How Relativity Contradicts Presentism

Simon Saunders
Faculty of Philosophy, 10 Merton St., Oxford

1   Introduction

> But this picture of a "block universe", composed of a timeless
> web of "world-lines" in a four-dimensional space, however strongly
> suggested by the theory of relativity, is a piece of gratuitous meta-
> physics. Since the concept of change, of something happening, is
> an inseparable component of the common-sense concept of time
> and a necessary component of the scientist's view of reality, it is
> quite out of the question that theoretical physics should require
> us to hold the Eleatic view that nothing happens in "the objective
> world". Here, as so often in the philosophy of science, a useful lim-
> itation in the form of representation is mistaken for a deficiency
> of the universe (Black, 1962).

The theory of relativity has excited more philosophical commentary, and ex-
erted more influence in mainstream philosophy, than any scientific theory,
with the possible exception of Newton's theory of gravity. But it is a re-
markable fact that its influence on metaphysics proper has been somewhat
marginal. That is probably a testimony to the anti-metaphysical attitude
that characterized so much philosophy in the last century, certainly in the
Anglo-American tradition, and certainly among more scientifically-minded
philosophers. Although the hey-day of logical empiricism is long-since past,
philosophers of physics have continued to remain cool to metaphysics. Since
they remain the ones best suited to explain the implications of relativity the-
ory for the philosophy of time, if they find no interesting links between these
disciplines, metaphysicians are unlikely to look for them.

I make this observation (and I promise to say no more in this vein) because
relativity theory, and specifically the special theory of relativity, does I believe
have a simple and direct bearing on a perennial question in the philosophy of
time. It would, I believe, *settle* this question, were special relativity the whole
of the story. I shall say something about the broader perspective of quantum
theory and general relativity at the end.

What traditional question does special relativity decide on? It is whether reality - what exists - is a four-dimensional web of worldlines (a "block universe"), or something less. There are competing versions of what this "something less" might be, but they are variations on what I shall call *presentism*, the view that only the present is real. The argument is simple, and I will state it with the minimum of technicality. Although, I say, it has been largely ignored, versions of it have been stated before; it was stated in brief by Gödel,[1] and at great length by Putnam.[2] But this latter version of the argument has been roundly condemned by Stein. This dispute between Putnam and Stein is in fact well-known in the philosophy of physics literature, but insofar as there is a consensus on it, it is that Stein was in the right.[3] I will come on to this dispute in due course.

2   Presentism

"Presentism", as I shall understand it, is the thesis that *the present is all that exists*. But this needs some unpacking. It is intended to be something more than a platitude, and surely the present is all that exists *now,* as the future is all that *will* exist, and the past all that *did* exist. Who will argue with these claims?

One way to get clearer on the presentist thesis is to say that it is meant *tenselessly*; that the copula in the sentence "the present is all that exists" is not itself tensed. But that is a doubtful maneuver. Very often the presentist will go on to deny that there is any meaningful, irreducibly tenseless use of "is", at least when it comes to the physical world; and that *passe* Mellor and others, it is equally possible to give tensed truth conditions for tenseless sentences as tenseless ones for tensed. Exercises in the philosophy of language do not seem to be settling anything.

But nebulous though it is, there is surely something about the presentist's position which is perfectly clear: it *is* intended to be a thesis about what to count as real. It is a realist thesis. It is a claim about temporal reality which is supposed to hold independent of our state of knowledge or beliefs. *We* and our works are not what the thesis is about; the presentist is making a claim

---

[1] For Gödel the point was obvious; he immediately went on to consider the situation in Einstein's theory of gravity, specifically in the light of his rotating universe solutions to the field equations of general relativity. The latter argument has been carefully analysed by a number of authors: see Stein (1994), Earman (1996), and Savitt (1997).

[2] Putnam (1967); versions of it were also stated by Rietdijk (1966) and Maxwell (1986), and these Stein has also criticised; but their interests were a little oblique to our topic, and their handling of it more muddled. Rietdijk's treatment, in particular, was just careful enough, and just muddled enough, to be conclusively refuted (see Torretti 1983, pp. 250-51l; see also Landsberg 1970 p. 1146-47). I shall confine myself almost entirely to Putnam's argument, and to Stein's response to it (Stein 1978, 1991).

