

ENDURING AND PERDURING OBJECTS IN MINKOWSKI SPACE-TIME[†]

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ABSTRACT

I examine the issue of persistence over time in the context of the special theory of relativity (SR). The four-dimensional ontology of perduring objects is clearly favored by SR. But it is a different question if and to what extent this ontology is required, and the rival endurantist ontology ruled out, by this theory. In addressing this question, I take the essential idea of endurantism, that objects are wholly present at single moments of time, and argue that it commits one to unacceptable conclusions regarding coexistence, in the context of SR. I then propose and discuss a plausible account of coexistence for perduring objects, which is free of these defects. This leaves the endurantist room for some maneuvers. I consider them and show that they do not really help the endurantist out. She can accommodate the notion of coexistence in the relativistic framework only at the cost of renouncing central endurantist intuitions.

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1.

Two rival accounts of persistence of material objects through time are currently on the market: *endurantism* and *perdurantism*.¹ Objects endure if they persist by being *wholly present* at different moments of time. One and the same object can be entirely present at t_1 , then it can be entirely present at t_2 ; when it is at t_2 , it is no longer present at t_1 , neither is any part of it. On this view, objects should be conceived as point-like beings or rather as three-dimensional entities that do not have “temporal thickness.” Of course, enduring objects pursue their careers in space, as well as time. Such careers or histories can be suitably represented by worldlines (or rather “worldworms”) in the four-dimensional space-time. George Gamow might be an example of an enduring being. He would in that case have been wholly present: in 1927 in Russia, in 1930 in Denmark, in 1935 in the United States.

Objects perdure if they persist by virtue of having (spatio-)temporal parts, or stages, at different times, no part being fully present at more than one time. In this picture, objects *themselves*, rather than their histories, are worldlines (worldworms). Thus ‘George Gamow from 1927 in Leningrad, through 1933 in Paris, to 1940 in Washington, DC’ would name a perduring four-dimensional object.

Endurantism and perdurantism presuppose very different and, according to the majority view, incompatible ontologies. It is widely believed that our ordinary intuitions favor endurantism, whereas modern science and, in particular, relativity theory favors perdurantism. Two comments are in order here. Whereas endurantism can indeed draw support from a variety of common-sense intuitions, it is not the case that the opposite perdurantist view is *blatantly* counterintuitive. It is easy to point out certain persistent and broadly perdurantist intuitions. For example, we tend to think (see Maxwell 1985, 30) of our *distant* past and future as “being there,” enjoying some kind of

¹ These terms are originally due to Mark Johnston and David Lewis. See Lewis 1986, 202, Johnston 1987. On the perdurantism-endurantism debate see, e.g., Armstrong 1980, Haslinger 1989ab, Heller 1990, van Inwagen 1990, Carter and Hestevold 1994, Merricks 1994, 1995. For useful definitions of the notions of ‘temporal part’ and ‘being wholly present at t ’ see, especially, Markosian 1994, Zimmerman 1996.

existence in a certain region of space-time. Thus Gamow vividly describes his wild past years² as “lying” in Stalinist Russia. This is by no means intended to imply that common-sense intuitions (when confronted, say, with views based on established science) must always pass a final verdict in metaphysical debates,³ but only to emphasize that in the case at hand such intuitions may, after all, be ambiguous.

It is true, on the other hand, that the whole idea of perdurantism as an alternative to endurantism has found support in the rise of relativistic physics. In particular, the four-dimensional ontology of perduring objects is suggested by the language of space-time diagrams widely employed in special relativity since Minkowski’s epochal work (1908).⁴ But whereas the perdurantist ontology is *suggested*, and the endurantist ontology *disfavored*, by special theory of relativity, it is a different question if and to what extent the former is *required*, and the latter *ruled out*, by this theory. The question seems to be of crucial importance to the whole controversy about the nature of persistence.

The paper addresses this question. My strategy is the following. I take the essential idea of endurantism, that objects are wholly present at single moments of time, and argue that it commits one to unacceptable conclusions regarding coexistence, in the context of special relativity. I then propose and discuss a plausible account of coexistence for perduring objects, which is free of these defects. This leaves the endurantist room for some maneuvers. I consider them and conclude that they do not really help the endurantist out. She can accommodate the notion of coexistence in the relativistic framework only at the cost of renouncing central endurantist intuitions.

² In the autobiography entitled, not surprisingly, “My Worldline.” See Gamow 1970.

³ Personally, I am opposed to this thesis, as will become clear below.

⁴ A certain interpretation of this language has given rise to the “Block Universe” view of the four-dimensional world in which all point events have the same ontological status. This fact, however,—if it is a fact—does not, by itself, entail any immediate consequences for the issue between endurantism and perdurantism, as the issue in question is about the ontology of material objects, whereas the Block Universe debate (see Putnam 1967, Rietdijk 1966, 1976, Stein 1968, 1991, Sklar 1985, Ch.11, Maxwell 1985, Hogarth and Clifton 1995, Dorato 1996) is about the ontology of *events* and the nature of time. One might suspect these two different issues may nonetheless be intimately related. Whether this is so is an open question (see, in this connection, Carter and Hestevold 1994, Merricks 1995). As will become clear, the arguments of this essay do not rely on any such possible relation.

2.

I take it to be uncontroversial that various material things in our world coexist whereas others do not. This claim is sufficiently general and neutral with respect to the endurance versus perdurance controversy. The endurantist and the perdurantist would certainly want to construe coexistence (or the lack of it) differently. But no one of them would be willing to deny, on pain of solipsism, that she coexists with various objects—tables and chairs, as well as other persons—and no one would be inclined to admit that, in any interesting sense of coexistence, she coexists with all of them indiscriminately. Whether objects endure or perdure, there must be a sense of the coexistence relation such that I bear this relation to Bill Clinton but not to Napoleon.

I also take it for granted that the coexistence relation C must be *symmetric*. An account on which x coexists with y , $C(x, y)$, but y does not coexist with x , $\sim C(y, x)$, would hardly have anything to do with the notion of coexistence.⁵

Consider two point-like enduring objects $E1$ and $E2$ and their worldlines $L1$ and $L2$ representing their spatio-temporal careers in Einstein-Minkowski space-time.⁶ In view of the above considerations, the endurantist would certainly want to say that, in a wide variety of cases, these objects will coexist. What are necessary conditions of the coexistence of $E1$ and $E2$? Given that enduring objects are wholly present at single points of their histories, they cannot coexist unless they are, in *some* sense, *co-present* to one another. To put it differently, coexistence of enduring objects must be grounded in some relation R between their momentary spatio-temporal locations $O1$ and $O2$ —a relation that would express the fact of their co-presence.

⁵ Indeed, what would an advocate of such an account *mean* by coexistence? After all, things either do or do not exist. If x exists and y coexists with it, then y exists as well. But x also exists, as per the initial assumption, and, hence, coexists with y .

⁶ The arguments of this paper could alternatively be formulated to apply to real objects, i.e., spatially extended ones, rather than idealized objects lacking spatial thickness. This, however, would involve unnecessary complications and detract from clarity in graphic illustrations widely used below. Furthermore, relativistic considerations of spatial extension and spatial shape lead to another argument in favor of perdurantism, which I put forward elsewhere (Balashov 1998). Here I deliberately abstract from such considerations and employ the above-mentioned idealization. It will become clear to the reader and the substance of my arguments does not turn on this idealization.

In the classical Newtonian framework, co-presence was entirely unproblematic. E1 and E2 could be said to coexist just in case they both exist *at the same time*, or belong to the same “present.” More formally, Newtonian space-time is uniquely decomposable into the set S of hyperplanes of *absolute simultaneity*⁷ (sometimes also referred to as “planes of becoming”), $S = \{ \text{HPS}'_{\text{abs}} \}$, where t_{abs} is the absolute Newtonian time. In this pre-relativistic framework, relation R could be defined as follows:

$$R^{\text{N}}(\text{O1}, \text{O2}) \leftrightarrow (\exists t_{\text{abs}})(\text{O1} \in \text{HPS}'_{\text{abs}} \ \& \ \text{O2} \in \text{HPS}'_{\text{abs}})$$

and the corresponding principle of coexistence for enduring objects would be (‘N’ standing for “Newtonian”):

$$\begin{aligned} &(\text{C}^{\text{N}}) \text{ Any two enduring objects coexist iff their locations belong to the same } \text{HPS}'_{\text{abs}} : \\ &\text{C}^{\text{N}}(\text{E1}^{\text{O1}}, \text{E2}^{\text{O2}}) \leftrightarrow R^{\text{N}}(\text{O1}, \text{O2}). \end{aligned}$$

Here ‘E1^{O1}’ and ‘E2^{O2}’ denote enduring objects E1 and E2 located at O1 and O2 respectively. The relation of coexistence C^{N} defined in this way is symmetric because it is grounded in the symmetric relation R^{N} . C^{N} is also transitive: $C^{\text{N}}(\text{E1}^{\text{O1}}, \text{E2}^{\text{O2}}) \ \& \ C^{\text{N}}(\text{E2}^{\text{O2}}, \text{E3}^{\text{O3}}) \rightarrow C^{\text{N}}(\text{E1}^{\text{O1}}, \text{E3}^{\text{O3}})$. In general, on this pre-relativistic view, everything coexists with everything else by virtue of being co-present with it in every reference frame.

