Presentism and the Space-Time Manifold[*]

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I. Introduction: Presentism Among the A-Theories

The A-Theory of Time and the B-Theory of Time

McTaggart gave the name "A-series" to "that series of positions which runs from the far past through the near past to the present, and then from the present through the near future to the far future, or conversely"; and the name "B-series" to "[t]he series of positions which runs from earlier to later, or conversely".[1] McTaggart's rather bland labels have stuck, and been put to further use. The "determinations" (his word), or properties, *being past*, *being present*, and *being future* are generally called the "A-properties". The relations of *being earlier than*, *being later than*, and *being simultaneous with*, are the "B-relations". These days, philosophers are said to hold an "A-theory of time" or a "B-theory of time", depending upon their attitudes to these properties and relations.

Some philosophers suppose that there are objective distinctions between what is present and what is past and what is future. In order to tell the full truth about time, they think, one must advert to the A-properties. Naturally enough, such philosophers are called "A-theorists". Although A-theorists disagree about many details, they agree that the present is distinguished from past and future in a deep and important way. Exactly how to describe this difference is a vexed question, and some philosophers have argued that would-be A-theorists inevitably fail to stake out a coherent position.[2] I shall not attempt a full-scale defense of the coherence of the A-

theory here; but hopefully the following characterization will suffice to convey, in a rough-and-ready way, the nature of the A-theorists' convictions about time: The A-theorist grants that every thing in time (setting aside the possibility of a beginning or end of time itself) is "past relative to" some things, "future relative to" others, and "present relative to" itself — just as every place on earth (setting aside the poles) is south relative to some places, north relative to others, and at the same latitude as itself. But the A-theorist insists that this attractive analogy between spatial and temporal dimensions is misleading; for, of any time or event that is past, present, or future in this merely relative way, one can also ask whether it is, in addition, past, present, or future in a *non*-relative way — past, present, or future *simpliciter*. The A-theorist takes the merely relative A-determinations to be based upon facts concerning which times and events are *really* past, present, or future, not merely relatively so. "B-theorists", by contrast, deny the objectivity of the division of time into past, present, and future; they regard the spatial north-south analogy as deeply revelatory of the purely relative nature of this division (though many B-theorists admit that there is some intrinsic difference between spatial and temporal distances). To arrive at more objective facts about time, one must turn to relations like *being earlier than*, *being later than*, and *being simultaneous with* — the "B-relations".[3]

The A-theory is almost certainly a minority view among contemporary philosophers with an opinion about the metaphysics of time.[4] Nevertheless, it has many defenders — Ian Hinckfuss, J. R. Lucas, E. J. Lowe, John Bigelow, Trenton Merricks, Ned Markosian, Thomas Crisp, Quentin Smith, Craig Bourne, Bradley Monton, Ross Cameron, William Lane Craig, Storrs McCall, Peter Ludlow, George Schlesinger, Robert M. Adams, Peter Forrest, and Nicholas Maxwell, to name a few.[5] Several of the most eminent 20th century philosophers were A-theorists, notably C. D. Broad, Arthur Prior, Peter Geach, and Roderick Chisholm.[6]

The B-theory can claim support from two of the founders of the analytic movement in philosophy: Gottlob Frege and Bertrand Russell.[7] In the years since, it has achieved broad acceptance. D. C. Williams, W. V. O. Quine, Adolf Grünbaum, J. J. C. Smart, David Lewis, D. H. Mellor, Paul Horwich, Tim Maudlin, Frank Arntzenius, Theodore Sider, Robin Le Poidevin, Nathan Oaklander, Steven Savitt, and Thomas Sattig are just the tip of the B-theorist iceberg.[8]

B-theorists have raised many kinds of objections to the A-theory and to the particular kind of A-theory I find most attractive, namely, *presentism*.[9] What follows is a defense of presentism in the face of just one of these: that the view has been refuted or at least badly undermined by discoveries in physics. The rejection of Newton's substantival space by the natural philosophers and physicists of the nineteenth century had already created an environment somewhat hostile to presentism, as shall emerge in my discussion of one of Theodore Sider's objections to presentism (the objection described near the end of Section III, based on cross-temporal relations involving motion). Einstein's Special Theory of Relativity (SR) and General Theory of Relativity (GR) seem only to have made things worse. Both imply the "relativity of simultaneity"; and this raises obvious questions for all A-theorists. If, as A-theorists believe, there is an objective fact about what is presently happening, there must be an objective fact about which events are simultaneous with one another — in other words, a fact about simultaneity that is not relative to anything, including the frames of reference of SR, or the local frames of GR. But, on the face of it, these scientific theories require that simultaneity be frame-relative.

Before launching into description of the variety of A-theories, and defense of the kind I prefer, I should mention some things that will not be discussed in this essay. The first is a philosophical debate that is sometimes conflated with the A-theory-B-theory dispute: namely, the question whether time has an intrinsic direction to it; that is, whether the relation *being*

earlier than holds between moments or space-time locations independently of the contents of space-time. No one, to my knowledge, has defended the following combination of views: time lacks an intrinsic direction but includes objective distinctions between past, present, and future. The idea is not completely incoherent: one might attempt to reconstruct the difference between distance-into-the-past and distance-into-the-future on the basis of facts about what is present and "direction-neutral" temporal distance facts.[10] But the project will probably seem quixotic to most A-theorists (I know it does to me!). B-theorists, however, are sharply divided on the question whether time has an intrinsic direction. Two temporal directions are distinguishable from the spatial ones in the space-time of SR and in manifolds compatible with GR — at least, in the less bizarrely shaped ones. But some philosophers of physics deny that one direction is more deserving of the label "forward in time", when considered all by itself, in abstraction from space-time's material contents. These deniers of intrinsic direction claim that the actual difference between forward and backward in time does not supervene upon facts about intrinsic structure alone, but only upon such facts *plus* contingent facts about the contents of space-time, such as the distribution of matter. Both A-theorists and the friends of intrinsic temporal direction are often said to believe that "time flows", or to believe in "objective passage"; and their opponents may be said to champion a more "static" conception of time. But the two controversies are obviously quite different. Only the bona fide A-theory–B-theory debate shall figure in this chapter; for an up-to-date discussion of the question whether time has an intrinsic direction, see Huw Price, "The Flow of Time", in this volume.[11]

Many other important issues will be set aside, including the allegation that A-theorists and B-theorists are simply talking past one another. Some philosophers claim not to be able even to understand the A-theory–B-theory debate; and they cannily manage to extend this

inability so that it includes all the terms that might be used to explain it to them.[12] Fortunately, a number of effective therapies have been developed for those who find themselves losing their grip on the nature of the disagreement between A-theorists and B-theorists, or between presentists and non-presentists. The best treatment for the condition is something I discuss elsewhere.[13]

Other issues to be set aside include the majority of the objections that have been raised against the A-theory in general and presentism in particular. Chief amongst these is the argument that truths about the past need "truthmakers" (where a truthmaker for a proposition is some part of the world in virtue of which the proposition is true), and that the presentist lacks the resources to provide them.[14] In the face of this challenge, some presentists cast about for present states of the world that will ground truths about the past[15]; while others question the legitimacy of the demand for truthmakers.[16] I shall take it for granted that presentists can appeal, unproblematically, to facts about what was the case at each instant in the past — at least, that purely *qualitative* facts about each past moment are well-grounded. Even granting so much as that, presentism's critics can raise serious objections based on what physics seems to say about the nature of space-time.

The two problems upon which I focus are these: (1) Determinate facts about the state of the universe at each instant may fail to provide an adequate basis for certain cross-temporal facts that are physically important and objective. Theodore Sider has challenged the presentist to find a basis in reality for these physical facts; and I offer a couple of ways in which a presentist could meet the challenge. (2) The very idea of well-defined instants seems to be inconsistent with SR and GR, but crucial to any version of the A-theory, presentist or not. The most common

objection along these lines, made by Putnam, Sider, and others, is that presentism is inconsistent with SR; and therefore false.

The chapter is a long one; so a little guidance may be helpful. I spend the remainder of this first section describing the kind of presentism I prefer, and contrasting it with other A-theories. It turns out that there is considerable pressure on presentists to accept the existence of certain things that, intuitively, are "in the past". (A plausible response to the pressure, introduced in section I, will prove relevant to the question of section III: what theory of the manifold should presentists adopt in the face of Theodore Sider's worries about cross-temporal states of motion?) Section II introduces SR and GR as theories about the structure of a four-dimensional manifold; I claim it is "safe" to assume substantivalism, and I focus on the Minkowskian manifold structure of SR. In section III, I argue that a presentist who accepted SR should have to suppose that the present slices the Minkowskian manifold in a certain way; and that its past and future locations would constitute a foliation of the manifold. I offer presentists two ways of thinking about the metaphysics of this ostensibly four-dimensional entity, including one that manages to reject "past" (i.e., formerly occupied) and "future" (i.e., soon to be occupied) space-time points. I show that the presentist who takes my approach to the manifold can deal with the kinds of fundamental cross-temporal relations needed by post-Newtonian theories of motion and gravitation. In section IV, I argue that the conflict with SR is not as deep as has been suggested. In particular, the oft-heard charge of "inconsistency" is not so straightforward as it is made to seem. Whatever disharmony remains between the A-theory and SR is of dubious significance. SR is of interest mainly as an approximation to GR, and it is even less clear whether presentism is inconsistent with GR. Furthermore, quantum theory may well call for radical changes in our conception of space-time; and some of the proposed changes

promise to reinstate a way of slicing the manifold that would *have to* coincide with the A-theorist's division of the manifold into a series of successive presents. It is unclear whether these versions of quantum theory will win out over competitors that leave space-time looking more as Relativity sees it. But SR is false, and GR faces challenges from an even more impressively confirmed physical theory. These facts can hardly be irrelevant to the significance of arguments that assume their truth.

Principal Varieties of A-Theory: Presentism and the Growing Block

A-theorists disagree among themselves about the exact nature of the distinction between past and present things and events, and also about the distinction between present and future things and events. Presentism is an extreme form of the A-theory, but perhaps also its most popular variant. Analogous to a doctrine in the metaphysics of modality called "actualism", presentism is the view that all of reality (with the possible exception of utterly atemporal things, if such there be) is confined to the present — that past and future things simply do not exist, and that all statements that seem to carry an existential commitment to past or future things are either false or susceptible of paraphrase into statements that avoid the implication.

Some other A-theorists, though not presentists themselves, are like the presentists in distinguishing themselves from B-theorists by the restrictions they place upon what exists. "growing block" theorists, such as C. D. Broad, regard future events and things as non-existent, and present things as special in virtue of being the latest parts to have been added to a four-dimensional reality. According to the "growing blocker", to become past is to cease to be on the "cutting edge" of a growing four-dimensional manifold of events. For Broad, ceasing to be present, and becoming past, involves no intrinsic change whatsoever: "Nothing has happened to

the present by becoming past except that fresh slices of existence have been added to the total history of the world."[17]

Contemporary growing blockers, unlike Broad, tend to insist that events and things that become past do more than merely "recede" into the block. The reason they disagree with Broad can be brought out using a famous argument of Arthur Prior's. Prior (a presentist, himself) claimed that, if our past headaches were as painful as present ones, their merely becoming past would hardly be a matter for celebration.[18] Prior was wrong to think that this observation constitutes a knock-down argument for the A-theory.[19] Still, Prior's worry about the status of past thoughts can be turned into a cogent critique of Broad's version of the growing block theory, along the following lines.

A-theorists are trying to develop a metaphysical theory of time that validates a conviction shared by most people in most times and places: namely, that the change from being present to being past is a deep and important one. It would be strange to believe this, while professing utter ignorance about which things have undergone the supposedly radical change. According to Broad, however, any particular judgment I make about which events actually *are* present will be correct only briefly (for brief events, at any rate), and then forever wrong as the event of my judging them to be present recedes into the past, intrinsically unchanged. Equating the present with the edge of Broad's growing block is costly: it leads to absolute skepticism about what time it is![20]

Trenton Merricks points out that Broad could, perhaps, dodge this skeptical bullet by distinguishing between two notions of "being present": an objective one and a subjective one. To say that some event is *subjectively* present is just to say that it is simultaneous with one's location (at the time one makes the judgment) within the four-dimensional growing block; while

to speak of the *objective* present is to speak of what is on the block's "cutting edge". "Being past" and "being future" would admit similar disambiguation into subjective meanings ("being earlier than one's location" and "being later than one's location") and objective, more "metaphysical" meanings ("being embedded within the block" and "not existing at all…yet!"). According to this modification of Broad's growing block theory, in ordinary thought and speech we use "A-determinations" subjectively, so that we remain forever by-and-large right about what time it is; however, when discussing the metaphysics of time, the same words are to be given the growing blocker's metaphysical interpretation. But Merricks has a challenge for a growing blocker who would make such a distinction: If all our ordinary judgments about past, present, and future are *subjective* ones, what has the growth of the block to do with *time*? The growing blocker's "objective present", "objective past", and "objective future" have become technical terms within an unmotivated metaphysical theory.[21]

The canny growing blocker should part company from Broad, insisting instead that events and objects change radically when they cease to be present. An event is only *really happening* when it is on the cutting edge. Although the growing blocker admits that events continue to *exist* when they are past, she can maintain that they are only *doing something* (e.g., they are only in the process of bringing about other events) when they are present. Something similar should be said of the objects to which events happen; Bucephalus (Alexander the Great's horse) is only stamping his hooves, reflecting light, and rearing on his hind legs when he is *presently* doing these things. On the proposed version of the growing block view, past events and objects more closely resemble *merely possible* ones than presently occurring ones.[22]

Elsewhere in this volume, Barry Dainton calls this sort of metaphysics of time "Growing Block + Glowing Edge", or "Grow-Glow" for short. I prefer to call it a "ghostly growing block"

metaphysics. Were I to defend this sort of theory, I should prefer to say that objects and events on the edge are not "aglow" with a strange light; rather, they are *normal*, simply existing or occurring in the fashion to which we are accustomed. It is the objects and events entirely in the past that are strange — that is, strangely intangible.

The ghostly growing blocker can do justice to the feeling that an important change has taken place when an event or object has become past, and she can plausibly explain how we know what time is present. Suppose that Newton once observed a shadow on a sundial and made the following judgment: "At present, it is exactly 3pm". Within a ghostly growing block, Newton, the sundial, and the events of observation and judgment have all undergone radical changes since that judgment was made. Newton has no shape or size or location; no brain with which to think or eyes to see. Since neither Newton nor any of his temporal parts (if such there be) can see or think, the events that are the observation and thought, whatever they are now like, can hardly be said still to be *occurring*. And if Newton has neither brain nor eyes, he can hardly be convicted of making an ongoing mistake about what time it is. The ghostliness strategy can be extended to all the interesting properties of events and objects; to be *truly* loud, tall, hungry, etc. is to be *presently* loud, tall, hungry, etc.

Although this view makes sense of our relief when pain is past, and of our knowledge of what time is present, it has less appealing consequences as well. Consider first the objects that linger on, after having undergone processes that would ordinarily be said to have destroyed them utterly. The ghostly growing blocker must say that a horse can exist although it is not actually alive or even spatially located; a hand-grenade can exist, though it has been blown to bits. Indeed, every particle in an object could have been converted into energy within the sun, and the object (and the particles, for that matter) would still exist — though it would then lack all spatial

location, and be in some sense "outside of space". A physical object that ceases to have any shape or size or location at all is extremely "thin", insubstantial. Recoiling from this result is what drives many of us toward presentism. Consider, secondly, the events that must be supposed to exist after they have ceased to occur, such as a game of horseshoes or an explosion. Now, on one conception of events, their continued existence would not be too surprising. Some "event-talk" seems naturally to be construed as reference to something like Chisholm's "states of affairs", events of a kind that can *exist* though they do not occur — and, in fact, may *never* occur.[23] My playing a game of horseshoes with Bob Dylan is one of the things I hope will happen, but which probably will not occur. If the subject term of the previous sentence — "My playing a game of horseshoes…" — refers to anything, it refers to a kind of thing that may or may not occur; and that, even if it does occur, could have existed without occurring. Names for events that are constructed by nominalizing sentences (e.g., "my playing a game of horseshoes with Dylan", "The exploding of the hand grenade") seem more susceptible to this construal than names for events that do not have a "verb alive and kicking" inside them (e.g., "the game of horseshoes between me and Dylan", "the explosion of the hand-grenade").[24] Most of our talk about events does not go by way of nominalizing sentences, and is harder to construe as referring to things that could exist without occurring. The game of horseshoes I played with my uncle, the explosion of the hand-grenade in the Knesset in 1957… it is harder to imagine that these would have existed whether or not we had thrown any horseshoes, and whether or not the grenade had malfunctioned.[25] If there are such things as events or states that could not exist without occurring — particular games, explosions, headaches, and kickoffs that would not have existed if no horseshoes were thrown, nothing ever exploded, no one felt pain, and nothing was kicked —

then the presentist is likely to doubt whether such things can continue to exist after they have ceased to occur; but the ghostly growing blocker must suppose that they never go away.[26]

Similar morals apply to a third, less popular style of A-theory, sometimes called the "moving spotlight" view. According to moving spotlighters, reality has always consisted of everything that will ever have existed — in other words, spotlighters resemble B-theorists in their acceptance of "eternalism" about what there is; existence claims are eternally true if they are ever true. Here is a bad version of the spotlight theory, susceptible to the same objections that were lodged against Broad's growing block[27]: All events and objects are spread out in a great four-dimensional block, and the *only* changes that happen to them are changes in their A-properties as they go from being far future to near future, near future to present, present to near past, near past to distant past, etc. Unless some other changes accompany the change from being future to being present, and from being present to being past, there could be no way for us to know what time it is. Nothing in our brains or minds could possibly be sensitive to facts about what is present, if the "presentness" of events behaves like a mere spotlight (one might as well say "shadow"), passing over the block without affecting the things it strikes. The natural way out for the spotlighter is to utilize the ghostliness strategy I urged upon growing blockers: deny that merely future and merely past events are really happening; and strip merely future and merely past individuals of all their interesting, manifest properties.

As it happens, few A-theorists are spotlighters; most of us want to say that the future is "open" in a way an eternalist must deny.[28] So I shall ignore the view, and concentrate on presentism and (the ghostly version of) the growing block.

Pressures to Accept Some Past Things

Growing blockers may be saddled with an implausibly ghostly afterlife for everything that ever exists. But presentism's utterly empty past creates problems of its own — for there are many cross-temporal relations for which the presentist seems to lack adequate grounds, and even simple cross-temporal truisms like "England had three kings named 'Charles'" prove difficult for presentists to interpret.[29] Solving these problems may well push the presentist at least some distance toward acceptance of a ghostly growing block. In this section, I describe a couple of stock puzzles about cross-temporal relations, in order to show how the pressures arise.