[3] Among those who have endorsed Stein's objections to Putnam's argument, see Clifton and Hogarth (1995), Dickson (1998 p.165-73), and Shimony (1993), with qualifications). So far as I know only Callender (1998) has expressed any real reservations; but see also Saunders (1996, 1998).

about reality, not about what we know or say about it.

The claim can also be put in negative terms, as the view which is opposed to the tenseless view of time (according to which all events exist on a par, regardless of whether we consider them as past, present, or future). On the tenseless view, talk of events as past, present or future is really talk about ourselves, of the relation of events to how we are momentarily arranged. The word "now" is like the word "here"; mention of "future" and "past" is like pointing this way and that way in space.

That is all that is needed to bring out the conflict with special relativity. If presentism is a thesis about ontology, and says that existence consists of a three-dimensional spatial reality; if, in elaboration of this thesis, it opposes the tenseless view of time, and denies that talk of events as past, present or future is elliptical talk about the relation of events to our momentary selves: then it contradicts special relativity. It contradicts it in the sense that it implies that special relativity is badly deficient as a fundamental theory of the world.

Of course special relativity is an empirical theory. One might take the view that presentism is concerned with a level or reality which is beyond the reach of experimental methods.[4] But I do not grant that physics is so limited in scope, or that metaphysics can find anything deeper. But I will not argue for either of these claims here.

3   How Relativity Contradicts Presentism

The difficulty posed by special relativity is extremely simple. According to presentism, all that is physically real is the present - a system of physical events all of which are simultaneous with each other. No other events are real. Precisely what this system of events may be, *now*, as I snap my fingers, may not be known to me; but there is a fact of the matter as to what it is, and it is a universal fact which embraces us all. It is an intersubjective reality - now, as a snap my fingers - and it is a reality which contains us only as an incidental part. But even if one knew all that there is to know, consistent with special relativity, one would not be able to say what this system of events might be. According to presentism, therefore, special relativity is radically deficient as a description of reality. It is blind to the sequencing of what is physically real.

There is no such problem in the Newtonian case. There, knowing all there is to know, the set of events simultaneous with this event - as I snap my fingers - is unambiguously defined. It is all and only those events absolutely simultaneous with it. In that theory there is postulated a relation, absolute simultaneity, which partitions events into disjoint classes, namely instants of time. It does so democratically: no one event of each class is singled out in the definition of the partition. To be precise, this relationship of absolute

---

[4] For a metaphysician who hovers uncomfortably between this view, and the view that anyway relativity does not contradict presentism, see Smith (1993 p.2-4.).

simultaneity is reflexive, symmetric and transitive, so instants of time are *equivalence classes* of events. This relation, moreover, plays a crucial role in the subsequent definition of the dynamical laws of motion (and of suitable initial data for those laws); it could hardly play a more fundamental role in Newton's theory. And we ourselves, and our momentary and spatial arrangements, are manifestly incidental to its definition; we are incidental to what each reality consists in. Newtonian theory, gratifyingly for the presentist, is attentive to what is physically real. Not so special relativity.

The argument is so simple that it speaks for itself. No technical result is needed: it is of the essence of the theory of special relativity that absolute simultaneity as such does not exist. Everyone knows that there is nothing else to replace it - there is no other non-trivial symmetric and transitive relation intrinsic to Minkowski space. Of course, making reference to the matter content of spacetime as well, there may well be methods for defining a partitioning of spacetime into spaces (for defining global instants, as required by presentism), but none of them are likely to claim any fundamental status. It is unlikely that any can be taken seriously, if we are concerned with the definition of the totality of what is physically real. Only given a matter distribution of exceptional symmetry - for example, a stream of particles all moving inertially, with zero relative velocities - would a slicing of spacetime into spaces at different times (a *foliation* of spacetime) be obviously privileged. The presentist will *literally* need a river for there to be time, according to his metaphysics.[5]

One need only consider the realistic candidates to see the difficulty. Given any one inertial (straight) worldline, one can define a natural slicing of Minkowski space into spaces at different times, namely into the set of (parallel) timeslices orthogonal to it. But how can the whole of reality - what is physically real - depend on a *single* worldline? *What* is this thing which has this special privilege - or *who* is it - that has this extraordinary status? In fact, from a physically realistic point of view, there are *no* objects which always move inertially. Nor, in an infinite universe, does anyone know how to construct such a world-line: one cannot define the centre of mass of the universe as a whole if it is infinite; and one cannot make do with any part of it without privileging that part. Why *that* part, and not some other? Even in the finite case the option of the centre of mass is not very attractive, involving as it does messy and arbitrary conventions (there is no unique definition of the centre of mass frame in the finite case, again in contrast to the situation in Newtonian theory). The presentist cannot be neutral on this score; to suppose it can be settled by convention is precisely to take the view that what is real - the