This simple account becomes inadequate in the relativistic context where absolute simultaneity is rejected in favor of relative simultaneity. Two enduring objects may be co-present (that is, their momentary spatio-temporal locations may be simultaneous) in one (inertial) reference frame but not in another. To express their coexistence, the endurantist can no longer rely on

⁷ A hyperplane (HPS) is a three-dimensional “plane” in a four-dimensional space. It is a three-dimensional analog of a normal two-dimensional plane. An HPS associated with a given event is a set of events simultaneous with it in a given reference frame. Unlike in the relativistic space-time, an HPS for a given event in Newtonian space-time is frame-invariant.

relation R^N holding in *every* reference frame if it holds in *any*. This does not mean that no other relation R can be singled out to ground the coexistence of enduring objects in an objective and relevant way. But the requirements of objectivity and relevance impose constraints on any candidate for R .

(*Objectivity*): Given any two enduring objects $E1$ and $E2$ entirely present at their spatio-temporal locations $O1$ and $O2$, there must be a *fact of the matter* as to whether $R(O1, O2)$ holds.

(*Relevance*): $R(O1, O2)$ must express the fact of *co-presence* of $E1$ and $E2$.

Whereas *Objectivity* is self-evident, *Relevance* needs some clarification. There are many objective relations between spatio-temporal locations of enduring objects. But most of them express facts that are not in the least relevant to coexistence (i.e., co-presence) of such objects. Thus “ $O1$ is two thousand miles closer to the Andromeda nebula and three seconds later than $O2$, as measured in Andromeda’s rest frame” is such an objective relation which is completely irrelevant.

Another constraint on R comes from the fact that R is expected to ground a symmetric relation C . The latter cannot be symmetric unless R is itself symmetric.

(*Symmetry*): $R(O1, O2)$ must be symmetric.

In the next section I consider some obvious candidates for R and in §6 a non-obvious one. I argue that none of them gives an acceptable account of coexistence consistent both with the endurantist ontology and special relativity. In §§4 and 5 I show that the perdurantist ontology fares better in this respect.

3.

3.1. *ENDURANTIST* says: Let R be the relation of simultaneity $R_{\text{abs}}(\text{O1}, \text{O2})$ in one distinguished reference frame F_{abs} not tied up to either E1 or E2:

$$R_{\text{abs}}(\text{O1}, \text{O2}) \leftrightarrow (\exists t_{\text{abs}})(\text{O1} \in \text{HPS}'_{\text{abs}} \ \& \ \text{O2} \in \text{HPS}'_{\text{abs}}),$$

where t_{abs} is time measured in F_{abs} . One may not know *which* reference frame is F_{abs} but this is immaterial. What matters is that there is one. This gives rise to the following account of coexistence for enduring objects:

(CE_{abs}): Any two enduring objects coexist iff they are co-present in F_{abs} .

The coexistence relation defined according to CE_{abs} is objective, symmetric, and transitive.⁸

Objection: But it is irrelevant. Although there is, on CE_{abs} , a fact of the matter as to whether E1 and E2 are co-present *in* F_{abs} , there is no fact of the matter as to whether they are *co-present* (period). If special relativity is true, no reference frame is objectively distinguished. CE_{abs} attempts to preserve the classical (i.e., pre-relativistic) notion of co-presence in a context where it is meaningless. One cannot accept special relativity, together with its weird consequences, as true but continue to adhere to compromised pre-relativistic concepts, such as absolute simultaneity.

3.2. *ENDURANTIST*: Let's talk about co-presence of E1 and E2, not in some distinguished reference frame (there isn't any) but in E1's or E2's rest frame. Consider:

$$R_{[1,2]} \leftrightarrow \text{O2} \in \text{HPS}^{\text{O1}},$$

⁸ It is transitive in the following sense: given that E1, E2 and E3 are located at O1, O2 and O3 respectively, then, if E1 coexists with E2 and E2 coexists with E3, then E1 coexists with E3 (where coexistence is construed according to CE_{abs}).

where HPS^{O1} is the hyperplane of simultaneity drawn through $O1$ in the reference frame in which $E1$ is at rest, and the corresponding account of coexistence:

$CE_{[1,2]}$: Any two enduring objects $E1$ and $E2$ coexist iff they are co-present in $E1$'s rest frame.

Objection: This won't do. The relation of coexistence defined according to $CE_{[1,2]}$ is objective and may be relevant. But it is not symmetric, because the underlying relation $R_{[1,2]}$ is not. In Figure 1, $R_{[1,2]}$ holds but $R_{[2,1]}$ does not, because $O1 \notin HPS^{O2}$.

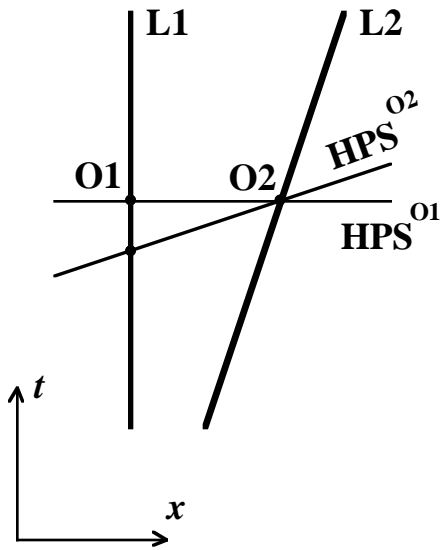


Fig. 1. Assuming that $E1$ is at $O1$ and $O2$ is simultaneous with $O1$ in $E1$'s rest frame ($O2 \in HPS^{O1}$), $E2$ is co-present with $E1$. $O1$, however, is not simultaneous with $O2$ —and, hence, $E1$ is not co-present with $E2$ —in $E2$'s rest frame: $O1 \notin HPS^{O2}$.

Taken at face value, $CE_{[1,2]}$ would assert that, in the situation depicted, $E2$ coexists with $E1$, but $E1$ does not coexist with $E2$, which is, to put it mildly, somewhat puzzling.

3.3. *ENDURANTIST:* But perhaps we can remedy the situation by upgrading $R_{[1,2]}$ to a symmetric relation R :

$$R(O1, O2) \leftrightarrow O2 \in \text{HPS}^{O1} \ \& \ O1 \in \text{HPS}^{O2}$$

and correspondingly symmetrizing $\text{CE}_{[1,2]}$, by promoting it to CE:

(CE) Any two enduring objects coexist iff they are co-present with one another in their respective rest frames.

CE (just as the grounding relation R) is objective, relevant, and symmetric, as required. Moreover, it is transitive.

Objection: Granted. But on CE, only those enduring objects coexist that are mutually at rest. Indeed if E1 and E2 are moving with non-zero relative velocity, this will preclude R (hence CE) from holding. Take any point O1 on the worldline L1 of E1 (Figure 1). Assume that E1 fully exists at O1. There may be a point O2 on L2 of E2 that is simultaneous with O1 at E1's rest frame. But O1 is not simultaneous with O2 in E2's rest frame. Thus, on CE, objects not mutually at rest cannot coexist. But very few (if any) objects are, strictly speaking, mutually at rest. Hence most of them (if not all) cannot coexist. Gamow, for example, cannot coexist with M31, the Andromeda "nebula."⁹ This result is unwelcome, for Gamow surely can and does coexist with M31, as well as with many of his other favorite galaxies.

3.4. *ENDURANTIST:* I agree. This is indeed a most strange result. But couldn't we avoid it by *relaxing* R in the following way:

$$R_{\text{relax}}(O1, O2) \leftrightarrow O2' \in \text{HPS}^{O1} \ \& \ O1' \in \text{HPS}^{O2?}$$

Here O1' and O2' are locations of E1 and E2 distinct from O1 and O2. The idea is illustrated in Figure 2.

⁹ Unless their states of motion are co-ordinated in a very special way, which they are not.

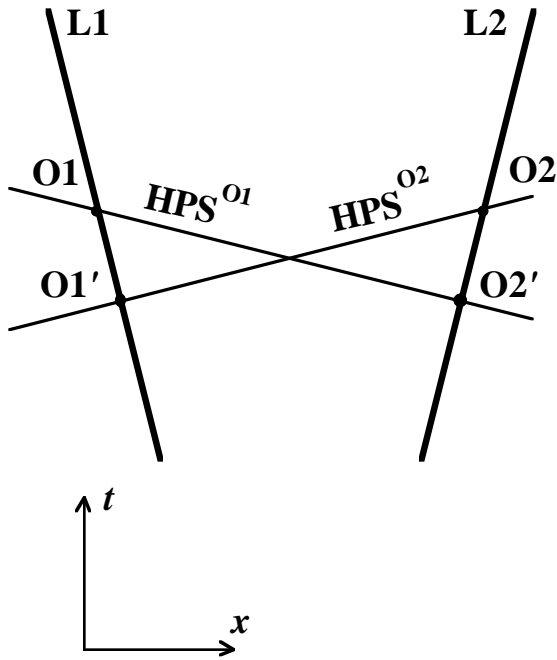


Fig. 2. E2, when it is at $O2'$, is co-present with E1, when it is at $O1$, and E1, when it is at $O1'$, is co-present with E2, when it is at $O2$.

E1 and E2 are said to coexist just in case E2, when it is at $O2'$, is co-present with E1, when it is at $O1$, in E1's rest frame, and E1, when it is at $O1'$, is co-present with E2, when it is at $O2$, in E2's rest frame. We do not require that $O1'$ and $O2'$ coincide with $O1$ and $O2$ (although they may, in a special case, when E1 and E2 are mutually at rest).¹⁰ This enables us to avoid the unwelcome consequences of adopting R and CE (E1 and E2 in Figure 2 coexist even though they are not mutually at rest) and at the same time to preserve the required symmetricity and objectivity.