The A-theory, in every version, carries with it a commitment to *tense logic*. The fundamental truth-bearers (for which I shall use the term "proposition" as a place-holder, leaving their nature up-for-grabs) must be susceptible of change in truth-value. Objective facts about what is present, past, and future require propositions that are flat-out *true* (not merely true relative to one time, but false relative to others) but that will not always be true and that have not always been true.

Typically, the presentist's fundamental machinery for talking about the past and future truth of these temporally variable propositions consists in what Theodore Sider has called "slice-operators": tense operators that (when attached to simple present tense sentences) take us from a sentence expressing a proposition about the present to a sentence expressing a proposition about an *instantaneous* location in the past or future. The simple tense operators "*F*" and "*P*" in Arthur Prior's systems of tense logic are slice-operators.[30] "*Fp*" and "*Pp*" could be given the informal glosses: "It will be true, at some future instant of time, that *p*" and "It was true, at some past instant of time, that *p*". Tenses, construed as sentential operators, allow presentists to make distinctions of scope when tense operators and quantifiers interact. A past tense operator can, for instance, take wide scope or narrow scope in a sentence containing quantification over past

things. The distinction can be detected in the pair: "It was true, at some past instant, that some dinosaurs roam the earth" (in which tense has wide scope), and "There are things that used to be dinosaurs roaming the earth" (in which tense has narrow scope). The presentist supposes that these sentences express distinct propositions; that each is a plausible candidate for the meaning of "Dinosaurs roamed the earth"; and that the latter does not follow from the former. The presentist can accept the wide scope interpretation of "Dinosaurs roamed the earth"; she need harbor no skepticism about whether there were dinosaurs; but her presentist scruples direct her to reject the narrow scope interpretation.

Slice operators of this sort "require talk of the past and future to proceed 'one time at a time'".[31] Alternative operators that allow a false proposition to *have been true* in virtue of what went on over a span of time — "span operators", as they're called — are problematic in various ways, at least for presentists.[32] But slice operators make it difficult for the presentist to find adequate grounding for various kinds of cross-temporal relations; and even some simple past-tense claims become hard to translate into a formal slice-operator language.[33] If my great-grandfather and I never co-exist, at no time do I stand in the relation of great-grandson to him. Of course I *am* his great-grandson, and he *was* my great-grandfather; but what does this assertion amount to, if there is no instant at which we are related? Perhaps this assertion is not really as relational as it sounds; or perhaps it is true in virtue of a relation between me and some kind of surrogate for my no-longer-existing grandfather.[34] The growing blocker avoids the problem by affirming the ongoing — albeit ghostly — existence of my grandfather.

The ghostly growing blockers are committed to the automatic, ongoing existence of *everything* that comes into existence; according to their metaphysics, going out of existence is an impossibility. Although we would-be presentists shy away from ghostly past things, the puzzles

about crosstemporal relations may nevertheless force us to posit the ongoing existence of certain entities that would normally be said to be "in the past". For example, continuous causal processes seem to require fundamental relationships between events or states of affairs that occur at non-overlapping instants or intervals. If some such causal relationships really are fundamental, and really are relations, then they had better hold — at some time or other — between some pairs of entities. One response to the challenge is to construe the causally related events as something like Chisholm's states of affairs. By consigning causal relata to a category of entity that can be expected to exist even if they never occur, the puzzle about crosstemporal causal relations begins to look more tractable.[35]

Of course, if one must keep doing this sort of thing for all manner of entities, including ones that violate our deepest presentist instincts, one should begin to wonder whether the ghostly growing block theory of time is not, after all, the best version of the A-theory. I am hopeful that we A-theorists will not be forced to accept the continued existence of too many of the things we ordinarily say have "ceased to be". To this category, I would consign all spatially located particulars that seem hard to imagine existing while no longer being located anywhere. Events may also belong in this category — but only if events are *not* taken to be Chisholmian, proposition-like states of affairs. Many metaphysicians think that — instead of, or in addition to, states of affairs that can *exist* without *occurring* — there are "concrete" events that must occur in order to exist. Such event-like entities have been called "particularized qualities", "particular characters", "abstract particulars", and "tropes"[36]; they belong in the same category as what Aristotle called "individual accidents", and seem similar to what the early moderns called "modes".[37] In our ordinary "event talk" we seem to shift back and forth between these two conceptions.

For present purposes, I shall assume that, in addition to states of affairs that may or may not obtain, there are also events of this more "concrete" sort. The stingy metaphysician in me would like to avoid commitment to both kinds of event. If I accept all of the more abstract states of affairs, so I can have the right kind to serve as causal relata, do I really need the more concrete events as well? Is there anything left for them to do? For now, I shall allow for the existence of both states of affairs and more concrete, trope-like events. Throughout this essay, when I speak of past events ceasing to be, I have in mind events construed in this second, concrete fashion; the existence of the more abstract states of affairs, after they have ceased to occur, strikes me as relatively unproblematic.

Presentists face further pressures to accept a plethora of states and events, besides the need for co-existing causal relata. All manner of states and events may be needed in order to respond to (what Zoltan Szabo calls) "semantic arguments" against presentism: arguments to the effect that a certain inference pattern must be respected in any plausible semantics of, say, English; and that such a semantics validates inferring "There are *F*s" from some obviously true claim, though the presentist says "There are no Fs". David Lewis, for example, argues that the presentist cannot make sense of simple assertions like "England has had two kings named 'Charles'". It is difficult to state tense-logical truth-conditions for the sentence that do not imply the truth, at some past time, of the proposition that there are two men named 'Charles' who are or were or will be kings of England" — which need not have been true, in order for the original sentence to be true. But, as Szabo points out, similar problems arise for sentences like "The election could have had three different outcomes" (where the outcomes are incompatible), and "Three ghosts are supposed to inhabit the woods" (where the ghosts are entirely imaginary). A Davidsonian "event" or "state" semantics is suggested by these examples and by a wide variety

of linguistic data. Many philosophers and linguists accept such a semantics for reasons other than its usefulness with possible events and imaginary entities; but, once it is taken on board, it further earns its keep by helping to make sense of statements about the elections and the ghosts, without requiring commitment to the possibility of an election that has an impossible outcome or the existence imaginary ghosts. The first example becomes something like "There are three different states of the-election's-possibly-having-an-outcome"; the second, "There are three states of the-wood's-being-supposed-to-have-a-ghost".

Szabo argues that the postulation of non-obvious quantification over events or states is independently motivated, and provides the presentist with natural materials for dealing with Lewis's example (by means of "There are two states of England's having had a king named 'Charles'") and many others. Of course, there is an ontological cost for the presentist who makes this move: the continued existence of the two states in question, long after the kings have ceased to exist. The automatic and ongoing existence of such "resultant states" generates commitment to a host of entities: for every past state or event, there is the current state of its having occurred. Szabo argues that the commitment to resultant states is in harmony with other things presentists often say, and not so costly:

> They can be seen as shadows of the past, and as such, they are the sort of things presentists like to appeal to when they seek truth-makers for past tense sentences. But I am not pulling them out of a hat — I claim that a good semantic account of simple natural language sentences quantifies over them.[38]

Suppose the presentist accepts Szabo's offer: every event and state that ever occurs to an entity of any sort leaves behind, as a kind of shadow or echo, a forevermore existing state that does not depend upon the ongoing existence of the entity to which the original event or state occurred. These resultant states would comprise a ghostly image of the past, rather like the ghostly growing blocker's faded objects and events, but with most of the original objects removed.

The presentist may, then, be forced, by various problems about cross-temporal relations, to recognize certain kinds of more-or-less abstract entities — states that exist without occurring, resultant states that automatically appear and cannot go away. A growing blocker *might* be able to tell a more plausible story than the presentist about the nature of resultant states. A B-theorist *might* be able to do without them altogether — if he can find an alternative to an event or state semantics for non-temporal examples (the election outcomes, the witches) and other data that seem to require a generous attitude toward such states. But, if a presentist is forced to accept them, she should not feel too badly about it. A ghostly manifold of resultant states can be independently motivated from within the philosophy of language, and is easier to believe in than a ghostly manifold of horses and hand-grenades.

A very different response to problematic cross-temporal claims is to grant that, strictly speaking, the statements are false — though they come extremely close to being true. If the presentist can find plausible grounding for present truths describing, in general terms, the past history of the universe on the most fundamental level; then she can say that truths about particular non-existent things, and about the enumeration of such things, are at least "quasi-true" — i.e., true but for the falsity of a certain metaphysical thesis, namely, eternalism. And that is true enough for ordinary purposes.[39] Later, I consider an argument against presentism based on certain cross-temporal relations that play a crucial role in contemporary physics — a case in

which the presentist does not, I believe, have the luxury to allow that, strictly speaking, the relational claims are false-but-quasi-true. The argument may drive the presentist to accept a different kind of more-or-less abstract or ghostly thing: a four-dimensional manifold of empty points, representing places where events were once occurring or where matter was once located. In this context, too, I will explore the possibility that something like resultant states — "trajectories" that happen to a series of points — may provide us with a less objectionable surrogate for a block of past things.

II. The Relativistic Manifold: Its Ontological Status and Intrinsic Structure

Space-Time Substantivalism

Precise physical laws are expressible as mathematical relationships. All decent candidates for the laws of motion or electrodynamics or other fundamental physical phenomena occurring in space and time appeal to mathematically describable relationships holding among locations in space and time. At the end of the day, different metaphysicians want to say different things about the ontological status of "locations in space and time". But we must all somehow make sense of the idea that space-time locations stand in precise distance relations of various kinds, and so constitute a "manifold" — for a manifold is any set of things that are interrelated in such a way that their structure can be described geometrically. A *space-time* manifold is a set of minimal-sized locations in space and time, "points" at which something could happen or be located.

"Substantivalists" and "relationalists" disagree about just how seriously one ought to take the manifold and its points. Substantivalists advocate "admitting space-time into our ontology";

it is an extra part of "the furniture of the universe"— a sort of invisible jell-o filling up the otherwise empty spaces between objects (and suffusing their insides as well). Relationalists, on the other hand, hope to be able to treat the web of spatiotemporal relations attributed to the manifold as a sort of imaginary scaffolding; the fundamental spatiotemporal relations hold among the kinds of things we say "fill" locations or "happen at" them — particles, fields, and events, for instance.

I have encountered quite a few philosophers who have no patience for speculation about the metaphysics of worlds that are not governed by the *actual* laws governing physical things in *our* world — whatever those laws might turn out to be. I can think of only a couple of philosophical positions that justify the rejection of all such speculation. Some may be deeply skeptical about our ability to answer metaphysical questions concerning worlds with different laws: we should not pretend to have *any* insight into the realm of the merely possible, because metaphysical possibility and necessity are meaningless or beyond our grasp. Since fewer philosophers nowadays are quite so skeptical about our ability to understand questions about necessity and possibility, I sometimes suspect that impatience with speculation about contra-legal worlds is based upon a tacit metaphysical commitment to the *necessity* of whatever the actual laws turn out to be — a respectable metaphysical position defended by Sydney Shoemaker, among others.[40] But false physical theories about our world, when they do not contain hidden inconsistencies, certainly do not *seem* impossible; so, in the absence of argument to the contrary, I take them to be descriptions of possible space-time worlds. Some of these descriptions seem to require a space-time manifold with built-in structure of its own, and others do not.[41] By my lights, then, the debate between space-time subtantivalists and relationalists should be seen as an argument over whether or not the physics of *our* world requires taking the

manifold seriously as a cosmic jell-o. Its existence is a contingent and, broadly speaking, empirical matter.

Since the modern era, four kinds of space-time have proven most appealing to scientists: (1) Newton's space-time consists of a persisting, infinite, three-dimensional Euclidean space together with the series of times at which it exists. These days, Newtonian space-time is often described, somewhat anachronistically, as a four-dimensional manifold of points. A Newtonian four-dimensional manifold is a series of distinct, infinite, Euclidean, three-dimensional spaces; each is instantaneous in temporal length, and spread out continuously in a fourth, temporal, dimension. An objective relation of same-place-at-a-different-time holds between the points of different three-dimensional spaces. (2) Galilean space-time is just like Newton's at each moment, but does not include a non-relative same-place-at-a-different-time relation, though it does admit of another kind of fundamental cross-temporal relation, namely, straight lines representing possible inertial paths through space-time. (3) The space-time posited by SR is a manifold exemplifying a less intuitive geometrical structure, to be described below. It is often called "Minkowski space-time", since Minkowski is responsible for formulating Einstein's theory in terms of the geometrical structure of a four-dimensional manifold of points. (4) The various four-dimensional manifolds consistent with GR approximate the structure of Minkowski space-time in arbitrarily small regions around each point, but can have variable curvature on a larger scale. The different kinds of space-time manifold follow from or fit together with different physical theories, which require different fundamental measurable distance relations among the parts of the manifold. And there are ongoing arguments among metaphysically-minded philosophers of physics about which of these theories, if any, requires our taking a substantivalist attitude toward the space-time manifold it describes.

The substantivalist-relationalist debates are made possible by the fact that, on the spectrum between observable and theoretical entities, a space-time manifold is far to the theoretical side. A substantival space-time manifold, and the points of which it consists, are things that *seem* to be required by various physical theories; but there is room for doubt about whether this requirement is real — in other words, relationalism does not fly in the face of experience, at least not directly. Like quarks or "dark matter", if we come to believe in the existence of a space-time manifold at all, it will be because physics needs it; and we should therefore let our best physics tell us what it is like. SR is, at best, only approximately true; for a long time now, GR has looked like our best theory of the structure of space-time. Gradually, the difficulties in squaring GR with quantum theory have become clear to more and more people working on foundational physics; it is no longer obvious what space-time will look like, in tomorrow's theory of quantum gravity. In this paper, I will eventually try to evaluate the following very popular style of argument against presentism: Presentism (and other versions of the A-theory) are metaphysical theories that conflict with Relativity; but Relativity is our best physical theory of space-time (or so it has been assumed); since our best physical theories are better grounded than any metaphysical theory could possibly be, presentism should be rejected. Since critics ought to grant that SR is false, "Relativity" in such arguments had better mean GR. The basic question, then, is whether GR is in conflict with presentism. However, SR is a simpler theory, and more familiar to non-specialists. The manifold it describes can seem like a "special case" of GR (its metric looks like that of an infinitely large, flat, empty GR space-time), and the theories posit similar *local* space-time structure. Furthermore, similar larger-scale features generate an apparent conflict between each version of Relativity, on the one hand, and presentism, on the other. Understandably, many B-theorist critics have made use of SR in their

arguments against presentism; I will often follow their lead, while keeping in mind that the most important question is how the arguments play in the context of GR. (When I say, in what follows, that "Relativity implies such-and-such", I mean that both theories have this implication.)

In my responses to arguments against presentism, I shall assume substantivalism about the manifold. Here, briefly, is my justification for regarding this as a safe assumption. The serious question on the table is not whether presentism conflicts with SR, but rather whether it conflicts with GR.[42] The fact that GR is probably not the final word on space-time structure will become relevant later. For now, however, I shall be asking what the presentist should say were it to turn out that GR is the best theory of the space-time manifold; and, for much of the time, the issues raised by SR will be similar enough so that Minkowski space-time can go proxy for whatever relativistic manifold we might be thought actually to inhabit. Although relationalism within SR may not be hopeless, attempts to understand GR in a relationalist fashion wind up positing something that, for present purposes, is enough like substantival space-time as to make no difference.

GR puts constraints upon the structure space-time could display, but it is consistent with an infinite variety of differently shaped manifolds. The space-time manifolds of GR can be finite or infinite in size; and their metrical properties generally vary from place to place. By contrast, the space-times posited by Newton and Minkowski are infinitely-extendable, and everywhere-the-same — features that make it easier to use certain relationalist tricks to avoid serious commitment to the manifolds the theories seem to describe.[43] Some philosophers have special reasons to want such tricks to work: Leibniz has his principle of sufficient reason, which would be violated by God's choosing to create in one part of these manifolds rather than another. Some philosophers subscribe to a kind of causal criterion of existence, according to which one should

not posit anything that cannot, at least in principle, be affected by something else; and the manifolds described by Newton and SR are unaffected by their contents. Other philosophers (plausibly, to my mind) argue that, although the space-time described by SR would not be changed by the presence of matter, and may not in any straightforward sense *cause* the motions of particles (at least, not in the way *forces* cause motion); nevertheless, a substantival manifold earns its keep by playing an important explanatory role in the theory: namely, that of defining the "default" states of motion, thereby allowing for a sharp distinction between dynamics and kinematics. These are deep waters.[44] But, however the debates about SR and substantivalism turn out, there are powerful reasons to think that GR (and, for that matter, Galilean space-time) requires substantivalism. In a broad survey of the substantivalism-relationalism dispute, Tim Maudlin concludes that, given GR, substantivalism — or something near enough to it — is inevitable, since "[t]he set of all spatiotemporal relations between occupied event locations cannot generally provide enough information to uniquely settle the geometry of the embedding spacetime."[45] The relationalist needs a "plenum" of entities — a field of some kind — upon which to hang GR's web of spatiotemporal relations; and the best candidate for this field is very hard to distinguish from the kind of entity substantivalists have always wanted.

It is true that more philosophers of physics are defending something they call "relationalism"; but the kinds of relationalism are, from my point of view, so close to substantivalism as to make no difference. Advocates of the "hole argument" for relationalism about GR's space-time do not, to my knowledge, question the need for a four-dimensional plenum to bear the properties of the metric field.[46] Julian Barbour's recent work, advocating "the disappearance of time" in the context of GR, may require some qualification of Maudlin's arguments. But the qualifications would not prove relevant to my purposes. Barbour articulates

a kind of eliminativism about relations between time-like slices of a manifold satisfying GR; but his theory is, and arguably needs to be, substantivalist about the space-time points of the slices themselves.[47]

It is relatively safe, then, to assume substantivalism about GR's manifold. And, since the space-time of SR is mainly of interest for its approximating the structure of GR, and raising the same problems for presentism in a simpler context, it will be safe to treat its manifold in a substantivalist fashion as well.

Relativistic Space-Time Structure

If Relativity is the best physical theory of the space-time manifold, presentists have some difficult questions to answer: How should we think about its intrinsic structure? Does only one slice of it exist? Does the relativity of simultaneity conflict with the presentist's need for objective facts about what is present? Before tackling these questions in the next two sections, I need to place the bare bones of the theory on the table. The aspects of Relativity that are supposed to raise the most trouble for the presentist can best be described by contrasting Minkowski space-time (and, ultimately, the manifolds of GR) with Newton's theory of space-time, and with Galilean theories of space-time.