---

[5]For a more general criterion, less dependent on symmetry, suppose that hypersurfaces are defined as everywhere orthogonal to the integral curves of the four-velocity field of the fluid. Then the fluid had better be irrotational (lacking "twist"), if the surfaces are not to intersect. (For a simple geometric illustration, think of a twisted rope; it cannot be cut so as to cut each strand of it orthogonally.) Gödel was led to his rotating universe solutions to the Einstein field equations by considerations of just this sort: see Malement (1994).

breaking down of spacetime into spaces at different times - is not of fundamental import, but a matter of convenience, a matter of convention. That is precisely what the *tenseless* theory says. This is not an option available to the presentist.

In the general case, and in an infinite universe, in practise one seizes on a segment of a particular worldline or worldtube of some body (or bodies slowly moving with respect to each other). At any point of it a spacelike hyperplane can be constructed to which it is orthogonal. If approximately inertial, a family of hyperplanes can be constructed which are non-intersecting, at least locally. This is the technique used in positional astronomy: Ephemeris Time is precisely such a system for partitioning events in the history of the solar system into spaces at different times (more precisely, it is a based on the relative configurations of the Earth-Moon-Sun system). By its means, if there ever does come into being a community of astronauts in space, moving about the solar system, it will still be possible to agree on what events in whose lives get to take place at the same time. The criteria will be public and intersubjective. No particular person will be singled out in counting what is real (of what belongs to which moment in time). But the community as a whole is singled out. The Earth-Moon-Sun system acquires a very special status. As the basis for the criterion of what is real, it is parochial. It will hardly do for metaphysics. It is as embarrassing as Newton's hypothesis as to what is really at absolute rest (the centre of mass of the Solar System). What is so special about the Earth, Moon and Sun?

The presentist has little option but to hold out for some as yet unknown criterion for determining what is physically real - for splitting Minkowski spacetime into spaces at different times. Special relativity, the presentist must conclude, is radically incomplete. But the alternative view is that progress in physics has counted against presentism. Physical theories were once compatible with it, but then they were not.

4   The Dispute Between Putnam and Stein

This argument is I believe unassailable, but it is similar to Putnam's, and Putnam's has been roundly condemned. On what grounds?

First Putnam's argument. He considers what he calls "the view of the man on the street". It is the same as presentism: it is the view that "all (and only) things which exist now are real". Putnam now assumes:

> 1. I-now am real. (Of course, this assumption changes each time I announce that I am making it, since "I-now" refers to a different instantaneous "me".)
> II. At least one other observer is real, and it is possible for this other observer to be in motion relative to me. (Putnam 1967 p. 240.)

He also assumes what he calls "the principle that There Are No Privileged Observers":

> III. If is the case that all and only the things that stand in a certain relation R to me-now are real, and you-now are real, then it is also the case that all and only the things that stand in the relation R to you-now are real. (*ibid* p.240).

Putnam gives no argument for this principle, and in his subsequent use of it only transitivity is explicitly mentioned; but by the letter of III it is clear that R must also be symmetric. And so it should be, if of all the events which are real, no one of them is to be privileged. If not, then if we start from a fiduciary event x (there is at least one real event, by I), and define the others that are real as those which stand in relation R to x, then the set $\{y : Rxy\}$ that we end up with cannot also be defined by starting with another element of this set. In other words, each set will have to be specified by the relationship R and a *particular* element of it (not *any* element of it); so for each set one element of it would have to be privileged. Likewise if R is symmetric but not transitive. Since R is surely reflexive, "no privilege" exactly forces R to be an equivalence relation. When the elements in question are events in the lives of observers - person-stages - the principle is "no privileged person-stages". ("No privileged observers" has a better ring.)

Finally, Putnam requires:

> IV. R is definable in special relativity.

