teorema
Vol. XXXIX/3, 2020, pp. 5-15
ISSN: 0210-1602
[BIBLID 0210-1602 (2020) 39:3; pp. 5-15]

Fragmentalism and Special Relativity

Thomas Hofweber and Marc Lange

RESUMEN

En 2005, Kit Fine propuso una nueva interpretación de la teoría especial de la relatividad relacionada con su versión fragmentalista del realismo sobre el tiempo. En Hofweber and Lange (2017) criticamos la interpretación fragmentalista de la relatividad especial de Fine argumentando que no puede explicar por qué las transformaciones de Lorentz se mantienen entre diferentes fragmentos, mientras que la interpretación estándar minkowskiana puede explicar esto fácilmente. Martin Lipman defiende en Lipman (2020) la interpretación fragmentalista de la relatividad especial contra nuestra objeción. En este artículo elaboramos nuestro argumento en contra de la interpretación fragmentalista de la relatividad especial y respondemos a la crítica de Lipman a nuestro argumento.

PALABRAS CLAVE: *teoría especial de la relatividad, fragmentalismo, Realismo sobre el tiempo, explicación.*

ABSTRACT

In 2005 Kit Fine proposed a new interpretation of the special theory of relativity connected to his fragmentalist version of realism about tense. In (Hofweber and Lange 2017) we criticized Fine's fragmentalist interpretation of special relativity by arguing that it cannot explain why the Lorentz transformations hold between different fragments, whereas the standard Minkowskian interpretation can easily explain this. Martin Lipman defends the fragmentalist interpretation of special relativity against our objection in (Lipman 2020). In this article we elaborate on our argument against the fragmentalist interpretation of special relativity and respond to Lipman's criticism of our argument.

KEYWORDS: *Special Theory of Relativity, Fragmentalism, Realism about Tense, Explanation.*

The interpretation of the special theory of relativity (STR) that is now standard was given its canonical formulation by Minkowski, who famously declared in 1908: "Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality." [1952, p. 75]. On this view, various familiar putative facts (such as that two given events take place five meters apart) do not obtain. Such a putative fact is no

more real than that the kettle is three degrees warmer. (Warmer than what? The pot? Than it was a minute ago?) Two given events are not three seconds apart *full stop*. Rather, the genuine facts about the spatial and temporal separations between events, the shapes of objects, and so forth are relative to inertial reference frames and differ from frame to frame; there are no non-relative facts about these matters.

On this standard interpretation, a frame-relative fact about, say, the distance between two events is a projection onto the given frame of more fundamental facts, each of which involves both space and time and each of which is "frame-invariant", i.e., the same in every inertial reference frame. For instance, the "spacetime interval" between a given pair of events is frame-invariant and is decomposed into different spatial and temporal components in different frames. These components are "mere shadows" of the spacetime interval separating the two events – projections of the interval onto different spatial and temporal axes in different frames. The frame-invariant facts are responsible for the frame-relative facts; the frame-relative facts are mere appearances of the universe's frame-invariant features. The spacetime interval between two events unifies the different perspectives each consisting of the facts relative to this or that reference frame. Here is a typical expression of this standard interpretation of STR:

> [A]n observer on the earth sees and measures an oblong block; an observer on another star contemplating the same block finds it to be a cube. Shall we say that the oblong block is the real thing, and that the other observer must correct his measures to make allowance for his motion? All the appearances are accounted for if the real object is the four-dimensional, and the observers are merely measuring different three-dimensional appearances or sections; and it seems impossible to doubt that this is the true explanation [Eddington (1920), p. 181].

The Lorentz transformations relate two events' spatial and temporal separations in one frame to their separations in another frame. The reason why the various frames stand in this particular coordination is that the spacetime interval is invariant across all frames. Reality explains appearances; how things appear from different perspectives is explained by how things really are.