Different theories about the nature of space-time say different things about the kind of structure the manifold contains — they describe its parts as interrelated in different ways. A crucial part of the manifold's structure is *metrical*. Metrical structure is what makes the manifold measurable; for present purposes, it can be thought of as the sum total of all the fundamental distance relations holding among the manifold's points. On the Newtonian conception, there are, at any given moment, facts about the spatial distance relations among the

points that comprise all of space at that time. There are also facts about the temporal distances between any two temporal locations in the manifold. But Newton posited a further kind of metrical structure: objective relations of spatial distance between points at different times. On his view, there is a single right answer to the question: What is the spatial distance between this point, at this time, and that point, at that other time? The answer might be one mile, or one inch, or 100,000 miles. But the answer might also be zero, in which case the two points represent *the very same location* at different times. (Newton understood absolute sameness of position in the four-dimensional manifold of space-time locations as due to the presence of a three-dimensional Euclidean object — absolute space — that persists through time. For two events to occur at "the same place at different times" is for them to occur in a bit of space that has persisted from one time to another. The Newtonian manifold of distinct possible event-locations is still, in a sense, four-dimensional. For it is one thing for an event to occur in a given region of space at one time, and quite another thing for the same sort of event to occur in that same region, say, five minutes later. So the two possible-event-locations must be regarded as separated in a fourth dimension, the temporal one.)

Newton's notion of absolute sameness of place over time can be contrasted with that of merely relative sameness of place. Suppose I forget my book on a train, and return to find it in the very same place I left it, relative to the parts of the train (it is still there on my seat). If the train has been traveling in the meantime, the book is in a different place relative to the surface of the earth (it was in New York but is now in New Jersey). In addition to all such merely relative relations of same-place-at-a-different-time, Newton's space-time includes a non-relative, objective relation of same-place-at-a-different-time, a relation built into the structure of space-time itself. The other theories about the metrical structure of space-time mentioned above — the

Galilean theory, SR, and GR — deny that the points of space-time stand in such relations. Galilean space-time rejects absolute sameness of place over time; so it rejects Newton's brand of space-time, in which an objective relation of same-place-at-a-different-time is underwritten by the persisting parts of a three-dimensional space. It does recognize absolute simultaneity, however; and, at each instant, there exists a set of possible places at which events could occur at that time, spread out in three spatial dimensions, constituting a Euclidean space. Although absolute sameness of place does not hold between points in different instantaneous spaces, there are cross-temporal relations built into Galilean space-time geometry: Some paths constitute straight lines in a time-like direction. Their straightness consists in the fact that they are the "natural" or "default" paths of particles through the manifold. The time-like straight lines represent possible *inertial states of motion*, motion explicable in purely kinematical terms. The physical significance of their straightness is most naturally described dispositionally: if an object occupies a portion of such a line, and there are no forces at work, it stays on the line.

The intrinsic metrical structure attributed to the manifold by SR and GR is radically different from that of Newtonian space-time, and quite different from that of Galilean space-time as well. The structure of the Newtonian manifold, as I described it, is based upon three fundamental types of relations among points: (i) spatial distance relations within each momentary three-dimensional space, (ii) temporal distance relations between the points in different spaces, and (iii) a "same-place-at-a-different-time" relation between points in different momentary spaces. SR (upon which I will mainly focus) bases the structure of space-time upon a very different relation of "space-time distance". As in Galilean space-time, in SR there are sets of points lying on straight lines in time-like directions; and their straightness represents the fact that they are the inertial paths of (subluminal) particles. Again, as in Galilean space-time,

Newton's same-place-at-a-different-time relation is eliminated, at least as a basic metrical feature; instead, only highly derivative, relative notions of same-place-at-a-different-time make sense. But SR goes further down the road of relativization than Galilean space-time. In SR, even separable spatial and temporal distances between points come to seem second-rate, because they, too, are merely relative. What are the truly intrinsic, not-merely-relative metrical features of space-time? Relations of space-time distance among points — or, better, path-dependent distance relations in terms of which distance between points can be defined. Space-time distances in SR come in three quite different flavors: Points can be separated by positive, negative, and null space-time distances. Without plunging into the mathematics of space-time distances, it is not easy to explain what these distance relations really amount to. They are measurable quantities closely tied to the explanations of motion that Relativity affords; and parts of their roles can be described dispositionally, in much the way I explained the role of straight time-like lines in Galilean space-time.

Here are some connections to motion that will hopefully shed a little light on the nature of the fundamental geometrical features in the manifold of SR. SR's relations of space-time distance give a sense to "straight lines" in the manifold — the shortest distance between two points. But what is SR saying about points when it says they lie along a straight line and stand in *positive* distance relations? These straight lines play the same basic function as the straight, time-like paths in Galilean space-time. Such a line is said to have a time-like direction; and it corresponds to the possible path of a particle that is moving at subluminal speeds and neither accelerating nor decelerating — an object in a state of inertial motion. What does it mean, in SR, to say that points within the manifold are at zero space-time distance from one another? Not that they are "the same place" or "the same point". It means that they correspond to points along a

path that light would take in a vacuum. What does it mean, in SR, to say that points are on a straight line and standing in *negative* space-time distance relations? In that case, the line is "space-like"; it corresponds to a straight line in a certain kind of three-dimensional region of the manifold — a region that, according to at least one inertial frame, has no depth in the time-like direction.

The straight lines of Minkowski space-time may usefully be compared with those of Galilean space-time by means of familiar space-time diagrams. Figure 1 depicts Galilean space-time around a point, *x*. The temporal dimension "goes up" (i.e., higher points represent the locations of later events), one spatial dimension is represented by the horizontal lines, another is depicted by imagining the parallelograms as flat squares passing through the paper, and a third spatial dimension is suppressed. Straight lines passing through *x* in a temporal direction represent space-time paths through *x* that could be taken by particles moving inertially — that is, undergoing no acceleration or deceleration. A particle that has occupied a series of points on one of these straight lines will be told to "stay on this line, in the future", unless forces come into play.

In a diagram of Galilean space-time, one must ignore that fact that some of these lines are perfectly vertical, and others slanted. The vertical ones do not represent "the same place again", and objects remaining on these lines are not objectively stationary, while objects occupying slanted lines are in absolute motion. In Newtonian space-time, there is such a thing as absolute sameness of place and absolute motion, but in Galilean space-time, all velocity is relative. Nevertheless, acceleration and deceleration — departures from inertial motion — are *not* merely relative in Galilean space-time. The straightness of temporally oriented lines does indicate

something objective about a space-time path — the fact that it is an inertial path — but the angle of such a line does not.

The straightness of lines in the two spatial dimensions of figure 1 is more straightforward: it is just the familiar straightness of spatial lines in a two-dimensional Euclidean plane. Since there is a suppressed third spatial dimension, each plane really represents a three-dimensional Euclidean space — a different, instantaneous, three-dimensional space for each instant in the temporal dimension. Crucially, at each point on a particle's space-time path, there is exactly one of these three-dimensional Euclidean spaces — the space of the entire universe, as it exists simultaneously with the event of the particle's occupying that point. The straight spatial lines through *x* that are depicted in the diagram constitute exactly one two-dimensional plane; and that plane stands in for exactly one three-dimensional space: the universe at the moment simultaneous with the event-location labeled *x*.

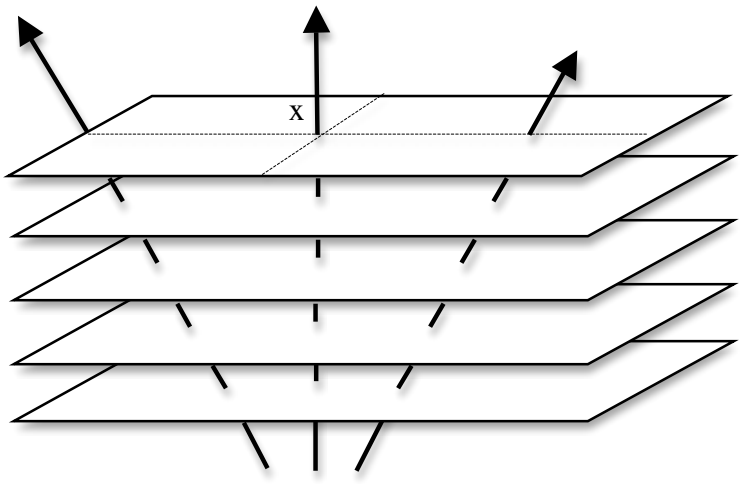

Figure 1: Galilean Space-Time

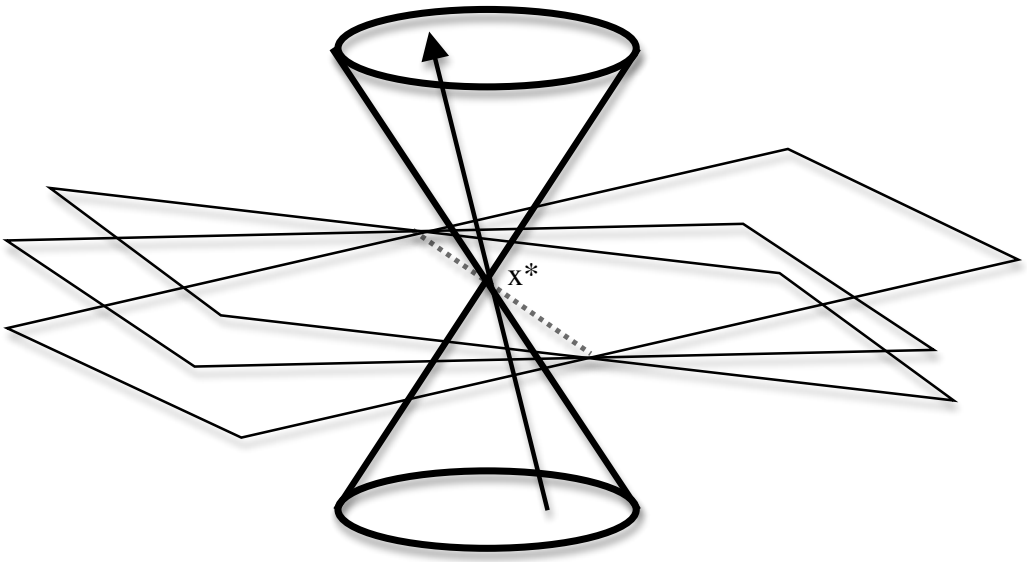

Figure 2: Minkowski Space-Time

Space-time diagrams of the Minkowskian manifold are similar in many ways. In figure 2, up-down represents time; left-right represents one space-like direction; a second spatial direction is suggested by the imagined "depth" of the cones; and a third spatial dimension is suppressed. The straight lines along the surfaces of the cones that meet at *x** represent an objective feature of the Minkowskian manifold's structure that has no counterpart in Galilean space-time. The points on a straight line passing through *x** and staying on the surfaces of the lower and upper cones are all said to be at zero- or null-distance from *x** — though this does not mean the points are at the same place in a way that would make sense in Newtonian space-time, say. The cones are called "light-cones" because a straight line on *x**'s lower (backward) cone represents a path along which a flash of light could have reached *x**; a straight line on *x**'s upper (forward) cone represents a path that could be taken by a flash originating or passing through *x**. Straight lines extending from *x** *within* its forward or backward light-cone contain points in positive distance relations from *x**; like the vertical lines in figure 1, they lie along a path in a time-like direction from *x**, and represent possible trajectories of objects moving inertially through *x**.

The relations of positive and null space-time distance represented by these two kinds of straight line give space-time the structure it needs to tell particles and photons "what to do next." Where will a photon go if it is located at a certain point (and in a vacuum)? The sets of points that are on light-like paths (points each of which is at zero space-time distance from the others) tell a photon that has been moving along one of them to "stay on this line, in future". Where will a particle go if it is located at a certain point and moving inertially? The points constituting straight lines with positive distance relations tell a particle that has been moving along one of

them, and that is not acted upon by any forces, to "stay on the same line, in future". One might sum up these relations by saying that a path of points at zero-distance from one another is connected by a relation of "light-like accessibility"; and that the straight lines with positive distances among their points are connected by a relation of "inertial accessibility".[48]

The third kind of straight line in Minkowski space-time extends from *x** into the "bow-tie-shaped" region outside the two light cones. (As I mentioned above, space-time distance relations holding between space-like separated points on a line are represented as negative numbers in typical formulations of SR.) Inspection of diagram 2 reveals, however, that straight lines at right angles can be inscribed through *x** in many different ways, determining many different two-dimensional planes passing through *x** — planes that cut across one another but share a line that includes *x**. In the full, four-dimensional manifold, these planes correspond to various three-dimensional regions, overlapping in two-dimensional planes that include *x**. In SR, the space-time distance relations in these regions give each of them the geometrical structure of a three-dimensional Euclidean space. But what are these different spaces like?

Each flat spatial plane extending from *x** represents a slice of the manifold with a special status; it is intimately related to exactly one of the inertial paths passing through *x**. So, whatever else these planes are like, they can at least be seen to have a relative kind of privileged status; inertial paths play a special role in the geometry of Minkowski space-time, and each combination of a point, and an inertial path through that point, determines just one of these planes. The respect in which a given plane is privileged, relative to a point and an inertial path, is often presented in these terms: It is the plane an observer at that point, on that inertial path, would choose as containing events simultaneous with her, if she accepted a certain operational definition of "distant simultaneity".

The proposed definition of "distant simultaneity" is often motivated by telling this sort of story: When you are trying to find out "what time it is elsewhere", you naturally use whatever signals are most reliably constant in speed. SR gives a special, objective role within its space-time structure to light (the null-paths are specially reserved for flashes of light in a vacuum); what could be more reliably constant than that? And so you might be led by this thought to adopt the "Poincaré-Einstein" or "Radar" method for determining a relation plausibly worthy of the name "distant simultaneity": You send a light signal, noting your local clock time; you ask the distant recipient to note her local arrival time, returning a light signal just as she sees yours; then you note the arrival time of her signal; divide your total time by half; and figure that, whatever was happening to you at the halfway point was simultaneous with the arrival of your flash at her location. Applying this method in all directions to discover "what is going on simultaneously with *x*" at every point in the universe would yield a different two-dimensional plane for different inertial paths through *x*. "Observers" in different states of motion "passing through" one another at *x* would slice the bow-tie region of space-time in different ways, if they rely upon the Radar method for determining distant simultaneity.

However "natural" it may be to use light signals and the Radar method, hoping thereby to discover facts about distant simultaneity, it is not obvious that this procedure will deliver a relation coinciding with the relation of simultaneity between occurrences that we appeal to when we say they are "both happening now". Of course the B-theorist may say, "It is obvious that there is *nothing better*, so we might as well use this one." But one might reasonably wonder whether there is some other means of signaling that gives self-consistent results, but that sometimes conflicts with those delivered by the Radar method — in which case, there would be a competing set of candidate simultaneity relationships among the same events. The Radar

method gives us a relation worthy of the name "optical simultaneity"; but one can imagine discovering other methods that yield different results — "telepathic simultaneity", say, if there were such a thing as faster-than-light telepathy; or "quantum measurement simultaneity", a notion needed for some interpretations of quantum theory (below, I say a little more about the reasons some versions of quantum theory introduce a simultaneity-like relation — one that is especially relevant to quantum measurements).

More to the point, the A-theorist is committed to thinking that there are facts about simultaneity that go deeper than any operational definition given in terms of a particular means of signaling — objective facts about which events are presently happening, for example.[49] So the A-theorist is bound to be suspicious of the proposed identification of simultaneity with the deliverances of the Radar method. As many A-theorists have pointed out, Einstein's claim that, in SR, the relation of distant simultaneity must be defined by means of optical simultaneity, is based upon profoundly verificationist assumptions; those who are not verificationists are free to wonder whether simultaneity might be something deeper and non-relative, as A-theorists believe.[50]

For now, however, I shall set aside worries about the relationship between "*real* simultaneity" and the Radar method's surrogate for distant simultaneity. Instead, I shall ask merely whether the method picks out an interesting structural feature of the manifold posited by SR. And the answer is, clearly, yes, it does.[51] Assuming SR, the Radar method provides a perfectly natural way for an inertially moving observer at the point x to divide up all of space-time into three-dimensional regions. Extend a time-like straight line through x in both directions along your inertial trajectory; use the Radar method at each point on the infinitely long line to

pick out a three-dimensional slice of the manifold; and the result will be an exhaustive division of the manifold into non-overlapping, flat surfaces, on the basis of optical simultaneity.

The important fact, for present purposes, is that such a *foliation* of a manifold — an exhaustive division into three-dimensional, non-overlapping regions each of which "slices" the manifold "all the way through" — is the result of applying the Radar method to just one of an infinity of inertial paths through x, none intrinsically better than the others, at least so far as the geometry of SR is concerned. If two observers were in different states of motion but passing right through one another at x, they would come up with different answers to the question "what is happening right now?" using the Radar method; and, extending their inertial paths into the past and future, they would come up with complete foliations of the manifold that cut across one another.

The metrical structure described by SR does not, then, privilege just one way to "slice" the manifold into non-overlapping, continuous, three-dimensional, space-like regions. According to SR, there are infinitely many ways to exhaustively divide the four-dimensional manifold into a series of slices, each slice corresponding to a three-dimensional space that at no point has any thickness in a time-like direction.

The same can be said in the context of GR, but with important qualifications. One serious issue that arises in GR, but which I shall have to set to one side here, concerns some of the stranger shapes that have been contemplated as possible space-time manifolds. An empty, flat GR manifold has a metric like that of SR around each point; but in a manifold containing matter, the light-cones must be bent toward the location of mass, with greater curvature near larger masses. GR is, in effect, a set of equations that puts constraints on the varieties of possible combinations of manifold-plus-contents. GR manifolds come in all sorts of shapes; but

the ones that look like they come close to resembling our space-time (black holes and all) include a "global time parameter" — which means they can be exhaustively sliced up into ordered, space-like three-dimensional regions without time-like depth at any point. And, most importantly for present purposes, just as in the case of Minkowski space-time, these manifolds admit foliations that cut across one another.

The equations of GR have solutions that allow the manifold to take on all kinds of bizarre shapes. For example, GR does not rule out the possibility of "closed time-like curves" — paths through space-time that loop back upon themselves. And some of the more oddly-shaped manifolds do not submit to a natural, exhaustive slicing into space-like regions — they are "non-foliable". Such space-times pose difficult questions for the presentist, who expects a manifold with a time-like direction to have a privileged foliation — a division of the manifold into slices each of which contains events that were all happening at once. Physicists sometimes dismiss these non-foliable models of space-time as "not physically real" or "pathological", in much the way retarded solutions to Maxwell's wave equations are thrown out as "unphysical" for implying waves that move backwards in time. I take it that, in both sorts of cases, the physicists who say these things mean more than just that such models do not describe the actual world — after all, lots of solutions to Einstein's or Maxwell's equations are *known* to be failures as descriptions of our universe, but are not deemed "unphysical".[52] I should think the A-theorist may, with a relatively clear conscience, reject non-foliable models as *not genuinely possible ways for time to be*.[53]

One might think that philosophers are overstepping their bounds if they deny, for philosophical reasons, the existence of non-foliable manifolds when, on the face of it, current physics does not rule them out. Perhaps… but philosophers frequently engage in such forays

into physical territory. Physics, by itself, is unlikely to rule out the possibility of lots of bizarre things that philosophers routinely reject as not *genuinely* possible. For example, physics has nothing to say about such controversial mental phenomena as "qualia" or "irreducible intentionality"; but, according to physicalist orthodoxy in philosophy of mind, these are impossible phenomena, whether or not they are ruled out by physics. The A-theorist should not lose much sleep over GR's failure, by itself, to imply the impossibility of temporal loops and other surprising space-time shapes that create problems for her view.[54] More worrisome is the prospect of a conflict between presentism and the attempts to describe, at least approximately, the actual structure of our space-time by means of SR and GR.