The similarity of Putnam's argument to the one I have given should be perfectly clear. Indeed, given a partitioning of Minkowski space M, one can always define an equivalence relation in its terms. Let the timeslices of M - the partitions - be labelled by a parameter t, denote $\{M_t\}$. Then R is the co-membership relation

$$R = \{< x, y >; \exists t \text{ such that } x \in M_t \text{ and } y \in M_t\}. \tag{1}$$

It is obviously an equivalence relation, and, given $\{M_t\}$, it is obviously definable in special relativity. The question that remains is how the partitioning of Minkowski space was arrived at. If by a relationship on M - essentially reversing the procedure just sketched - then we are back to Putnam's approach. But whatever the method, a principle analogous to III will apply. I would add that not only can it not privilege any particular person, but it had better not privilege any particular community, either. A metaphysics which is explicitly community bound is not worthy of the name.

Putnam considered only partitions defined by a relationship R, not the more general case. A quick result follows on the narrow reading of IV, that R must be defined in terms of the *geometry* of M. Then, trivially, there are only the two equivalence relations, $\{< x, y >; x, y \in M\}$ - all events are real

- and $\{< x, y >; x = y\}$ - only the fiduciary event x is real. If these are the only possibilities, it is not hard to see which we should choose.

But Putnam did allow that R may be defined by reference to the matter distribution. The result still follows, failing any special symmetries, but whilst intuitively plausible it is harder to prove. Putnam did not prove it.[6] He only considered the most obvious candidates for it, in particular Einstein synchrony, denote Ein; this obviously fails, because for points on an arbitrary collection of timelike lines it is neither symmetric nor transitive. He also considered the worldline-independent relation of past causal connectibility, denote Con. Let $x \leq y$ iff x is in or on the past light cone of y; then Con is the relation $\{< x, y >; x \leq y\}$. Although reflexive and transitive, it is not symmetric. This too is of no use to the presentist.

Putnam did not put it in quite these terms, however. In this latter part of his paper, where he introduced Con, he spoke rather of truth-values of statements, not of the reality of events. He considered Con in this context, as the suggestion that only statements about events in the lower half of my light-cone have a truth value. Of this he remarked:

> This last move, however, flagrantly violates the idea that there are no Privileged Observers. Why should a statement's having or not having a truth value depend upon the relation of the events referred to in the statement to just one special human being, *me*? (*ibid* p.246)

The point is not entirely self-evident. A statement may fail to have a truth value because it may fail to refer to anything, and whether or not a statement refers (and what it refers to) may well depend on whether it has a relation to a particular human being - so much is true of any statement containing an explicit or implicit indexical. And Putnam did not make it clear that one can hardly insist on his requirement III, of "No Privileged Observers", as it was originally stated, in this new context, for no-one will demand *symmetry* in this case. By shifting to the question of what statements have truth-values, it is surely intended that we include statements referring to *past* events as well as to present ones. Putting it in non-linguistic terms, it is not the thesis of presentism, but rather the the thesis that *only the present and the past is real*. Call it "possibilism"[7] If defined by a relation, the possibilist will obviously not want it to be symmetric. If an earlier event is real in relation to a later one, that should not imply that the later one is real in relation to the earlier. Given possibilism, we should not expect to obtain a democracy of timelike-separated observers.

---

[6]It is an immediate corollary of the result of Clifton and Hogarth (1996), namely that in the absence of symmetries, there is no worldline-dependent relation which is so much as transitive. Perversely, they took this to lend support to *Stein's* argument, rather than Putnam's (for it generalizes Stein's proof that Con is the only intrinsically-definable non-trivial transitive relation on M; see below).

[7]In line with Savitt's terminology (Savitt 1998).

But possibilists will still insist on the remaining requirement built into III, that if you are real to me, then what is real to you is real to me as well. Transitivity is necessary here as before. And now one might be lulled into thinking that transitivity is *sufficient* for possibilism: that possibilism differs from presentism only in that it demands a weaker version of III.

The waters are now seriously muddied, for of course transitivity is *not* enough for possibilism. The constraint is operating, here as before, that what is present - meaning, according to possibilism, what is the *boundary* of all that is physically real - is an intersubjective and non-parochial affair. But this latter constraint can no longer be imposed by formal conditions on R, if R relates all and only the events which the possibilist considers as real.

