Cartesian coordinate systems. The flatness of the spacetime of special relativity means that certain spacetime coordinate systems have a privileged status with respect to the spatiotemporal distance relations holding between spacetime points. The coordinate differences of such points with respect to these special coordinate systems encode, in a direct manner, the spatiotemporal distances, just as the coordinate differences in Cartesian coordinates encode Euclidean distances.[10] But just as no one would attach ontological weight to features of an object that are relative to a choice of Cartesian coordinates, so no one *should* attach significance to properties of objects that are essentially defined in terms of canonical frames of reference.

From the physicist's perspective, the content of spacetime is as it is. One can choose to describe this content from the perspective of a particular inertial frame of reference (i.e., to describe it relative to some standard of rest and some standard

[8]Sider's treatment is arguably more sophisticated than our chosen quotation suggests. In Section 6, we will partly endorse his critique of an anti-endurantist argument by Yuri Balashov. Nonetheless, there remain vestiges of frame-relativization even in that critique.

[9]Perhaps there is a third option: it is a frame-independent matter that the object has all such parts, but it is a frame-dependent matter which proper subset of these parts counts as the set of its *temporal* parts. We find it hard to see what work the honorific "temporal" does on such a view.

[10]For two spacetime points with coordinates (x, y, z, t) and (x', y', z', t'), the distance between them is given by $\sqrt{|(x-x')^2 + (y-y')^2 + (z-z')^2 - (t-t')^2|}$ just as, in Euclidean space, the distance between two points with coordinates (x, y, z) and (x', y', z') is given by $\sqrt{(x-x')^2 + (y-y')^2 + (z-z')^2}$. If $(x-x')^2 + (y-y')^2 + (z-z')^2 - (t-t')^2 > 0$ the points are *spacelike related* (i.e., they are some spatial distance apart). If $(x-x')^2 + (y-y')^2 + (z-z')^2 - (t-t')^2 < 0$ the points are *timelike related* (i.e., they are some temporal distance apart). If $(x-x')^2 + (y-y')^2 + (z-z')^2 - (t-t')^2 = 0$ the points (assuming they are distinct) are *lightlike related*.

of distant simultaneity that are optimally adapted to the geometry of spacetime but are otherwise arbitrary). But one can equally choose to describe the contents of spacetime with respect to some frame that is not so optimally adapted to the geometric structure of spacetime, or indeed, choose to describe it in some entirely frame-independent manner.

Second, Sider's frame-relativized definition tells us that the perduring object has 'temporal' parts located at certain regions of spacetime (subregions of the 'times' of inertial frames) within the object's worldtube. What of the other subregions of its worldtube? Does it have parts located at these? We do not doubt that Sider answers affirmatively. This may even follow from the principle of unrestricted mereological composition, to which Sider signs up. But this would be to miss the point that, from a relativistic point of view, the assumption that a perduring object has parts at *every* proper subregion of its worldtube is overwhelmingly natural. Call this the *doctrine of arbitrary spatiotemporal parts*.[11] From a relativistic point of view, it should be a starting point, not something that falls out from a frame-relative generalization of the non-relativistic notion of a temporal part together with unrestricted composition. Indeed, from the relativistic perspective, the existence of specifically 'temporal' parts of an object does not even warrant comment.

This last claim might seem too strong, for, in the non-relativistic context, a perduring object's temporal parts perform a vital function. Consider the spatial analogy. It is not incidental to an object's spatial extension that it has parts located in subregions of the region it occupies. One wants to say that it is spatially extended *in virtue of* these parts. Likewise, one might say that an object's having some particular spatial shape *simply consists in* its having parts arranged in a particular spatial configuration. In a similar way, the non-relativistic perdurantist will say that an object persists (i.e., extends through time) *in virtue of* having distinct temporal parts located at each time. Do temporal parts play an analogous role in the context of relativity? Do they explain how persisting objects succeed in being extended in, say, *timelike directions*?

Before answering, we should clarify what might be meant by a relativistic (in-

[11] *Cf.* Sattig (2006, 54). It faces the following problem. Objects can be 'gappy' if (e.g.) they are composed of finitely many pointlike parts standing in finite spatiotemporal distance relations. What should we take as the worldtube of such an object? If one took the view that the object's exact location in spacetime was simply the fusion of the exact, pointlike locations of each of its parts, then the doctrine of arbitrary spatiotemporal parts falls out, but threatens to become a triviality (we ignore for the time being the possibility of extended simples). But such a definition of a composite object's worldtube is, in certain respects, unnatural. Consider the purely spatial case, and an object composed of interacting pointlike parts whose short-range repulsive forces prevent other objects from entering a continuous spatial region that contains all the parts of the object. (For example: consider a table!) Don't we want to say that such an object occupies a continuous spatial region? If a more inclusive definition of an object's worldtube is adopted, then more work is required to articulate the relativistic intuition that lies behind the doctrine of arbitrary spatiotemporal parts.

stantaneous) 'temporal' part. We have already reviewed Sider's definition: a temporal part of an object exists at, and only at, a time in some inertial frame, and overlaps everything that is part of O that exists at that time. Thomas Sattig has recently offered a rather different definition that we nonetheless take to be equivalent:

(TP:R_{SR}) A spacetime point or region R is a *temporal part* of a spacetime region R' relative to a frame of reference $f =_{df} R$ is a maximal sum of parts of R' that are simultaneous relative to f.

(TP:O_{SR}) An object x is a *temporal part* of an object y relative to a frame of reference $f =_{df}$ (i) x is part of y, (ii) y [exactly] occupies a spacetime region R, (iii) x occupies a point or region that is a temporal part of R relative to f, and (iv) x does not occupy any other region. (Sattig 2006, 179)

Here is how the basic entities that these definitions pick out can be characterized in a more relativistically acceptable manner. First, let us say that a perduring object's *path* is the spacetime region that it exactly occupies.[12] The characterization is then that:

TP P is a instantaneous temporal part of O just if (i) P is a part of O, (ii) P exactly occupies a region R_P that is *spacelike*,[13] (iii) R_P is a *maximal* spacelike subregion of the path R_O of O and (iv) R_P is *flat*.

The vital question is now whether the perdurantist should adopt *TP*. Clause (i) needs no justification. (ii) captures the idea that the part is 'instantaneous'; i.e., that it has no temporal extent. (iii) corresponds to Sider's requirement that a temporal part of O at t overlap *every* part of O that exists at t. We are happy to be stipulative here. (iv), on the other hand, is quite without motivation. It is a relic of the frame-relative perspective. While flat regions of spacetime are in some sense geometrically privileged, there is no reason to suppose that this gives them any special metaphysical status, in the context of questions about persistence or otherwise. More significantly, one surely wants a definition applicable in the context of our best theory of space and time, general relativity. While this theory allows spacetimes containing flat spacelike regions, generic matter-filled worldtubes will have *no* flat maximal spacelike subregions. The obvious emendation, therefore, is simply to drop clause (iv). *This* gives our preferred definition of an instantaneous temporal part.

[12] We will soon replace this definition with Gilmore's more general, and hence more useful, notion (Gilmore forthcoming, §2). The general style of definition that we see as suitable for the relativistic context is very similar to the style adopted by Gilmore. As we said above (p. 1), our general criticism that philosophers do not take relativity seriously enough should not be taken to apply to Gilmore.

[13] A region R is *spacelike* just if every pair of distinct points in R are spacelike separated. This is just Gilmore's notion of *achronal* (Gilmore forthcoming, §2).

Now it is certainly true that temporally extended objects are temporally extended in virtue of being composed of temporal parts. But our earlier claim still stands: from the relativistic point of view, temporal parts are hardly worth defining. Consider a spatial analogy. I position my desk so that one edge runs exactly North–South. Is it true that my desk extends in the North–South direction in virtue of being composed of a set of two-dimensional parts running East–West? Yes. But it is *equally* true that it extends in the North–South direction in virtue of being composed of a set of two-dimensional parts running North–South. Its being composed of the set of *pointlike* parts standing in the configuration they in fact stand in explains its being extended in a North–South direction just as well too. It should be clear that relativity's unification of space and time leaves no distinctive work for the notion of a temporal part to do in explaining persistence.

2.2 Formulating Relativistic Endurance

Much of our discussion of relativistic perdurance is applicable to the analogous topic of relativistic endurance. To this topic we now turn.

In the non-relativistic context, enduring objects are meant to be entities that are (1) only *spatially* extended (if extended at all) and (2) wholly present at each moment at which they exist. Since we are supposing that they are, tenselessly, at each of these times, they are (3) multiply located. Since enduring objects change, they cannot in general possess properties *simpliciter* but rather (4) instantiate a property only relative to a time.

It should be clear from our discussion of perdurance that the *wrong* way to relativistically re-construe all this is to replace reference to moments and times with reference to the times of inertial frames. One should not say, for example, that relative to each inertial frame, an enduring object is wholly present at multiple times in that inertial frame.[14]

We recommend that the would-be endurantist adopt the following position in the context of relativity.[15] Corresponding to the non-relativistic properties (2) and (3), the endurantist should say that persisting objects are *multiply located in space-*

[14]We have already mentioned that Sider's discussion of relativistic endurance places undue emphasis on times-in-frames (see fn 8). Rea proposes that the endurantist restrict composition to "times in frames of reference" (Rea 1998, 234). Sattig proposes that relativistic endurantism be formulated as the claim that: "(i) an ordinary object occupies multiple spacetime regions, and (ii) these regions are temporally unextended, or instantaneous, relative to some inertial frame of reference, and lie on different frame-relative hyperplanes" (Sattig 2006, 179). It should be clear why we object to at least the formulation of all these proposals.

[15]Despite the reservations expressed in the last footnote, Sattig's view is close to the one we recommend in that it involves entities that are not temporally extended exactly occupying multiple regions of spacetime. It is again Gilmore who has articulated the most satisfactory relativistic version of endurance (*cf.* Gilmore forthcoming, §2).

time: they are (tenselessly) wholly present in multiple regions of spacetime.[16] Corresponding to property (1), the endurantist should hold that these regions are not temporally extended, i.e., they are *spacelike*: any two distinct points in such a region should be spacelike related. Corresponding to property (4), the endurantist should hold that persisting objects do not (in general) instantiate properties *simpliciter*, but rather only *relative to particular spacetime regions*, viz. their locations (or suitable regions that contain their locations). All of this leaves open the question of *which* spacelike regions an enduring object occupies. We postpone proper discussion of this question until Section 5.

A few comments on the idea that objects can be *multiply* located are in order. Some find the very idea paradoxical.[17] We will not try to convince everyone that the notion makes sense, but we are concerned to carry with us those who have no problem with the idea of endurance in a (tenseless eternalist) non-relativistic context. To this end it is useful to distinguish two conceptions of the spacetime of Newtonian physics. According to one way of thinking Newtonian spacetime is at some level of abstraction no different from relativistic spacetime. One has a four-dimensional manifold of spacetime points that stand in the very same kind of spatial and temporal distance relations. The only difference concerns the patterns in which these various relations are instantiated. In the Newtonian case, *every* pair of spacetime points stand in some temporal distance relation, and *all and only* those between which there is zero temporal separation stand, additionally, in some spatial distance relation. In the relativistic case, spatial (i.e. spacelike), temporal (i.e. timelike) and null distances are mutually exclusive. Every pair of points stand in one of these relations, but if they stand in one of them, they do not stand in either of the others. Anyone who assimilates the spacetimes of Newtonian physics and relativity to this extent surely will not have trouble with the notion of multi-location in the latter but not the former.