III. A Manifold for Presentists

The Shape of the Present

I have advocated the assumption of substantivalism, at least as a theory about our universe's manifold. The following seems to me to be regarded as a good bet, at least among philosophers of physics: Even if GR turns out not to be, strictly, true; nevertheless, a physics that adequately describes the laws of motion in our universe will likely imply the existence of a manifold with similar metrical structure. It would, then, be a bad bet for presentists to hitch our wagons to relationalism about the space-time manifold, given the difficulty of being a relationalist about a manifold with GR-like structure; and a fairly safe bet for us to appeal to space-time points, substantivally construed, in our attempts to develop an adequate presentist metaphysics for a universe like ours. In this section I consider what presentists should say about the nature of this manifold.

In the first half of this section, I consider what the presentist should say about the shape of that part of the manifold that contains currently occurring events and currently existing objects. I attempt to articulate the basic convictions that drive me toward the A-theory; and then, supposing the manifold to have the metric of Minkowski space-time, I try to work out what part of it must be filled with objects and events right now. The conclusion is not surprising: The presently filled region is a complete "slice" of the manifold, with no depth in a time-like direction at any point. Here, the potential for conflict with Relativity becomes apparent; it will be addressed in the final section of the paper.

Having reached a conclusion about how much of the manifold is presently filled with events and objects, I turn in the second half of this section to the question: How much of the manifold *exists*? Just the ultra-thin slice in which present events are happening and objects are located, or also parts that merely *were* the locations of events and objects? Theodore Sider has advanced an argument against presentism on the basis of cross-temporal relations needed to distinguish between different states of motion. One way to respond to his challenge is to accept the existence of past (i.e., formerly occupied) points. Although that would not be a terrible result, I will suggest an alternative response as well. In either case, it shall become clear that "space-time" is a bit of a misnomer for the presentist's manifold; it is a substantial, though theoretical, object that persists *through* time; it is not something that could contain time itself as one of its dimensions.

Why I Believe in an A-theoretically Privileged Foliation

I am an A-theorist because I am convinced that there is a big difference between an event that is really happening to me, and one that merely has happened or will happen to me. The ones that

are *really* happening are — in some objective, non-relative way — "more real" than the others. They constitute a miniscule proportion of the events that occur over the course of my life. Assuming SR, I inhabit a four-dimensional manifold, and the events in my life occur at different points along a path in one of its four-dimensions, my "world-line". So I affirm:

(1) There is an objective, important difference between events that are really happening to me, and ones that merely *did* or *will* happen to me; and the events that are really happening to me are confined to a tiny region, *r*, on the world-line I will eventually have traced through the manifold.

Although I think only some of the events on my world-line are special in this way, I should not take myself, or my world-line (including my current state of motion, which is a function of the shape of my world-line near *r*) to be deeply special — I should be surprised to discover that I play a unique role in the physics or metaphysics of space-time.[55] Because there are so many other people, places, and world-lines, and no reason to think I occupy a privileged place relative to all of them, I should adopt the following as an extremely likely working hypothesis:

(2) I am not metaphysically special, unique among all human beings with respect to some important, objective feature of the manifold; neither is the region *r*, nor is my world-line.

Of course I should not rule out, *a priori*, the idea that, lo and behold! and despite all odds, I just happen to be standing at "the center of the universe" (if there were such a thing) or at some other spatiotemporally special place. But any discovery along those lines would have to be based on serious study of the actual structure of our manifold, and my place in it. Only the extreme egotist would assume such a thing right off the bat in his theorizing about time; and anyone bold enough to do so is almost certainly mistaken, and surely does not *know* that he occupies a special place.

It is a favorite pastime of philosophers to contemplate a kind of "me-now" solipsism: What if nothing else is going on but what is happening to me? The supposition is useful for shaking loose some kinds of philosophical fruit. But I have no reason to *believe* such a thing, because:

(3) If the only events in the universe that are really happening are the ones happening to *me* at *r*, then *r* and I would be very special.

From these three assumptions, it follows that *what is really happening* excludes many events that already happened to me and many that have not yet happened to me; but also includes many other events that do not happen to me at all.

(4) Events are really happening to me, at *r*, and to many other objects at points on their paths through the manifold. (From 1, 2, & 3)

The extent of what is really happening must "stick out" into the manifold beyond the brief events happening at *r* on my world-line. One could call the part of the manifold at which events are really happening, "the present". The question then becomes: What is the shape of the present?

The metrical properties of the SR manifold have been sketched. It is an infinitely large, connected set of points, each of which lies at the intersection of infinitely long straight lines consisting of points at positive, negative, and null distances. These lines inscribe forward and backward light-cones around each point, including points at time-like separation within the cones, and space-like separation within the "bowtie" region outside the cones. SR attributes this much geometrical structure to the manifold, and nothing more. If the present, around *r*, has a shape that is recognized as "natural" by the lights of SR, it must be definable in terms of these fundamental metrical properties of the manifold. The choices are quite limited.

(5) According to SR, the only geometrically distinguished subsets of points that include *r*, along with many other locations in the manifold, are the following: (a) the points at space-like distances from *r*, i.e., the ones filling the "bowtie" region around *r* in a two-dimensional space-time diagram; (b) the points in or on *r*'s forward light-cone; (c) the points in or on *r*'s backward light-cone; (d) the points on the various planes associated, by the Radar method, with continuous paths passing through *r*; (e) three "hyperboloids of revolution" about *r*; or (f) some set of points definable in terms of these distinctions.

But each of these alternatives has its problems. If the only events really happening were the ones at space-like separation from me (i.e., ones occurring in the "bow-tie"-shaped space-

time region around the point at which my real experiences occur), then I would occupy a very special place in the cosmos — the present would "emanate" from me, so to speak. Something similar would be true if the only events really happening were the ones on the surface of my backward or forward light-cone. I might think my research is really "cutting edge"; a critic may find my views old-fashioned, retrograde; but neither of us will be inclined to link reality to one of my light-cones, putting me ahead or behind everyone else in my progress through the manifold. Similar criticisms would apply to identification of the present with the entire contents of my backward or forward light-cone, or the combination of the two; associating the present with any of these regions would not only make me special, but would be quite perverse, at least in the latter two cases.

Forget the light-cones, then. Suppose, instead, that I try to make use of the flat planes of simultaneity that include *r*. There are, however, infinitely many, none of which can claim any geometrical distinction. The only hope for selecting one is to choose a particular state of motion through *r* — for instance, my own. So suppose the only events in the universe that are really happening are the ones on the plane that would be picked out by use of the Radar method at *r* by someone on an inertial world-line having the state of motion I have, at that point. If that were the case, my world-line in the vicinity of *r* would be very special; use of the Radar method by observers in relative motion would place my current experience in a different plane, one that cuts across mine. I would be able to use light signals and assumptions about the equality of the round-trip speed of light to correctly determine the shape of the present; but those in relative motion would get the wrong results, were they to use the same method and assumptions. Choosing some other observer's state of motion will simply privilege a different path through *r*.

The hyperboloids of revolution are included only for completeness. I will not describe them in detail, except to say that they are surfaces consisting of points at a constant space-time interval from *r*.[56] Some are hyperbolas stacked within my rearward light-cone, others are stacked within my forward light-cone, and another family divides up the bow-tie area around *r*. Choosing the points on one of the surfaces in one or more of these families as "the present for *r*" would be odd for all sorts of reasons. Such a choice would not only make *r* very special (serving as a sort of generating point for the hyperboloids from which the surface was chosen); it would also leave a space-time gap between *r* and the other events going on now, since none of the hyperbolas in any of the three families is connected to *r*.

Sets of points distinguished by some combination of these distinctions will remain centered around me and my world-line. For example, one might focus on the points *on or below* my inertial plane at *r* but above my rearward light-cone; but, again, that would make *r* and my current state of motion very special.[57]

I hold a privileged place in all the divisions of the manifold that include *r* and that can be defined in terms of SR's fundamental metrical properties. There simply are no more "objective lines" that SR can discern passing through my current experiences and out into the rest of space-time; no more regions that SR recognizes as natural or objectively special. That is to say:

(6) If the region in which events are happening were restricted to (a), (b), (c), (d), or (e), I or *r* or my world-line would be very special.

Which leads to the conclusion:

(7) If the region in which events are really happening coincided with a set of points including *r* that are geometrically distinguished, according to SR, then I or *r* or my world-line would be very special. (From 5 & 6)

I should suppose that it is vanishingly unlikely that the present takes one of these distinguished shapes centered on me, given the infinite number of alternative perspectives that could have been privileged instead of mine. And so, from (2) and (7), together with conclusion (4) (which affirms that there *is* a larger region of the manifold including *r* in which events are really happening) and (1) (which requires that this region be less than the whole of the manifold), I must conclude that:

(8) There is a region of the manifold in which events are really happening, it includes *r* and many other points, and it does not coincide with any region that is geometrically distinguished, according to SR.

In all likelihood, then, the present "lights up" a part of the Minkowskian manifold that is geometrically undistinguished, according to SR.

Can I, on general presentist principles, reach a more precise judgment about the shape of the region in which events are really happening? How much of the manifold, in my vicinity, should I suppose is "lit up"? I shall allow myself what I regard as a quite reasonable assumption about the connection between causation or causal dependence and an event's *really happening*; and I shall suppose that the physics of SR correctly describes the structure of the manifold, and that it implies that causal processes propagate along continuous paths. On these assumptions, it

turns out that the present must be an exceedingly thin slice through the bow-tie around my current position. Although this is the natural conclusion for an A-theorist to draw about the shape of the present, I will be deriving it *not* from outmoded assumptions about the structure of the manifold — i.e., I do not assume that it is Newtonian or Galilean, with a built in, geometrically privileged foliation. Instead, the conclusion follows from the very general A-theoretic principles (1), (2), and (3), and assumptions about the way causation works in a Minkowskian manifold that seem to be close approximations of the way causation typically works in the real world.

Events in my history seem always to have been caused by events that have already happened. (This is a conviction about the direction of causation relative to the A-series, not a view about the direction in which causes tend to produce effects within the Minkowskian manifold.) Generalizing from my own experience, the following, then, seems likely:

(9) For any events e^1 and e^2, e^2 is causally dependent upon e^1 only if, when e^2 was happening, e^1 had already happened.

SR puts constraints on the propagation of energy, and the paths of particles and light — all of which, I assume, carry causal dependencies. If all interactions are mediated by processes no faster than light — a prohibition that need not be built into SR, but that is generally coupled with it — then causal dependencies within the manifold follow continuous paths of light-like or inertial accessibility.[58] As noted earlier, it is a nice question how a presentist should make sense of causation between non-existent past events and existing present events; and I suggested that the causal relata are not concrete events — the kind of thing that would have to pass away when

it ceases to happen — but the more abstract category of states of affairs. However the metaphysics of causation is to be handled, the presentist should agree with SR that causal relations or dependencies of some kind hold along the paths traced by particles and processes. And so I affirm:

(10) If a particle, photon, or wave occupies a path in the manifold, its occupancy of a point *r* on that path is causally dependent upon its having occupied the points on that path that stand in light-like or inertial accessibility relations to *r*.

But if occupation of a point *p* by a particle *x* is an event that is causally due to the particle's occupation of locations "lower" on its world-line, then (9) implies that *x*'s occupying those inertially accessible points has already happened when *x* occupies *p*. All the points on *x*'s world-line from which *p* is inertially accessible represent places *x* occupied in the past, since *x*'s existence in those places was partially causally responsible for its continued existence at points between them and *p*.

How far does the present extend out into other parts of the manifold from my current location? Shortly, I will consider three different conceptions of the nature of the non-present parts of the manifold. One of them (my favorite) treats presently occupied points as the only real locations, past and future ones being, strictly, non-existent (though we have means to describe what they were like, and which current locations are related to them). For now, however, I shall take a very flat-footed approach: the manifold of SR is a four-dimensional, eternally existing, geometrically unvarying space in which some of the straight lines are paths of inertial and light-like accessibility — their "straightness" simply consisting in their standing in such accessibility

relations. On this — no doubt simple-minded — conception of the manifold, the possibility arises, in principle at least, of one family of causally interacting particles and fields moving through one part of the manifold, while another family of particles and fields is moving through regions of the manifold formerly occupied by the first family but causally unconnected with them. On less flat-footed conceptions of the manifold, the possibility of non-interacting "parallel universes" within the same manifold will not arise; but it is not something I will rule out at this point. And its conceptual possibility makes vivid the fact that distances along a path of inertial accessibility need not, strictly speaking, be temporal distances. If simultaneous events could occur at points separated in this dimension, the distance along the shortest path between them could hardly be a distance within *time itself*. The straightness of paths in the so-called "time-like" directions of the manifold is part of the structure of a substantival entity postulated (like "dark matter") to explain certain observable phenomena. It can do this explanatory job even though extension in this direction is not literally temporal.

For now, pretend that the manifold through which matter and energy move is an eternally existing Minkowskian one, with a fourth-dimension corresponding to the direction of inertial accessibility. In the event that an atom or photon were currently located at a point within the backwards light-cone of the current position of another atom or photon, the one could never "catch up with" the other — at least, not if the laws governing the motions of particles and waves have been and will always remain the same everywhere, so that the same kinds of particles or waves will always take the same amount of time to traverse the same distances in the manifold's fourth dimension. On this assumption, one can say something quite definite about the shape of (what I shall call) "*my* universe" at other points within it. My universe comprises the regions of the manifold occupied by the current states of things that could come to effect me in the future,

plus regions occupied by current states of things that could effect them, and so on. That's the intuitive idea, one that can be spelled out a little more precisely in two stages:

(D1) *S* is the *immediate causal environment* of the current state *s* of $x =_{df} S$ is the set of all pairs $\langle y, z \rangle$ such that *y* is a particle, wave, or other process and *z* is a current state of *y* that could, at some point, come to have an effect upon a state of *x* that is also partly causally dependent upon *x*'s current state *s*.

(If it is possible for a single object to be moving through the manifold at regions separated from one another in the fourth, non-spatial dimension, such an object will have a different immediate causal environment relative to the different states at the different regions it currently occupies.)

(D2) *R* is the universe of *x*, relative to the current state *s* of $x =_{df} R$ is the smallest region satisfying the following recursive condition: for every pair $\langle y^1, z^1 \rangle$ in the immediate causal environment of *x*'s current state *s*, *R* includes the location at which z^1 is happening to y^1; for each such $\langle y^1, z^1 \rangle$, and for every pair $\langle y^2, z^2 \rangle$ in the immediate causal environment of y^1's current state z^1, *R* includes the location at which z^2 is happening to y^2; and so on.

The shape of the rest of "my universe" must be a thin slice of the manifold cutting the interior of my current bow-tie region. First, consider my immediate causal environment. Take any particle or photon or wave that begins from a region within my backward light-cone, passes through the bow-tie region around my current position, and comes to have a causal impact upon

my world-line at a point currently in my forward light-cone. If SR is true, every such particle, photon, or wave will successively occupy points along paths of inertial and light-like accessibility; and the occupancy of later parts of those paths by a particle, etc. will be causally dependent upon its occupancy of earlier parts of those paths. The occupation of points on these paths constitutes a series of events, each of which is a stage of the process leading up to eventual contact with me. If one of these stages is occurring now, it cannot be in or on my forward or backward light-cone — that is, so long as one assumes that the laws governing the propagation of matter and energy in each part of the manifold will always remain the same. If the stage were on or in my backward light-cone, it would never catch up with me; if it were on or in my forward light-cone, I would never catch up with it. Consequently, for any currently existing particle or process that will eventually affect me, if there is a state of that particle or process occurring anywhere, and it is a state that will eventually affect me, it must be happening within my current bow-tie region. So long, then, as the particle does exist (so long as it is not able to pop out of existence from time to time and then reappear on its path), it must be *somewhere* now — at some point on its path through the bow-tie. And the region it occupies must be extremely thin in the fourth, non-spatial dimension, for the same reason that my current stage must be temporally thin. Consider any two stages in the history of the particle's trip to meet me; (10) requires that one stage is causally dependent upon the other; and so, given (9), by the time the causally dependent one is occurring, the other stage has already happened.

If this is true for me, and for the processes and particles that constitute my immediate causal environment, it should be true for those processes and particles as well, at their current stages. And so the shape of the universe of material events surrounding my current location in the manifold must extend out into the bow-tie region around me at least as far as there are things

that will interact with things that will interact with…things that will interact with me in the future; it must never dip into the interior of anyone's forward or backward light-cones. The shape of the present — at least, of my present universe, setting aside the possibility of parallel, causally disconnected universes — is just what one might have expected, then: A thin slice through the locations at space-like distances from me.[59]

Nothing in the reasoning that has taken me to this conclusion has carried the slightest suggestion that the slice in question is the hyperplane associated with my inertial frame (or the frame of the arbitrarily chosen particle in my body) or with the inertial frame of any other object, for that matter. Nor has there so far emerged any reason to think that the slice takes the form of a perfectly flat hyperplane at all. Were I to believe that the actual manifold was Minkowskian, then, for all I would know at this point, the universe of occupied points around me might have the shape of a "non-standard simultaneity slice" — that is, it may not be one of the planes in the manifold resulting from employment of the Radar method within a single inertial frame. Perhaps that would be the most natural thing for me to think, in these hypothetical circumstances; but nothing about SR or the A-theory implies that the A-theoretic foliation of a Minkowskian manifold *must* take this form.

Eventually, we must set aside the fiction that our world inhabits the infinite flat manifold described by SR. Even if GR is not the final word about space-time structure, at least our manifold comes closer to satisfying the metrical constraints of GR. Gravity is the manifestation of mass as it warps space-time, and SR's metric is not ours. GR predicts there will not, in worlds like ours, even *be* universe-wide inertial frames. It would be injudicious (to say the least!) for the A-theorist to suppose that being present is essentially tied to a physical phenomenon that *does not actually exist*! This is one of the points at which one must keep in mind that

Minkowskian metrical structure is only approximately correct, and that structure peculiar to it will not prove useful to any A-theorist who is trying to find the shape of the present in the real world.