Objection: But it does not preserve the required relevance. Instead of expressing the fact of co-presence of E1 and E2 when these are entirely present at their spatio-temporal locations $O1$ and $O2$, R_{relax} does something completely different. It attempts to parcel out a certain relation between two enduring things E1 and E2 entirely present at $O1$ and $O2$ in terms of the already familiar (from §3.2) relations of co-presence $R_{[1,2]}$ and $R_{[2,1]}$ involving *four* items: 'E1-at- $O1$ ', 'E1-at- $O1'$ ', 'E2-at- $O2$ ' and 'E2-at- $O2'$ ':

¹⁰ Notice that $O2'$ may coincide with $O2$ without $O1'$ coinciding with $O1$. For generality, however, all four points are kept distinct here.

$$R_{\text{relax}}(O1, O2) \leftrightarrow R_{[1,2\prime]}(O1, O2\prime) \& R_{[2,1\prime]}(O2, O1\prime),$$

where $R_{[1,2\prime]}(O1, O2\prime) \leftrightarrow O2\prime \in \text{HPS}^{O1}$ and $R_{[2,1\prime]}(O2, O1\prime) \leftrightarrow O1\prime \in \text{HPS}^{O2}$.

But clearly, R_{relax} has nothing to do with co-presence of E1 and E2. The latter are enduring objects fully present at single moments of time. Consequently, each such object occupies, at any moment, a single spatio-temporal location. Unlike a perduring object, it is not spread out over many such locations. When we ask whether E1 and E2 coexist (i.e., are co-present, in any relevant sense of the term), the question is about E1 and E2 at *particular* locations, say at O1 and O2. Since E1 is fully present at O1, O1' cannot represent it in a single alleged relation of co-presence (i.e., relation R_{relax}) with E2 (fully present at O2). Similarly, since E2 is fully present at O2, O2' cannot represent it in a single alleged relation of co-presence with E1. This would be a representation *in absentia* devoid of any ontological meaning. It is true that such items as 'E1-at-O1' and 'E1-at-O1'' refer to one and the same thing, namely E1. But only one of these items is available at a time, when the question is about co-presence of enduring objects.

To put it less formally, suppose I am here and you are in interstellar space. You-at- t (some particular time measured in your rest frame) may be co-present with me-today in my rest frame, and I-yesterday may be co-present with you-at- $(t + \text{one day})$ in your rest frame. But this does not tell us anything relevant about our coexistence. The question is *either* about me-today *or* about me-yesterday. If it is about me-today, then me-yesterday is irrelevant to our coexistence, and vice versa. Me-today and me-yesterday cannot *both* be summoned to represent me in a *single* relation of co-presence with you. Notice that they could be so summoned were I a *perduring* object. In such a case, both me-today and me-yesterday would be *parts* of me and hence could both legitimately speak for me in a single relation of coexistence with another perduring object.¹¹

¹¹ Provided the relata of such a relation are four-dimensional *wholes* rather than momentary parts of perduring objects. More on this in later sections.

“Relaxing” R in the way suggested might be legitimate in the perdurantist framework but it is at odds with the endurantist ontology.

4.

Although the accounts of coexistence considered above do not exhaust all options that are in principle available to the endurantist, they perhaps exhaust the most obvious ones. According to CE_{abs} , coexistence of enduring objects depends on their co-presence (i.e., on the simultaneity of events representing their momentary locations) in a *particular*, privileged reference frame. But if special relativity is true, no frame is objectively privileged. CE_{abs} unsuccessfully attempts to capitalize on the pre-relativistic idea of absolute simultaneity in a context where it is no longer valid. CE, on the other hand, acknowledges the novelty of this context, parts company with classical notions, and provides an account of coexistence for enduring objects which is consistent with relativity and all formal requirements (i.e., objectivity, symmetricity, and relevance). In particular, it secures objectivity by making coexistence of enduring objects hinge upon their co-presence in *their* reference frames.¹² But CE commits the endurantist to the unacceptable view that very few (if any) objects populating our world can coexist.

Yet another proposal might be to ground coexistence of enduring objects in their co-presence, neither in a distinguished frame, nor in their own rest frames, but *in some frame or other*. I examine such a proposal in §6. At the moment, however, I think it appropriate to indicate how perdurantism can *obviously* succeed where endurantism has *obviously* failed. What is required is a workable notion of coexistence for perduring objects. Such a notion will surely be different from that for enduring objects, because, on the perdurantist view, objects are *really* four-dimensional: they are extended *both* in space and time. The perduring Gamow, for example, *is* his worldline (worldworm), and the perduring M31 *is* its worldline (worldworm). Coexistence of the perduring Gamow and M31 could therefore be couched in terms of total four-dimensional entities that are

¹² Indeed, given any two enduring objects E1 and E2, their rest frames are uniquely determined and so are relations between their locations in those frames.

extended through time rather than three-dimensional entities that can be wholly present at different moments of time. One plausible solution to Gamow's difficulty noted at the end of the previous section is as follows: Gamow can (and does) easily coexist with M31, because in some frame of reference (not necessarily his or Andromeda's rest frame), some (spatio-)temporal part of Andromeda is co-present with some (spatio-)temporal part of him, and vice versa. In general, objects can be said to coexist, on the perdurantist view, by virtue of having parts that are co-present in some reference frame.

This account of coexistence for perduring objects requires further justification and elucidation. Initially, one might be prompted to be rather generous about coexistence of perduring objects. One might, in fact, be inclined to say that *all* perduring objects trivially coexist. In one sense suggested by the Block Universe picture this is indeed the case.¹³ All point events in that picture *tenselessly* coexist. Physical objects, on the perdurantist view, are represented in Minkowski diagrams by worldlines (worldworms), which could, in principle, be construed as strings (string bundles) of events stretched out in space-time. Consequently, any such object could be said to coexist with any other.

This sense of coexistence, however, is neither interesting nor relevant to the problem at hand. Although perduring objects are all spread out in space-time, this does not mean that they and their parts cannot bear less trivial (spatio-)temporal relations to one another. I trivially coexist with Napoleon, for we are both stretched out, on the perdurantist view, in space-time. But even on that view, I bear a more interesting relation of coexistence to president Clinton that I do not bear to Napoleon: Clinton and I have *space-like separated parts* and, as a result, our temporal extensions, in a sense, "overlap." On the contrary, no part of mine is space-like separated from any part of Napoleon. My and Napoleon's worldlines are not far enough apart in space to make any segments of them space-like separated. As a result, every part of me lies in the *absolute* future of each part of Napoleon.

¹³ See Rietdijk 1966, Putnam 1967.

This justifies the following principle of coexistence for perduring objects (as well as its nickname):

(CP) (“Overlap”) Any two perduring objects coexist iff they have space-like separated parts.

It is worth emphasizing that the above principle has the existential form. One important fact about space-like separated parts of perduring objects is that these parts are co-present with one another in some legitimate (i.e., inertial) reference frame. This relation of co-presence is frame-dependent and hence does not represent an “intrinsic” aspect of pairs of parts of perduring objects. The relation of coexistence governed by CP, on the contrary, is an invariant feature of a pair of perduring objects: given any two such objects, there is a frame-independent fact of the matter about their coexistence.

Although coexistence thus construed is symmetrical (as it should be), it is not, in general, transitive. It seems, however, that the principles of special relativity (and, in particular, the idea of relative simultaneity) would not allow anything stronger than that. In making a transition to the relativistic context, one has to be prepared—regardless of whether one is an endurantist or a perdurantist—to make some changes in the notion of coexistence. One should not expect this notion to emerge completely intact from the transition at hand. Notice, however, that, in case of CP, the principle of coexistence of *total* four-dimensional perduring objects, the lack of transitivity should not strike one as a surprise at all. Transitivity would be lacking even in a *pre-relativistic* analog of CP, which could be formulated in terms of absolute simultaneity between objects’ parts in Newtonian space-time. On such a principle, I (i.e., the whole long thing) coexist with my father (because our temporal extensions literally overlap in absolute Newtonian time) and he coexists with my grandfather. But I do *not* coexist with my grandfather, and this is anything but surprising (Figure 3).