We suspect, therefore, that those who think they can make sense of endurance in a Newtonian context, but think they cannot do so in a relativistic context, conceive of Newtonian spacetime in a very different way. When it comes to Newtonian spacetime they believe (*ex hypothesi*) in the equal reality of all parts of the four-dimensional manifold of possible event locations, but they do not see this manifold as a fundamentally unitary entity, the partitioning of which into times (surfaces of simultaneity) is merely a function of the temporal distance relations between its

[16]There is more to be said about this notion of being (exactly) located at a particular region of spacetime or, correlatively, of *exactly occupying* such a region. Although we will touch on some of the issues, we refer the reader to Sattig's discussion (2006, 48) and, especially, to Gilmore's in this volume (forthcoming, §2).

[17]Barker and Dowe (2003, 2005) provide an interesting argument to this effect. Our preferred response is that of Gilmore (forthcoming, §2): an object can exactly occupy a set of regions without exactly occupying the fusion of those regions.

parts. Rather, they will take times as fundamental and see the four-dimensional manifold one obtains from their union as the thing that has a secondary status. For such an endurantist, *existing at* more than one time might seem importantly different from being *located* in more than one place in a single space. And exemplifying a property in a time-relative manner may not simply be a matter of exemplifying a property relative to the (temporal) location one is at.

Our challenge to such endurantists is to articulate what goes on when an enduring object time-travels so as to coexist with its younger self. It would be a problem for the endurantist if he could not accommodate the conceptual possibility of time travel (*cf.* Sider 2001, 101–9). The most natural, and we think correct, endurantist description of the envisaged scenario is that the enduring object not only exists at many different times but also exists at (is located at) more than one place at the same time. It is no more problematic to think of property instantiation as relativized to spatial locations as to temporal locations: in one place, the time traveler is standing (and dark haired); in another he is sitting (and grey haired).[18] But this type of spatial multi-location, and location-relative property instantiation is all the endurantist needs in order to understand multi-location in relativistic spacetime.

2.3 Formulating Relativistic Truth Conditions

So far we have sought to articulate the versions of various views familiar from non-relativistic debates (eternalism, endurantism and perdurantism) that are *natural* from the relativistic point of view. Our task is almost done, but there is one position that we have not yet examined, namely the tenseless theory of time and its indexical treatment of tensed utterances. Recall that, according to this view, tensed utterances (located as they are at certain times) are held to be true just if the appropriate things are going on at those times (or, for utterances in tenses other than the present, at times bearing the right temporal relations to the time of utterance). Since there are no times in relativity, some revision is in order here too.

In spite of our earlier complaints, with regard to tensed utterances frame-relativization might seem legitimate. Familiarity with relativity should not prevent us from acknowledging a natural propensity to believe in (absolute) simultaneity. The detenser sees our present tense utterances as an attempt to talk of those events we believe to be occurring *at that time*. Given relativity, such a belief is arguably just false. But a more charitable interpretation regards it as merely incomplete, this being remedied by supplying a frame to accompany our talk of that which is 'simultaneous'. The most obvious way to do this is to idealize and use the frame in

[18]Here we disagree with Sider (2001, 104–5). Our time traveler is located at P and is standing there at t, and also located at P' and is sitting there at t. At t he is both sitting and standing. There is no contradiction, for he does these things in different places. But he is *not* (then) both sitting and standing *at* P'; at *this* location, he is *only* sitting.

which the speaker is (instantaneously) at rest at the spacetime 'point' at which the utterance is made. One then applies the standard non-relativistic account of the tenseless truth conditions of tensed utterances to this utterance with respect to this frame.

This way of interpreting tensed utterances will have some counterintuitive consequences. Suppose (improbably) that two people are discussing the goings on in some far distant solar system in their mutual topological present.[19] Given the distances involved, these two speakers need only be moving with respect to each other with a small relative velocity for one and same event to count as having occurred many years ago for one speaker but to be an event that will occur many years in the future for the other. But given the speed of light (and given the time it takes to have a thought or make an utterance), such anomalies only show up when astronomical distances are involved. For all practical purposes, when our talk is confined to discussing processes and events that occur over even the smallest timescales that we can perceptually discriminate, at locations no more spatially distant from us than, say, the diameter of the Earth, with respect to any shared region of spacetime all speakers will agree concerning which tensed sentences are true, no matter what (within practical limits) their relative velocities.

While the frame-relativized proposal for interpreting tensed utterances will get the truth values of realistic tensed utterances right, we wish to suggest an alternative, which we think has some rather attractive consequences.

Tensed utterances describe the world from a particular spatiotemporal view. Our spatiotemporal view of the world privileges a spatially extended present. Why?[20] We think a plausible answer starts with the suggestion that we take the present to be the location of the objects with which we can *inter*act. The past can only causally affect us; we cannot, as of the here and now, affect it. The future can only be affected by us; it cannot affect us in the here and now. But objects and events in the present both act on us and can be acted on by us (and by acting on us through our senses, they do so in a much more immediate and vivid manner than objects in the past).

Setting things up in this way leads to an obvious question: in the context of relativity, what is the extent of the domain of those objects which, at some moment in our lives, both can act upon us and be acted upon by us? Here by 'moment'

[19]The *topological present*, or *absolute elsewhere* of a spacetime point p is the set of points that are spacelike related to it. From the perspective of any point, relativistic spacetime can be considered to be divided into three exclusive regions: the absolute future of that point (the set of all points that can be connected to p by a future-directed timelike or lightlike curve starting at p), its absolute past (the set of all points that can be connected to p by a past-directed timelike or lightlike curve starting at p), and its absolute elsewhere.

[20]The following takes its inspiration from Butterfield (1984) and Stein (1991, 158–62) though it hardly does justice to these subtle papers. We strongly recommend the latter to any philosopher tempted to engage in frame-relativization of their favorite concepts in the face of relativity.

we mean a temporally extended but short-lived (i.e. momentary) interval, and the answer will depend on its temporal extent. Let us first take it to be the duration of the specious present, the time it takes to have a single thought or enjoy a single experience. This, let us say, is about 0.2 of a second. Call the temporally extended spacetime region you occupy (partially or multiply) during this 'moment' *NOW*. To be something that can affect you in the NOW, an object must be located within the backward lightcone of the future boundary of NOW. To be something that can be affected by you, as located in the NOW, the object must fall within the future light cone of the past boundary of NOW. Call the region bounded by these two lightcones the *Stein Present* of the NOW.[21] The NOW's Stein Present is a four-dimensional discus-shaped region centered on the NOW. The immediate thing to note about it is that it is, spatially speaking, very wide (of the order of 60,000 kilometers), even though it is, temporally speaking, very thin (no wider that 0.2 seconds, where it overlaps the NOW).

The source of the presentist's (false) intuition might then be as follows. They are inclined to accord a kind of ontological privilege to that with which they can (then) interact. What they can interact with, at a particular near-momentary subregion R of their worldtube, is the contents of that region's Stein Present. But we noted above that such a Stein Present has very little temporal thickness and is very large in spatial extent. Such a region is easily mistaken for an instantaneous, global present.

We propose to link tensed talk to Stein Presents as follows. Our tensed talk, which reports our spatiotemporal perspective on the world as at R, should be partially analyzed in term of R's Stein Present. The present tense is correctly used at R to talk about objects and events as they are in the Stein Present of R, the past tense is correctly used to talk about objects and events as they are in the absolute past of R, and the future tense is correctly used to talk about objects and events as they are in the absolute future of R.

These categories are not exhaustive. There are regions of the absolute elsewhere of R that fall outside its Stein Present. But this is just as it should be. It is intuitively right that, if the temporal extent of the now is of the order of a specious present, then one cannot correctly use the present tense to talk about some event in one's absolute elsewhere that is, say, four light years away. It also means that, during the eleventh Apollo mission, no one in mission control in Houston could sensibly ask "What is Armstrong doing now?" while he was on the Moon. But rather than being a problem for the proposal, this just highlights that the duration of 'now' is (normally) longer than the specious present and is, quite generally, context sensitive.[22]

[21] After Stein (1991, 159–60), who singles out the same region for somewhat different reasons.

[22] Consider how extended the 'now' must be for the following exchange to be appropriate. Longtime family friend: "What are Alice and Bob up to now?" Alice's mother: "They're trying for a baby."

3 Coexistence, relativity and endurance

We have already provided *inter alia* an initial sketch of our preferred version of relativistic endurance (see Section 2.2). It is now time to consider the recent spate of anti-endurantist arguments that appeal to relativity. Our primary purpose is to demonstrate that they all fail, but discussion of the arguments will also provide us with an opportunity to articulate further what relativistic endurance must involve.

We start with an argument, due to Yuri Balashov, that appeals to a notion of non-trivial coexistence (Balashov 2000*a*,*c*). Our discussion is indebted to Gilmore (2002), who we think has already given the decisive rebuttal. Balashov has since replied to Gilmore (Balashov 2005), marshalling against endurantism further arguments based on coexistence and relativity that he first employed against stage theory (Balashov 2002). We will see that these arguments are no more effective.

Balashov assumes eternalism, but suggests that both endurantists and perdurantists should acknowledge a non-trivial sense of 'coexist' such that the set of things with which an object coexists (as located at some spacetime region R)[23] is neither empty (except for the object itself) nor simply the set of things located somewhere in spacetime (2000*a*, 139; 2002, 230–1). The following claims, which we take to be true when appropriately understood, illustrate the idea. We both (now) coexist with Yuri Balashov, and have done since birth. We both used to coexist with Quine, but do so no longer. At no point in our lives has either of us coexisted with Napoleon.

Balashov's original argument, as Gilmore nicely sets out, involves three principal claims (Gilmore 2002, 243–4). (1) In the relativistic context, the non-trivial coexistence of two objects should be taken (by both perdurantists and endurantists) to be grounded in the (at least partially) spacelike separation of the two spacetime regions that the objects occupy. (Gilmore calls this *CASS*: Coexistence As Spacelike Separation.) (2) The endurantist, but not the perdurantist, must understand non-trivial coexistence in a 'tensed' or 'temporally loaded' manner. (Gilmore calls this the *Asymmetry Thesis*.) (3) A temporally loaded notion of coexistence (but only a temporally loaded notion) based on spacelike separation leads to absurdity.

[23]Where possible we will speak of objects' locations intending to cover both the (exact but non-unique) locations of enduring objects and the (partial) locations of perduring objects. Note that the qualifying relativization of coexistence to a spacetime region is as appropriate for (the temporal parts of) perduring objects as for enduring objects. Often property instantiation by temporal parts of perduring objects is property instantiation *simpliciter* whereas, for enduring objects, it must (almost) always be relativized to a spacetime region (a possible exception being any constant properties such as the charge of elementary particles). But which objects a temporal part of a perduring object coexists with in a non-trivial sense is just as much a function of its spacetime location as it is for enduring objects. Since the temporal part of the perduring object has but one location, the location relativization can be dropped without ambiguity; the same is obviously not true in the case of enduring objects.

(Gilmore calls this the *Absurdity Thesis*.) We will consider these claims in order, agreeing with Gilmore that (1) and (3) are false. As regards (2), we will concede some ground, but not enough to make Balashov's argument go through.