So much for the current shape and location of the present, on the assumption of SR. What about its past shapes and locations? Everything said so far could have been said by me when I occupied points on my world-line that fall within my rearward light-cone, and could be said in the future when I occupy points in my forward light-cone. The causal constraint requires that the present stages of the processes in my bow-tie region move ever forward; and so one can see the beginnings of an argument for an A-theoretically privileged *foliation* of the manifold: a series of slices, each member of which is a set of points in the manifold at which events were happening all at once. This sort of foliation of a Minkowskian manifold need not coincide with any foliation that has a simple metrical description using the resources of SR, like a series of hyperplanes associated with an inertial path through the manifold; and, even if it did coincide with such a foliation, many other foliations would be equally metrically "special", by SR's standards. So the presentist has added some distinctions not found in SR's description of the manifold. The final section will ask: Just how bad would this be? Does it amount to *inconsistency* with SR? Would adding an A-theoretically privileged foliation call for a revolution in physics? Or could it merely be the addition of something SR does not, by itself, describe — like, for example, the unique center of mass that some finite universes contain, and the "privileged frame" associated with that center of mass. Anyhow, what does this matter, if SR is not true? But first, I consider what a presentist should say about the existence and nature of not-currently-occupied points within the manifold; and, in doing so, I respond to an objection to presentism due to Theodore Sider.

Points Where Nothing Now Happens

So far, I have been describing the SR manifold as though it is an eternally existing, unchanging four-dimensional object. Many presentists, once they are convinced that we must posit a four-dimensional substantival manifold for physical reasons, will suppose that its points come into existence with the events that occur at them, and immediately (and permanently) cease to exist when the instantaneous events in them have occurred. Call these A-theorists "one-slice presentists". As shall appear, presentists may have reasons to believe in the co-existence of points that stand in relations of light-like and inertial accessibility; and, more generally, to believe in the ongoing existence of all locations in which events *were* but *are no longer* occurring. I give the name "growing-manifold presentists" to A-theorists who accept the existence of just points that are presently or were formerly filled; but who deny the existence of future objects and points not yet filled, and who also deny the existence of Bucephalus and other paradigmatic cases of things that have ceased to be. Above, I surveyed some of the pressures that might force presentists to accept the ongoing existence of rather abstract *resultant states* for every event or state that ever occurs or obtains. Such things would constitute a sort of echo of the entire past — a ghostly history with something like a fourth dimension corresponding to the order in which the resultant states came into existence. Manifold substantivalism, coupled with post-Newtonian theories of motion, may require a similar concession: the ongoing existence of an empty (but haunted) "house" in which the ghostly events once occurred.

Sider has given what he takes to be a powerful argument against presentism, based on the fundamental status accorded to certain cross-temporal relations by physics; but his argument may just as easily be reinterpreted as an argument that the presentist should accept the existence of a

four-dimensional manifold that includes, in addition to points at which things are presently happening, also at the very least points that *were* once similarly occupied. (I shall generally ignore questions about future things, including not-yet-filled regions; like many presentists, I am perfectly content to let facts about them remain unsettled.) Of course, if acceptance of empty, formerly-filled points represents a high cost for the presentist, Sider's argument still packs a punch. I shall argue that (a) the cost is not so high, and (b) the presentist may not even have to pay it.

Sider's starting point is the fact that, since the rejection of Newton's absolute space, the states of motion physics ascribes to objects seem to require cross-temporal relations that cannot be captured with the resources afforded one-slice presentists by slice-operators alone.[60] The sentences expressible by means of "one-time-at-a-time" tense operators provide the presentist (or other A-theorist) with a series of instantaneous "snapshots" of the world. In the absence of Newton's persisting substantival space — e.g., in the space-times of the Galilean theory, SR, and GR — the snapshots merely tell us the relative spatial locations of objects at each instant. But, says Sider, "the sentences [expressible by slice-operators] do not specify how the snapshots line up with each other spatially, since such facts are not facts about what things are like at any one time."[61] The one-slice presentist cannot simply let cross-temporal spatial relations slide, making do only with cross-temporal comparisons of position that are relative to objects persisting throughout the times at which the comparisons are made. It turns out that, according to any of these theories, there is a big physical difference between, for instance, a particle that is moving inertially throughout a period, and a particle that is undergoing acceleration during a period. The relative velocities of two particles may be recovered from the snapshots (assuming the snapshots include information about the identities of particles in different slices); but which particle is

moving inertially, it would seem, cannot be recovered. Compare a particle *a*, accelerating to catch up to and pass a particle *b* in inertial motion during a period *T*, with an unaccelerated particle *a** steadily overtaking and passing a particle *b** that is rapidly decelerating during a similar period *T**. *a* and *b* may stand in the same relative velocities at each instant in *T* as *a** and *b** in the corresponding instants of *T**. So snapshots of the particles at each instant would not seem to be able to distinguish the two cases. Indeed, in the absence of a space-time manifold that continues to exist, it is not clear how to derive even the *continuity* of the paths of particles from the facts about slices alone.[62]

But why do the slice-operators only "take pictures" of the parts of the manifold that are filled at a given instant? Sider assumes that a presentist must be a one-slice presentist, rejecting points that merely *were* or *will be* occupied by events and objects. But suppose that at least the formerly-filled points do still exist. Their ongoing existence could preserve the distinctions between continuous and discontinuous, inertial and non-inertial paths taken by particles; and they could do so under at least two different assumptions about their behavior once they are empty. (1) The presentist could adopt a sort of "empty box" view of formerly-filled points, the presentist could suppose that formerly occupied locations in the manifold continue to exist with their relations of light-like and inertial accessibility intact — e.g., points once occupied by a photon moving through empty space remain at null distances from one another, the end-points of a path along which a particle moved inertially remain at positive distances from one another and the path remains straight. (2) The presentist could instead conceive of formerly-filled points as constituting a sort of "ghostly box"; she could treat these regions in the way the ghostly growing blocker treats past individuals: the formerly-filled points continue to exist, but they have only

backward-looking properties and relations, where the empty-boxer sees spatio-temporal geometry still intact.

A simple example illustrates the difference between the two approaches: Consider a continuous series of points *S*, and another point, *x*; and suppose SR's description of the manifold would have us say that *S* constitutes a segment of a straight line with positive length, with *x* as its endpoint in the direction of inertial accessibility (i.e., *x* is accessible to particles moving along *S*). The empty-boxer will take this to mean that, were a particle now to begin occupying the points along *S*, successively, then — in the absence of forces — it would come to occupy *x* (in the fullness of time — which, for the empty-boxer, is clearly not just another dimension of the substantival manifold). The ghostly-boxer, on the other hand, will take this to mean that, had a particle successively occupied the points along *S*, then — in the absence of forces — it would have come to occupy *x*; but she will deny that these dispositional facts are *still* the case. Points, once occupied, are mere shadows of their former selves, no longer connected to one another by robust accessibility relations. Either they can no longer be occupied by anything — perhaps because they no longer belong to the kind, *locations* — in much the same way that, in the ghostly growing block, past horses are no longer horses. Or the points *could* be occupied, in principle — that is, it is not absolutely impossible. However, if, somehow, something were in one of them, it would no longer be near any other locations. An object at such a point would be at a place that *used to be* on a path to somewhere, but that is now a dead end.

Given either an empty but intact box, or a ghostly one, past-tense slice operators can describe the facts about the points a particle occupied at every instant in its history; and the present truths about the relations between the points in the empty or ghostly box — truths about

which ones are or were mutually inertially or light-like accessible — will fully characterize the shape of the trajectories constituted by these points.

Does acceptance of the existence of a four-dimensional manifold, in the form of an empty or ghostly box, constitute a great cost or ontological burden for the growing-manifold presentist? One-slice presentism does not seem to me vastly superior to presentism with a four-dimensional manifold of either empty or ghostly regions; because the reasons for positing the box are simply the largely empirical reasons which, I take it, support substantivalism as a somewhat surprising, contingent thesis, true because of the kind of universe we inhabit.

Why should one-slice presentism be the "default" version? I do not see that the pull I feel toward presentism has much to do one way or the other with ontological commitment to the structured four-dimensional manifold of points described by Relativity. I begin my philosophical reflection convinced that there exist only a relatively few events and objects. I exist, and the sounds I am hearing; but I find it hard to believe that there are any such things as the Peloponnesian War and Alexander-the-Great's horse, Bucephalus; or the first manned Martian landing and my first great-grandchild. At least, if there *are* such things, I need to be argued into believing in them! On the other hand, I do not — or at least *should* not — begin my philosophical reflection with strong convictions about the existence of quarks, or dark matter. The space-time manifolds of SR and GR resemble quarks and dark matter more than they resemble horses and wars, with respect to our reasons for believing in them. They are theoretically posited entities that earn their keep by the crucial roles they play in successful scientific theories. Suppose I come to believe in a four-dimensional manifold with a specified structure because interactions among objects alone are not enough to explain why observable things behave as they do. Should this bother me, *as a presentist*?

Not much, I think. A space-time manifold is a strange beast — at least, when it is construed substantivally, as a sort of four-dimensional, invisible, permeable cosmic jell-o. The manifold of Galilean or Minkowskian space-time, and the manifolds allowed by GR, are not the kinds of thing one should have posited, had they not seemed necessary to play a role in some well-confirmed scientific theory. An A-theorist, like everyone else, should look to science for information about the structure of such things, including their metrical properties and the number of dimensions they have. My convictions about the unreality of past and future objects and events, on the other hand, are convictions about horses and wars and people; they have little to do with questions about what sorts of theoretical entities should be allowed to figure in scientific theories.[63]

Accepting the ongoing existence of formerly occupied parts of the manifold provides one way to ground the cross-temporal relations to which Sider has drawn attention; and the costs to the presentist do not strike me as terribly high. But I see the makings of a still more excellent way — at least, in a Minkowskian manifold, and probably in foliable GR space-times as well.

If one takes for granted the metric structure of Minkowskian space-time or a not-too-bizarre manifold satisfying GR's constraints, surrogates for past points can easily be constructed out of the points in the present slice. For each past point, there is a region in the presently existing slice of the manifold that contains all and only the points on the slice that were inertially or light-like accessible from the past point; the region in question is the presently existing slice of the point's forward light-cone. In SR and foliable GR space-times, these regions could be used as descriptive names for each formerly-filled, now non-existent space-time point — each such point has exactly one point-surrogate in the presently existing slice. If the presentist is allowed to help herself to the facts about which collections of points constitute point-surrogates, the current

geometry of the present slice will include enough information to recover all the facts about which past space-time points constituted inertial and light-like paths. For every presently existing point *p* and every inertial or light-like path a particle could have taken that leads up to *p*, there is a unique set of point-surrogates consisting of all and only the surrogates for points on that path. In Minkowskian space-time, that is all the metrical structure there is. I hope that the general strategy could be extended to GR. I believe that, in foliable GR manifolds, the present slice can be relied upon to include a surrogate for each past point; and I suspect that all the geometrical properties of paths through the manifold could be recovered, given: (i) facts about which sets of past-point-surrogates lie along geodesics ending in presently existing points, plus (ii) facts about which past points constituted a privileged slice and what its intrinsic curvature was like. But I confess that a proof of the adequacy of this approach is beyond me.

Although, in general, I am setting truthmaker worries to one side, the nature of the current proposal will be made a bit clearer by advancing a possible account of the ontological grounds in the present for the space-time structure of nested light-cones characterizing past points. The fact that a certain region constitutes a point-surrogate (it represents all and only the present points accessible from a single past point), together with the present facts about overlap of point-surrogates, encodes a lot of information about the past. Take a point *p*, and two past-point-surrogates *R1* and *R2*. Suppose that what needs present grounding is the fact that the shortest path between these three points was a straight time-like line in Minkowski space-time. A one-slice presentist could fall silent, claiming that there is no more to say about the grounds for this fact than that *p*, *R1*, and *R2* are "co-trajectoried" — a relationship holding among the point and the two regions just in case they are point surrogates for no longer existing points that stood in inertial accessibility relations to one another and to the present point. But it would be

nice to be able to say something more; a relation like the proposed *being co-trajectoried* — one that only holds among instantaneous things — seems a funny sort of relation to be at the basis of *cross-temporal* space-time structure. Would it not be better if the straightness of a path throughout a period were based upon features of something that persists throughout the period?

Earlier, I gave reasons why simple claims about the past (e.g., "England has had two kings named 'Charles'") have been thought to force presentists to recognize a host of resultant states (e.g., two states of England's having had a king named 'Charles'). A one-slice presentist who accepts the ongoing existence of resultant states could make use of them here, positing a persisting state for every inertial path that passes through a presently existing point. For each time-like straight line that a B-theorist sees in a Minkowskian manifold, the one-slice presentist will see a possible inertial trajectory, only one point of which actually exists. A one-slice presentist looks at a point, *p*, in the presently existing slice and sees infinitely many different ways in which a point-sized particle in inertial motion could have reached *p* — infinitely many inertial trajectories meeting at the point. For each of these trajectories, she could posit a distinct state consisting of *p*'s *being part of an inertially connected trajectory*, a state that is occurring to *p* now, and that has occurred to the continuously many other points in the past that would have been occupied by a particle in inertial motion on that trajectory. On this metaphysics of the manifold's structure, the states I am calling "trajectories" outlive the past space-time points to which they occurred; and facts about past space-time points, and about which ones were mutually inertially accessible, are grounded in facts about these current states, and facts about which ones co-occurred — i.e., which such states overlapped by happening to the same point in the past. In fact, it is tempting to regard the trajectories as not just the grounds for the metrical relations among points, but the grounds for their very existence. A point in the manifold could

be identified with the set of trajectories that uniquely converge upon it. Reducing points to trajectories would mean that the co-occurrence or intersection of trajectories could not be explained in terms of the trajectories "happening to the same point". However, given substantivalism's requirement that we posit, among the most brutal of facts, a manifold with intrinsic Minkowskian structure, I see no objection to construing this brute structure in terms of brute physical facts about which groups of trajectories have and have not co-occurred or converged. There are general truth-maker worries about what grounds truths about the past of a presently existing thing, but these truths about backward-looking properties of trajectories seem little worse than truths about whether I was happy yesterday.

Is it possible, in the context of GR, to deny the existence of past space-time points and to recover past space-time structure by appeal only to persisting trajectories and their past co-occurrence relations? I am not sure. In foliable space-times, the strategy of constructing unique present surrogates for past space-time points will procure a surrogate for every point from which a signal could have been sent. But one would have to tell a slightly different story about what makes for the straightness of a trajectory in a GR manifold; the gloss I gave about the relations among points along inertial paths in Minkowski space-time could not be quite right. The presence of a particle with any mass alters the shape of space-time, in GR; so it is problematic to treat formerly-empty straight time-like lines as having the shape they would have had, had there been particles moving along them. (The surrounding space-time would have to display a different metrical structure, raising doubts about the "transworld identity" of the path itself.) As a first pass, one can say at least this much about the physical meaning of straight time-like paths in a GR manifold: they are the possible paths of idealized massless test particles. There may be other obstacles to utilizing the one-slice presentist strategy in the context of GR, in which case

the presentist is once again under pressure to admit the ongoing existence of formerly-occupied manifold points.[64]

How ad hoc and revisionary are these one-slice, trajectory-based strategies for the present grounding of past space-time structure? The one-slice presentist must, in general, be willing to allow present truths about the past to be true in virtue of backward-looking states and properties of presently existing things. Given the existence of point-sized locations, if they stand in significant relations to no longer existing things, it must be in virtue of backward-looking states. Relativity requires an infinity of different inertial trajectories by means of which a thing could get into a given point. If we accept the need to posit a resultant state for every past event or state — a view that has some independent support from semantics, and seems to be needed by the presentist in order to deal with more mundane past-tense claims — it is but a short step to recognize an infinity of distinct states happening to a point, each representing one inertial trajectory by which a thing could get to that point. Such states do not seem much stranger than other backward-looking states.[65]

This constitutes my response to Sider's objection to presentism based on the need for cross-temporal relations in order to distinguish different states of motion. In the final section, I shall consider some objections that appeal to Relativity. But first, as an aside, I note that the metaphysics of the manifold advocated here affords the presentist a ready reply to one of the stock philosophical objections to the A-theory, based on the alleged need for "hyper-time".

Yes, But is it Space-Time?

For the B-theorist, the slices of the four-dimensional, substantival manifolds described by SR and GR can be taken to include within them a genuinely temporal dimension. Not so for the

presentist. The empty boxer, the ghostly boxer, and the one slice presentist can all agree about the following: points that were occupied, but are so no longer, are not in any straightforward sense temporally related to presently occupied points. Separation in the direction of inertial accessibility is not literal temporal separation; to call a point "past" is simply to say that events were happening there, but are not now happening there. The empty boxer cannot say that "past points" are earlier than present events, in some absolute sense. In principle, events could happen once again at formerly occupied points; and parallel universes might be moving through the manifold, the one ahead of the other — in which case, the formerly-filled points would also be soon-to-be-filled points; such regions would, in a sense, be both part of the past and the future, and not, in themselves, either earlier or later than the events presently going on. Ghostly boxers and one slice presentists will most likely deny the possibility of formerly occupied parts of the manifold coming to be occupied again. The former will probably want to say: once ghostly, always ghostly. And the latter will likely hold that points can never come back into existence once they have ceased to be. But these presentists, too, will deny that the distance relations between points filled successively are straightforward temporal distances, like *being five minutes earlier than*. The points filled five minutes ago are not five minutes earlier than current events; it is the *event of their being filled* that is five minutes earlier than current events.

The fact that the slices of an A-theorist's manifold are not straightforwardly earlier or later than one another helps defuse a common philosophical objection to the A-theory — namely, that the A-theory requires an implausible commitment to at least two temporal dimensions; and, if two, then infinitely many. Suppose, contrary to fact, that the distances between distinct slices in an A-theorist's manifold *were* genuinely temporal distances, like *five minutes earlier than*. In that case, her manifold would have a temporal dimension built right into

it; and when she also affirms that parts of it are filled but will no longer be filled, she would have thereby generated a second temporal dimension — a "hyper-time" in which changes occur to a thing that already possesses its own, distinct, intrinsic temporal ordering.[66] But, as I argued, that is not how presentists should think about the manifold; and, indeed, "space-time" is a very misleading label for our manifold (and so it is a label I have tried not to use when describing the A-theorist's version of Minkowski's four-dimensional manifold). Like the B-theorist's space-time, it consists of possible locations in which events can happen; and both presentist and B-theorist manifolds have a metrical structure that satisfies the mathematical description of a Minkowskian four-dimensional space. Nevertheless, the fourth dimension of the presentist's (so-called) "space-time" is not time itself. The presentist's manifold has no true temporal extent to it (except in the way ordinary objects have temporal extent: namely, by existing for awhile, which the empty box and ghostly box views allow the parts of the manifold to do); and the real meaning of its various dimensions is given by the physical theory that demands that we posit such a manifold. And that theory, SR, ties its most fundamental "time-like" distances to states of motion of particles, and the propagation of light; consequently, instead of calling the relations between such points "time-like" and "light-like", I prefer to speak of inertial accessibility and light-like accessibility. The relations in question may or may not be *fundamentally* dispositional — perhaps there are categorical relations among points that underlie and explain why some are mutually inertially accessible, others mutually light-like accessible, and so on. But whatever their ultimate nature, the basic "time-like" distance relations in the presentist's manifold will not be ordinary temporal relations like *being five minutes earlier than*. The wise presentists will insist, with good reason, that these ordinary, truly temporal relations simply do not characterize the substantival manifold posited by physical theories like SR or GR.