Were transitivity all that is required by the possibilist, the relation Con would be just the ticket. This is exactly Stein's response to Putnam: it is enough to define a relation "already happened", and it is enough if this relation is transitive and definable in terms of the intrinsic geometry of M (reflexivity as before can be stipulated). Con does the job. Stein made this clear in his first paper on the subject (Stein 1968, p.5); in his second he went on to prove that Con is essentially the only such transitive relation on M (Stein 1991).

As for Putnam's error, Stein located it in the passage just cited:

> The answer is that "having or not having a truth value", in this question, must be understood classically to mean "at a given time" .... but "at a given time" is not a relativistically invariant notion, and the question of definiteness of truth value, to make sense *at all* for Einstein-Minkowski space-time, has to be interpreted as meaning "definiteness at a given space-time point (or event) - to be vivid, "definiteness for me now". The "Privileged Observer" (or, rather, privileged event) is - in effect- named in the question, and therefore has every right to be considered germane to the answer. Putnam's objection has an exact analogue, whose inappropriateness is plain, in the pre-relativistic case; namely, the question "why should a statement's having or not having a truth value depend upon the relation of the events referred to in the statement of just one special time, *now*?" (Stein 1968 p.15).

According to Stein, Putnam presupposes notions that are simply not available in special relativity. He has failed to take note of the changed situation in that context, that "definiteness to the present" has to be replaced by "definiteness at a given space-time point". Clearly, on making this replacement, one cannot rule out reference to a particular point, no more than in the non-relativistic case can one rule out reference to a particular instant.

All well and good, but clearly this changed situation is simply *no longer hospitable* to presentism. In the pre-relativistic case "an instant" is a public reality, on which all who were included in it could intersubjectively agree. It offered room enough for an account of the whole of reality (it was a *plausible*

reality, at least for some). But nothing like this can be said of a spacetime point. If this is really all that special relativity provides, short of the whole of Minkowski spacetime, we have no option but to opt for the latter. If it is true that "the now" can only be a spacetime point - as Stein seems to imply - then presentism is *obviously* untenable. A single point in spacetime *cannot* be all that is physically real.

Stein is in fact perfectly indifferent to presentism.[8] He makes this clear in the paragraph that follows:

> ...in Einstein-Minkowski space-time an event's present is consti-
> tuted by itself alone. In this theory, therefore, the present tense
> can never be applied correctly to "foreign" objects. This is at
> bottom a consequence (and a fairly obvious one) of our adopt-
> ing relativistically invariant language - since, as we know, there
> is no relativistically invariant notion of simultaneity. The appear-
> ance of paradox only confirms that the space-time of Einstein and
> Minkowski is quite different from pre-relativistic space-time. (*ibid*
> p.15)

The tenseless point of view is so natural that it is not even worthy of comment: *of course* the present of an event is constituted by itself alone; what else is one to think in special relativity! Stein is not concerned with the metaphysical thesis of presentism. He is impatient with talk of the view of the man in the street - he finds it curious that special relativity should be held hostage to that - because for Stein, it is a *fairly obvious consequence* of relativity theory that an event's present is constituted by itself alone (the second of the two trivial equivalence relations). *Obviously* the presentist's position is untenable, given special relativity. Precisely so; the only question is why Stein disputed Putnam's conclusions.

There is one more respect in which the shift of topic, to possibilism and definiteness of truth value, may have led to confusion. What is the status of future contingencies? Rietdijk advanced an argument similar in certain respects to Putnam's, but used it to conclude that special relativity implies *determinism*. Almost twenty years later, and without reference to either Putnam or Rietdijk, so too did Maxwell. It was this that prompted Stein's second paper on the subject, in which he proved that *Con* was essentially unique. It was titled "On Relativity Theory and the Openness of the Future". Clifton and Hogarth's generalization of this result, to include worldline-dependent relations (in the absence of symmetries), was entitled "The Definability of Objective Becoming in Minkowski Spacetime". Black shifted without comment from the view that reality is a 4-dimensional whole, to the view that change is unreal; Shimony, approvingly citing Stein's response to Putnam, was

---

[8]Compare Torretti (1983 p.250): 'Each event is (tenselessly) real and determinate, in this absolute sense, as its own worldpoint. No tensed, frame-indepenent statement can add to it or detract from its reality...' I do not believe that the presentist, or anyone even loosely associated with presentism, can agree with this statementl.

concerned to deny that change was illusory. Evidently there are two further questions at stake in all this: one, whether indeterminism is consistent with special relativity, and two, whether the tenseless view of time is committed to the view that change, or becoming, is unreal. But one can answer these questions either way and yet reject presentism;[9] Putnam made no mention of either of them.