3.1 The Coexistence Relation

Balashov settles on spacelike separation as the appropriate relativistic relation to ground non-trivial coexistence because he sees it as the best candidate that is (i) objective, (ii) symmetric and (iii) relevant.[24] We shall see in a moment that Gilmore rejects (i), favoring instead of CASS a *frame-relative* coexistence relation. We noted in Section 2.3 that giving frame-relativized truth conditions for tensed utterances is not obviously misguided. This fact can be used to motivate Gilmore's proposal, for surely the obvious *non-trivial* notion of coexistence is just the (present) tensed notion, and is thus intimately related to our earlier discussion of tense. We explore this connection below. In fact, the frame-relativized truth conditions proposal can also be used to motivate an alternative candidate coexistence relation that meets the objectivity requirement. Unfortunately, as we shall see, this second proposal has other unwelcome features. Our proposal to interpret tensed utterances in terms of Stein Presents suggests a third option. We review its strengths before contrasting the proposal with Balashov's CASS. Our problem with CASS is that it does not, after all, meet the relevance requirement.

We do not question the last two of Balashov's three putative desiderata. We take it as analytic that coexistence is symmetric. (Our preferred parsing of the relation is: *x coexists* with *y* iff *x* exists for *y* and *y* exists for *x*. So conceived, it is clearly symmetric, although *exists for* may not be.) The criterion of relevance is also not disputable. If the coexistence of *x* and *y* is to be understood as grounded in some further relation holding between them (or their locations), it had better be clear *why* this relation's holding means that *x* and *y* coexist. But what of objectivity?

Gilmore's preferred alternative to CASS is a frame-relativized notion of coexistence: *x* (as at *p*) and *y* (as at *q*) coexist *relative to frame F* iff their locations (*p* and *q*) are simultaneous-in-*F* (Gilmore 2002, 254). There is an obvious connection between Gilmore's suggestion and the frame-relativized truth conditions proposal of Section 2.3. Suppose one adopts our proposal that *x* coexists with *y* iff *x* exists for *y* and *y* exists for *x*. Then any speaker *S*, as located at *r*, can truly say that *x* and *y* coexist (present tense) just if, for *S* as at *r*, *x* exists (present tense) for *y* and *vice versa*. In other words, any speaker *S* can truly say at *r* that *x* and *y* coexist (present tense) just if there are locations *p* and *q* of *x* and *y* that are simultaneous with *r* in the instantaneous rest frame of *S* at *r*. But that is just to say that *x* and *y*,

[24] See Balashov (2000*a*, 139–49; 2000*c*, S555) for a discussion of the merits of CASS. See Balashov (2000*a*, 133) for the three desiderata.

as at these locations, coexist relative to *S*'s rest frame in Gilmore's sense. (Similarly, *S* can truly say at *r* that the two objects coexist*ed* if they have locations that are simultaneous with respect to *S*'s instantaneous rest frame at *r* but which lie on a plane of simultaneity to the past of *r*, relative to this frame.)

As Gilmore concedes, the proposal violates (i), where this is understood as requiring that there be an absolute fact of the matter (and not merely a variety of frame-relative facts) about whether two objects coexist (Balashov 2000*c*, S553). However, the machinery of frame-relative truth conditions can be used to construct a coexistence relation that satisfies (i) after all. In the analysis of the preceding paragraph what counted was whether x exists for y and y exists for x from some third-person perspective. Different perspectives, and thus different frames, yield different answers to the question of whether x and y coexist. But perhaps we can satisfy (i) by finding an objectively preferred frame (or even pair of frames) to give an objectively preferred answer. One obvious suggestion is to ask whether x exists for *y from y's (tensed) perspective* and whether y exists for *x from x's (tensed) perspective*.

Combining this idea with the frame-relative truth conditions for tensed utterances, however, yields a notion that Balashov considers and rightly rejects (Balashov 2000*a*, 136–7). Here is the problem with it. x, as at p, coexists with y, as at q, iff x exists for y at q and y exists for x at p. But to exist for x as at p (in the present-tensed, frame-relativized sense), y need only be located at *some* point that is simultaneous with p in x's rest frame (as at p). This need not be q, which in general will *not* be simultaneous with p (in x's instantaneous rest frame at p). Similarly, for x to be real for y as at q, x need only be located at *some* point that is simultaneous with q in y's rest-frame (as at q). Again, this need not be p. But surely the coexistence of x as at p with y as at q, if this is to be a matter of the spatiotemporal relations holding between their locations, should just be a matter of the spatiotemporal relation between p and q, not a matter of how *four* of their locations are interrelated.[25]

That frame-relativized truth conditions yield such an unsatisfactory notion of non-trivial coexistence could actually be taken as a reason to reject the frame-relativized truth conditions proposal. How do our alternative truth conditions in term of Stein Presents fair? We think that Stein Presents may be rather well suited to grounding the kind of non-trivial coexistence relation required.

The idea that there is a link between non-trivial coexistence and tensed attributions of existence suggests the following. Consider two persisting objects x and y located at p and q respectively. We are supposing that p and q are pointlike (or, if the idealization that x and y have no spatial extent is dropped, that p and q have

[25]Balashov thinks that coexistence so construed would involve "representation *in absentia*" (Balashov 2000*a*, 137), but since each of the four locations involved has the relevant enduring object tenselessly located at it, we have trouble understanding what Balashov means by '*in absentia*' here.

no temporal thickness). Even so, there may be associated with x, as at p, a contextually determined, temporally extended now (NOW_p), centered on p. Where x is something that has experiences, the extent of such a NOW will never be less than x's specious present. If x is capable of relatively sophisticated reflection on its spatiotemporal environment, then, as seen above (p. 13), context may determine that the NOWs associated with some points of its worldline have a temporal extent greater than this. A non-sentient persister has no specious present; does this mean that for each point p of its worldline the only relevant Stein Present is simply p itself? At one level this seems correct: there is no non-trivial notion of coexistence applicable to such objects because, having no perspective at all, they have no spatiotemporal perspective on the world. There can be no question of which objects exist *for them* as at p. On the other hand, it seems that someone *might* legitimately talk of the (non-trivial) coexistence of non-sentient objects, in which case, we suggest, the contextually determined duration of the *speaker's* NOW, at the time of any such attribution, is used to determine extended NOWs for the objects under consideration.

With temporally extended NOWs for x and y (associated with points p and q) in hand, we can make the following proposal: x and y coexist just if p falls within the Stein Present of NOW_q and q falls within the Stein Present of NOW_p. The proposal gives our illustrative coexistence claims the right truth values. But more than this, coexistence turns out to be very close to what one might, pre-theoretically, have taken it to be. If x and y coexist (as at p and q respectively), then x is in the present of y and *vice versa*. Their presents (at p and q) substantially overlap and so, as at these regions, there is a reasonable sense in which they *share a common present*. And, reassuringly, since communication is a specific form of interaction, we will always coexist in the non-trivial sense with those with whom we are (then) communicating.

As defined, coexistence is symmetric. But the more basic notion in terms of which it is defined—x exists for y at q iff x is located somewhere within y's Stein Present at q—is not. In most cases the relation will hold in both directions (as one would hope), but it need not do so. And this, we think, is as it should be. Elephants, and indeed humans, have a much slower metabolism than gnats. This means that a gnat's Stein Presents (assuming these are taken to be determined by the duration of the gnat's specious present) are much less spatially extended than ours. But this seems intuitively right. The spatial horizons of the world of the gnat *are* more limited than ours. Now consider two inhabitants of spacetime with wildly different metabolic rates (an extreme case of the elephant and gnat). They could be located in regions R and R' respectively such that the inhabitant with the shorter specious present, located at R', exists for the inhabitant with the more extended specious present, located at R, but not *vice versa*. This again seems to us to be the right result.

Clearly work needs to be done to flesh out these tentative suggestions, but our conviction is that the machinery of Stein Presents promises to provide an intuitively satisfying notion of coexistence that obviously meets the relevance requirement. Contrast this with Balashov's CASS (or with his replacement CASH (Balashov 2005, 20), according to which a collection of n objects coexist as at their n respective locations iff these locations all lie on a flat spacelike hypersurface). This allows that objects can coexist no matter how distant, and thus no matter how causally *disconnected*. As our earlier discussion of Stein Presents should suggest, we think this gets things exactly the wrong way round.[26] Once one learns to take relativity seriously, it should be obvious that, to controvert Balashov's example, Gamow and the Andromeda Nebula do *not* coexist in anything but the eternalist's universalist sense.[27]

3.2 The Asymmetry Thesis

We now turn to the second of Balashov's three central claims. The Asymmetry Thesis is the assertion that only endurantists are committed to a 'temporally loaded' understanding of coexistence (Balashov 2000*a*, 150–3; 2000*c*, S552–3; 2005, 12–4). In seeking to understand this claim one needs to keep two things in mind. First, Balashov assumes that the relativistic endurantist will be an eternalist detenser, so, although Balashov's language in places suggests otherwise, 'temporally loaded' is not meant to indicate that the eternalist is committed to, e.g., a tensed view of time. Second, both the perdurantist and endurantist should admit the propriety of *tensed talk*, where this is understood as (no more than) a way of describing the world in a perspective-dependent way from a particular spatiotemporal point of view.[28]

So what *does* Balashov mean by 'temporally loaded'? Balashov is explicit that the difference between enduring and perduring objects that grounds the legitimacy of applying 'temporally loaded' determinations to the former but not the latter, is

[26] In terms of the desiderata of this section, we therefore think that CASS in fact violates (iii).

[27] Balashov defends this aspect of his proposal by suggesting that even in the non-relativistic case, where existing *at the same time* is (allegedly) uncontroversially the relation that grounds non-trivial coexistence, causally unconnected items coexist (Balashov 2005, 6). It should be clear from our previous discussion of Stein Presents why we are as suspicious of this idea in the non-relativistic context as we are in the relativistic one.

[28] Again, Balashov's language at times suggests that the perdurantist cannot admit the legitimacy of tensed talk. In fact, Balashov is only keen to stress that perduring objects are *singly* located in spacetime and, as such, can only have *one* spatiotemporal perspective on the world. He should not deny that various tensed claims are true or false with respect to such a perspective. The temporal parts of a perduring object have their own unique spatiotemporal perspectives with respect to which different tensed claims will be true and false. Balashov admits that there is therefore a sense in which perduring objects have many different spatiotemporal perspectives on reality, but he downplays it as a merely vicarious sense (Balashov 2005, 14–6).

that enduring objects are *multiply* located in spacetime whereas perduring objects are *singly* located. This, in turn, is held to mean that enduring objects (and only enduring objects) "change their position in spacetime" (2000*a*, 162). Thus, it is claimed, for an enduring object as located at any one of its many locations, the world is divided, not just into those things with which it coexists (in the non-trivial sense) and those with which it does not, but also into those things with which it *still* exists, or with which it *no longer* exists, and so on (2000*a*, 149–50; 2000*c*, S557–8).

Occupying more than one location in spacetime is certainly a *necessary* condition of changing one's location in it. But it is not sufficient. We basically agree with Gilmore when he responds that change of position in a space M is change of position in M with respect to some temporal dimension T *separate from* M (2002, 249; forthcoming, §2). Balashov, however, is not suggesting, as Weyl apparently once did, that endurantists should think of persisting objects as "crawling upward along" their worldlines (Weyl 1949, 116). All Balashov means is that enduring objects have many distinct spacetime locations *with respect to the proper time* along their trajectories (Balashov 2005, 14). For the eternalist detenser, this is a perfectly respectable tenseless fact. And since one should be happy to recognize, in general, that an enduring object's instantiating incompatible properties at different moments of proper time along its trajectory constitutes *change*, why can it not similarly be said that an enduring object changes its spacetime location with respect to its proper time?