By contrast, Fine (2005) has proposed a radically new interpretation of STR, according to which there are non-relativized facts about the spatial and temporal separations among events, the shapes of objects, and so forth. On this "fragmentalist" picture, all of the facts in *every* frame hold

full stop: the fact that events e_1 and e_2 are simultaneous, the fact that e_1 is later than e_2, and the fact that e_1 is earlier than e_2. Thus, incompatible facts obtain and reality overall, über-reality, is incoherent. But reality furthermore consists of a collection of maximally coherent "fragments" of über-reality. One fragment contains the fact that e_1 is earlier than e_2 and all of the other facts from über-reality that cohere with it, whereas another fragment contains the fact that e_1 is simultaneous with e_2 and all of the other facts that cohere with it, and so on. Fragmentalism is intended to provide a new, non-standard form of realism about what might otherwise be understood as perspectival facts. Fine's main target in his (2005) is a realist theory of tense and the philosophy of time, but he also applies his general framework to STR. In fact, Fine thinks that the fragmentalist interpretation of STR is one of the arguments in favor of a fragmentalist form of realism about tense [see, for example, Fine (2005), p. 305].

In Hofweber and Lange (2017), we argued that the fragmentalist interpretation of STR has several unattractive features by comparison to the standard interpretation and accordingly should be rejected. Lipman (2020) has recently offered a defense of fragmentalism about STR against some of our critique. In this brief note, we aim to elaborate on our criticism of the fragmentalist interpretation of STR and to address Lipman's arguments in defense of it.

One of our main objections to fragmentalism was that it cannot explain why the Lorentz transformations hold between different frames (or, in fragmentalist terms, between different fragments). The standard interpretation has no difficulty in explaining this fact: the Lorentz transformations are explained by the spacetime interval's invariance. While the fragmentalist accepts that the Lorentz transformations can thereby be deduced, the fragmentalist cannot take this deduction as explanatory. Whereas the standard interpretation takes the Lorentz transformations as arising from the way that Minkowski spacetime decomposes into different spatial and temporal appearances in different reference frames, fragmentalism takes each of those fragments as more fundamental than various appearances of a common reality. The fragmentalist has no resources (we argued) to explain why the fragments are coordinated as they are. The fragmentalist cannot find those resources in the notion of coherence itself, since fragmentalism takes coherence as a primitive notion, and the fragmentalist cannot find those resources in über-reality, since it simply contains all of the incoherent facts without giving any guidance on how those facts become grouped into internally coherent fragments.

Lipman (2020) aims to respond to our objection. He proposes several ways that a fragmentalist could face the challenge of explaining why the Lorentz transformations hold: (1) The fragmentalist could accept Minkowski spacetime in addition to the various fragments and even take the frame-invariant facts as grounding perspectival ones. (2) The fragmentalist could insist that the Lorentz transformations' holding between fragments is a brute fact or law, (a) since the Lorentz transformations could just as well explain the spacetime interval's frame-invariance as *vice versa* and (b) since for the Lorentz transformations to be brute would be no worse than for the spacetime interval's invariance to be brute (as it is on the standard interpretation). We are unpersuaded by each of these suggestions and will spend the remainder of this paper briefly explaining why.

Let's begin with Lipman's suggestion [(2020) p. 31] that "there is nothing in the fragmentalist interpretation that is incompatible with postulating a Minkowskian spacetime next to the various fragments and taking the distributions of the variant properties to be grounded in the spacetime intervals of the Minkowskian spacetime." There are at least two problems with this suggestion. The first is that the fragmentalist can give no reason why various facts (such as that e_1 and e_2 are simultaneous) are grounded in facts about the spacetime intervals between events in Minkowski spacetime. On the standard view, the fact about the spacetime interval between e_1 and e_2 is explanatorily prior to the fact that e_1 and e_2 are simultaneous in a given frame because the frame-relative facts correspond to how the frame-invariant reality appears from a particular frame. This priority is responsible for the direction of explanatory priority; the spacetime interval's invariance can thereby explain why the resulting frame-relative facts obey the Lorentz transformations. This explanation is not available under fragmentalism even if the fragmentalist accepts the Minkowskian facts as part of über-reality. In particular, for the fragmentalist the relevant facts to be explained are (for instance) absolute simultaneity facts, such as that e_1 is simultaneous to e_2 full stop. Nothing in the standard Minkowskian explanation of how frame-relative facts depend on frame-invariant facts carries over to a potential fragmentalist explanation of how absolute perspectival facts depend on frame-invariant ones. The fragmentalist cannot accept the standard explanations, since their explananda are crucially different (e.g., that e_1 is simultaneous to e_2 in a given frame). To allow the frame-invariant facts to be (as Lipman proposes) present in über-reality, in addition to many other facts, suggests nothing about how the frame-invariant facts can manage to ground the perspectival facts. If the fragments are not mere appear-