The one clear respect in which Stein flatly denies a step in the argument as I hanve given it is this:

> ...in effect what he calls the principle of No Privileged Observers just requires R to be an equivalence relations. But such a requirement has in fact no connection with the privilegedness of observers; and it is moreover extremely inappropriate to Einstein-Minkowski space-time - in which (unlike pre-relativistic space-time, with its temporal decomposition) there are no intrinsic geometrical partitions into equivalence classes at all, besides the two trivial ones...(*ibid* p.19)

Stein denies that to partition a set into classes by means of a relation, in such a way that each class can be defined independent of the choice of any particular element of that class, the relation must be an equivalence relation. I say he is mistaken.[10]

How might *Con* be used to define a partitioning of Minkowski space? There is a near neighbour to it which does the job quite easily. Let $x \preceq y$ iff x is on the surface of the past light-cone to y. Define *Berk* as the relation $\{< x, y >; y \preceq x\}$. Berkeley's criterion, indeed, was that to be real (to x) is to be seen (by x, so to be on the past light-cone to x).[11] Let us now partition up M into disjoint sets in the obvious way, as a nesting of lightcones. We do not obtain a foliation in this way, for the partitions are not spacelike surfaces, but put that aside. The real difficulty is that each partition has a distinguished point - the apex of each cone - and the partitioning as a whole clearly distinguishes a unique timelike line - the locus of these distinguished points. Such is the price for using a relation which is not an equivalence relation. Now suppose this partitioning has the metaphysical significance

---

[9] The presentist, of course, may disagree; so too will "A-theorists", who find compelling McTaggart's argument that the B-series is inadequate to the description of change. I have more sympathy for Maxwell's claim, that special relativity poses problems for indeterminateness (see my 1996, 1998, for further discussion).

[10] Compare Sklar, '...why one should think that such a doctrine of "No Privileged Observers" would lead one immediately to affirm the transitivity of "reality for", given that one has already relativized such previously nonrelative doctrines as that of simultaneity, is beyond me.' (Sklar 1981 p.130). The answer is that Putnam's aim was exactly to show that once "simultaneity with" is relativized in a way which is non-symmetric, and non-transitive, then "reality for" must be relativized simililarly: in which case it is unacceptable.

[11] Of course Berkeley was not proposing that all that exists is what is visible to a unique x - a unique and particular event in space and time; rather, he proposed that it is what is visible to God.

accorded to it by the presentist: a given one of them is to define the whole of what is physially real, a mater on which all will agree. So what is this worldline - the worldline of *what* or of *whom* - that is to have this extraordinary significance? It can hardly be one of the obvious candidates from the tenseless point of view (one's own worldline, or the worldline of the earth, or of the centre of mass of the sun, earth and moon), wherein no ontological significance resides (for on the tenseless point of view the fundamental ontological reality is the whole of Minkowski space, and everything in it). We have been over this before

On the tenseless view, all events are real; the signficance of the partitioning is quite different. If asked which relationship gives the "correct" partitioning, the answer will depend on how the question is construed. *Berk* is a natural candidate, but so is *Ein* - in each case referred to a particular timelike line. If the question is construed as what to count as the past, or what to count as the present, most of us will settle for a foliation of spacetime, on which we can reach community-wide consent. It is *Ein*, and Ephemeris Time, that we will choose.[12]

5 Prospects for Presentism

Putnam made mistakes in his argument, but that does not explain its reception. Dickson has diagnosed the fault with it - as we have seen Stein says the same - as the sheer *inappropriateness*, in special relativity, of Putnam's assumptions; that "before special relativity can have anything to say about the doctrines in question, they must be expressed in a language that is meaningful in a relativistic context" (Dickson p.170). Stein's sympathy with Carnap's philosophy is well-known (Carnap was committed to the doctrine of incommensurability long before Kuhn): evidently it retains its appeal for Dickson as well.

But we can meet this objection head-on. The requirement of intersubjectivity is certainly relativistically meaningful. The inference from that to the requirement that R be an equivalence relation was independent of spacetime considerations altogether. To infer from that that there must exist a privileged foliation to Minkowski spacetime is *precisely* to spell out the doctrine in relativistically invariant terms. The fact that this doctrine is then *ruled out* by special relativity was precisely Putnam's point.