Part of our problem with this idea is the uncritical employment of the notion of proper time as applied to a persisting object. Thus far we have tacitly accepted Balashov's idealization of persisting objects as spatially unextended. Balashov views this idealization as harmless (2005, 2; 2005, 8), at least as regards the current argument, but in this respect it is not. How might a notion of proper time for a spatially extended worldtube be defined? The obvious thought is that we should consider the worldline of the *center of mass* of the object, and regard proper time along this curve as giving the 'proper time of the object'. Unfortunately the center of mass of an object is not a relativistically well-defined notion.[29] Perhaps, however, Balashov does not need *the* proper time of the object to be well defined. It might be enough to consider the proper time along *any* timelike worldline lying within the

[29]Balashov equates an 'object's proper time' with "the age of the object in its rest frame" (Balashov 2005, 9). But the (instantaneous) rest frame of a spatially extended object is equally not well defined. The problem is very simply illustrated. Consider an object that has just two pointlike parts of equal mass. Suppose that, with respect to some frame of reference F, they 'oscillate', moving uniformly towards each other for a period of time before moving uniformly away from each other at the same speed for an equal period of time. The situation described involves the composite object's being at rest in F. But consider a frame comoving with one of the particles during its motion towards the other particle. The object will also be, periodically, at rest in *this* frame for periods that begin with the other particle's change of direction and end with the comoving particle's change of direction. So the object is at rest in *both* of two frames in relative motion.

worldtube of the object; one might then say that the enduring object changes its spacetime locations with respect to any such temporal parameter.

This suggestion founders on a more substantial problem. As we will see in Section 5, the relativistic endurantist should not suppose that the locations of a spatially extended persisting object *foliate* the object's worldtube (or are otherwise parameterizable by a *single* real number). The most plausible version of relativistic endurantism has persisting objects located at continuously many *overlapping* spacelike regions of spacetime. This means that, associated with each point along some timelike curve within an object's worldtube, there is an infinity of regions that the object occupies, not one. We conclude that, for realistic persisting objects, no sense can be made of such an object's 'proper time', and *a fortiori* no sense can be made of its changing its location with respect to proper time.

It is also important to recognize how insubstantial a notion of change of spacetime location Balashov's notion of an object's proper time would provide, even if it did make sense. Talk of the *object's* proper time, or of the object occupying a certain region *when it is a certain age*, might lead one think of these notions as involving something over and above the spatiotemporal distances between the object's locations, as if the object could occupy the very same set of spacetime locations, but at different moments of its proper time. This would, of course, be a mistake. To the extent that one can make sense of an enduring object's proper time, this can be nothing other than the timelike distance along the spacetime curve composed of its locations.

Let us recap. Balashov believes that the enduring object's multiple location means that there is a sense in which the object changes its spacetime location and thus that one can legitimately talk about other objects *still* or *no longer* coexisting with that object. We have seen that, to the extent that sense can be made of it, the idea that the enduring object changes its spacetime location comes to nothing over and above the object's being multiply located in *timelike* separated regions. But perhaps the distinction between being multiply and singly located by itself gives us that the 'temporally loaded' determinations *still* and *no longer* etc. are appropriate for enduring objects alone.

After all, these temporal modifiers suggest the contrast (or comparison) of *one* spatiotemporal perspective with a *previous* one.[30] What does it mean to say that, for persisting object O, as located at p, some other object O' *still* exists? Surely this involves the combination of two ideas: (a) O' exists (in a non-trivial sense) for O, as at p, *and* (b) O' *also* exists for O, as at some *other* location p', where p' is in the absolute past of p. Similarly, it would not be correct to say that O' *no longer* exists for O as at p, if it were not the case that (c) O' does *not* exist for O, as at p, and (d) O' *does* exist for O, as located at some p' in the absolute past of p. It seems that

[30] Just as "*not yet*", for example, involves a contrast between one perspective and a *later* one.

Balashov is right to suggest that such locutions are intimately tied to the object's being multiply located.

It follows that, in this rather minimal way, there really is an asymmetry between perduring and enduring objects in this regard. Whilst it can be correct to say of some *perduring* object O, partially located at p, that some other object O' no longer exists, this is to be analyzed as: (e) O' does not exist for *the part of* O located at p and (f) O' does exist for *a part of* O located in the absolute past of p. Such 'temporally loaded' locutions thus *are* applicable to perduring objects, but they do not mean exactly what they mean when applied to enduring objects. As Balashov stresses, whilst objects may *literally* still or no longer exist for enduring objects, for perduring objects they may do so only in a *vicarious* sense (Balashov 2005, 16).

3.3 The Absurdity Thesis

We have therefore conceded to Balashov a slight asymmetry between enduring and perduring objects. But so understood it is not an asymmetry than can underwrite the Absurdity Thesis. To see why, we turn to the scenarios that Balashov believes to spell trouble for the endurantist.

Suppose that one followed Balashov and took non-trivial coexistence to be grounded in spacelike separation. In that case two objects O_1 and O_2 as at p_1 and p_2 could both coexist with O as at p (p and p_1 are spacelike separated as are p and p_2), even though O_1 and O_2 do not coexist with each other (p_1 and p_2 are not spacelike separated) (Balashov 2000*a*, 155; 2000*c*, S560). Spacelike separation is a non-transitive relation and so, if it is what grounds non-trivial coexistence, this will be non-transitive too. *But why should this trouble the endurantist?*

Balashov's answer is that this is because the endurantist requires a 'temporally loaded' sense of coexistence according to which objects are sorted into those no longer existent, those still or already existent, and those not yet existent (2000*a*, 149; 2005, 12–3). She "must be committed to this distinction in virtue of the basic principle of her ontology" (2000*a*, 151). We simply deny this: while the endurantist is *entitled* to a certain literal understanding of such 'temporally loaded' claims, there is no reason why she must employ them. But in any case, adding to the description of the allegedly problematic scenario the relevant 'temporally loaded' determinations will not make it appear any more absurd. That is, nothing is added by noting that enduring object O, as at some spacetime location, can *still* exist with one object and *already* exist with another, when these latter two objects do not coexist with each other. This addition merely introduces a comparison of how things are at that particular location of O with how things are at past or future locations of O. But if the scenario as originally described is not obviously problematic, how could bringing in these comparisons make it so?

In fact, in his reply to Gilmore, Balashov concedes that, if the endurantist goes

so far as to accept CASS—that spacelike separation grounds non-trivial coexistence—then he will *not* accept that the scenario just described involves an absurdity. The lack of transitivity involved is just what is to be expected (Balashov 2005, 18).

Balashov thinks that the way the endurantist defender of CASS can avoid absurdity is by denying that O, as at p, coexists with *both* O_1 (as at p_1) and O_2 (as at p_2), for *ex hypothesi* p_1 and p_2 are not spacelike separated. For what it is worth, we see no reason why the CASS endurantist *should not* admit that O coexists in this way with both O_1 and O_2, whilst simply denying that such coexistence is rendered absurd by O_1 (as at p_1) and O_2 (as at p_2) not coexisting with each other.[31] Be that as it may, of more importance is Balashov's next move, for he thinks the endurantist *will* want to talk about the coexistence of more than two objects at once: CASS, he thinks, requires generalization.

3.4 Objections from CASH

The generalization that Balashov suggests is CASH (Coexistence As Sharing a Hyperplane of simultaneity): a collection of n objects coexist, as at their n respective locations, iff these locations all lie on a flat spacelike hypersurface (2005, 20). Balashov thinks: (I) this notion is preferable to a more liberal alternative (coexistence as sharing of an *arbitrary* spacelike hyper*surface*), (II) that CASH involves a kind of 'contextuality' (the details of which we will not discuss) that is problematic for the endurantist (but not the perdurantist) and (III) that CASH involves a kind of 'chronological incoherence' (which is again problematic for the endurantist but not the perdurantist). We disagree with all three theses.

With regard to (I), first note that CASH, rather than the more liberal notion, is simply not available in the context of general relativity, or even in a generic curved spacetime (like our own!), where there are (typically) *no* flat spacelike hypersurfaces. Second, as will be discussed in Section 5, the endurantist should not restrict the locations of persisting objects to *flat* spacelike regions of spacetime *even when these are available*. It follows that even when there are flat spacelike hypersurfaces, most locations of enduring objects do not fall within them. What do we say about the coexistence of enduring objects as located at these non-flat spacelike regions? Third, Balashov's reasons for rejecting coexistence as the sharing of arbitrary spacelike hypersurfaces are misguided. He writes:

> [S]uppose three objects coexisting in a certain spatially flat temporal-like world form an Euclidean triangle there (i.e., a triangle whose angles sum up to two right angles). Adding other objects to the coexistence pool could make things go 'wild', even among the members of

[31] Gilmore makes the same point (2002, 246).

> the original group: the triangle they define might suddenly stop being Euclidean, and this for no physical reason. (Balashov 2005, 35)

By a "temporal-like world" Balashov simply means a global spacelike hypersurface. Balashov believes that the endurantist should:

> . . . take the facts about what object belongs to what temporal-like world at what point of its career – and what other objects it shares that world with – as the ground of all the important features exhibited in the temporal 'multi-universe'. These include temporary properties of objects and their changing relations with each other. The fact that all enduring objects trivially share the single spacetime manifold gives no further purchase.
>
> The endurantist must thus recognize existence in a temporal (or temporal-like) world and sharing such a world as basic facts. (Balashov 2005, 29–30)

We have quoted at length because we think this passage reveals the fundamental misconception that lies behind Balashov's unsuccessful coexistence-based arguments against relativistic endurantism. It suggests that Balashov, for reasons that we cannot fathom, conceives of the endurantist as committed to a more substantially 'temporally loaded' view of the world than anything we conceded in our earlier discussion of the Asymmetry Thesis. It is for this reason that we simply deny what Balashov claims in theses (II) and (III), that 'contextuality' and 'chronological incoherence' are any more problematic for the endurantist than the perdurantist. *Both* the perdurantist and the endurantist can see them as nothing more than relativistically novel aspects of the way in which different spatiotemporal perspectives within a single spacetime interrelate.

As we understand the position, the relativistic endurantist should take the tenseless facts about which spacetime regions enduring objects exactly occupy as basic. It will follow from this pattern of multi-location in *spacetime* that various global three-dimensional hypersurfaces in spacetime will have as subregions some of the locations of some of the enduring objects in spacetime. *Perhaps* the right way to analyze tensed utterances made within a relativistic world is in terms of such three-dimensional hypersurfaces (though, as we discuss in Section 2.3, we doubt that this is the case). But for enduring objects, just as much for perduring objects, such talk merely encodes certain location-dependent perspectives. The endurantist should not take such hypersurfaces, and co-location on such hypersurfaces, as basic. Quite the opposite is in fact true.