ances of Minkowski spacetime, then why do the frame-invariant facts ground the perspectival facts?

The second problem with Lipman's suggestion that the fragmentalist can regard the perspectival facts as grounded in the frame-invariant facts is that it gives up on Fine's original ambition of formulating a new form of realism about tense and other perspectival facts, which to us is one of the main reasons why fragmentalism is of interest and significance in the first place. Lipman's own version of fragmentalism might not share this ambition, and in that spirit he insists that strictly speaking, the fragmentalist makes claims only about what facts obtain in reality [in the sense of Fine (2001) and Fine (2005)], not about priority and fundamentality. It should be clear that this by itself is too thin to yield a form of realism. Let's illustrate this point in terms of realism about tense. In order to yield a form of realism about tense, it is not enough to hold that tensed facts are identical to tenseless ones, and thus that tensed facts obtain in reality since tenseless facts do. Similarly, to generate a form of realism about tense, it is not enough to hold that tensed facts are reducible to tenseless ones and thus again obtain in reality, nor is it enough to hold that tensed facts are grounded in tenseless facts. Fine himself says as much, when he discusses how realism about tense should be understood and formulated. After insisting that the issue concerns whether tensed facts (such as the fact that I am sitting) obtain in reality, he notes:

> It is of course essential here, if this formulation of the issue is to be properly understood, that the reality of the fact that I am sitting, say, should not be taken to consist in anything like the reality of the fact that I am sitting at t, where t is the time at which the assertion of reality is made. It is the reality of something intrinsically tensed that is in question [Fine (2005), p. 268].

That does not require, of course, that tensed facts be fundamental. They could be grounded in all kinds of things, such as in other perspectival facts. But for the resulting view to be a form of realism about tense, tensed facts cannot simply be grounded in tenseless facts that relativize events (such as that I am sitting) to a time. The same applies to fragmentalism about STR.

But be that as it may, the real issue is not who is a proper realist and who isn't. The real issue is how the fragmentalist can explain why the fragments form in just the right way: there are only fragments that relate to each other according to the Lorentz transformations. Even if the

fragmentalist weakens their realism and accepts a priority of the frame-invariant facts, the question remains how this view explains the proper forming of fragments. We will revisit this issue shortly.

Let's now turn to Lipman's suggestion that whereas the standard interpretation takes the spacetime interval's invariance as explanatorily prior to the Lorentz transformations, the order of explanatory priority could just as well go the other way around. Lipman notes that in our paper, we cited many scientists who have taken the spacetime interval's invariance as explanatorily prior to the Lorentz transformations because the frame-relative facts are mere appearances of an underlying unified reality. Lipman expresses puzzlement at "the exact dialectical significance" [(2020), p. 33] of our point. He offers us two options. On the one hand, our point may be a sociological observation: that the scientific community has generally accepted the standard interpretation of STR. In that case, Lipman says, our point should have very limited persuasive force. We may owe deference to scientists in their judgments of the plausibility of various empirical claims, but the issue at stake here is a metaphysical matter; fragmentalism agrees with the standard interpretation on all of STR's empirical claims. (That is why fragmentalism and the standard interpretation are rival interpretations of the very same scientific theory.) On the other hand, our point may be that the interval's invariance indeed has explanatory priority. In that case, we should not be citing scientists' declarations; we should be arguing "on the basis of simplicity, plausibility, the ability to integrate with further theories, the ability to save the phenomena, and so on", that is, "the methods of the metaphysician. There is no good basis for deferring to the views of scientists on these abstract and non-empirical matters" [Lipman (2020), p. 34].