The B-theorist is in no position to criticize the presentist for making use of fundamental manifold structure that does not correspond neatly to ordinary spatial or temporal relations. For the B-theorist should agree with at least this much of the presentist's account of space-time geometry: everyday expressions for temporal relations, like "five minutes later than", do not correspond directly to the truly fundamental distance relations in Minkowski space-time. Many ordinary temporal judgments presuppose that spatially distant events can be simultaneous; if such judgments can be true at all, they must be construed as invoking frame-relative temporal notions. *Being five minutes earlier than*, for example, would seem to be infected with such frame-relativity; for I can ask, "What was going on in New York and L.A. five minutes ago?" The B-theorist can provide plenty of frame-relative temporal distance relations that are pretty good candidates for what I meant by this; but none of them would correspond to a fundamental metrical relation in Minkowski space-time.

IV. Presentism and Relativity

Sketch of Putnam's Argument

Hilary Putnam, Theodore Sider, and others have claimed that presentism is inconsistent with SR, and that this constitutes a conclusive refutation of presentism.[67] On the basis of conflict with SR, Putnam concludes that "the problem of the reality and the determinateness of future events is solved…by physics and not by philosophy".[68] According to Sider, the argument that SR and presentism are inconsistent "is often (justifiably, I think) considered to be the fatal blow to presentism."[69]

Putnam (rightly, by my lights) attributes to "the man on the street" (and, presumably, the women there too) a combination of views that amounts to presentism: "All (and only) things that exist *now* are real" — and he insists that, by "real", we ordinary people-in-the-street do not mean something merely relative, so that what is real-to-me might not be real-to-you; we mean to be talking about a transitive, symmetric, and reflexive equivalence relation, one that holds between events currently happening to us and at least some other events happening elsewhere, to other things — including events happening to things in motion relative to us.[70] He then assumes that this equivalence relation must by "definable in a 'tenseless' way in terms of the fundamental notions of physics". But the metric of a Minkowskian space-time does not include a relation that fits the bill — one that will carve the manifold into equivalence classes of co-present points in a way that does not look "accidental (physically speaking)".[71] "Simultaneity relative to coordinate system *x*", for some arbitrarily chosen inertial frame of reference, will provide an equivalence relation, alright; but there are infinitely many coordinate systems to choose from, and nothing physically special about just one of them. No other relations look any more promising.[72] So Putnam concludes that presentism is inconsistent with SR, and alleges that this inconsistency proves presentism's falsehood.

Distracting elements in Putnam's presentation and a misunderstanding of his intentions have rendered some discussions of his argument otiose. Stein started things off on the wrong foot, raising objections to Putnam's argument that no presentist or other A-theorist could use.[73] If Stein's response were an adequate rebuttal of Putnam's intended conclusion, Putnam could not have been attacking presentism or the A-theory, after all. Although some philosophers of physics have thought Stein's reply to Putnam was a success,[74] it seems obvious to me (and to many others[75]) that, whatever Stein may have taken to be the target of Putnam's argument,

Putnam was indeed attacking presentism and Stein's reply was simply a red herring. After a couple of muddles are cleared up, Putnam's argument turns out to be relatively simple: The presentist supposes that one foliation of Minkowskian space-time is very special; but no foliation is geometrically special; the presentist must, then, deny that SR tells the full story about space-time structure; and that is tantamount to rejecting SR.

Ted Sider offers an argument that is similar to Putnam's, at least in its overall thrust. After running through all the ways a presentist might try to define the shape of the present in terms of the manifold's Minkowskian geometry, Sider concludes that the presentist has little alternative but to suppose that the present effects a foliation that is "arbitrary" — that is, one not "distinguished by the intrinsic geometry of Minkowski spacetime."[76] But positing such a thing is "scientifically revisionary"; if presentists take this route, "[a] physical theory of time other than special relativity must be constructed".[77]

Many philosophers have endorsed the Putnam-Sider line of reasoning: SR is incompatible with the introduction of an A-theoretically privileged foliation, and this incompatibility is enough to refute presentism, along with any other A-theory that requires a similar addition.[78] Others are more cautious. For instance, Steve Savitt, Simon Saunders, and Bradley Monton agree that the presentist who found herself inhabiting an otherwise Minkowskian manifold would have to posit a privileged foliation; and that doing so would be incompatible with SR.[79] But Savitt, Saunders, and Monton go on to note that the relevance of such incompatibility is not entirely obvious, given the fact that SR is *not* our best theory of the space-time manifold. It is, after all, only approximately true,[80] and GR is, if not the final word, at least a closer approximation. Saunders and Savitt point out that GR may prove to be a more hospitable environment for the presentist than SR.[81] Saunders and Monton note that the

difficulties squaring GR with quantum theory throw its status into question as well; and a successor theory uniting gravity and quantum theory holds out even more hope for the presentist who is looking for a physically privileged foliation.[82]

In this section, I shall tease apart two things all these authors might mean by their talk of "inconsistency" or "incompatibility" with SR. One fairly clear criterion for inconsistency with SR has been put to use in debates about the compatibility of quantum theory and SR: a theory is inconsistent with SR if the laws of the theory appeal to "intrinsic structure" pertaining to "space-time itself", structure that goes beyond the Minkowskian metric. Several interpretations of quantum theory require the addition of a foliation that would constitute additional intrinsic structure, in this sense. But it is worth pointing out that not every added foliation qualifies as inconsistent by this standard. A theory can even add a causally-relevant foliation without violating SR, so long as the laws that make use of the foliation appeal not to intrinsic structure but to a foliation privileged by the material contents of the manifold. On a second, much weaker reading of inconsistency with SR, the A-theory will stand guilty; but the seriousness of the charge is far from clear. After disentangling these two forms of potential conflict with SR, I emphasize the strangely hypothetical nature of the supposed conflict: SR is false, and the outcome of extending the criticism to more realistic contexts is uncertain. Finally, I shall respond to Craig Callender's claim that A-theorists cannot expect aid and comfort from quantum theory.

Stronger and Weaker Forms of "Inconsistency with SR"

The grounds adduced for the inconsistency of SR and presentism seem straightforward enough, on first blush. As Saunders puts it: the metric of a Minkowskian manifold does not contain a

"non-trivial symmetric and transitive relation" that would divide the manifold into intrinsically distinctive equivalence classes, each of which could serve as a member of the presentist's privileged foliation. Of course the presentist's successively co-filled regions *might* happen to coincide with a series of slices having a relatively short geometrical description (e.g., they might coincide with the simultaneity-slices of one particular inertial frame). But even that much geometrical naturalness is not required by presentism; and, in any case, even a neat series of hyperplanes would have infinitely many rivals, cutting across the first series but satisfying the same geometrical description. Adding an A-theoretically privileged foliation to a metrically Minkowskian manifold inevitably results in a theory according to which there is more to space-time than what is described by SR.

But more needs to be said about the conditions under which an added foliation constitutes additional structure inconsistent with SR. Obviously, not just any addition of contents to the manifold should count as inconsistent with SR. The theory does not pretend to tell the whole truth about the actual physical universe we inhabit; it must be supplemented with additional laws about the behavior of specific physical phenomena, and with contingent facts about the material contents of space-time (e.g., "initial conditions"), before it can begin to predict any actual occurrences. Such supplementary physical theories and contingent facts "add structure to the manifold", in the broadest sense, without falling afoul of Relativity. The presentist posits a privileged foliation, alright; but why is this not simply adding some contents to space-time, no worse than a physical theory that attributes a certain finite shape to the material contents of the universe, say; or a theory of electro-magnetism that ascribes field values to every point in the manifold?

Those who accuse the A-theory of inconsistency with SR must be relying upon a criterion according to which the A-theorist's foliation constitutes an impermissible addition to Minkowski space-time, but a big bang theorist's bounded physical universe counts as harmless additional contents. The best place to look for explicit attempts to develop a criterion that would yield such a ruling is the debate over whether quantum theory can be interpreted so as to be consistent with Relativity. Tim Maudlin's work on this topic is particularly subtle and illuminating. Maudlin formulates his proposed criterion in this way: a theory is inconsistent with SR if it attributes more "intrinsic structure" to the manifold than is found in its Minkowskian geometrical properties. More generally, consistency with SR or GR is, he says, "a matter of formulating a theory so that it employs nothing more than the metric when describing space-time itself."[83] B-theorist critics invoke the prestige of physics, alleging that presentism is refuted "by physics itself" or claiming that it is "scientifically revisionary". By doing so, I take them to have incurred an obligation to use a notion of inconsistency with SR that is relevant to conflicts between SR and other scientific theories. I shall assume that, when scientists or philosophers of physics are asking about the inconsistency of one or another theory with Relativity, it is something like Maudlin's "additional intrinsic structure" criterion that is — or at least should be — in play.

Maudlin explores the subtleties of this criterion — when is a feature "intrinsic", belonging to "space-time itself"? — but one thing seems obvious enough: There are possible distributions of matter in a space-time with Minkowskian metrical properties that are consistent with SR, despite the fact that they effectively "privilege a foliation". Here is what should be an uncontroversial example: suppose there were, spread evenly throughout the cosmos, a kind of particle every member of which is moving inertially and at rest relative to every other. This

family of fellow-travelers would select an inertial frame; and there would be exactly one foliation of the Minkowskian manifold in which every slice is orthogonal to the path of every one of the special particles.[84] Since the foliation is the result each particle would get by using the Radar method to settle questions of distant simultaneity, the foliation could be called the "optical simultaneity slices" relative to that frame. The family of particles is, by hypothesis, very special; and the frame they pick out is, for that reason, also special. Should we say that any physical theory that posited such particles would be inconsistent with SR? If, according to the theory, the particles just *happen* to be traveling together in this way, then surely not. So long as the choice of their inertial frame is a contingent matter determined by initial conditions, it should not be attributed to space-time itself, even if they *must* travel on parallel paths. The particles choose a set of parallel inertial paths, and make these paths and the accompanying foliation special; but there need be nothing intrinsically special about the paths in virtue of which the particles *must* take them, rather than those of some other inertial frame.

A less contrived example of a foliation-selecting physical phenomenon in a Minkowskian manifold is the frame of reference associated with the center of mass of the universe. The center of mass determines an inertial frame and a corresponding set of optical simultaneity slices. Now, it turns out that one cannot, in SR, always count on there *being* such a frame; in some cases of matter distributed in a Minkowskian manifold, there will be too many equally good contenders for "the" center-of-mass frame; and in others, none at all.[85] So, like the field of special particles, the presence or absence of a unique center of mass is a contingent matter — though not so surprising a contingency as a uniform distribution of co-moving particles. But again, the point of the example is that no one would suppose this hypothesis — that the universe has a center of mass — is inconsistent with SR, despite the fact that it makes one foliation of the manifold look

special. What makes the A-theorist's foliation worse? The critic alleging inconsistency between presentism and SR owes us some explanation of the difference between an A-theorist's additional structure and these examples of harmless-though-foliation-privileging material contents.

One might try to make heavy weather out of the idea that attributing mass and energy to regions of space-time does not add intrinsic features to the manifold — even if it happens to privilege a foliation — since particles and fields are, in some sense, extrinsic to the manifold in which they are located. This seems a poor place to draw a deep distinction, however. Do we really want to say that the presence of matter or energy in a region is an *extrinsic* fact about that region? The physical contents of a region seem tolerably intrinsic to it. Given the representation of matter and energy fields by tensors, the physical features at a point have *implications* for arbitrarily nearby regions; but the field values at a point still seem *relatively* intrinsic to the point, and certainly intrinsic to regions that include a sphere of any size with the point at its center. One might try saying that the A-theorist's foliation depends upon properties exemplified by parts of the manifold itself, while the mass-energy distribution does not. But this, too, is a doubtful move. The value a field has at a point is often said to be a property of the point itself; and "supersubstantivalists" go further, treating particles as parts of the manifold that display the right sorts of properties. No one has ever suggested that either of these doctrines requires the denial of SR. And, in any case, it is not clear that the A-theorist must regard the fact that the points in a slice are all co-present as being due to properties the points themselves exemplify. A-theorists are not obliged to be supersubstantivalists. Why should we not say that the slices in the A-theoretically privileged foliation are special in virtue of facts about their contents, not in virtue of anything the points in these slices are doing all by themselves? The points in a special slice

could be said to be co-present in virtue of the fact that the particles and fields occupying those points are occupying them all at once.

How else might the critic of presentism distinguish between benign extrinsically imposed structure, and SR-violating intrinsic structure — and do so in such a way that foliation-privileging material contents qualify as extrinsic, while the metrical properties of Minkowskian space-time and the presentist's foliation qualify as intrinsic? One might try to forge a connection between extrinsicness and *contingency*: had the material contents of a region failed to be there, the region could still have existed; but had presentness failed to strike a region of space-time, that region could not have existed. One might think the presentist is committed to the latter thesis, because, on most A-theorists' conception of things, time (and so space-time) is impossible without an objective, moving present.

The hypothetical wielders of the proposed contingency-criterion are granting that the distribution of mass and energy in a region can be consistent with SR, yet impart additional intrinsic structure to the region in at least one sense; the mass-energy distribution is entirely a matter of what is happening *within* the boundaries of the filled region. But they are claiming that the region itself could have existed apart from the physical phenomena filling it — either with different fields and particles, or utterly empty of all but metrical properties. And the claim has plausibility, at least while we are pretending that SR describes the true manifold structure. Consider, for example, a finite universe in a Minkowskian manifold. Did the boundaries of the physical universe *have* to be located at precisely these space-time points? Not if this very manifold could have existed without matter, or with matter elsewhere instead. (Could the region occupied by the physical universe have existed with different metrical properties? That seems much less plausible — though I should not know how to begin assessing the pros and cons.)

These suppositions suggest a distinction that is in the right neighborhood; one that puts ordinary, physical content on one side and the metric of space-time on the other: A theory posits additional intrinsic structure to space-time itself if it attributes *non-contingent* intrinsic structure that goes beyond the metric; but attributing contingent intrinsic structure is not a problem. But does this sort of criterion yield the desired result: that the presentist's foliation is intrinsic?

If the contingency of the shape of the physical universe in a Minkowskian manifold is sufficient reason to call that feature extrinsic to the structure of space-time itself, then the presentist's privileged foliation could easily qualify as well. After all, the reasons I rehearsed for being an A-theorist did not compel the presentist to identify the privileged foliation with that of an inertial frame, let alone a *particular* inertial frame. It might be a necessary fact, with respect to each point of space-time, that it is included in some A-theoretically privileged slice or another; but the actual "angle" with which the manifold is cut by successive co-present events, and even whether the slices are flat simultaneity slices, can be regarded as deeply contingent. So, if SR were otherwise adequate as a description of the metrical properties of the manifold, and the contingency-criterion were used to judge whether some bit of additional structure fails to violate SR, the A-theorist's privileged foliation could be — and, by my lights, should be — regarded as contingent and therefore consistent with SR.

One might try imposing an even stronger contingency-criterion for determining whether something is intrinsic structure that does not count as a violation of SR. The presence of a finite physical universe within a Minkowskian manifold, M, would be a quite radically contingent feature of M, if M could have existed with *no* matter or other physical phenomena inside it. An A-theorist who believes the A-theory is necessarily true — there could be no temporal universe without objective facts about past, present, and future — might seem to be in a bind here. Could

the presentist go a comparable distance toward contingency, supposing that the Minkowskian manifold has a privileged foliation but could have existed with no privileged foliation — no series of slices of successively co-present events? If the unproblematic nature of contingent physical "fillings" of space-time requires that one take seriously the idea of an utterly empty manifold, I do not see why the presentist should not be able to do the same; the empty-boxer, at least, would have an easy time of it. Imagine a community of non-spatial Cartesian souls, communicating telepathically (the detail is added so as to make it clear that time is truly passing in the world they inhabit); and imagine further that, co-existing with these souls, there is the empty-box presentist's four-dimensional manifold of points, satisfying the geometrical description of a Minkowskian manifold. Spatially located events *could* happen at its points, although no such events ever happen in the world inhabited by the souls. The result is a Minkowskian manifold that could have contained an A-theoretically privileged foliation, but that does not as a matter of fact do so. It appears that, just as Minkowski space-time can be imagined without material contents, the empty-boxer, at least, can imagine it without a privileged foliation — even if the A-theory is necessarily true. A one-slice or ghostly-box presentist could make this move, so long as she could convince herself that points of Minkowski space-time which in fact never co-exist, or in fact never co-exist while exemplifying their fundamental causal structure, *could* co-exist while devoid of events and objects. If the contingency of physical phenomena in a region can only be secured by the critic's insistence that the points of Minkowski space-time could have existed with nothing in them, it is far from clear that the presentist, of whatever stripe, cannot legitimately claim to be able to imagine similar scenarios — possible circumstances in which the points exist without ever being present.

I do not say that this way of understanding inconsistency with SR has much going for it. For one thing, it would be difficult to extend this contingency criterion to a manifold satisfying GR, and still derive the result that its material contents are extrinsic but its metrical properties are not. Given GR, one cannot simply imagine away material contents without altering the metrical properties of the manifold — unless the contents are replaced by ones that put the very same constraints upon the space-time metric (for example, a proton in a region would have to be replaced by a particle with the exact same mass and any other properties affecting space-time metric; could such a particle be anything but a proton?).

A salient fact about the two examples of frame-privileging, SR-consistent physical phenomena — the inertial frame of the family of co-moving particles, and the center of mass frame — is that the foliation each privileges is causally inefficacious; at least, nothing in my descriptions of these frames gave them any causal job to do. This thought provides a more promising explanation of the innocence of frames distinguished by the material contents of the manifold. Here is the rough idea: It is no crime against Minkowskian space-time to posit contingent phenomena that happen to distinguish one frame from all the others; but what one cannot do, consistent with SR, is to posit *laws* governing some phenomenon (whether the phenomenon be physical or metaphysical) that *directly invoke* a privileged frame. What is inconsistent with merely Minkowskian intrinsic structure is to explain some fact about the contents of space-time as being due to the special nature of one foliation, and then not be able to appeal to any deeper laws that fail to mention that foliation. If the laws of a theory merely pick out the relevant frame of reference in terms of contingent material contents, and the contents merely *happen* to pick out that frame; then it is the material contents that are doing the work. But if a theory's most basic laws (whether they govern physical or metaphysical features of the

manifold) must invoke one inertial frame of reference or foliation "by name", as it were; then there is something special about the frame or foliation itself, quite apart from the manifold's content. The law is an indication that the manifold includes built-in "rails", directing things in a certain way; some structure that is part of space-time itself is doing the work.