So, to turn to Balashov's example of three objects forming a Euclidean triangle, the endurantist will see the scenario as involving the following basic facts. There are many flat hypersurfaces wholly containing the three objects. Obviously, *with*

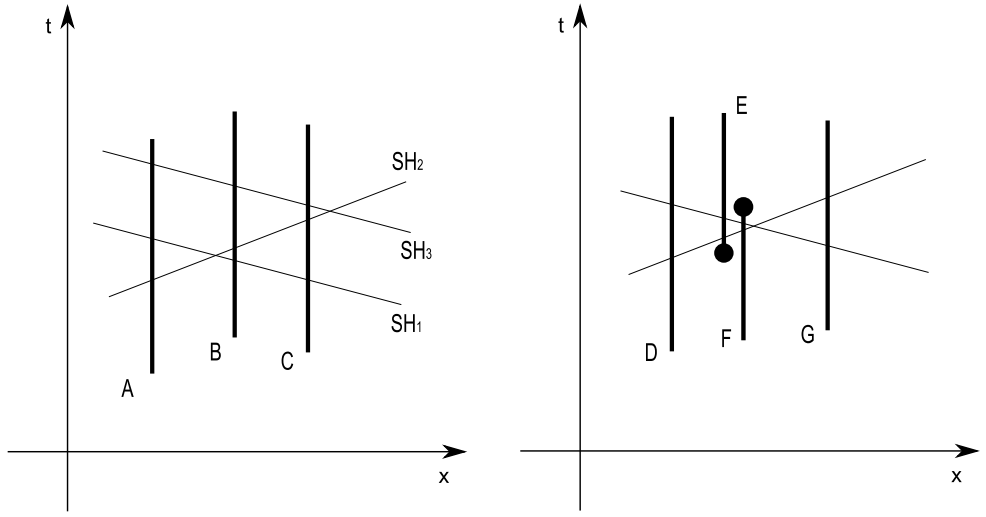

Figure 1

respect to these surfaces, the triangle the three objects form is Euclidean. But equally there are countless other surfaces containing these three objects, and with respect to these surfaces the triangle they form will not (generally) be Euclidean. This will be so whether or not the universe of the three objects contains an additional object. But in the example we suppose that there is an additional object. Moreover this additional object is such that (i) no location of it is a subregion of an everywhere spacelike surface with respect to which our first three objects form a Euclidean triangle, but (ii) some location of it is a subregion of an everywhere spacelike surface also including our first three objects but with respect to which the triangle they form is not Euclidean. That, at a fundamental level, is all the endurantist is committed to. Nothing goes "wild", is "unstable" or changes from being Euclidean to being non-Euclidean "for no physical reason."

A final comment on Balashov's claim that CASH involves chronological incoherence is in order.[32] Balashov's argument begins with the claim that certain sequences of spacelike hyperplanes containing more than one object are "chronologically incoherent": as the sequence progresses one moves in a future direction along some object's worldtube, but in a past direction along another's. (Thus consider a sequence that runs from SH_1 to SH_2 in Fig. 1(a), where A, B and C are the worldtubes of three objects.) However, Balashov admits this to be no serious prob-

[32]Balashov employs an extremely similar argument against stage theoretic views of persistence (Balashov 2002). Our criticisms of the argument against endurantism apply *mutatis mutandis* to that against stage theory.

lem provided there *is* a sequence that is *not* chronologically incoherent. He adduces the sequence of hyperplanes parallel to SH_1 and SH_3 as just such a sequence.

Balashov next contends, however, that "there are cases where a chronologically coherent series of temporal-like worlds is *not* available (unless one makes such a series improperly short)" (2005, 33); and moreover that such cases are problematic for the endurantist but not perdurantist. His example of just such a case is Fig. 1(b).

We set aside the claimed disanalogy between endurance and perdurance, for Balashov's central contention—that no chronologically coherent sequence of hyperplanes is available—seems to us to be plainly false. *Every* foliation of spacetime by spacelike hyperplanes constitutes a chronologically coherent sequence, and since they run from the most distant past to the farthest future, they can hardly be deemed "improperly short." As such a sequence progresses, one moves in a future direction along the worldtube of *every* object (that has a worldtube that intersects the hyperplanes in question).[33]

4 Problems with 'Wholly Present'

We now turn to a very different style of objection to the combination of endurance and relativity. Even in the non-relativistic context, many suspect that no sense can be given to the endurantist's central explanatory notion of *wholly present*, or at least no sense that differentiates endurance from perdurance (See Sider 2001, 63–8). We think the shift to ideas of *exact location* and of *multiple location* avoids some of the problems. Steven Hales and Timothy Johnson, however, think that there is a specifically relativistic problem with an object's being wholly present in more than one spacetime location. In particular, they argue that in a relativistic spacetime, "*no* object wholly exists at each moment of its existence" (Hales & Johnson 2003, 535, our emphasis). We shall see that their argument can be quickly dealt with.

[33]We find it hard to understand why Balashov either overlooks the existence of such sequences, or sees them as somehow inadmissable. Consider, again, Fig. 1(b). There are infinitely many spacelike hyperplanes containing all four objects, *D*, *E*, *F* and *G*, including, let us suppose, ones where *D* is five years old and ones where *D* is forty-five years old. It is true that, because *F*'s worldtube terminates close to where *E*'s worldtube begins, a chronologically coherent sequence every hyperplane of which contains *all four* objects will be relatively short-lived (no such sequence can contain both the five-year old *D* and the forty-five year old *D*). However, these shorter sequences are always segments of longer, chronologically coherent sequences. According to such a longer sequence, three of the objects coexist for a time, then the fourth comes into existence and all four coexist briefly, and then one of the original three ceases to exist. We do not understand why Balashov appears to view such long-lived sequences as illegitimate. Granted, no such sequence contains, e.g., *D* coexisting with all three other objects both when aged five and when aged forty-five. But why think that such sequences are in any way inadequate for this reason? The fact that there are chronologically *incoherent* sequences according to which *D* coexists with all four others both at age five and at age forty-five seems to us to be simply irrelevant.

We quote their own summary of the argument in full, for it illustrates our theme that relativity is not taken seriously enough even by those whose arguments appeal to it. They write:

1. Endurantism is defined in this way: *o* is an enduring object iff *o* wholly exists at each moment of its existence. That is, at every time *t* at which *o* exists, every proper part of *o* is at *t* (definition)

2. If SR is correct, then in the rest frame of an object *o*, each proper part of *o* is at a specific time *t*, and that time is the same for all parts. But for an inertial reference frame moving with respect to an object *o*, each proper part of *o* at a different position along the direction of relative motion is at a different time. That is, in a frame moving relative to *o*, *o* has proper parts at *t*, before *t* and after *t* (premise)

3. SR is correct (premise)

4. Thus if there is a reference frame moving with respect to an object *o*, then in that frame *o* has proper parts at *t*, before *t* and after *t* (from 2, 3)

5. The universe is not static, and so for any object there are inertial frames other than the rest frame (premise)

6. Thus every object has proper parts at different times (from 4, 5)

7. Hence no object wholly exists at each moment of its existence, and endurantism as defined in (1) is false. (from 1, 6)
(Hales & Johnson 2003, 535)

We have already discussed at length why relativistic endurantists will not accept anything like Hales and Johnson's definition of endurantism. Rather than talk of times, they will talk of objects wholly existing in, or being exactly located at certain *spacetime regions*. Note also that Hales and Johnson's explanatory gloss on the definition, in the second sentence of (1), appears to commit the endurantist to mereological *constancy*: that each proper part of an object must be located in a subregion of *every* region occupied by the object. One might think that such a restriction on endurantism is quite unmotivated.

Hales and Johnson's first premise (2) needlessly appeals to frame-relative concepts and, more seriously, appeals to the notion of the rest frame of the object, which we saw in the previous section is, in general, meaningless. They appear to argue, from how things will be described in two comoving inertial frames, that if an enduring object is wholly located in one set of parallel flat spacetime regions, then it must also be located in another set of parallel flat spacetime regions that

intersect the regions in the first set. We shall see in the next section that the endurantist *should* accept this conclusion, but they should not accept this argument for it.[34]

We do not quarrel with (3), except to note that, because it is not a quantum theory, even *general* relativity could not be considered as 'correct' without qualification.

(4) and (5) suggest to us that Hales and Johnson have not fully grasped the notion of a frame of reference. Even if the universe were static, there would still exist an *infinity* of inertial frames with respect to each of which the universe's static configuration could be (differently) described.

We take (6) to be obviously *compatible* with endurance. In fact, since endurantism just is the thesis that the object (and hence its proper parts) wholly exists at many different times (or, better, spacetime regions), to deny (6) would be to deny endurantism! It follows that (7), as allegedly derived from (1) and (6), is simply a *non sequitur*.

To be fair to Hales and Johnson, part of the problem is with their own summary of the argument. The idea behind the passage from (6) to (7) is the following. Suppose that part of an enduring object O becomes damaged at some point in O's career. Consider a spacetime location R of O that, intuitively, lies immediately prior to the damage event. This event, and thus a location of the damaged part of O, will be timelike related to some parts of R. But it will also be spacelike related to other parts of R. Hales and Johnson's thought is that there is a proper part of O, viz. its damaged part, that is *not* located within R, *even though* this part, because it is spacelike separated from *some* parts of O as located at R, is judged to be simultaneous with those parts, as located at R, in some frame of reference.[35] If O has a proper part *not* located at R, how can O be *wholly* present there?

The problem with this line of reasoning is obvious to see. For all Hales and Johnson have said, the damaged part of O, located in the immediate future of R, is *also* located somewhere in R. Relative to R it is undamaged. Relative to the location in the immediate of future of part of R, it is damaged. But since O is an enduring object, its parts also endure. They too are multiply located in spacetime.

[34]For discussion of why not, see Gilmore (forthcoming, §4.1).

[35]We have included this last observation for the sake of completeness, since it is an aspect of their example that Hales and Johnson make much of. We, however, fail to see what it adds. Not unlike Balashov, they take spacelike separation to be at least a *sufficient* condition for a (presumably) non-trivial notion of coexistence. They reason that *if* the damaged part of O coexists (in this sense) with some parts of O located at R, but is not itself located at R, then O is not wholly present at R. But *if* the non-existence at R of a proper part of O is problematic for the endurantist's notion of wholly present, we see this as problematic *whether or not* this part coexists in a non-trivial sense with other parts of O at R, for it certainly coexists with them in the eternalist's sense. For further critical discussion of the role of coexistence in Hales and Johnson's argument, see Miller (2004, 355–9).

This observation saves endurantism from Hales and Johnson's criticism, however, only to suggest another problem. What of objects that gain and lose parts? How can they be *wholly* located in each region of spacetime in which they exist?[36] We do not have much to say here, other than that this is a well known (alleged) problem for (eternalist) endurantism, as potent in the non-relativistic context as the relativistic.[37] To some extent, switch to talk of 'exact location' mitigates the appearance of a problem, but if one thought that the *exact* location of an object O in a region R involved a combination of (i) no region of R not being occupied by a part of O and (ii) no part of O lying outside R, then the problem remains. The situation currently being considered certainly violates the second of these conditions.

We shall see at the end of the next section that the perspective that we ultimately recommend to the endurantist simply side-steps some of these problems. Before we get there, however, we have another set of objections to relativistic endurantism to consider. Our discussion of Hales and Johnson's argument revealed that there is no problem in principle with the idea that an enduring object may be exactly located in two intersecting spacetime regions the points of each of which are simultaneous with respect to different frames of reference. But *should* the endurantist conceive of enduring objects as located in such regions? In fact, it is time to return to a more general question, first raised in Section 2.2. If enduring objects are exactly located in multiple spacelike regions of spacetime, in *which* such regions, precisely, are they typically located?

5 Gilmore and the Every C-Slice Principle

Gilmore's approach to this question is to first define the "path" of an object:

> R is the *path* of $O =_{\text{df}}$ R is a region and is the union of the (region or) regions that O exactly occupies. (Gilmore forthcoming, §2)

He then asks precisely where an object is located within its path (Gilmore forthcoming, §4). The perdurantist answer is that an object exactly occupies its entire path. The endurantist instead regards an object as exactly occupying multiple regions within its path. Very well; but which regions?