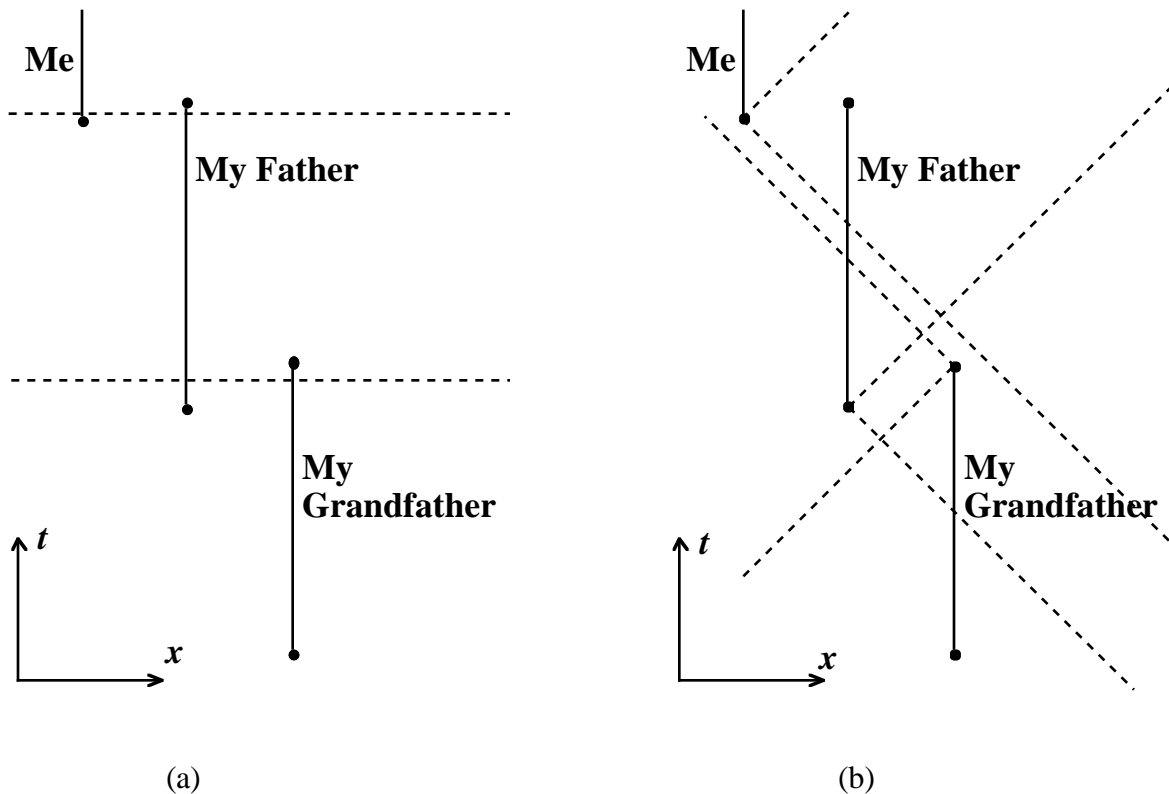


Fig. 3. Coexistence (“Overlap”) of four-dimensional objects (a) in Newtonian space-time; (b) in Minkowski space-time. In both cases, I “overlap” with my father and he “overlaps” with my grandfather. But I do not “overlap” with my grandfather.

On CP, many perduring things interestingly coexist and many interestingly fail to coexist. Thus Gamow coexists with Andromeda and knows this for sure. Looking at M31 through a telescope, Gamow can legitimately infer that (1) unless Andromeda had ceased to exist immediately upon emitting the light he is perceiving, there is some further part of Andromeda to which one of his parts bears the relation of space-like separation and (2) there is an earlier part of him that is space-like separated from the observed part of Andromeda. Hence, on CP, Gamow coexists, that is, relativistically “overlaps,” with Andromeda. It is in this sense that perduring objects can interestingly coexist by virtue of having parts that are co-present in some frame.

On the other hand, a person born after 24 February 1987 does not (very unlike Gamow) coexist, on CP, with the star in the Large Magellanic Clouds whose explosion astronomers

observed, on that date, as supernova SN 1987A. A person (say, Jill) born after that date can legitimately infer that no part of that star is space-like separated from any part of her (Figure 4). In this sense, perduring objects may interestingly fail to coexist.

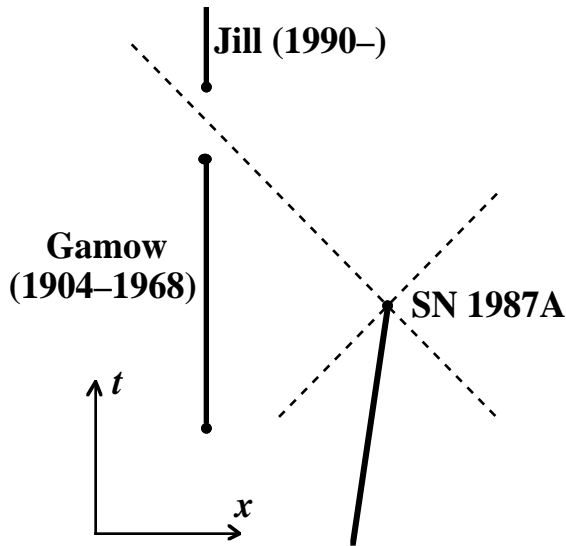


Fig. 4. Gamow does whereas Jill does not coexist, on the perdurantist view, with the star that exploded as supernova SN 1987A.

5.

The above account of coexistence for perduring objects (that is, CP, or “Overlap”) might strike one as being counterintuitive. Coexistence, on CP, turns out to be a *tenseless* relation between four-dimensional entities, whereas the pre-theoretical idea of coexistence appears to possess an irreducibly tensed core and apply primarily to three-dimensional beings, which can wholly exist at different moments of time. This intuition should not be allowed to prejudge the issue between endurantism and perdurantism in light of the arguments advanced above. *If* objects perdure, then (a) it seems *prima facie* natural to construe their coexistence tenselessly, and (b) so construed, it retains, as a relation, its salient features, despite the challenge of relativistic physics.¹⁴ *If*, on the

¹⁴ The coexistence relation regulated by CP is *tenseless* because it holds between entities that do not change their location with time. There is no question here of something coming to coexist with something else. I cannot say that I came to coexist with Bill Clinton when I was born, and that this coexistence will cease to take place when one of us dies. This would be appropriate if I were a

other hand, objects endure, then (a) their coexistence must, of course, be interpreted in a tensed way (e.g., as in CE¹⁵), but (b) thus interpreted, it flies in the face of relativity.

What is it, exactly, about perdurantism that enables its advocate to offer an interesting, consistently tenseless, and relativistic account of coexistence, as expressed by CP (“Overlap”), but prevents the endurantist from making the same or a similar move? To endure, says Lewis, is to be fully present “at more than one time” (1986, 202). All this means, an endurantist might argue, is that Gamow, for example, was fully present at any time at which he existed, there being nothing special about any particular moment of his (spatio-)temporal career. In a sense, Gamow can be said to fill his whole four-dimensional history by virtue of being entirely present at each of its stages (cf. van Inwagen 1990, 251). Of course, he does not occupy his entire history at any particular time. But the perdurantist would also not want to say that all parts of Gamow are present at any given time (and place). The endurantist could maintain that different moments of the history of an enduring object might be just as fit for grounding its coexistence with another enduring object as are parts of perduring objects. Consequently, if the perdurantist is entitled to interpret coexistence tenselessly, along the lines of CP, so is the endurantist. This suggests the following endurantist analog of CP (“Overlap”):

(CE_{OVI}) Any two enduring objects coexist iff their histories have space-like separated moments.

three-dimensional object that can be wholly present at more than one time. But four-dimensional entities do not really come to be or go out of existence. Each of them just has a particular temporal extension. And it turns out that some such extensions overlap (in a relativistic sense expressed by CP). But whether they overlap is a completely tenseless, or atemporal, issue.

¹⁵ It should be noted that ‘tensed’ and ‘tenseless’ are used here in a special sense different from that employed in tense logics. The coexistence relation governed by CE (and by other endurantist principles considered in this paper) is temporally-loaded, or tensed, because it holds between entities that change their position in space-time and, consequently, coexistence itself becomes a function of time. On CE, x coexists with y always at some particular t , in this case a moment of the universal Newtonian time shared by x and y . In the relativistic framework, Newtonian time has to be replaced by *proper time* measured in the rest frame of a particular object. Instead of saying that x coexists with y at t , we say that x , *when* it is wholly present at some moment of its proper time t_x , coexists with y , *when* it is wholly present at t_y . But the tensed aspect of coexistence remains essential to endurantism in that framework. More on this in §6.

The upshot of CE_{OVI} is that moments of histories of enduring objects could play precisely the same role in securing those objects' coexistence as parts of perduring objects do and, consequently, the arguments of the previous sections do not favor perdurantism over endurantism, in light of relativistic considerations. They would favor perdurantism only if there were something special about particular moments of histories of enduring objects that disqualified their other moments from playing important ontological roles assigned them by CE_{OVI} . As long as all moments are on ontological par, one is free to assign any of them substantive ontological functions.¹⁶

It is not difficult to show, however, that whereas CP (“Overlap”) is entirely appropriate for the four-dimensional ontology of perdurantism, its endurantist counterpart, CE_{OVI} , is out of place in the three-dimensional ontology of endurantism. Both CP (“Overlap”) and CE_{OVI} appeal to some relation holding between three-dimensional entities in order to substantiate a claim about other entities of which these are parts. In CP, three-dimensional entities are parts of perduring objects. In CE_{OVI} , they are moments in histories of enduring objects. Both perduring objects and histories of enduring objects are four-dimensional beings. But histories of enduring objects are not the same as objects themselves. It was noted above that, in a way, an enduring object, such as Gamow, completely fills its four-dimensional history. But unlike a perduring object, it does not fill it by virtue of being a four-dimensional object. It does so by being fully present at different three-

¹⁶ The view that all moments of time are on ontological par is inconsistent with a certain theory of time known as *presentism*. On that theory, only the present exists, whereas the past does so no longer and the future not yet. Of course, the past did exist and the future will, but insofar as they do not exist, their contents do not possess any robust ontological status. In particular, they do not possess the status required to secure coexistence of enduring objects according to CE_{OVI} . Therefore, given presentism, CE_{OVI} is invalid. This, however, is hardly relevant to my purposes, because this paper takes the relativity theory seriously and presentism, with its pre-relativistic notion of absolute present, is arguably ruled out by SR. For a recent attempt to defend presentism in the face of SR, see Hinchliff 1996. For criticisms of Hinchliff's arguments, see Savitt 1998, Callender 1998.

It is more important to note here that the *denial* of presentism does not, pace Carter and Hestevold 1994 and Merricks 1995, entail the four-dimensional ontology of objects. I will not argue here against the link between the denial of presentism and perdurantism (an interested reader is advised to consult Mellor 1981 and van Inwagen 1990; cf. also Johnston 1987, Haslanger 1989a) but will simply assume that no such link exists and, hence, that *independent* arguments are needed to demonstrate that SR requires perdurantism and undermines endurantism—the arguments I offer in the present paper.

dimensional stages of its history at different times. The whole four-dimensional history of the enduring Gamow may be conveniently labeled ‘Gamow₄’, because it does not contain anything except him. But whereas, on the perdurantist view, the real Gamow is simply identical with Gamow₄, this is not so on the endurantist view. On that view, the real Gamow is a three-dimensional being that is wholly present at any moment (and at a corresponding place), at which he exists.