This is, put very roughly, the option Maudlin takes in his discussion of the distinction between intrinsic space-time structure and mere material contents. Maudlin shows that, although the basic idea is clear enough, it can be a subtle matter whether a particular theory invokes laws that violate a criterion along these lines. When do the laws of a theory *directly* invoke a privileged foliation, frame of reference, or other aspect of space-time and its contents? It is not always obvious. Maudlin articulates criteria that, "applied with good taste, are the best we have to go on when trying to determine the intrinsic structure of space-time." Still, "it is not always clear how one determines when these criteria have been met."[86] I will not try to do full justice to the details of Maudlin's discussion of the criteria. But the difficulties he notes can be brought out, in an informal way, by briefly describing one of his chief examples: the question whether positing a lumeniferous ether constitutes a return to Newtonian absolute space.

The fundamental metrical structure of Galilean space-time does not include a cross-temporal relation of sameness-of-place — unlike Newton's persisting three-dimensional space, which, when combined with time, results in a manifold of place-times that *does* contain such a relation. In the absence of absolute sameness of place, Galilean space-time does not admit absolute velocities, only velocities that are relative to one or another frame of reference — which can be thought of as a set of (real or merely possible) objects in inertial motion that do not move relative to one another. By the 19th century, scientists knew that the velocity of light did not depend upon the velocity of its source, strongly suggesting that it behaved like a wave in a

material medium; and so they set about the task of discovering the frame of reference in which this medium, the ether, was at rest. Although they failed to find it, one wonders: "[W]hat would have happened if the ether frame had been detected, if light propagated in only one inertial frame?"[87] Would such a discovery have justified rejection of Galilean space-time in favor of the Newtonian variety?

If the laws governing light (and other electromagnetic phenomena) contain velocities, they appeal to what would be, in Galilean space-time, a frame-relative property of light. So long as there is a material medium to distinguish the relevant frame of reference, no additional space-time structure is needed; the laws of the theory need not directly appeal to the frame of reference, but can be formulated in terms of velocity relative to the material medium. But is the ether an independent, material medium? Maudlin offers a number of considerations relevant to answering this sort of question, only a couple of which I shall describe here. Does the so-called "ether" admit of different properties in different places? According to "ether drag" theories, for example, the speed of light would have been determined by different frames of reference in different locations. On such a theory, the ether seems much like a universal fluid, and space-time itself remains Galilean. Does the "ether" have to be everywhere? If the ether had turned out not to be universal (if, say, there were "ether vacuums" through which light could not pass), then again the ether would seem more like material content, less like intrinsic space-time structure. But if the so-called "ether" existed everywhere, determining one inertial frame; and if it were said to have no other properties characteristic of material things (e.g., it cannot be "thinned out or compressed"); then, by Maudlin's lights, it would have to be regarded as 'sufficiently "ethereal" to escape classification as a material substance', and "the existence of the

naturally preferred frame of reference would have to be taken as evidence that Newton was right and that there is more to space and time than the Galilean structure."[88]

Maudlin's goal is to develop a criterion for determining whether various interpretations of quantum theory are inconsistent with SR in virtue of positing intrinsic space-time structure beyond the Minkowskian metric. Some versions of quantum theory require non-relative facts about which of two spatially separated events is earlier than which. (Two theories of this sort will be described shortly.) These extra facts about quantum-theoretic priority imply that one foliation of the manifold is especially relevant to the results of quantum measurements. One might think that, just in virtue of including laws about a privileged foliation, such theories would have to be inconsistent with SR. But the morals learned from the case of the ether suggest that there may be subtleties here, and that one must proceed with caution. The mere presence of some contingent phenomenon that privileges a foliation does not automatically add intrinsic space-time structure; the quantum theorist's violation of SR cannot consist merely in positing some relation among points that effects a foliation. Suppose the laws of the proposed version of quantum theory allow that the foliation could have cut the manifold in various ways, or that the relation between points that determines quantum priority could have failed to generate a complete foliation. In that case, applications of the criteria that should lead us to say that the ether was mere material contents would yield the same result for the added foliation. The real threat to SR is not the addition of some content that enables one to pick out slices as special; but rather the positing of laws about the quantum foliation that appeal, directly, to a particular reference frame.

Must the laws of these varieties of quantum theory appeal to a *built-in foliation*? Not necessarily. As Maudlin and others have pointed out, if the foliation that determines quantum-

theoretic priority were lawfully correlated with the optical simultaneity slices of the center-of-mass frame for the universe, the resulting version of quantum theory would not appeal directly to one particular frame and its accompanying foliation. The location of the quantum-theoretic foliation would, on this supposition, be governed by the material contents of space-time; it would divide the manifold in the way that it does *not* because of any "rails" built into the manifold, telling events which slices they should occupy; instead, the "rails" would be laid down by the way matter is distributed.[89]

In the effort to prove the bare consistency of such a version of quantum theory with SR, one might flesh out the picture a bit: Imagine a kind of world in which space-time is otherwise Minkowskian and there occur phenomena at least superficially similar to our quantum events. Suppose that, as a matter of law, quantum measurements can only occur in such worlds if the universe has a well-defined center of mass; no center of mass frame, no quantum measurements. And which quantum measurements occur earlier than which is determined by priority within the series of optical simultaneity slices associated with the center-of-mass frame. Far-fetched? Yes. But that should not be relevant to the mere question of the *consistency* of SR and a theory that makes use of a privileged foliation in its laws. That question is answered by the existence of possible worlds in which quantum phenomena are tied to a special foliation, but the foliation in question does not constitute intrinsic structure beyond the metric of a Minkowskian manifold.

Here is another sort of law that, by Maudlin's standards (as I understand them), really ought to be judged consistent with SR: The foliation relevant to priority among quantum events is determined by the state of motion of just one particle emerging from the big bang; and, for every particle that existed at the origin of the physical universe, there was an equal chance that its initial state of motion would be the one to "choose" the quantum-priority frame of reference.

Neither of these imagined theories about a quantum-priority foliation would be at all plausible, were it being proposed as a theory of how quantum phenomena actually work. Maudlin rejects the center of mass idea immediately as a non-starter, not for inconsistency with SR, but for its improbability: one should expect the laws actually governing quantum phenomena to generalize to many different possible mass distributions; in particular, they ought to be able to hold in worlds with systems of particles lacking a unique center of mass. And so Maudlin does not pursue the idea that quantum theory and SR might *actually* be rendered consistent by means of a lawful connection between quantum priority and the center of mass of the universe. The stochastic law selecting a single particle to determine the foliation is my own invention; but I do not suppose it is any more plausible. Still, the conceptual possibility of such laws shows that a quantum theory of this general type — one requiring a non-frame-relative priority relation for quantum events, and thereby adding a privileged foliation to the manifold — is not inconsistent with SR, at least not given Maudlin's understanding of what constitutes additional intrinsic space-time structure.

The criterion we are using for determining inconsistency with SR is: postulating laws that directly appeal to intrinsic space-time structure beyond the Minkowskian metric. There are, in principle, ways for a quantum-theoretically privileged foliation to be governed by laws that respect this criterion. But then there must be, at least in principle, ways for the A-theorist to posit a "wave of becoming" that also respects this criterion. The A-theorist's privileged foliation is, in effect, the "mark" left by the wave of co-present events as they pass through the manifold; and, so long as only *consistency* is at issue, one may suppose that its progress is governed by principles ("metaphysical laws") similar to the proposed quantum theoretic laws: the series of co-present points is determined by the center of mass frame, or selected by the initial state of one

randomly chosen particle emerging from a Big Bang. In such worlds, facts about the contingent physical contents of the manifold would, in effect, tell the wave which slices to occupy; the "rails" along which the A-theorist's present must move would be laid down by matter, and no additional intrinsic space-time structure need be invoked in the fundamental laws governing the moving present.

Peter Forrest reaches a similar conclusion, in the course of arguing that his growing-block A-theory is not undermined by the (approximate) truth of SR.[90] Forrest asks us to consider the following hypothesis: as a matter of natural law, "Time passes in such a way that *some* system of parallel hyperplanes are successive presents"; but, within a Minkowskian manifold, the laws of temporal evolution do not determine which of the many possible series of hyperplanes it shall be.

> Once a given system of parallel hyperplanes has established itself, then the law tells us that all subsequent presents are also parallel, but how it got established is something to do with initial conditions, or, more accurately something to do with the early stages of the universe when Special Relativity was not a good approximation.[91]

Forrest identifies SR with the following two theses: "It is a law of nature that the electromagnetic constant *c* has a fixed value in cm per secs", and "All laws of nature are invariant with respect to changes from one frame of reference to another moving relative to the first with some uniform velocity less than *c*."[92] A law to the effect that the wave of becoming takes the form of *some* series of hyperplanes does not, he says, violate SR, so understood. "All [SR] implies [about the laws governing the A-theoretically privileged foliation] is that, whatever

the system of successive presents is, any relativistic transformation of this system would also be a (nomologically) possible system of successive presents."[93] By Forrest's lights, then, endorsing an A-theory that included these laws about the wave of becoming would not violate SR — so long as the additional laws (if any) that govern the "establishment" of the actual A-theoretically privileged foliation are also invariant with respect to the relevant changes in reference frame.

Forrest's requirement that, to be consistent with SR, the laws must display a certain kind of invariance is, in effect, a way of requiring that laws not appeal directly to additional space-time structure. On Forrest's supposition, each of the infinitely many time-like foliations of the otherwise Minkowskian manifold could have been the A-theoretically privileged foliation — that is, whatever laws govern the wave of becoming, they do not rule out any of these alternatives. The manifold has no "built-in" grain telling the present where it must go. What *does* select one series of slices is, he supposes, something to do with initial conditions; and if specifying these conditions does not, in itself, violate the criterion, then neither the laws nor the conditions that select a foliation violate SR. (Forrest has his own ideas about how a wave of becoming actually became established in our universe: he believes there are probably laws linking the privileged foliation with a frame of reference in which the expansion of the physical universe is nearly isotropic.)[94] Positing a wave of becoming inevitably privileges a single foliation; nevertheless, if the laws determining its location do not themselves appeal to non-Minkowskian space-time structure, the privileging does not require that the foliation be special in-and-of-itself — in advance of the contingent conditions that choose one foliation to be the lucky winner. A wave of becoming that obeys this law requires no more help from the manifold than the family of particles envisaged earlier: particles that inevitably move inertially and at rest relative to one another, but that could have been introduced into space-time in any frame. I shall call a "Forrest-

style law" any law about the A-theoretically privileged foliation that (i) allows nothing but the Minkowskian metric to determine a range of possible foliations, but (ii) does not dictate which of these foliations is actually selected.

What kind of initial conditions could determine the "angle" at which the present slices the manifold, given Forrest's laws about the evolution of becoming within a Minkowskian manifold? Consider the position of a one-slice presentist who believes in a finitely old physical universe, one that begins with a "bang" and is not caused by earlier events in space and time. If this presentist also takes SR to be the best theory of the manifold, she should probably deny that SR requires that any point-sized regions existed, prior to the first physical events. Matter, energy, and four-dimensional manifold come into existence together. One can take the earliest trajectories and *imagine* them having existed, occurring at (or, according to the reductionist about points, constituting) points that no longer exist; but, according to the one-slicer, the physical world has just come into existence, and these past points are mere fictions. Now the question that emerged from discussion of Forrest-style laws is this: Could the initial conditions of the material contents of the universe at the "bang" determine where the wave of becoming will lie, and do so in a way that does not depend upon laws appealing to additional intrinsic space-time structure, beyond the Minkowskian metric? Our one-slice presentist can easily formulate hypotheses that would do the trick. She can use either of the mechanisms considered above for determining a quantum-priority foliation. Perhaps the overall distribution of mass at the beginning of the physical universe selected a becoming frame; or some randomly chosen particle selected a frame. Neither supposition requires laws that directly invoke a particular foliation. Who knows how many other SR-consistent proposals the creative A-theorist might cook up — if, unlike us, she happened to live in a world that seemed, ultimately, to be Minkowskian?

What if *nothing* about the physical contents of the manifold determines the becoming frame? Would that be tantamount to adding intrinsic structure to the manifold itself? The following scenario calls for exercise of "good taste" on the part of anyone trying to judge whether it involves laws appealing to an intrinsically special foliation. Suppose one-slice presentism is true; but that the selection of a foliation is not determined, stochastically or otherwise, by the material contents of the universe. However, Forrest's imagined laws governing the wave of becoming are also true; and they determine its future location, given its past locations. Does this combination satisfy Maudlin's criterion for inconsistency with SR? Does it require laws invoking additional intrinsic manifold structure? The answer is, I submit, not a clear and definite "Yes". Granted, according to this combination of the A-theory with laws about the shape and location of the present, there is an additional *brute fact* about space-time that renders one foliation special. But, given the contingency of this fact, and the nature of the law supposed to govern the wave, it is not obvious that the brute fact requires laws appealing *directly* to a particular frame of reference and its associated foliation. Does the manifold itself provide the "rails" along which the wave must move? Or should we rather say that *nothing* provides the "rails"? An A-theory combined with a Forrest-style law governing the evolution of the wave of becoming, if it leaves its actual location completely unexplained, seems to me to be at best a borderline case of inconsistency with SR. The possibility of borderline cases should not come as a surprise. The moral has already been drawn from Maudlin's discussion of the ether: It is sometimes a subtle matter whether to say that a certain theory attributes structure to the manifold itself, or merely adds material content.

I have rejected a number of ways in which one might try to spell out "inconsistency with SR", and focused on the most promising proposal that one finds actually being applied to

scientific theories. There may be some alternative interpretations of "inconsistency with SR", applicable in scientific contexts, with which I have not engaged. But one gets no help finding them when examining the arguments of Putnam, Sider, and others who allege inconsistency between presentism and SR. Putnam and Sider do not discuss the possibility that the material contents of space-time might play a role in determining the location of the A-theoretic foliation in a Minkowskian manifold; presumably, they do not think the idea is relevant. But, given a Maudlin-style criterion of "inconsistency with SR", the possibility is highly relevant.

Unlike Putnam and Sider, Simon Saunders does consider the idea that a presentist might want to posit lawful connections between the series of co-present slices and some foliation-privileging physical phenomenon. He seems tacitly to agree with Maudlin's parallel judgment in the case of a quantum-foliation: If it *could* be made to work, it would save presentism from inconsistency with SR. But he rejects the maneuver:

> Of course, making reference to the matter content of space-time 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.[95]

Saunders alleges that a physically definable foliation must be "obviously privileged"[96] if the presentist is going to suppose that it coincides, in a non-accidental way, with the wave of becoming.

There can be no doubt that Saunders is onto something here. When the distinguishing mark of a physically privileged foliation is not very "deep" or natural, it becomes less plausible for an A-theorist to suppose that the foliation coincides, contingently but lawfully, with the progress of the wave of becoming. There is good reason to grant this: Positing non-accidental correlations between some highly natural kind and a relatively superficial or gerrymandered kind is always less plausible than positing such correlations between two highly natural kinds. The presentist is bound to think that her relation of absolute simultaneity constitutes an important "joint in nature"; and so she should be very surprised to find it lawfully linked to some "grue"-some physical feature.

So I accept something that is certainly in the vicinity of what Saunders is claiming: Suppose there were a presentist whose evidence otherwise supported SR, and who could find only gerrymandered or highly contingent physical phenomena to select a foliation; such a presentist should conclude either that something like Forrest's law is correct (the manifold allows for the wave of becoming to pass through at many angles, and it is a brute fact which one is chosen) or that the true principles governing the wave of becoming advert to space-time structure beyond the Minkowskian metric. I have granted, begrudgingly, that the former course might be thought to qualify as a borderline case of inconsistency with SR, by a Maudlin-style criterion, though no more than that; but the latter would obviously qualify as inconsistency with SR.

While I do not deny, then, that this sort of presentist, in these circumstances, would be forced in the direction of inconsistency with SR; I would emphasize that this is a highly hypothetical statement about what a presentist would have to believe in certain circumstances — circumstances which, as shall appear, do not apply to today's presentists (as Saunders himself

points out; in fact, I suspect that our differences may be primarily a matter of emphasis). The imagined linkages between the wave of becoming and a certain physically privileged foliation are supposed to be contingent. If somewhat implausible laws governing the present are not impossible, but merely unlikely, then there are possible worlds in which the link is a lawful one — even if the inhabitants of such a world ought not to believe in it. When the question is that of the bare *consistency* of presentism with SR, it would be wrong to require that the linkage must seem obvious to us, or be highly natural; it need only be a possibility. From the point of view of establishing consistency, Kent Peacock is right: "the interesting question is not what *metrical* structures can *necessarily* be found in *all* time-oriented spacetimes, while assuming from the outset that there are no spacelike dynamical interactions [e.g., superluminal motion]. … The aim is to determine what is possible, not what is necessary."[97]

When Sider, Putnam, and other critics invoke SR as evidence against presentism, they portray the presentist as *rejecting* a scientific theory. Accepting presentism, they say, would be "scientifically revisionary", it would require that one "reject" SR, and so on.[98] To justify the solemn invocation of science by Putnam, Sider, and others, the kind of inconsistency in question would have to be of a sort that holds between, say, Bohmian quantum theory and SR, or SR and GR. Maudlin's examination of inconsistency in such contexts is hard to gainsay; and, by his standards, there are numerous, non-crazy hypotheses according to which presentism and SR would be consistent. I conclude that Putnam and Sider have not made a case for their conclusion that presentism would *require* the revision of a well-established scientific theories, *even if* SR were a well-established scientific theory (which it is not; but more on that issue later…).

There are ways to force the presentist into imagined circumstances that would demand rejection of SR. The presentist can hardly deny that the wave of becoming moves through the

manifold in a way that is governed by *some* kinds of laws or principles. For example, assumptions (9) and (10) were found to put serious constraints on the shape of the present, and accessibility relations within the manifold determine the direction in which it moves. Assuming that a wave of becoming moves through a manifold that, A-theory aside, looks Minkowskian; and that no facts about the material contents of the manifold determine the "angle" at which the series of co-present events slices the manifold; and that the laws or principles governing the successive locations of the wave are not Forrest-style laws; then, at last, one has specified a possible world in which some extra intrinsic fact about the manifold itself *must* be what governs the location of the A-theoretically privileged foliation. But one should hardly, at the end of this series of stipulations, proclaim: Therefore presentism is inconsistent with SR; let alone, proclaiming: Therefore presentism is false.