Gilmore suggests and then criticizes four different answers. The Rest Frame Principle holds that an object exactly occupies regions of its worldtube all the parts

[36] If we are right to interpret Hales and Johnson's gloss on their definition of endurantism, quoted above, as entailing mereological constancy, it would seem that their endurantist opponent will be untroubled by this new argument!

[37] See Merricks (1999), which is devoted to this objection against the combination of eternalism and endurance.

of which are simultaneous in the rest frame of that object (forthcoming, §4.2).[38] The Top Down Principle assumes a privileged temporal foliation of spacetime. Objects exactly occupy only those maximal regions of their worldtubes that are also subregions of the leaves of this foliation (forthcoming, §4.3). The Bottom Up Principle, very roughly, imagines tiny timers attached to the pointlike parts of an object. These measure the proper time along the trajectories of the parts in question. Initially (and in a rather idealized way) the timers are set to zero. The object then exactly occupies regions of the worldtube where the timers on the pointlike parts all read the same (forthcoming, §4.4).

We will not repeat Gilmore's decisive objections to these three principles. Instead we focus on a fourth option, the Every Slice Principle (Gilmore forthcoming, §4.1). This holds that an object exactly occupies each and every achronal slice through its worldtube.[39] How is "slice" to be interpreted? Flat hyperplanes have no special metaphysical significance and in any case are not available in a curved spacetime such as our own. Gilmore therefore means by "achronal slice" *any* hypersurface that is everywhere spacelike. In general the (spatial) geometry of such a surface will be curved. One further qualification is also required: such regions must be *maximal*, where a region is a maximal achronal slice through an object's worldtube iff it is not a subregion of any other achronal regions within the object's worldtube.[40] (In fact Gilmore only adds this qualification in response to an objection we consider below (p. 35; Gilmore forthcoming, §4.1).) In what follows we refer to the Every Slice Principle (thus interpreted) by the acronym *ESP*. The idea, to repeat, is that enduring objects exactly occupy every maximal achronal region within their worldtube.

Gilmore raises three apparent problems for ESP. We will find it easiest to discuss them in reverse order. We begin, then, with his observation that, for the identification an object exactly occupying one region with an object exactly occupying another, "an appropriate sort of causal relation (often called 'immanent causation')" must hold between these 'objects' (forthcoming, §4.1). This very general principle he calls *MURIC* (MUlti-location Requires Immanent Causation). We are minded to accept it.[41]

Gilmore believes that ESP is incompatible with MURIC. In particular, the very same object can, according to ESP, exactly occupy both of the overlapping regions R_a and R_b in Fig. 2. But according to Gilmore MURIC does not permit this, since

[38] We use "worldtube" as a synonym for Gilmore's "path".

[39] Recall from fn 13 that a region R is achronal iff every pair of distinct points within it are spacelike related.

[40] *Cf.* Sattig's definition of a temporal part of a region (p. 8 above).

[41] In particular, we think that Humeans about causation should find the principle no less plausible than non-Humeans, at least when applied to familiar composite persisting objects like tables and people.

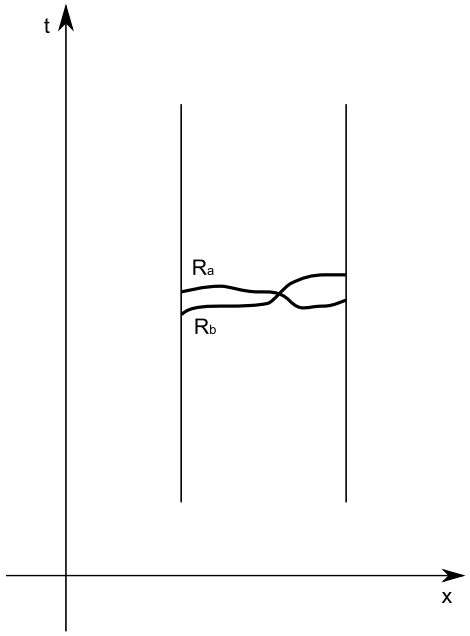

Figure 2

the object at R_a cannot be the (immanent) cause of the object at R_b, nor *vice versa* (forthcoming, §4.1). If we are wedded to MURIC, it seems that ESP will have to go.

Let us take a step back. Anyone initially attracted to ESP will surely regard R_a and R_b as containing objects and, indeed, objects of the same *type*; the remaining question is whether they contain the very same object. Let the object at R_a be O_a and that at R_b be O_b. In line with MURIC, we should indeed decide whether O_a and O_b are one and the same based, in part, on whether they are causally related in an appropriately intimate way. But we say that they *are* so related. In particular, every *part* of O_a is either (i) an immanent cause of the state of a particular part of O_b (viz. itself), (ii) in a state that is immanently caused by a part of O_b, or (iii) must be reckoned a part of O_b because it is exactly located in a region where R_a and R_b overlap. (The same holds *mutatis mutandis* for every part of O_b.) Granted, the state of O_a *as a whole* is not causally grounded in the state of O_b, or indeed *vice versa*; but the satisfaction of (i) to (iii) surely constitutes excellent grounds to nonetheless identify O_a and O_b.

We think that this observation saves ESP from Gilmore's MURIC objection, but consideration of the remainder of Gilmore's discussion will be instructive. In response to his alleged difficulty with MURIC, Gilmore offers the defender of ESP an amended version. Gilmore calls this *MURIC**:

> Necessarily, for any material object O and distinct spacetime regions

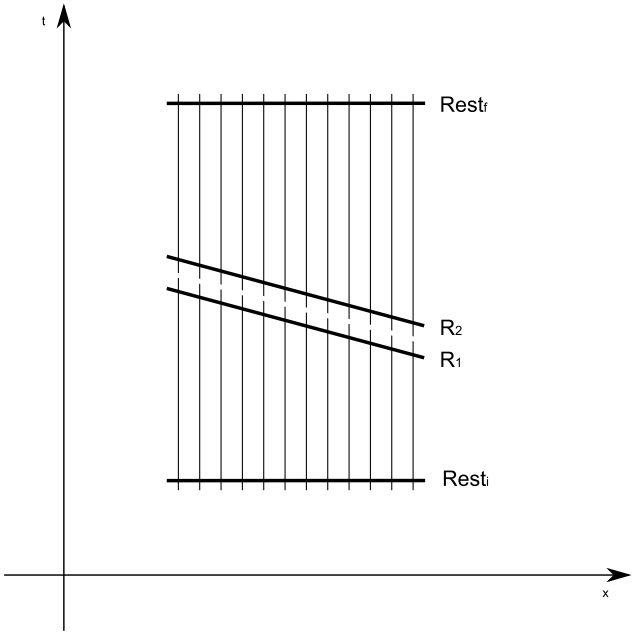

Figure 3

> R_1 and R_2, if O exactly occupies both R_1 and R_2, then there is some region R such that:
>
> (i) R_1 and R_2 are achronal slices of R,
>
> (ii) there is a set S of achronal slices of R such that every point in R belongs to at least one member of S, and for any two members, x and y, of S, the contents of x bear the appropriate sort of immanent causal relation to the contents of y, or vice versa. (forthcoming, §4.1)

After noting two points in favor of MURIC*, Gilmore objects to it as follows. Consider an entity composed of several molecules bound together. In the rest frame of that entity, the molecules are all replaced, successively but extremely rapidly, by intrinsic duplicates to which they are causally unrelated. With diagrammatic gaps representing non-causal replacement (but not spatiotemporal gaps) we thus have the situation depicted in Fig. 3.

The objects exactly located at the regions labeled R_1 and R_2 are surely distinct, since they are on opposite sides of a causal discontinuity. But MURIC* apparently

lets us down, in that it fails to rule out their identity.[42] This is because, at least according to Gilmore, there *is* a set S satisfying requirement (ii) of MURIC*: (e.g.) the set of parallel slices running from Rest_i to Rest_f (forthcoming, §4.1).

Since we do not judge MURIC and ESP to be incompatible (for the reasons given above), we feel no pressing need to defend MURIC*. Nonetheless, it is being saddled with another's guilt. Is it true that *every* two members of the set of rest slices bear the "appropriate sort of immanent causal relation" to each other? Surely (the contents of)[43] Rest_i and Rest_f are *not* immanently causally related, since they lie on opposite sides of a causal discontinuity! Gilmore thinks that Rest_i and Rest_f *are* so related because he explicitly assumes that "the relevant immanent causal relation is transitive" (forthcoming, §4.1); and because (for some appropriately chosen parametrization by the real numbers of the parallel slices running from Rest_i to Rest_f) Rest_n is very plausibly immanently causally related to Rest_{n+1} for all n (even within the region of causal discontinuity).[44]

It is the transitivity assumption, and not MURIC*, that is to blame here. Indeed this assumption even troubles MURIC itself. On the basis of transitivity Gilmore explicitly conceded that *any* two rest-frame slices are immanently causally related to each other. Rest_i and Rest_f are therefore immanent-causally related; and so *even according to MURIC*, their contents may be identified. We take this to be a *reductio* of the transitivity claim.

Transitivity also causes difficulties for the less liberal forms of relativistic endurantism that Gilmore considers after rejecting ESP (see p. 28 above). Any causal discontinuity not parallel to the permitted object-containing slices of a worldtube gives rise to the very same problem.

Indeed, the combination of transitivity and near-instantaneous 'immaculate replacement' raises the same issues even in the *non*-relativistic case. Suppose that horizontal lines in Fig. 3 represent planes of absolute simultaneity. Any two successive simultaneity slices through the worldtube in question would be immanently causally related. By transitivity then, Rest_i and Rest_f are again immanently casually related, and no MURIC-like principle will prevent us from identifying them.

[42] MURIC and MURIC* only place *necessary* conditions on when the occupiers of two regions may be regarded as one and the same, so should not putative counterexamples involve cases where we *want* to say two such occupiers are the same despite MURIC(*) vetoing this? The case under discussion involves exactly the reverse. Gilmore is right to see it as problematic, however, for the lack of appropriate casual connection between them is the *only* thing preventing our regarding the occupiers of R_1 and R_2 as the same, and hence it is down to MURIC(*) to rule out their identity.

[43] *N.B.* that in what follows we occasionally omit this qualification.

[44] Within this region, only a single particle is ever non-causally replaced from one rest slice to the next. Since, as Gilmore points out, we do allow that objects can persist through the gain and loss of parts, such slices "are as intimately causally related as any two slices through a spatially extended, persisting thing ever are" (forthcoming, §4.1).

The most obvious moral here is that the relevant immanent causal relation is not transitive. Recognizing this is the only way to uphold what should be an uncontroversial truth: that objects that are causally isolated from each other are not immanently causally related. Admittedly, the endurantist has a problem if they think that immanent causal relations are *sufficient* for identity. If this were the case then the fact that immanent causal relations hold between any two successive rest slices would make each such slice identical to the next. By the transitivity of identity, we could then conclude that *all* such rest slices—including Rest_i and Rest_f—are identical.

The endurantist must therefore deny that being immanently causally related is sufficient for identity.[45] Somewhere along the chain of (pairwise) immanently causally related slices, identity is lost: there are (at least) two such successive slices that do *not* contain the very same object. This will be because, to put it in rough terms, 'too much' of the object has by this stage been replaced 'too quickly'. True: in a different context these two slices might contain the very same object. But that is just to say that identity can fail to hold as a result of accumulated changes. We do not find this entirely implausible, but the more relevant point is that, however the endurantist deals with non-instantaneous causal discontinuities, they are not a specifically *relativistic* problem.