The disanalogy between CP and CE_{OVI} can now be clearly seen. According to CP, space-like separation of some parts of perduring objects is constitutive of the coexistence, that is, “overlap,” of wholes, which are objects themselves. In a similar vein, space-like separation of some parts of histories of enduring objects is constitutive, on CE_{OVI}, of the coexistence, or “overlap,” of the corresponding wholes, namely, the *histories*. But this does not tell us anything relevant about the coexistence of enduring objects themselves, since the latter are not the same as their histories. The coexistence of the four-dimensional Bacon (1561–1626) and Descartes (1596–1650) is essentially a matter of the (relativistic) overlap between these objects. But it is simply not the case that the coexistence of the three-dimensional Bacon and Descartes is essentially a matter of the corresponding overlap between their *histories*. Consider the enduring Bacon fully present in 1580 in England and the enduring Descartes fully present in 1630 in Holland. Clearly, *these* objects do not coexist. But, according to CE_{OVI}, they do. One could hardly imagine a more conspicuous *reductio*.

It has been noted above that coexistence, or “overlap,” of perduring objects is, on CP, a tenseless relation holding between four-dimensional entities, whereas the intuitive notion of coexistence seems to be tensed and to apply primarily to three-dimensional beings, which can wholly exist at different moments of time. Whereas the “tensed” part of this intuition has a distinctively endurantist origin and, hence, is neither essential nor even available to the perdurantist, she could preserve the other part of the intuition in question, namely, the three-dimensional sense of coexistence, if only within the framework of the perdurantist ontology. A natural way to do it

would be to talk of the coexistence of momentary *parts* of perduring objects, rather than total four-dimensional wholes:

(CP*) Two parts of perduring objects coexist iff they are space-like separated.

CP* can be looked upon as involving a hidden existential generalization. It says, in effect, that two parts of perduring objects coexist just in case they are co-present in *some* reference frame. The relation determined by CP* is tenseless because it holds between entities—namely, parts of four-dimensional objects—that do not change their (spatio-)temporal locations with time. This relation is symmetric, frame-invariant, and not transitive and fares, on these counts, no worse than the one defined by CP for total perduring objects. A major reason for favoring CP* over CP, again, might be that it seeks to retain, within the framework of perdurantism, at least part of the endurantist intuition about coexistence as a relation between things that are restricted to particular times, rather than being spread out in time. Whether the perdurantist would be inclined to be bound by this intuition or not, it must be noted that CP* does not allow one to preserve it in full. On CP*, a given part of one perduring object coexists, in general, with many parts of another object—in fact, with infinitely many of them—indiscriminately. This is arguably not a part of the endurantist intuition about coexistence.

Nonetheless, CP* may be a viable alternative to CP and I have no principled reasons against it. Instead of talking about the coexistence of four-dimensional wholes (CP), the perdurantist could choose to talk about the coexistence of their three-dimensional parts (CP*). CP*, however, might inspire a hope that a precise endurantist analog of CP* could be summoned in defense of endurantism against the arguments of §§2 and 3. It is this hope that must now be examined.

6.

The endurantist counterpart of CP* could be formulated as follows:¹⁷

¹⁷ This formulation of CE* is due to Carolyn Brighthouse. My thanks to her.

(CE*) Any two enduring objects coexist iff their locations are space-like separated.

Another way to express CE* is to say that two enduring objects E1 and E2 coexist iff there is some reference frame F and time t such that E1 and E2 are both wholly present at t relative to F . The coexistence relation construed in accordance with CE* is obviously symmetric. It is also frame-invariant, hence objective. Indeed, although co-presence of E1 and E2 at t makes sense only relative to a particular frame of reference, the existence of such a frame is all that is required for coexistence of E1 and E2. And such a frame surely exists if the locations of E1 and E2 are space-like separated. This makes CE* immune to the objections of Section 3. Lots of enduring things interestingly coexist, on CE*, in some (but not in all) circumstances and many interestingly fail to coexist at all. For example, I-today (i.e., me wholly present at a certain moment of my proper time measured in my rest frame and somewhat imprecisely denoted here as ‘today’) coexist with Clinton-today (i.e., Clinton wholly present at a certain moment of his proper time measured in his rest frame and loosely referred to as ‘today’). But I-today do not coexist with Clinton-yesterday. I also never coexist with Napoleon. True, the relation defined by CE* is not transitive, but neither CP nor CP* fare any better. Hence if CP* (or CP) is acceptable, so is CE*.

On closer inspection, however, a notable difference comes to light. Whereas on CP*, a given part of one perduring object can coexist, as just noted, with many parts of another perduring object, a given enduring object can, on CE*, coexist with another enduring object *more than once*. Thus, E2 coexists with E1 located at O1 *both* when E2 is at O2⁽¹⁾ *and* when it is at O2⁽²⁾ (see Figure 5), because both O2⁽¹⁾ and O2⁽²⁾ are space-like separated from O1.

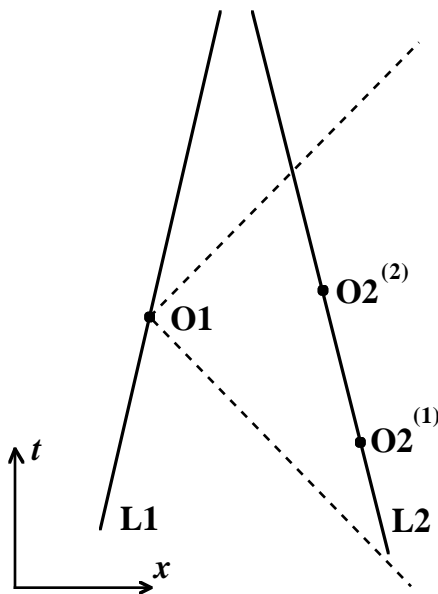


Fig. 5. E1, when it is at O1, coexists with E2, when the latter is at any point in the topological present of O1, in particular, when it is at O2⁽¹⁾ and when it is at O2⁽²⁾.

For example, if I am an enduring object, I must conclude, based on CE*, that I coexist, on 27 October 1997, at 9:00 am, according to my clock (EST), with ex-president Gorbachev, when his clock shows 6:00 pm (Moscow time) and when it shows 6:00 pm plus or minus a fraction of a second. In general, I coexist, on 27 October 1997, at 9:00 am EST, with all enduring objects in the universe that are fully present at space-time points located outside the future and past light cones of me-now.¹⁸

This, as I will show in a moment, is troublesome. The trouble comes, in effect, from the “if” part of CE*. To respect both the endurantist ontology and special relativity, CE* introduces a peculiar combination of tensed and tenseless elements. On the one hand (as already mentioned in notes 14 and 15), the coexistence relation it espouses is not fully tenseless in the way the relations governed by CP and CP* are. On CE*, it is imperative, *from the point of view of E1*, to ask *when* it coexists with E2: E1 coexists with E2 always *at a given moment*—for example, *when* E1 is at O1,

¹⁸ It should be noted that, although illustrations involving conscious beings are particularly revealing, nothing in my arguments turns on the notion of conscious perception. The principles of existence and coexistence examined in this paper deal primarily with *objective*—monadic and relational—matters of fact, not with subjective phenomena, such as perceptions of those facts by conscious beings.

as in Figure 5. On the other hand, CE* seeks to meet the relativistic requirements by denying what CE asserts, namely, that coexistence of E1 and E2 hinges on there being a fact of the matter as to *where* (on its worldline) E2 is *when* E1 is, say, at O1. E2 may be at any point in the *topological present* of O1, that is, outside the past and future light cones of O1. E2, in fact, fully exists at *all* such points *at different times* and at all such times it coexists with E1, when the latter is at O1. The denial that, when E1 is at O1, other enduring objects coexisting with it must be at some particular points on their worldlines commits the endurantist to a certain ontological latitude that is potentially damaging in a way the corresponding latitude sanctioned by the perdurantist principle CP* is not. A cure, I will argue, can be purchased only at the cost of renouncing some important endurantist intuitions.

Let me begin by introducing the notion of Coexistence*¹⁹ based on a straightforward generalization of CE*.

(Coexistence*) An enduring object E2 coexists* with E1 fully present at O1 just in case there is a point O2 such that E2 is fully present at O2 and O2 is space-like separated from O1.

Another way to express the idea of Coexistence* is by saying that E2 coexists* with E1 fully present at O1 if and only if the topological present of O1 includes some part of E2's worldline.²⁰

To illustrate, Gorbachev, but neither his vigorous critic Sakharov, nor Gorbachev's great-grandson, coexists* with me-now (Figure 6).²¹

¹⁹ An asterisk is needed to distinguish Coexistence* from the notion of coexistence at work in CE* and other endurantist principles considered earlier.

²⁰ A further generalization of Coexistence* would yield the concept of Coexistence**:

(Coexistence**) Two enduring objects coexist** just in case their worldlines have space-like separated parts,

which is none other than the endurantist counterpart to the notion of “overlap” implied by CP, namely, the notion at work in CE_{OVI}. The difference, of course, is that the perdurantist principle CP speaks of the overlap of perduring objects *themselves*, and Coexistence**, or CE_{OVI}, of the overlap of enduring objects' *histories*. See §5.