At the other extreme is the deflationary, commonsensical reading of presentism, along the lines sketched by Savitt and Moratio. According to them, it is obvious that the past *did* exist, that the future *will* exist, and that only the present *is* (presently) real. What, I wonder, is obvious to them? That only my momentary self is (presently) real? That what is (presently) real is what is related by *Ein*? Or is it *Con*, or is it *Berk*? They may of course reply that it makes no difference which, but that is not a deflationary reading of anything.

---

[12]For a recent defence of the virtues of *Ein* over *Berk*, see Sarkar and Stachel (1999).

Somewhere in between is *quietism*, the view that special relativity cannot adjudicate on the matter unless supplemented by some form or other of verificationism (Sklar 1981). So it was with Einstein's elimination of ether; his approach to special relativity was explicitly verificationist, and only given this could he conclude that the ether did not exist. Indeed, the presentist has only to suppose that there is, in fact, a unique resting frame, albeit that no measurement can tell us what it is: this is the foliation he has been after all along. He can claim it serves an explanatory function in physics as well, citing Lorentz, for whom it was a "matter of taste", and citing Bell, for whom it was the best way "to teach the subject."[13] But here I think Stein is exactly right when he says (Stein 1991 p.155) that if it is verificationism that is needed, to do away with an absolute "up" in the face of rotational symmetry, then it is a form of it that is perfectly defensible, that we should all of us embrace: the form of it which eliminates an absolute state of rest in the face of the relativity principle. And, obviously, one can draw the same conclusion on the basis of a *realist* view of Minkowski space (not of course available to Einstein *circa* 1905).

I have maintained that presentism is a substantive position that places clear demands on the theory of special relativity. They are demands which I do not think can be met, consistent with that theory. This fact needs to be clearly appreciated, if there is to be movement on this subject. Movement there is, as soon as we consider the wider perspective of Einstein's theory of gravity, and dynamics proper.

Of course general relativity, just like the special theory, is committed to the principle of arbitrariness of foliation. Nevertheless, for an important class of spacetime models - *hyperbolically complete* spacetimes, for which the Cauchy problem is soluble - there is a natural definition of a global foliation, which has a number of desirable, dynamical properties. It is essentially unique; it is what is actually used in numerical calculations in geometrodynamics; it also has links to a number of open theoretical questions, particularly questions concerning the nature of scale in the classical theory.

I give this example, called *York time*,[14] after its discover James York, not because I am convinced it is fundamental, in classical theory, but as an example of the new avenues that are opened up as soon as one considers gravitational dynamics proper.[15] Certainly none of the arguments I have given

---

[13] This, the so-called "Lorentz pedagogy", has recently been defended by Brown and Pooley (2001); but in their view it is not committed to the view that any *one* frame of reference is truly the resting frame; they suppose that the forces which yield the contraction and dillation effects may be explanatory, even if there is no fact of the matter as to what they really are.

[14] For a simple exposition of its uses in Hamiltonian formulations of general relativity, see Wald (1984).

[15] And to repair my unhappy neglect of it in my (1996). The class of hyperbolically-complete spacetimes is of course only a sector of the full theory, and there are already problems with this in the quantum case, if black-hole evaporation is anything to go by; but it is an important sector all the same, and black-hole evaporation equally causes problems for unitarity.

here tell against it. And ultimately, of course, one must look to a quantum theory of gravity, where the interpretation of time in canonical approaches to quantization is anyway in dispute. If one throws into the equation the foundational problems of quantum mechanics, and the evident difficulty, in that context, of defining a Lorentz-covariant stochastic dynamics,[16] it is clear that here there is everything to play for. But we are not about to make progress with any of these fields if the metaphysics of presentism, in the most simple case of classical special relativity, is still in dispute. In this most simple case, I have argued, it can finally be laid to rest.

References

Bell, J. (1987), 'How to Teach Special Relativity', in *Speakable and Unspeakable in Quantum Mechanics*, Cambridge University Press: Cambridge.

Black, M. (1962), 'Review of G.J. Whitrow's "The Natural Philosophy of Time"', *Scientific American*, CCVI, p.181-2.