Gilmore's second criticism of ESP concerns time-traveling impenetrable extended simples (forthcoming, §4.1).[46] Consider again the worldtube of Fig. 2, interpreted now as that of an impenetrable extended simple. According to ESP, the object in question is located in very many subregions of that worldtube that overlap each other. R_a and R_b are examples (overlapping only at a two-dimensional region). But in that case these objects do interpenetrate after all!

Gilmore's immediate riposte in defence of ESP is that R_a and R_b contain *the same* object. Allowing such *self*-penetration is consistent with denying that any two *distinct* objects can interpenetrate. This response need not have a hint of 'magic physics' about it (how does the object 'know' that it is only with itself that it is allowed to interpenetrate?) because, for extended objects that are not simples at least, 'self-penetration' is really *overlap*, not interpenetration. ESP in no way suggests that any region of the worldtube of an object is occupied by matter twice over. The occu-

[45] If it is analytic that *immanent* causal relations hold only between states of the same object then we rephrase in terms of *quasi*-immanent causal relations: relations that are intrinsically identical to *bona fide* immanent causal relations except that they need not be accompanied by identity. The example in the main text illustrates how this might arise.

[46] It would be wrong for the defender of ESP to respond to this by simply refusing to be worried by any problem that arises only in such a *recherché* scenario. We have clear intuitions about time travel and interpenetration, both of which are respectable from the perspective of relativistic physics. While we may not have such good intuitions about extended simples, some speculative physics (viz. string theory) takes them seriously.

pants of R_a and R_b (for example) share a part, and so do not interpenetrate, in just the way that the central third of a desk shares a part with (but does not *penetrate*) the left-hand half of the desk. Gilmore's objects *are* simples though; they have no parts to share. But must the defender of ESP therefore allow that self-penetration occurs? Are regions of the worldtube of an extended simple persisting as per ESP multiply occupied by matter? If not, can we not still maintain that here we have overlap and not interpenetration?

No matter how one deals with the initial set-up, it is the next cycle of Gilmore's objection that he takes to spell trouble for ESP. Suppose that our simple's path extends around a closed time-like loop so that, in some region of spacetime, the object is on a collision course with its earlier self. The intuitive expectation is that the simple would *not* self-penetrate. But how can we uphold this given the earlier concession that our simple *can* self-penetrate?

We do not see why an answer is supposed to be difficult to give. If a world contains extended simples that do not interpenetrate, then (assuming the world is law-governed) it will, for example, be the existence of certain powerful short-range forces that ground non-penetration. The law will ensure that if two occupied disjoint subregions of some global spacelike surface S through spacetime are within some minimum distance from one another, then the pairs of subregions of spacelike hypersurfaces to the immediate future of S that are occupied by the same simples will be more distant from one another. The law will be oblivious to whether it is the same object occupying such pairs of regions or not, and it is entirely consistent with the kind of overlap required by ESP, which only ever involves occupation by the same object of two regions that do not both lie on some spacelike hypersurface. On the other hand, if the world is not law-governed, then the pattern of multi-location exemplified by our simples will be just a matter of brute fact. But then there is no reason why this brute fact should not be both consistent with ESP and involve no worldlines that intersect themselves.

We therefore reject Gilmore's second objection to ESP. But we offer a helping hand.[47] Suppose that our time-traveling object *can* penetrate other objects of its type (including itself).[48] Fig. 4 depicts the situation we have in mind; the diagonal worldtube is the time-traveled continuation of the vertical one.

In *this* case ESP is in a pickle. Consider EF and GH. Intuitively, the time-traveling object does not exactly occupy the fusion of EF and GH, but ESP threatens to yield the opposite result since this fusion is a maximal achronal slice through the object's worldtube.[49] Our intuition is even firmer that the object *does* exactly

[47]Thanks to John Hawthorne here.

[48]In this re-worked example our object, though still extended, need not be a simple.

[49]The mere fact that EF and GH are not contiguous should not by itself be held to rule out their exactly containing a single object, for many (perhaps most) objects *do* exactly occupy such regions (suits and football teams etc., but perhaps also many less 'dispersed' objects for, e.g., inter-molecular

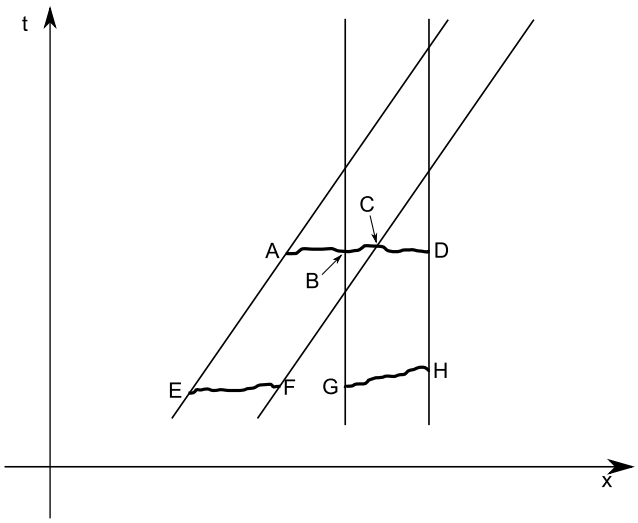

Figure 4

occupy EF and (separately) GH. But since neither of these regions is a maximal achronal slice through the object's worldtube, ESP denies this.[50]

The alert reader will object that the fusion of EF and GH is *not* in fact achronal; the existence of timelike loops means that EF is in the absolute future of GH (and *vice versa*). This fact secures the intuitively desirable result in this case: our time-traveling object exactly occupies both EF and GH (assuming that each region by itself intersects no timelike curve more than once) but not their fusion. Gilmore, however, cannot offer this response, for he defines ESP in terms of a "local" sense of achronal according to which EF and GH *are* achronal. (For details, the reader is referred to Gilmore forthcoming, §2, fn 19; §4.1, fn 33.) But nor should he, for abandoning the local sense of achronal for the global only courts other difficulties. For example, an object might not time travel itself, but might nonetheless exactly occupy a region containing points that are timelike-separated due to an 'almost closed' timelike curve (Gilmore forthcoming, §2, fn 19). ESP formulated in terms of the global sense of achronal prohibits this.

The moral is that ESP is in difficulty. Rather than offer yet another principled answer to Gilmore's location question, however, we instead advocate a point of view according to which the question itself is undercut. Since this viewpoint helps to answer Gilmore's final objection to ESP (i.e. *his* first objection), we give a brief account of this.

distances can be much greater than molecular widths).

[50] In fact, Gilmore notes (but does not solve) what is effectively a non-relativistic version of this problem (forthcoming, §4, fn 29).

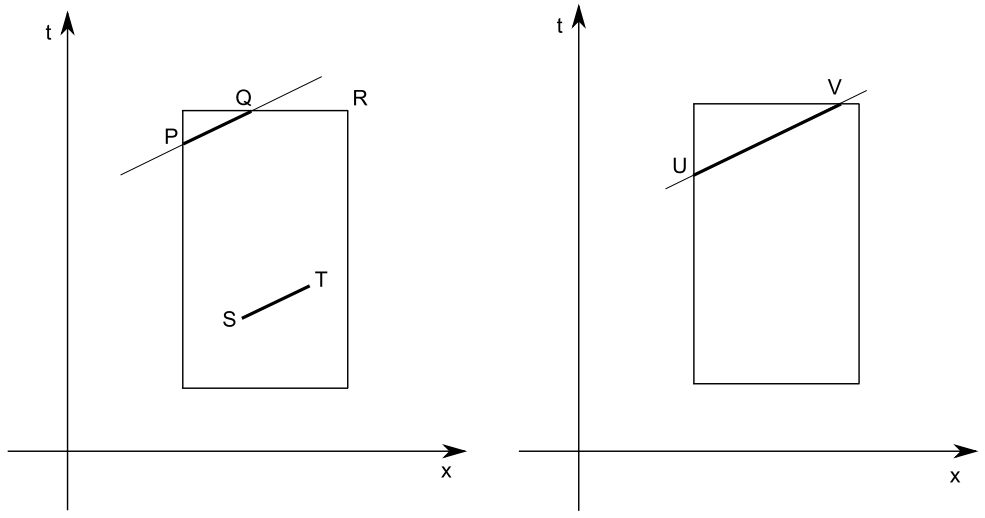

Figure 5

In fact it is this objection that leads to the requirement of maximality in ESP. Consider the worldtube in Fig. 5a, and in particular the (achronal) subregion PQ. ESP *without* the maximality requirement would rule that the object whose worldtube is depicted *does* exactly occupy PQ. But this answer becomes impossible to credit when we consider similar regions that are closer still to the top left-hand corner of the worldtube. In the most extreme case, such a region might contain only a single particle. Surely the object does not exactly occupy this region.[51]

Gilmore's solution is to note that PQ, rather like ST, is not a *maximal* achronal region within the worldtube; it is a subregion of many larger achronal regions, PQR for example.

We are not at all sure this that is the wrong response, but one might worry that it goes too far. Consider the region UV in Fig. 5b. Supposing the worldtube to be that of a human, this region might contain all the usual parts of a person except for a right hand. Should one say that such a slice does not contain the person in question? If instead we consider someone who *loses* a hand, ESP (subsequently) locates that person at just such a slice.

Our discussion of the time travel and corner slice objections to ESP has revealed that it *does* have problems. The root of these problems, however, does not lie with the details of ESP. We see no reason to suppose that *any* attempt to provide an answer to Gilmore's Location Question will be successful if that answer is meant to be applicable to all types of object, especially if the answer further restricts itself to

[51]Miller raises the same difficulty (2004, 365-6).

characterizing the objects' locations in purely spatiotemporal terms (as ESP does).

On the approach we prefer, the endurantist proceeds on a case-by-case, region-by-region basis, so that whether an object exactly occupies a region depends critically on the type of object being considered. The endurantist believes that objects are three-dimensional and exactly occupy multiple spacetime regions. But the precise locations of such an object are not determined by the fact that some spacetime region contains its worldtube and that certain subregions of this region satisfy certain geometric constraints. It is, of course, the other way around. Facts about where the object is located determine which region is its worldtube. This might be as true for point particles as for composite objects; some facts about where a particle is located, together with causal laws, will determine that the particle is also located in certain other point-sized regions.

For composite objects, bedrock is the pattern of (multiple) location of the fundamental entities that, at various spacetime regions, compose them. *Some* three-dimensional achronal regions will contain the right sorts of such entities, arranged in the appropriate way, for these entities to compose a particular type of object at that region. We thus arrive at three-dimensional objects. In general, whether a given three-dimensional region contains an object of a given type will not just be a matter of the intrinsic character of the contents of that region. It will also depend on regions to its past and future having the right kind of content.[52] And it will also depend on regions that are spacelike related to it having the right kind of content (statue shaped regions within blocks of marble are not statues).[53]

This gives us variously located three-dimensional objects. But some of these 'objects' are the very same object. Such identity facts will be determined by a mixture of spatiotemporal and causal considerations; but, just as with composition, the precise details may be expected to vary from kind to kind and from object to object. In any case, it is only at this late stage that the identifications that determine an enduring object's worldtube enter the picture. We only arrive at the path of an object of a certain type by first determining which three-dimensional regions contain objects of that type and then by determining which regions contain the same object. We then take the union of a set of such regions. But if the path is arrived at in this way, which locations within it are occupied by its object cannot be an interesting question that remains outstanding. We already know the answer.

[52] *Cf.* Sider (2001, 187–8).

[53] It is this type of consideration that gives the maximality requirement in ESP whatever plausibility it has, particularly in regard to the region ST in Fig. 5a.