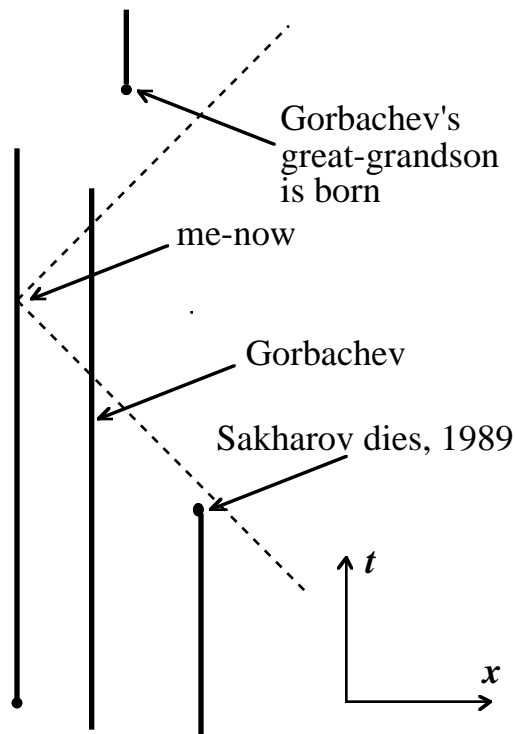


Fig. 6. I coexist*, on 27 October 1997, with Gorbachev, but not with Sakharov or Gorbachev’s great-grandson.

I submit that the endurantist who wants to adjust his views to the relativistic context needs the notion of Coexistence*, because this notion allows him to preserve, in that context, important tense-involving intuitions regarding the transient existence of objects other than himself—objects such as Gorbachev and Sakharov, which come to be and cease to exist. Coexistence* is an asymmetric existential generalization of a more basic concept of coexistence presupposed in CE*. It is asymmetric because it relates items of different nature: If x coexists* with y , x must be an enduring object and y must be an enduring object fully present at a particular point on its worldline. Coexistence* is an existential generalization of coexistence because it holds between x and y just in case there exists a point O on x ’s worldline such that coexistence (in the sense of CE*) holds between x -at- O and y .²²

²¹ I have made, of course, no attempt to draw diagrams, such as Figure 6, “to scale.”

²² It can be easily seen that a further existential generalization of Coexistence*, i.e., Coexistence** (see the previous note), restores the initial symmetry of coexistence.

The point of introducing Coexistence* is to provide a relativistic basis for a belief to which, arguably, the endurantist is committed: that the existence of other transient things goes hand in hand with her coexistence with them. In the old pre-relativistic setting, if I am an enduring object fully present at a particular time, there is a sense in which all other transient enduring beings sort themselves out into three different categories: those that *no longer* exist (e.g., Sakharov), those that are *still* or *already* in existence (e.g., Gorbachev), and those that do *not yet* exist (e.g., Gorbachev's great-grandson).²³ It is clear that, in the Newtonian framework, this difference with respect to existence is grounded in the fact that only objects in the second category, and not those in the first and in the third ones, bear a certain relation of coexistence with me-now, namely, the relation of coexistence_N*, which is the pre-relativistic analog of Coexistence*:²⁴

Coexistence_N*: An enduring object E2 coexists_N* with E1 fully present at O1 just in case there is a point O2 belonging to the same HPS^{t_{abs}} as O1 (or, simply, absolutely simultaneous with O1), such that E2 is fully present at O2.

What reason do I have to assert, on 27 October 1997, that Gorbachev, but not Sakharov, is *still* in existence? The reason seems clear: Gorbachev, but not Sakharov, coexists_N* with me-now.

Coexistence_N* supplies a necessary link between Gorbachev's continuing existence and Sakharov's being no longer in existence, on the one hand, and my existence today, on the other.

The concept of Coexistence* does precisely the same job in the relativistic framework, by building, not on the relation of absolute simultaneity (no longer valid in that framework), but on the Lorentz-invariant relation of space-like separation. If I am an enduring object fully present at a

²³ A presentist, of course, would deny that there is *any* sense in which there are objects that no longer, or not yet, exist. In this paper, however, I take a distinctively non-presentist stance, for reasons provided in note 16.

²⁴ 'N' standing, as before, for "Newtonian." Coexistence_N* is, in full similarity with Coexistence*, an existential generalization of the more basic pre-relativistic notion of coexistence presupposed in CE^N (see §2). By further generalizing it one would arrive at the notion of Coexistence_N** , the Newtonian analog of Coexistence**.

particular time *and place*, there is a sense in which some other transient enduring objects exist *no longer* (Sakharov) or *not yet* (Gorbachev's great-grandson)—because they do not bear the relation of Coexistence* to me-now, whereas yet others are *still* or *already* in existence (Gorbachev)—because they do coexist* with me-now.

To be sure, Coexistence*, just like its ancestor from CE*, conflicts with some of our Newtonian predilections, because it is relativized, not only to time, but also to space. Like its Newtonian predecessor, Coexistence* effectively changes the membership of the set of objects still or already in existence (and, hence, of those no longer and not yet in it) with time, namely, the proper time of a given enduring object. Sakharov is no longer in existence for me-now. But he was still in existence, together with Gorbachev and others, when I was fully present at an earlier point of my worldline (that is, when my local time-reckoning device indicated, say, 27 October 1987). See Figure 7.

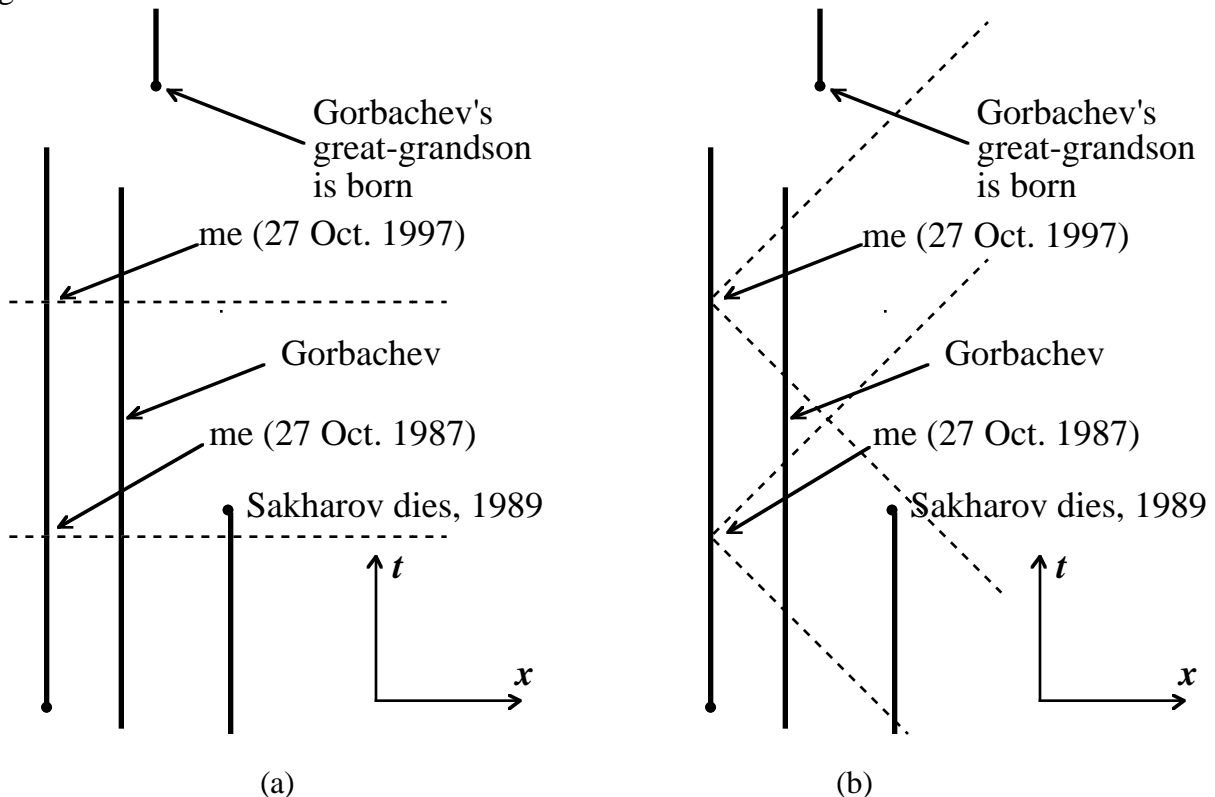


Fig. 7. The endurantist changing perspective on existence. When I am fully present on 27 October 1997, Gorbachev is *still (already)* in existence, his great-grandson *not yet*, and Sakharov *no longer*. When I was fully present on 27 October 1987, *both* Gorbachev and Sakharov *were* in existence. (a) Newtonian account; (b) relativistic account.

Quite unlike Coexistence_N^* , however, Coexistence^* makes the distinction among determinations “still (already) in existence,” “no longer in existence,” and “not yet in existence” relative to a spatial, as well as temporal, location. Speaking metaphorically, one can “revive” Sakharov not only by “going” back in time, but also by “going” further away in space. This is a natural cost (or benefit?) of replacing Newtonian space and time with the relativistic space-time. Notice, in this connection, that for an enduring object fully present at a certain point of its life career somewhere on Betelgeuse, both Clinton and Napoleon are in existence, the former existing already and the latter still. Alexander the Great, however, is no longer, and Miss America 3000 not yet. The point is that, although “still in existence” and “already in existence” become, in the Minkowski world, relative to a spatio-temporal perspective and not to a merely temporal one (as they were in the Newtonian world), the question of *what* objects are still or already in existence admits of a definite answer from *any* such perspective. Thanks to CE^* and its direct descendant, Coexistence^* , the important distinction between things that are (from the point of view of any enduring object at any point of its spatio-temporal career) still or already in existence and those that are not (any longer or yet) has a firm grounding in the invariant structure of Minkowski space-time.