We reject both of Lipman's options in the forms that he offers them. We cited scientists not only to justify our sociological claim that a given interpretation of STR is "standard", but also to justify our claims concerning the reasons why scientists have generally favored this interpretation. As the Eddington passage suggests, their reason is that the standard interpretation gives better explanations. There are many ways that we might try to cash out what makes those explanations better (including that they avoid positing distinctions that make no observable difference, that they are ontologically more parsimonious, they are more unified, that they avoid suspicious brute coincidences, and so forth). Though these scientists were reasonably explicit about their reasons (as when Einstein cited the requirement that a scientific theory "show as much unity and parsimony as possible" [(1944), p. 289]), it would perhaps

have been better for all of us philosophers had Eddington and the other scientists we quoted been more explicit about their reasons. But it is to those reasons that we take these scientific passages as pointing. We cited scientists not because we are generally prepared to bow to their authority on metaphysical matters, but rather because of the good reasons that they give (or have) for their interpretations. There is nothing wrong with citing scientists who are making good arguments for the standard interpretation.

Among the theoretical virtues that are typically listed as operating in scientific theory choice is unification [Lipton (2004), pp. 122,139; Psillos (2002), p. 616; Williamson (2016), p. 266].[1] The unification that the standard interpretation of STR supplies is the most obvious (though perhaps not the only) reason why it provides better explanations than fragmentalism does. Minkowski spacetime unifies the various appearances; it unifies not only space and time, but also electricity and magnetism.[2] Obviously, fragmentalism offers an extraordinarily disunified view of reality, with innumerably many fragments, each on a par with every other.[3]

In light of this, a fragmentalist might be inclined to reject unification altogether as an explanatory virtue. After all, why should explanations unify when reality is disunified? However, this move seems to us merely to highlight fragmentalism's excessive theoretical cost, considering how integral unification seems to be to scientific practice. To reject unification as an explanatory virtue would perhaps be a tempting option if unifying explanations were unavailable or if they required a tremendous sacrifice of other explanatory virtues. But in the case of the Lorentz transformations and other relativistic phenomena, unifying explanations are plainly available. At the very least, rejecting unification as an explanatory virtue cannot lend any support to fragmentalism unless that rejection can be motivated, in turn, by some consideration other than the need to prop up fragmentalism.

Finally, let's turn to Lipman's suggestion that the fragmentalist could regard the Lorentz transformations as brute facts – as laws having no further explanation. After all, Lipman argues, the standard interpretation posits some brute facts (such as the invariance of the spacetime interval), so why can't the fragmentalist instead construe the Lorentz transformations as brute? "Where two views differ in what grounds what, bruteness will emerge in different places. In such cases, our evaluation goes astray if we merely point out that a certain matter is brute on one view and not brute on the other" [Lipman (2000), p. 36].

This is an unfair charge against us. We recognized that "the coordinate transformation laws could be brute, i.e., have no explanation. Some laws are presumably fundamental, and the coordinate transformation laws could be among them" [Hofweber and Lange (2017), p. 875]. Our argument was not simply that certain facts that fragmentalism depicts as brute have explanations on the standard interpretation. That argument would fail to consider any facts that the standard interpretation depicts as brute. Rather, our argument was that various facts that fragmentalism depicts as brute (but are not brute on the standard interpretation) are precisely the sorts of facts that we would expect to turn out not to be brute. That is a fair argument to make. It is the same kind of argument as Copernicans powerfully made against the Ptolemaic picture of the heavens, for instance. The Copernican picture had some unexplained explainers. But it avoided any "suspicious" coordination between the Sun's motion and each superior planet's epicyclic motion – coordination that the Ptolemaic theory depicted as brute and that it needed in order to save the phenomena. That is, the Copernican picture avoided positing as brute various facts that seem likely to have explanations.