Brown, H., and O. Pooley (2000), 'The Origin of the Spacetime Metric: Bell's "Lorentzian Pedagogy" and its Significance in General Relativity', in *Physics Meets Philosophy at the Planck Length*, C. Callender and N. Huggett, eds., Cambridge University Press: Cambridge.

Callender, C. (1998), 'Shedding Light on Time', *Philosophy of Science (Proceedings)*, **67**, S587-S599.

Clifton, R. and M. Hogarth (1995), 'The Definability of Objective Becoming in Minkowski Spacetime', *Synthese* 103, 355-87.

M. Dickson (1998), 'Digression: The Block-Universe Argument', in *Quantum Chance and Non-Locality*, Cambridge University Press: Cambridge..

Earman, J. (1996), *Shrieks, Bangs,Whimpers and Grunts*, Oxford University Press: Oxford.

Gödel, K. (1949), 'A Remark About the Relationship Between Relativity Theory and Idealistic Philosophy', in *Albert Einstein, Philosopher-Scientist*, A. Schilpp, ed., Open Court, La Salle.

Landsberg, , P. T. (1970), 'Time in Statistical Physics and Special Relativity', *Studium Generale*, **23**, pp. 1108-59).

Malement, D. (1994), 'Commentary', in *The Collected Papers of Kurt Godel*, Vol.3, S. Fefferman, J. Dawson, W. Goldfarb, C. Parsons, and R. Solovay, eds., Oxford University Press: Oxford.

Maxwell, N. (1985), 'Are Probabilism and Special Relativity Incompatible?', *Philosophy of Science*, **52**, 23-43.

Putnam, H. (1967), 'Time and Physical Geometry', *Journal of Philosophy*, **64**, 240-47, reprinted in *Philosophical Papers, Vol. 1*, Cambridge University Press: Cambridge, 1975.

---

[16] See my (1996) for illustrations of the difficulties, and the reasons why they do not arise in the Galilean-covariant case. For the difficulty in generalizing the pilot-wave theory to the relativisic case, see my (1999); the latter are less directly linked to the foliation-arbitrariness, however.

Rietdijk, C. (1966), 'A Rigorous Proof of Determinism Derived from the Special Theory of Relativity', *Philosophy of Science*, **33**, 341-4.

Sarkar, S., and J. Stachel (1999), 'Did Malament Prove the Non-Conventionality of Simultaneity in the Special Theory of Relativity?', *Philosophy of Science,* **66**, 208 -20.

Saunders, S. (1996), 'Time, Quantum Mechanics, and Tense', *Synthese*, **107**, 19-53.

Saunders, S. (1999), 'The "Beables" of Relativistic Pilot-Wave Theory', in *From Physics to Philosophy*, J. Butterfield, and C. Pagonis, eds., Cambridge University Press: Cambridge.

Saunders, S. (1998), 'Tense and Indeterminateness', *Philosophy of Science (Proceedings)*, **67**, S600-611.

Savitt, S. (1994), 'The Replacement of Time', *Australasian Journal of Philosophy,* **72**, 463-74.

Savitt, S. (2000), 'There's No Time Like the Present (in Minkowski Spacetime)', *Philosophy of Science (Proceedings)*, **67**, S563-74.

Shimony, A. (1993), 'The Transient Now', in *Search for a Naturalistic World View*, Vol.2, Cambridge University Press: Cambridge.

Sklar, L. (1981), 'Time, Reality, and Relativity', in *Reduction, Time and Reality*, R. Healey, ed., Cambridge University Press: Cambridge.

Smith, Q. (1993), 'Introduction', in *The New Theory of Time*, J. Oaklander and Q. Smith, (eds.), Yale University Press: Newhaven.

Stein, H. (1968), 'On Einstein-Minkowski Space-Time', *Journal of Philosophy*, **65**, 5-23.

Stein, H. (1991), 'On Relativity Theory and the Openness of the Future', *Philosophy of Science*, **58**, 147-67

Stein, H. (1994), 'Commentary', in *The Collected Papers of Kurt Godel*, Vol.3., S. Fefferman, J. Dawson, W. Goldfarb, C. Parsons, and R. Solovay, eds., Oxford University Press: Oxford.

Torretti, R. (1983), *Relativity and Geometry*, Pergamon Press: Oxford.

Wald, R. (1984), *General Relativity*, Chicago University Press: Chicago.