But why should this distinction be regarded as being all-important to the endurantist? Isn't it one of those classical beliefs that are better left behind in making the transition from the Newtonian to the relativistic context? The answer, briefly, is that the endurantist must be committed to this distinction in virtue of the basic principle of her ontology, that an enduring object is fully present at any point of its spatio-temporal career (i.e., its worldline). That such a commitment is not misplaced is best seen by contrasting, again, the endurantist and the perdurantist frameworks. I will show that, in the latter framework, the corresponding distinction is not only unimportant, but meaningless. This will help to understand why it is both meaningful and important for endurantism.

One might start by reformulating Coexistence^* in the language of perdurantism. The idea (a wrong one, as will become clear shortly) behind such a reformulation might be that, as far as the issues raised here are concerned, endurantism and perdurantism are completely on a par: everything

that can be said about an enduring object fully present at O could be adequately paraphrased in terms of an O-part of a perduring object, and vice-versa. In particular, if the perdurantist is entitled to a certain notion of coexistence, so is the endurantist, and conversely, if a certain endurantist principle is problematic, its perdurantist counterpart cannot fare any better, with the consequence that the two doctrines of persistence stand or fall together in the context of SR. Surely, the strongest objections that can be made against the arguments of this essay are based on this alleged parity of reasoning.

Thus, the perdurantist analog of Coexistence* is as follows:

(Coexistence-P*) A perduring object P2 coexists-P* with the O1-part of another perduring object P1 iff P2 has a part located at a point O2 space-like separated from O1.

Coexistence-P* is an asymmetric existential generalization of CP* in precisely the sense in which Coexistence* is an asymmetric existential generalization of CE*.²⁵ To pursue the parallel further, the point of introducing Coexistence-P* might be to provide a relativistic basis for a belief that the existence of other “transient” perduring things (i.e., things only finitely extended in a time-like direction) goes hand in hand with one’s coexistence with them.

But the parallel stops being valid at this point, because the belief in question is foreign to the perdurantist ontology and cannot be accommodated in it. Recall the rationale for introducing the endurantist notion of Coexistence*: If I am an enduring object fully present at some time on 27 October 1997 and at a certain location in the United States, Coexistence* allows me to preserve, in the relativistic context, the sense in which other transient enduring objects sort themselves out into

²⁵ A further generalization of Coexistence-P*:

(Coexistence-P**) Two perduring objects coexist just in case they have space-like separated parts

is none other than CP, the criterion of “overlap” for perduring objects, considered in §§4 and 5.

those no longer existing (Sakharov), those still or already in existence (Gorbachev), and those not yet existing (Gorbachev's great-grandson). But if I am a perduring object having, among my parts, one located at some time on 27 October 1997 in a particular area of the United States, there is *no* sense in which some other perduring objects are "still" in existence and yet others are "no longer" (or "not yet"). "Still," "already," "no longer," and "not yet" are tensed determinations, and such determinations cannot be meaningfully applied in the perdurantist framework. Whether a perduring object, or any of its parts, exists in a certain spatio-temporal region is an atemporal, or tenseless, issue.

To clarify the matter a bit further, if I am an enduring object, I am fully present at each point of my spatio-temporal career: I am fully present on 27 October 1997 in one place, on 27 October 1987 in another place, and so on. At each such point, I can draw, based on Coexistence*, a distinction between objects still or already in existence and those no longer in it (or not yet). At different such points, this distinction is drawn differently: when I was fully present on 27 October 1987, Sakharov, for example, was still in existence, but he is no longer when I am fully present on 27 October 1997.

But if I am a perduring object, I am *never* fully present at any one point of my worldline. At any such point, I am present only partially, and being only partially present there does not entitle me to certain determinations, as regards the existence of other objects and their coexistence with me, that being fully present does. Among my parts, I have the 27 October 1987 one and the 27 October 1997 one. But none of them represents my point of view in a way in which being *fully* present on 27 October 1987 or 27 October 1997 does.

Yet another way to bring out the same point is to note that all the perdurantist principles of coexistence examined in this paper (i.e., CP, CP*, and Coexistence-P*) define coexistence as a relation holding between entities that do not change their position in space-time. Consequently, the question of the coexistence of total four-dimensional objects (as in CP), or of their parts (as in CP*), or of one total object with a part of another (as in Coexistence-P*) *presupposes* that *all* such entities exist atemporally at their spatio-temporal locations. The question is not about what *happens*

to coexist with one such entity *when* it is at a certain location. The facts about the coexistence of perduring objects, or of their parts, are tenseless facts, which do not change with time.

The concepts of existence and coexistence appropriate for the endurantist ontology are entirely different, because they involve a temporal perspective in a way their perdurantist counterparts do not. And they involve such a perspective because the very notion of being fully present at a particular time (and place) is a tensed notion. The time in question is not, of course, the old absolute Newtonian time, but the *proper* time measured in the rest frame of a given enduring object. Nevertheless, this measure of time is a natural and appropriate one for grounding tensed determinations in the relativistic context. When Gorbachev became exactly 65 years old, he was fully present at a point on his worldline located exactly 65 years away (as measured *along* this line) from its origin. Since he was *fully* present at that point, the transient existence of other objects was a well-defined notion for him. He could say, with ontological seriousness, that Sakharov was no longer in existence and Gorbachev's great-grandson not yet. If Gorbachev were to spend the later part of his life in a spaceship moving away at a great enough speed, Gorbachev's perspective on existence on his 65th birthday would be different. It might well be that his great-grandson would have *already* existed on that day. But the 65-year-old Gorbachev would still be located at a point on his worldline exactly 65 years away from its origin. In both cases, we have got *all* of him there.

If, on the contrary, Gorbachev is a perduring object, only a part of him is present on his 65th birthday, namely, his 65-year-old part. This part coexists, in the sense of CP*, with certain parts of other perduring things, and it coexists-P* with certain total four-dimensional things. But this manner of coexistence induces no tensed perspective on the existence of things other than Gorbachev in a way the endurantist concept of Coexistence* does. One cannot say that some perduring things are still in existence and others are no longer, *when* the perduring Gorbachev *happens* to be at a certain point of his spatio-temporal career. The perduring Gorbachev *never* happens to be there, only a small part of him does, and then even that part does not really "happen" to be there: rather, it simply exists there, in a completely atemporal way.

The purpose of a rather prolonged discussion in this section so far was to show (1) that it is imperative for the endurantist, but entirely meaningless for the perdurantist, to ascribe tensed determinations to the existence of other objects; and (2) that the principles CE* and Coexistence* provide an objective²⁶ ground for such determinations in the framework of SR. It is now time to reveal the pernicious side of these determinations.

The trouble, as hinted earlier, comes from the “if” part of Coexistence* (and of its ancestor CE*) conjoined with the above considerations linking Coexistence* with the existence of transient things surrounding a given enduring object. If an enduring object E1 is at O1, *all* other objects whose worldlines are at least partly swept by the topological present of O1 are *still* or *already* in existence. They are *equally* in existence. Such ontological generosity comes from replacing the absolute present of the Newtonian physics with the much more extensive topological present of SR. This generosity, as already noted, may be regarded as beneficial in some respects,²⁷ but there are cases where it becomes damaging.

Suppose Jill’s mother dies while giving birth to Jill, so that Jill’s mother’s end precedes, by a fraction of a second, Jill’s beginning (Figure 8). If I am an enduring object fully present at O, I have to conclude, based on Coexistence* and considerations of this section, that Jill’s mother *still* exists *and* Jill *already* exists. But clearly, there is no *tensed* sense in which they can be in existence together: Jill’s beginning lies in the *absolute future* of her mother’s end. My conclusion, informed as it is by relativistic considerations, is in strange discord with that relativistically-invariant fact.²⁸

²⁶ In the sense of being frame-invariant. See §2

²⁷ By “going” away in space, I can become, in a sense, a “contemporary” of Napoleon.

²⁸ The point of this rather contrived example is to ensure that there is an objective (i.e., frame-invariant) causal and chronological gap between Jill’s beginning and her mother’s end. If one is inclined to identify Jill’s beginning with an earlier moment, perhaps with the time of her conception, the example will have to be modified accordingly. Perhaps, Jill’s mother is artificially inseminated but dies, as a result of this operation, just a fraction of a second before the fusion of the gametes, from which Jill originated, takes place. The physicians, however, manage to save Jill’s zygote and let it develop in an appropriate environment.

A more mundane example would include the annihilation of an electron-positron pair with the production of a photon later transforming into a muon-antimuon pair. For a suitably situated enduring object (say, another elementary particle), the electron-positron and the muon-antimuon pairs are *both* in existence.

As noted earlier, illustrations involving persons are more vivid, but they should not be taken as implying that consciousness, perception, and other subjective phenomena play any essential role

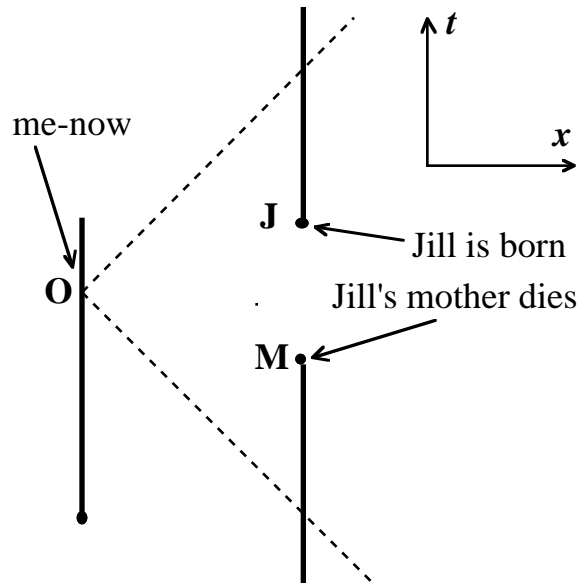


Fig. 8. I coexist*, when I am fully present at O, with both Jill and her mother.