In particular, we argued that the Lorentz transformations, understood (as the fragmentalist understands them) as relations between fragments, do not seem like the sorts of laws that are plausibly brute:

> We might expect the laws governing, say, the various fundamental interactions (or the "grand unified field") to be brute. But none of these laws includes the coordinate transformation laws.
> According to fragmentalism, the coordinate transformation laws connect distinct "fragments" of reality. Of course, laws of nature typically relate distinct events or facts, so fragmentalism's depicting the coordinate transformation laws as doing so does nothing to make fragmentalism implausible. But when laws of nature relate distinct events or facts, they generally do so for certain familiar reasons. Some laws relate causes to their effects, as when laws relate electric charges to the forces they cause or relate forces to the accelerations they cause. But fragmentalism does not depict events in one "fragment" as causes of events in another. Similarly, some laws specify the correlation between joint effects of a common cause, but once again, fragmentalism does not depict events in different fragments as having a common cause. In addition, some laws relate the ground of a disposition to the disposition it grounds, such as a law relating an element's atomic structure to its chemical activity. But this is obviously not the way to understand the transformation laws. That laws relating fragments would be sui generis does not show that they are impossible. But it does show that fragmentalism has an explanatory weakness compared to a

> rival view according to which the "fragments" are mere appearances of a common underlying reality [Hofweber and Lange (2017), pp. 875-876].

The Lorentz transformations are not the only laws that the fragmentalist must depict implausibly as brute but that have explanations on the standard interpretation. Consider the fact that in every single inertial reference frame (or fragment), bodies' uniform absolute motions over and above their relative motions make no observable difference. The standard interpretation explains this fact by identifying a common explainer: that in reality (that is, in the common reality of which the facts in various inertial frames are mere appearances), there are no facts about which bodies are in inertial motion and which are at rest. The reason why such "facts" make no observable difference is because there are no such facts. By contrast, the fragmentalist can point to no common explainer. Either it is some sort of coincidence that every fragment has this feature or it is a brute law that every fragment has this feature. Once again, the standard interpretation avoids portraying suspicious coordination between the frames (or fragments) as brute.

Likewise, the fragmentalist depicts each fragment as containing two kinds of forces, electrical and magnetic, that happen to produce the same electromotive force for the same uniform relative motions, no matter what the absolute motions are. This seems like a remarkable coordination within each fragment and a remarkable coordination across the fragments. The standard interpretation is that like space and time, the electric and magnetic forces are in fact a single force that appears as different combinations of electric and magnetic components in different frames. Once again, this sort of explanation is unavailable to fragmentalism. (It was precisely this explanatory advantage that motivated Einstein to propose STR in the first place; as we noted [Hofweber and Lange (2017), pp. 876-877], he made precisely this argument in the majestic opening paragraph of his first STR paper [Einstein (1905)/(1989), p. 140]). Once again, the argument is not simply that fragmentalism construes as brute certain facts that the standard interpretation explains. The argument is that fragmentalism is implausible in which facts it depicts as brute.

For the fragmentalist, the Lorentz transformations constrain which facts cohere with one another and thus which fragments form: all and only those that obey the Lorentz transformations. The sort of coordination that this constraint imposes is not generally an attractive candidate

for a primitive fact — either in metaphysics or in physics. Even for the fragmentalist, it would be *sui generis*: while other laws of nature determine which facts obtain, that is, what über-reality is like, the Lorentz transformations would determine which facts come together in fragments, that is, which facts cohere with each other. Since it imposes very specific and elaborate constraints on what is coherent with what globally, it is not attractive as a brute fact. Regarding the Lorentz transformations' explanation, a fragmentalist has nothing to offer, whereas the standard interpretation has a good explanation at hand. This consideration is not enough to show that fragmentalism is unintelligible or shouldn't be taken seriously, but it is good enough to support our conclusion that we should strongly prefer the standard interpretation of STR instead.[4]