6 Balashov on Explanatory Deficiency

Finally, we return to Yuri Balashov. In addition to the considerations discussed in Section 3, Balashov has presented a further argument against endurantism. His conclusion in its most general form is that, especially in comparison with perdurantism, endurantism is an explanatorily inadequate theory of persistence.[54]

What are the data to be explained? Balashov contends that one and the same persisting object exhibits a vast array of different three-dimensional shapes that all fit together into a smooth four-dimensional volume. According the Balashov, the perdurantist can easily explain this fact. For the endurantist, however, it remains a complete mystery (Balashov 1999, 651–3; 2000*b*, 333–4).

Of course in relativity when we say that an object exhibits a great variety of shapes this should not be understood in terms of variety *over time*. Rather Balashov suggests that shapes (and properties more generally) are doubly-indexed to both a *frame* and a time. Purportedly enduring objects then exhibit a multitude of such doubly-indexed shapes which, to repeat, "arrange themselves into a 'nice' 4D volume in space-time" (Balashov 2000*b*, 334).

This is not even the worst of it. Balashov writes that "a series of pictures of a single object taken from the same place at the same time" will, in certain circumstances, show the object as differently-shaped. How bizarre! But the situation he envisages involves momentarily coincident observers traveling at different velocities. According to relativity (says Balashov), in "different such perspectives an object presents itself in different shapes" (1999, 652).

Regarding these most recent claims, Balashov explicitly admits that talk of observers and their pictures should not be taken literally; he is interested "not with the subjective *appearance* of objects but with the way they *are* in and of themselves" (1999, 660, fn 5). This disclaimer is sorely needed though, since any snapshots taken by observers at the same spacetime point would in fact be *exactly the same*—whatever their relative velocities![55]

We therefore take Balashov's ultimate claim, stripped of its observational garb, merely to be that objects are different ways relative to two frames with respect to which two observers in relative motion are at rest. The fact that such observers may momentarily coincide adds nothing. Of course, the frame-relativized facts in-

[54]Balashov proceeds to this conclusion in two separate papers from two rather different starting points. In one he starts from a discussion of a two-dimensional spatial world ("Flatland") that is embedded in a three-dimensional space containing spatially three-dimensional objects (Balashov 1999). Right-thinking Flatlanders reason abductively to the conclusion that their objects are spatially three-dimensional; Balashov thinks this parallels the (this worldly) argument for perdurantism that we will soon discuss. In a second paper he attempts to illustrate the same line of thought using the traditional relativistic 'problem' of the Pole and the Barn (Balashov 2000*b*).

[55]Any and all light arriving at a point (P) emanates from just those points in P's backwards light-cone. The velocity of any observer at P is entirely irrelevant.

volved here should not be given undue weight. The more fundamental facts for the endurantist concern the shapes of an object's multiple locations. Relative to a particular frame, the object's shape is given by the shape of its locations containing only points that are simultaneous in that frame. So reduced, we find the phenomenon to which Balashov draws attention less sensational than originally expected.

What about the major explanandum though? One and the same object possesses what for Balashov is a vast array of frame-and-time-relativized shapes.

> All these 3D shapes taken together exhibit a remarkably unity: they can be lined up neatly in spacetime to fill a nice 4D volume, without 'corrugation' and 'dents'. How would the endurantist explain this unity among the 3D shapes? (Balashov 2000*b*, 334)

How indeed? Let us start with the non-relativistic case; there too the successive shapes of an enduring object aggregate up into smooth four-dimensional spacetime volumes.[56] But in this case the explanation is clear: a *causal* story accounts for the shape of an object's worldtube.[57] If one overeats, one's worldtube soon thickens. If one diets, it all-too-gradually narrows.

Miller makes this very point in response to Balashov:

> Various causal facts about an enduring object O at time t, make it the case that O will exist at t^*. So there is no explanatory mystery here. (Miller 2004, 367)

Later on:

> [W]e take as basic the three-dimensional objects and use the various 'rules' in the form of the laws of nature to predict what those objects will be like in the future. So it can hardly come as a surprise when we discover that those objects fill nice four-dimensional volumes: for that is precisely what we predicted, given our theory. (Miller 2004, 368)

We approve of this causal strategy. However, whilst Miller's remarks are entirely appropriate in the non-relativistic case, she is inexplicit as to how to alter the story—or even whether it needs altering—to deal with relativity. Interpreted

[56] Although Miller (2004, 367) makes the nice point that on mereological universalism most worldtubes are anything but smooth or nice. Balashov's claim is nonetheless broadly true for 'everyday' objects, although we should bear in mind that trees get pruned, watches disassembled, etc.

[57] We shall soon see that Miller (2004) makes this point. In addition it corresponds to an objection by Hud Hudson in the context of Balashov's Flatland. We agree with Balashov that the objection fails in that context, but Balashov goes on to mistakenly reject the relativistic analogue (1999, 660, fn 3).

relativistically, her causal story must be taken as frame-relative (witness the unqualified talk of times). There is the standard worry about the propriety of frame-relativization here, but in addition there is the new concern that such a causal story will privilege the frame in which it is told in a manner inconsistent with relativity. One might respond that the causal story can be given relative to *any* frame, and thus no frame is privileged. But suppose that, as is natural to interpret Miller, the causal goings-on in frame A are used to generate the successive shapes and properties of an object in that frame. What of the shapes and properties of the object in frame B? Perhaps these are to be derived from the successive shapes and properties in A, or (equivalently) from the object's worldtube as generated in A. But when, in the spirit of relativity, we also assert that the causal goings-on in B could have grounded matters, we surely risk undermining our explanation. How can the goings-on in A account for the shapes in B when the shapes in A are themselves accounted for by the goings-on in B? Does this not mean that *neither* frame tells the fundamental story?

We shall therefore amend this causal account. Sider (2001, 82–3) provides the basic idea when he suggests in response to Balashov that the endurantist begin by focusing on the parts of an object—and in particular its constituent particles.[58] He continues:

> Provided the endurantist can make sense of the part-whole relation in a relativistic context, then, she can account for the shapes of macroscopic objects in various reference frames. (Sider 2001, 83)

Balashov was aware of Sider's then-unpublished suggestion; his discussion includes a preemptive riposte. The kernel of this is that "instead of offering a real explanans… the move, in effect, boils down to restating the explanandum" (Balashov 1999, 655). How so?

Chemical explosions, the second law of thermodynamics and superconductivity are all adduced to articulate Balashov's point; but the central claim is clear enough. Why does an object, O, move from A to B? Answer: because its constituent particles take that path. Balashov would rightly claim that this just restates the explanandum. That O moves from A to B is tantamount to its particles doing the same. Of course *if* we somehow explain the one fact then, given certain facts about composition, we explain the other; but neither fact *by itself* explains the other. They are two sides of the very same coin.

[58]To engage with Sider and (later) Balashov, we speak as if objects were fundamentally constituted by particles. We intend no commitment to a fundamentally particulate ontology by this. Endurantism *may* be threatened by the fact that our best physical theories of matter are (relativistic) quantum *field* theories. But if this is indeed so, it is not a specifically *relativistic* problem for endurantism, and so not a topic for this paper.

This response rests on a misunderstanding. We grant that the spacetime path of an object involves little if anything more than the combined spacetime paths of its constituent particles. Nonetheless, the *point* of re-stating the explanandum at the particulate level (and, to clarify, we concede that it is a mere re-statement) is that we can *then* give a genuine explanation of the re-stated facts. This genuine explanation does not just amount to, as Balashov puts it, "putting [a] finger on the worldlines of such particles to find out what space-time point is occupied by what particle" (1999, 654). It rather requires us to say *why* a particle at one spacetime point is also at *this* adjacent spacetime point rather than *this* one; and such a story will be told in terms of physics. The various local fields around a particle determine where it 'next' is; such fields again determine where it is 'after' that; and so on until we have the complete worldline.[59] The same considerations determine the worldlines of all of an object's particles, and thus they ultimately account for its four-dimensional career.

Of course in everyday contexts we rarely consider such particulate explanations. But we saw a disadvantage to more macroscopic causal accounts: in which frame is the macroscopic story to be told? An advantage of the particulate explanation—and this is a point that Sider misses—is that the explanation of the particle worldlines can easily be stated in terms of a *frame-free* physics, and thus we can avoid even the appearance of a clash with relativity.

To repeat then, it is physical law that explains why a particle follows the worldline it does; this depends on the fields local to it. Similar facts explain the worldlines of nearby particles, leaving us with a fully-grounded four-dimensional 'sheaf'. *If* this sheaf is 'smooth' or 'nice' then this is because the trajectories of particles within material objects are constrained by physical law to remain in stable configurations. No endurantist magic is required. As for the endurantist's three-dimensional objects, these enter the picture via facts about composition. Once we have our story as to why the particles do what they do, compositional considerations of the sort outlined at the end of Section 5 licence the endurantist to re-state these microscopic facts in macroscopic, three-dimensional terms.[60] Small wonder, then, that the three-dimensional object-shapes thus derived coalesce into a smooth four-dimensional whole. They are each composed of constituent particles at different points along their worldlines; and considerations from physics ensure that, in the case of familiar objects, these worldlines are closely associated into a smooth volume.

Finally, we must comment on the *perdurantist's* predicament. Although perduring objects of course have a single four-dimensional shape, it seems just as true

[59]The scare quotes indicate that the relativistic endurantist should really eschew such temporal talk; but they are free to re-cast the point using exact occupation of spacetime regions.

[60]That this is indeed a *re-statement* was of course Balashov's earlier complaint.

for perdurance as for endurance that such objects are 'associated' with a multitude of different three-dimensional shapes.

Such three-dimensional shapes still aggregate into smooth four-dimensional world-volumes. According to Balashov,

> the four-dimensionalist has a ready and natural explanation of the this fact: different 3D shapes are *cross-sections* of a single 4D entity… (1999, 653; our emphasis)

Similarly:

> The explanation is that one is dealing with a 4D object presenting its various 3D *parts*… (1999, 653; our emphasis)

We agree that if objects perdure then the three-dimensional shapes are cross-sections through those four-dimensional objects. The question, though, is whether Balashov is entitled to simply *assume* the existence and shape of four-dimensional objects, only for this to then ground facts about the three-dimensional parts. Balashov thinks this is right and proper, claiming that "such parts are 'carved out' from a pre-existing ontological entity…" (2000*b*, 333). Yet there is no obvious sense in which the four-dimensional entity "pre-exists".[61]

We also take issue with Balashov's comment that the "facts about the occupation of 4D volumes by perduring objects are fundamental and irreducible to the facts about the mereological relations between four-dimensional wholes and their three-dimensional parts" (2000*b*, 323). It is misguided to think perduring objects are simply given. In fact this is no more true of perduring objects than of enduring ones; and the reason is the same in both cases. Put in terms of perdurance, objects have their four-dimensional shapes in virtue of their ultimate constituents. These, still according to perdurance, are extremely thin, tube-shaped four-dimensional entities; but what again determines the twists and turns of such tubes is local physics, which can be given a frame-free formulation. The locations of successive temporal parts of the perduring constituents are thus grounded; and within material objects, constituent worldtubes tend to coalesce. Hence we again explain the 'smooth' four-dimensional volume, with its three-dimensional cross-sections. As with endurance though, it is facts at the microscopic level that provide the ultimate explanation for three-dimensional shapes—whether these are grounded directly by such facts, or whether this proceeds indirectly through a similarly-grounded four-dimensional entity.[62]

[61] Balashov uses the same terminology elsewhere (1999, 654–6).

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