But of course, there is a rather innocent tenseless sense, appropriate for the perdurantist ontology, in which Jill and her mother are both in existence and one of my parts coexists-P* with both. My O-part, Jill’s mother’s last part, and Jill’s first part all exist atemporally in Minkowski world and are related in a manner that does not imply any troubling tensed determinations, such as “still” and “already.” It is not the case that Jill *already* exists and her mother *still* does. They simply exist, as being forever confined to their spatio-temporal regions, and the fact that my O-part coexists-P* with both is a further tenseless fact about Jill, her mother, and a part of me.

The only way for the endurantist to avoid a troubling conclusion (regarding Jill and her mother) would be to try to restore the parity with perdurantism. This, however, can only be done at the cost of renouncing important endurantist intuitions. Let me explain.²⁹ The endurantist might insist that the idea of an object’s being fully present at a *space-time point*, as opposed to the prerelativistic idea of its being present at a certain time (viz., the Newtonian absolute time), is a

in the arguments of this paper. Vividness could easily be sacrificed in the name of objectivity. See note 18.

²⁹ The endurantist suggestion presented in this paragraph is due to an anonymous referee, whom I follow here rather closely.

difficult or awkward one. Perhaps this relativistic idea (unlike the intuitive notion of being entirely present at a moment of classical time) should not be taken too seriously. Perhaps it is best construed as a merely technical notion that could be analyzed in a tenseless way, by analogy with the perdurantist analysis of the notion of spatio-temporal part: to say that an enduring object E exists at a space-time point O is to say no more than that O belongs to E's worldline.

Thus, to say that I am fully present at O, "witnessing" (in the sense implied by Coexistence*) Jill and her mother together in existence, is not to imply any distressing determinations concerning Jill and her mother's existence. What is involved in this situation may boil down to the following set of rather innocuous facts (see Figure 8):

O belongs to my worldline;

J belongs to Jill's worldline;

M belongs to Jill's mother's worldline;

O, J and M are related in a certain way in Minkowski space-time; namely, J and M are in the topological present of O.

The point of such a rendition might be to bar from the situation any sense in which my full presence at O could be taken seriously to imply as much as Jill and her mother's being "together" in existence.

I will make two points in response to this suggestion. First, it seems to me that, far from being "awkward," the notion of an enduring object's being fully present at a space-time point is a well-defined and entirely legitimate one, because it is strongly backed by the notion of *proper time* measured in the rest frame of the object. To say that Gorbachev is fully present in Moscow on his 65th birthday is to say, relativistically speaking, that he is fully present at a point on his worldline located exactly 65 years away from its beginning, as measured according to Gorbachev's local time, for example, by his "biological clock." If Gorbachev were heading away in a rocket, he would be

present at a different space-time point on his 65th birthday, but this point of his worldline would still be separated by exactly 65 years from its beginning, as measured by his biological clock.

Having thus been legitimized, the notion of being fully present at a space-time point (or a space-time region, in the case of real-life, i.e. spatially extended, enduring objects) retains its central place in the endurantist ontology. *Being fully present at a time and place*, just as its Newtonian predecessor *being fully present at a time*, is not something tangential to that ontology and, hence, not something that can be conveniently downplayed in certain situations; it is, in fact, part and parcel of the very concept of endurance. From the endurantist standpoint, my full presence at a certain time on 27 October 1997 (in a certain part of the continental United States) is the most important fact about my existence, a fact firm enough to ground my perspective on the existence of everything else. To the extent that endurantism may succeed in incorporating an interesting notion of coexistence in the relativistic framework, this notion becomes the only bridge that connects the existence of a given enduring object with the rest of the universe. But this bridge turns out to be *too wide*. It connects me with things that cannot be in existence together in any temporally-loaded sense of “together.”

Both endurantism and perdurantism emerge whittled-down out of the transition from the classical to the relativistic conception of space and time. But they are whittled-down to a very different extent. Both views of persistence must abandon the transitivity of the coexistence relation. Having paid this price, the perdurantist discovers, to her satisfaction, that, not only do the troubles stop at this point, but that the new spatio-temporal framework, that of Minkowski space-time, appears to be rather friendly to her, indeed, almost ready-made for accommodating her inherently tenseless ontology. For the endurantist, however, the troubles only begin here. The Minkowski world, having no place in it for absolute simultaneity, presents the endurantist with a dilemma: either to renounce all the tensed implications of her central idea of an object’s being fully present at a time (and place), or to endorse these implications and be committed to conclusions that are generally

disconcerting³⁰ and in some cases outrightly contradictory.³¹ Neither horn of the dilemma is acceptable for the endurantist. Or so I have argued.

7.

I have considered several principles of coexistence that might be proposed by the endurantist in the framework of special relativity and have shown them unpromising. Although these principles may not exhaust all possibilities open to the endurantist, I submit that they exhaust all the interesting and natural ones (CE* certainly topping the list). I conclude that the perdurantist is far better equipped for accommodating the notion coexistence in the context of special relativity than the endurantist.

What other, broader options are available to the endurantist, besides rejecting endurantism or rejecting the idea that objects can coexist? Putting aside such temptations as simply ignoring the special theory of relativity, one proposal might be to try to reinstate the notion of absolute simultaneity *within* the framework of this theory. If successfully pursued, this project would simply revalidate CE_{abs} of §3. What would such a project involve and what may be at stake here? These questions deserve, in my mind, most serious consideration, which I cannot afford here. But I do want to indicate briefly that the idea of restoring absolute simultaneity no longer has a distinctively pseudo-scientific flavor it has had until very recently.

It is a well-known fact that one could accept all the empirical consequences of SR (including length contraction, time dilation, and so on) and yet insist that there is a privileged inertial reference frame, in which meter sticks *really* have the length they have and time intervals between events refer to the *real* time. Associated with this reference frame would be a set of hyperplanes of simultaneity uniquely slicing space-time into equivalence classes of *absolutely* simultaneous events. A suggested privileged reference frame would not be distinguished in any empirical sense and would

³⁰ Except for cases where such conclusions might appear flattering, such as my being a “contemporary” of Napoleon, or even Alexander the Great, depending on the location of a cosmic enduring objects with which we all coexist*.

³¹ I am referring here to the sort of cases illustrated by the story of Jill and her mother. A contradiction arises there because the causal and chronological succession of Jill’s mother’s end and Jill’s beginning is in conflict with tensed determinations of being already in existence and being still in existence ascribed, respectively, to Jill and her mother by an outside enduring observer.

not be identifiable in any real experience. Thus the speed of light measured in any inertial frame would still be exactly c , the number obtained by dividing the *apparent* distance covered by light by the *apparent* time spent. The point of introducing the notion of a reference frame privileged in this sense would be to draw an ontologically important distinction between “reality” and “appearance,” while at the same time preventing any observer, in principle, from actually discovering the difference.

The possibility of such an “ether-compensatory”³² reading of SR comes from the fact that relativistic mechanics does not carry a particular ontological interpretation upon its sleeve. Of course, there are compelling theoretical reasons (see, e.g., Earman 1989, §3.4) to pursue the standard line and to underwrite the relativistic phenomena with a certain theory of the overall structure of space-time, namely, the Einstein-Minkowski one, whose symmetries precisely match those of the laws of motion. But one is not logically forced into this theory by the totality of empirical data. The question, then, is what sort of rationale would be strong enough to override the usual approach and allow space-time more intrinsic structure (say, in the form of the set of privileged hyperplanes of simultaneity, as just suggested) than is needed to “support” the laws of motion.

I submit that mere desire to save a particular metaphysical view (such as endurantism or presentism) would not, by itself, provide a good rationale for denying what the best available physical theory says about the space-time world. But remarkably, the endurantist can now find allies in quarters where she would least expect them to be. The latest developments in the foundations of quantum mechanics have highlighted the difficulties involved in providing Lorentz-invariant accounts of fundamental quantum phenomena (see, e.g., Maudlin 1994). In particular, quantum non-locality appears to be, *par excellence*, such a grossly non-invariant effect. In the Bohm-de Broglie alternative to the standard interpretation of quantum mechanics, non-locality strongly suggests (and, some argue, even requires) reinstating the notion of a preferred reference frame and, hence, a privileged foliation of Minkowski space-time into a family of hyperplanes of

³² See Sklar 1985, Ch. 11, especially p. 293; cf., however, Stein 1991, 154n2.

simultaneity.³³ It is clear that adding this structure to the space-time of SR would be the easiest and completely uncompromising way of salvaging the endurantist ontology in its entirety.

Two points are worth emphasizing here. First, taking into account the consequences of quantum mechanics makes a choice between the two interpretations of relativistic dynamics a “package deal”: one now has to find a single space-time framework that would best accommodate *both* relativistic and quantum phenomena. Second, if the arguments of this paper achieve what they purport, another remarkable “package deal” may now be on the table: deep ontological questions concerning persistence may become entangled with physical questions concerning quantum non-locality—a genuine “experimental metaphysics” in the making.³⁴

This said, I would like to end on a cautious note, by emphasizing that the issue of the peaceful coexistence between SR and quantum mechanics is a complex one and the impact of quantum-mechanical considerations that suggest reinstating absolute simultaneity should not be exaggerated. In any case, the purpose of this paper was to extend the debate about persistence into the framework of the standard, and still universally accepted, interpretation of SR.

³³ See, in this connection, Cushing 1994, §10.4.2 and references therein.

³⁴ The term “experimental metaphysics” is due to Abner Shimony.

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