Department of Philosophy
University of North Carolina at Chapel Hill
Caldwell Hall CB# 3125, 240 East Cameron Ave.,
Chapel Hill, NC 27599-3125, USA
E-mails: hofweber@unc.edu, mlange@email.unc.edu

NOTES

[1] Lipman (personal communication) agrees and sees unification as represented in his list under simplicity and theoretical integration.

[2] Maxwell's electromagnetic theory identified many physical laws linking electrical and magnetic forces, but it did not unify these two forces in the sense of revealing them to be aspects of a single force – that is, it did not unify them in the way that Newton's physics unified the forces causing the planets to orbit the Sun, the Moon to orbit the Earth, unsupported bodies near Earth to fall, the tides, and so forth. That ontological unification was achieved only by STR under Minkowski's interpretation. See Lange (2002), pp. 175-99.

[3] Lipman (2020), p. 27 mentions that fragmentalism has the advantage of preserving objects as having the properties that they seem to have, such as the paper cutout being square, whereas the standard interpretation must explain away these apparent facts, since the object's squareness is only frame-relative. This is presumably intended to be a theoretical virtue that favors fragmentalism. But this is not a real advantage, since on the fragmentalist's picture, the paper cutout is also a non-square (i.e., an oblong rectangle). The fragmentalist can claim that the world is as it seems to be, but the fragmentalist still needs to explain why there are various ways that the world also is but that it doesn't seem to be (e.g., the paper cutout is oblong but does not seem to be oblong). Any ad-

vantage that fragmentalism may gain from saving the object's squareness it loses by also embracing the object's being non-square as well.

[4] Our thanks to Martin Lipman for discussions and comments on an earlier draft.

REFERENCES

EINSTEIN, A. (1905), "Zur Elektrodynamik bewegter Körper"; *Annalen der Physik* 17 (10), pp. 891-921; in *The Collected Papers of Albert Einstein*, vol. 2, trans. Anna Beck, Princeton: Princeton University Press, 1989, pp. 140-71.

— (1944), "Remarks on Bertrand Russell's Theory of Knowledge"; in Paul Arthur Schilpp (ed.), *The Philosophy of Bertrand Russell*, Evanston, IL: Northwestern University Press, pp. 179-91.

EDDINGTON, A. S. (1920), *Space Time and Gravitation*; Cambridge: Cambridge University Press.

FINE, K. (2005), "Tense and Reality"; in *Modality and Tense: Philosophical Papers*, Oxford: Oxford University Press, pp. 261-320.

HOFWEBER, T. and LANGE, M. (2017), "Fine's Fragmentalist Interpretation of Special Relativity"; *Nous* vol 51.4, pp. 871-883.

LANGE, M. (2002), *An Introduction to the Philosophy of Physics: Locality, Fields, Energy, and Mass*; Malden, MA: Blackwell.

LIPMAN, M. (2020), "On the Fragmentalist Interpretation of Special Relativity"; *Philosophical Studies* 177, pp. 21-37.

LIPTON, P. (2004), *Inference to the Best Explanation*, 2nd ed.; Routledge: London and New York.

MINKOWSKI, H. (1952), "*Space and Time*"; in W. Perrett and G.B. Jeffery (eds.), *The Principle of Relativity*, New York: Dover, pp. 73-91.

PSILLOS, S. (2002) "Simply the Best: A Case for Abduction"; in A.C. Kakas and F. Sadri (eds.), *Computational Logic: Logic Programming and Beyond*, Berlin: Springer, pp. 605-26.

WILLIAMSON, T. (2016), "The Abductive Philosophy"; *The Philosophical Forum* 47 (3-4), pp. 263-80.