A Weaker Form of Inconsistency

Some critics have argued that Relativity undermines the A-theory on grounds other than inconsistency of the sort examined above. Some have said that the absence of a privileged foliation in SR (and in many models of space-time consistent with GR) shows that, if we believed the physical theory, we should conclude: as far as physics is concerned, the A-theorist's relation of absolute simultaneity is not *needed*. And then these critics go on to claim that, if physics does not need something, it is not there — or at least we have no reason to believe in it. As Adolf Grünbaum put it:

> It seems to me of decisive significance that no cognizance is taken of nowness (in the sense associated with becoming) in any of the extant theories of physics. If nowness

were a fundamental property of physical events themselves, then it would be very strange indeed that it could go unrecognized in all extant physical theories *without detriment to their explanatory success*.[99]

This is more or less how Craig Callender portrays the conflict between scientific theories and the A-theory, though his discussion is more nuanced than Grünbaum's. For a presentist to posit "Minkowski space-time with a preferred foliation", under circumstances when SR seemed otherwise adequate, would be to introduce "otherwise unnecessary unobservable structure to the theory".[100] By Callender's lights, reasonable belief in the A-theory would have to be supported by some powerful philosophical argument for an objective past–present–future distinction, if its existence does not fall out of our best physical theory of space-time. Until such argument is given, "merely as a by-product of scientific methodology, physics will not accommodate [the A-theorist's foliation]"; "physics — and science itself — will always be against tenses [i.e., A-theoretic distinctions] because scientific methodology is always against superfluous pomp."[101]

I do not expect many die-hard B-theorists to be moved by the brief objections I shall raise to criticisms of this general style: "Your distinction does not appear in physics; therefore you have no reason to believe it marks a real 'joint' in nature". The one thing I *do* hope will be apparent to all parties is this: An objection in this style is a far cry from the claims of Sider and Putnam. In general, a theory that posits something not found in another theory does not automatically lead to *inconsistency*, even when the theories are describing the same objects.

Comparison with epiphenomenalism in the philosophy of mind may be useful. Some philosophers of mind take seriously the idea that consciousness might be an epiphenomenal property of brains — something extra, beyond the physical phenomena described by

biochemistry, but just as fundamental. They do not have to say that biochemistry gets the workings of the brain *wrong*, only that it does not tell the whole story. One criticism of epiphenomenalism is that the extra mental phenomena are not needed to do any extra work, or that the work they are supposed to do could not be done by them. Continuing to believe in the phenomena, in such circumstances, would be to believe in something that is *dispensable*. Callender, and others, have criticized presentism and the A-theory along similar lines: everything about time that needs explaining is explained by physical theories that do not mention objective past–present–future distinctions; such distinctions are, therefore, dispensable.

It would be a gross overstatement to characterize such arguments as based on inconsistency, rather than dispensability. They are allegations of intellectual profligacy, of positing more distinctions when one could have gotten by with fewer. A criticism of the A-theory built along these lines, and appealing to SR, would go something like this: if the A-theorist's past–present–future distinction does not play a role in SR (nor in SR conjoined with a physics of particles and fields roughly similar to those of the actual world), then it would be irrational to accept SR while nevertheless retaining this extra distinction.

To make such a dispensability argument persuasive, a good deal should have to be said about the myriad distinctions one *could* rationally continue to regard as objective, despite their absence from fundamental physics: What makes *them* okay, and the past–present–future vulnerable? The less "Scientiphical" amongst us (to use Peter Unger's term[102]) will believe in many things that fail to put in an appearance in fundamental physics; it will be harder to convince us that, if physics does not mention the present, then it isn't there.

I will not attempt to address dispensability arguments in great depth, but confine my attention to a couple of recent versions in which some efforts are made to explain what makes

the A-theorist's foliation especially vulnerable, worse off than other things that seem important but are unmentioned in physics: namely, the foliation's "elusiveness". The criticism is similar to a familiar objection to epiphenomenalism about certain aspects of consciousness; so I begin with application of a dispensability argument to that case.[103]

I should not want to deny that, in certain circumstances, if some distinction or property fails to show up in a scientific theory of the things that (allegedly) have it, this should count strongly against the objectivity of that distinction or property. Only an extreme form of "physics-ism", however, would insist that, unless a term appears in (the final, true) physics, it cannot be used to accurately describe real things. But there are more plausible requirements one could invoke: for example, that all the objective aspects of resemblance among things supervene upon the exemplification of properties mentioned in (the final, true) physics. An epiphenomenalist about consciousness can obey the letter of this supervenience claim by positing laws of final physics which govern the generation of the epiphenomenal properties, thus drawing them into the "supervenience base". Invocation of psycho-physical laws in order to respect supervenience is not the merest cheat it might at first seem. Physics (*a fortiori* final physics) has high predictive ambitions, and should probably be regarded as truly *final* only when its laws subsume *all* fundamental phenomena — including, if the epiphenomenalists are right, some aspects of conscious experience, namely, their "qualia" or phenomenal properties. Physicalistically-inclined philosophers will not be mollified by the invocation of such laws by epiphenomenalists, however. Given epiphenomenalism, a fundamental physics that failed to mention such properties would explain every physical event that can be explained; what work is left for qualia to do? Why should we expect them to show up as fundamental, at the end of the day?

At this point, the fans of qualia can point out that we — most of us — find ourselves drawn to recognize possibilities that *require* the extra properties; for example, the possibility of qualia inversions or qualia absence in creatures physically indiscernible from ourselves ("philosophical zombies"). But there is a special reason for being suspicious of adding these distinctions among phenomenal states, *given epiphenomenalism*. Positing a truly epiphenomenal property raises serious questions about our ability to know that it is exemplified. If their epiphenomenal nature means that, even if they *did* exist, we could not know anything about them, then it would not matter that qualia are part of our commonsense conception of things: we have no reason to care about them, and should be skeptical whether they even exist.

Critics of the A-theory have marshaled superficially similar arguments against the presentist: a fundamental physics built around SR would not mention the A-theorist's privileged foliation; the reasons A-theorists posit the distinctions that yield the foliation may well be ordinary beliefs that most of us have; but, were SR fully adequate, the A-theoretic distinctions would be elusive and unknowable. If it would be utterly mysterious how we could know about an objective past–present–future distinction, we have no reason to care about it, and should be skeptical about its existence.

Shortly, I shall consider whether the failure of SR and GR to mesh well with quantum theory has cast doubt upon the significance of this argument. First, though, I look at a couple of concrete attempts to support the main claims: that, given SR, we could not know, and should not care about, the presentist's A-theoretically privileged foliation.

Steven Savitt considers the idea that a Minkowskian manifold could simply be augmented with brute facts about the frame picked out by successively co-present events, and he expresses sentiments like those of Callender and Grünbaum. Savitt identifies stronger and

weaker forms of "inertial chauvinism" — i.e., choosing one frame of reference, and its planes of simultaneity, as the one selected by the wave of becoming. The stronger form "holds the principle of relativity to be false"; but there is a weaker form that does not go so far as that:

> A weaker version of inertial chauvinism agrees that all admissible frames of reference "are completely equivalent for the formulation of the laws of physics" but asserts that one frame is *meta*physically distinguished. This metaphysically distinguished present cannot, according to the relativity principle, be ascertained by any (classical) physical measurement or experiment. If the present is indeed so elusive, I find it difficult to imagine what aid or comfort it could be to a metaphysician.[104]

Epiphenomenalism (about consciousness) could be faulted for introducing something that would have no impact upon us. There seems to be a similar objection behind Savitt's nice turn of phrase in the final sentence. He insists that, for a feature of space-time to play the role assigned to the privileged foliation by presentism, it must mark a deep and important divide; it must be something we presentists can regard as providing "aid" and "comfort", something that satisfies our conviction that the present is more robustly real than past or future. So far, I agree. But he further alleges that, if the location of the divide between present and past or present and future were "elusive" — and, here, the elusiveness can only consist in uncertainty about what is present at relatively large distances, the kind of uncertainty there would be in an otherwise Minkowskian manifold with no faster-than-light processes — then the present could not mark a divide that we would rationally regard as deep and important.

Put thus sparely, the objection does not seem to me to have much force. Why should the inability to *tell* which distant events are in the past make it irrational for us to *care* whether they are in the past? For most of human history, there has been massive, unavoidable uncertainty about the times at which distant events occur. Yet people often wondered, "What is really happening over there now?", even when "there" was a great distance away and the answer was not determinable to within a small margin of error by any known means. Was it irrational for us — we human beings — to take the answer to this question to be an important one, back in the days when we lacked reliable methods for determining precise relations of simultaneity over significant distances on the earth's surface? Insisting upon the following principle would impugn the rationality of too many people: "If a person faces unavoidable uncertainty about whether something is past, then it automatically follows that they ought not to care whether it is past." Granted, *if* the A-theory is false, and *if* we inhabit a Minkowskian manifold, and *if* there are no faster-than-light processes (something that does not fall out of the Minkowskian metric by itself), then we were making a mistake to think that we could be asking about a deep, objective fact with the words: "What is really happening at that distant location now?" So, given all those assumptions, we were making a mistake; but those are assumptions no one could make before the advent of Relativity, and they are assumptions that the presentist still rejects.

Our ancestors should not be convicted of *irrationality* for thinking that the differences between past, present, and future are important ones, simply because they lacked precise clocks and rapid signaling methods. And if the contemporary presentist were forced, by relativistic physics, to grant that the lack of precise methods is a matter of physical necessity, I do not see that this should make her any more irrational then our ancestors, were she to continue to regard it as an important one. What could be more important than existing or not existing?

Craig Callender also provides a special reason to think that the presentist's distinctions, if they do not coincide with something found in physics, belong on the chopping block. And his suspicions, too, are based on the idea that merely adding a metaphysically privileged foliation to Minkowski space-time would result in a difference about which we could not know anything. He makes roughly the same point as Savitt (though in a slightly different context). He imagines a situation in which the presentist posits a privileged foliation, while admitting that, due to ineliminable restrictions on the precision of measurements, the "angle" at which it cuts the manifold cannot be empirically determined. In that case, "*[y]our intuitions, introspections, etc., all being species of interactions, can be in principle no guide to which foliation is the true foliation or even whether there is one*. If the world becomes or enjoys an objectively privileged present, then it is not something at all connected to experience (assuming physicalism)" [author's italics].[105] Whether or not the presentist accepts "physicalism" or the thesis that "intuitions" are really "interactions" (i.e., physical events in the brain), she should happily grant that experience would be no guide to the precise location of her privileged foliation, given certain packages of hypotheses that recent physics has sometimes seemed to favor — for example, *if* SR were true, *if* all causation were local, *if* superluminal influences were impossible, and *if* there were no reason to think the present is lawfully connected to some foliation privileged by the physical contents of space-time. But the presentist should not, however, sit still when Callender baldly asserts that, in such circumstances, our "intuitions" could be no guide to the question *"whether there is [an A-theoretically privileged foliation]*". The "intuitions" in question are, presumably, simply the widespread A-theoretic "intuitions" to which I have appealed in the argument for a privileged foliation — "intuitions" here being simply another name (and, in the context, a derogatory one) for mental states also known under more familiar names such as "convictions" and "beliefs".

Why is it that these beliefs are useless for determining whether there is an objective past–present–future distinction? The only reason given here is: if we take them seriously, and if SR is true, they will force us to believe in something about which we cannot, in principle, know everything we should like to know. I find this no more impressive than Savitt's argument.[106]

I am prepared to grant that someone is in trouble if they try to hold a combination of views along these lines: There is a feature that belongs to certain parts of the physical world, this feature does not seem to play a role in the best science of that domain, and every brain or mind would be exactly the same even if *nothing* had had this feature. But the presentist, at least, is *not* in a position analogous to this sort of extreme epiphenomenalism. It is not as though presentism has the result that we can know nothing about which events are present and which are not. The presentist must admit that our knowledge of what is present does not extend *very far*, if superluminal signaling is impossible, space is Minkowskian, and we have no reason to link the present to a foliation that is privileged by physical contents. The more implausible forms of the moving spotlight and growing block A-theory may be open to this sort of criticism; if being lit up by a primitive property of presentness, or being on the cutting edge of the block, are the only factors distinguishing present events and things from past ones, the minds and brains of ourselves and all our ancestors would be exactly the same in every respect but this one; and we would almost always be wrong in our judgments about the location of the present. It is difficult to see what "aid and comfort" the spotlight or the edge could offer, on a version of the A-theory that makes it impossible to know even which events in one's own life are present and which are past. But the more plausible versions of the A-theory do not fall into this trap.

Presentism is a view that, for many of us, has considerable "intuitive" appeal — by which I mean little more than that, upon reflection, many people find themselves believing it.

Scientiphicalist enemies of the A-theory who would use dispensability arguments against presentism may be making a flat-footed claim like Grünbaum's. But if they are to do more than that, they need to produce subtler principles relating the content of physics to our ordinary beliefs about the world, including beliefs with metaphysical implications. Perhaps a more compelling argument against the A-theory can be constructed along these lines; but, so far, I have not seen it done.

How Bad Would an Added Foliation Be?

What problems would face a presentist who adds an A-theoretically privileged foliation to an otherwise Minkowskian world? Perhaps the laws governing the wave of becoming could be made consistent with the letter of SR, in one of the ways I have indicated. Perhaps it would not be so radically epiphenomenal or elusive as to be irrelevant to human concerns. But could it really be added to a Minkowskian manifold without radically altering SR's description of space-time?

Once again, it proves instructive to consider the case of grafting a quantum-mechanically preferred foliation onto an otherwise Minkowskian space-time. How radically would this alter one's physics? Here is Maudlin's assessment: "This would not demand the elimination of any relativistic structure, but would undercut the relativistic democracy of frames."[107] By not eliminating the manifold's structure — such as the facts about which time-like paths are straight and which are curved — the quantum theorist who takes this route would not be robbed of the explanatory resources of the Minkowskian manifold.

> …[N]o positive part of the relativistic account of space-time is being *rejected*: rather, in addition to the Lorentzian metric, a new structure is being *added*. Because of this, there is a straightforward sense in which no successful relativistic account of any physical phenomenon need be lost or revised: if something can be accounted for without the foliation, then one need not mention it. So there is no danger that existing adequate relativistic accounts of phenomena will somehow be lost: *in this sense, the content of relativity is not being rejected at all* [my italics].[108]

Can the presentist claim that, in an otherwise Minkowskian world, her added foliation would not rob her theory of the explanatory resources provided by SR? Those who take the manifold seriously could plausibly make this claim.

I have argued that, in order to make sense of cross-temporal facts about motion in a theory like SR, the presentist should accept the existence of a manifold with built in metrical structure. She may be able to get away with only allowing one slice of the manifold to exist at present, talking about the formerly filled points indirectly by means of present surrogates in the form of persisting trajectories; or she might be forced to accept the ongoing existence of an empty or ghostly manifold; but, in any case, she must find a way to ascribe, at least to past and present points, the fundamental metrical properties mentioned in our best physical theories. The presentist who has gone so far as this is at a distinct advantage, if she should happen to inhabit a world that otherwise looks Minkowskian. She can accept the existence of a manifold with built-in paths of inertial and light-like accessibility satisfying the Minkowskian metric. She can insist that the kinematical part of explanations of motion should appeal to the fundamental metrical properties of this Minkowskian manifold (as opposed to those of a Newtonian or Galilean

manifold). And this will take some of the sting out of the need to add a privileged A-theoretic foliation as a piece of extra space-time structure. There is a sense in which she does not reject relativity, because she can continue to give the same kinds of explanations of the same physical phenomena on the basis of the same metrical facts about the manifold's intrinsic structure.

The sense in which such a presentist accepts SR can be illustrated by considering one of Craig Callender's arguments against the A-theory. Callender has two options to offer the A-theorist, should she happen to discover that she lives in what otherwise appears to be a Minkowskian world: (i) "[O]ne could adopt the empirically adequate Lorentzian interpretation", thereby rejecting SR on metaphysical grounds and returning to a Newtonian manifold that posits absolute space and absolute time. (ii) "Alternatively, we might keep the Minkowski metric but add more structure to spacetime. We might add a foliation, i.e., a preferred stacking of spacelike hypersurfaces that divides the spacetime manifold. Becoming, then, could occur with respect to this preferred stacking".[109]

Callender would like to saddle the A-theorist with the first option: "by far the best way for the tenser to respond to Putnam *at al*. is to adopt the Lorentz 1915 interpretation of time dilation and Fitzgerald contraction."[110] He does not, however, explain *why* he thinks the A-theorist should take this route, rather than taking his option (ii). And when, later on, he faults the A-theorist for having to retreat to Lorentz,[111] one begins to suspect that Callender's second alternative was the better of the two all along.

The presentist could hardly be *forced* to become a Lorentzian simply by adding a preferred foliation. Lorentz's immobile, universal ether provided an absolute relation of sameness of place over time, effectively turning Galilean space-time into Newtonian space-time again. The ether serves as a privileged inertial frame. For presentism to force a return to

Newtonian space-time, it must do the same; the wave of becoming would have to successively occupy the optical simultaneity slices of some inertial frame. But presentism does not, by itself, require this. The argument I gave for the conclusion that the present takes the shape of a thin slice of the manifold, and that the series of co-present slices constitutes a complete foliation, did not entail that the events in a single slice must be optically simultaneous; for all I said there, the foliation could just as well consist of "nonstandard simultaneity slices", hypersurfaces that do not correspond to the planes of simultaneity determined by the Radar method from a particular inertial path through space-time. If the hypersurfaces were sufficiently irregular, the shortest path between two points on a slice might *never* consist entirely of points within the slice. When an object consists of several disconnected particles, a nowhere-flat present of this sort might nevertheless *sometimes* cut each of the particles' paths at a point that falls on a single flat simultaneity slice. But this would be the exception, not the rule. The actual shapes of objects at various times would rarely correspond to the three-dimensional shapes assigned to the same objects by any optical simultaneity slice.

Adding a foliation of this "wobbly" kind, or slicing the manifold in some other non-standard way, would fail to select an inertial frame to play the role of absolute Newtonian space, and so could not possibly constitute a return to Lorentz. A problem with a wobbly present in a Minkowskian manifold is that no Forrest-style law could govern its progress. One might suppose that its shape is somehow determined by the material contents of the manifold — perhaps the presence of matter in the present slice tends to warp the shape of immediately succeeding presents, in something like the way matter was expected to warp a mutable ether, before the negative results of the Michelson-Morley experiments undermined ether-drag theories. Without some such association, an irregular wave of becoming would be a source of

massive indeterminism.

Fortunately (for the sake of this very hypothetical presentist, in a world radically unlike ours…), even coincidence with the simultaneity slices of one inertial frame would not automatically constitute a complete retreat to Lorentz. What does Callender think would be so bad about a Lorentzian approach to the physics of space-time, and how could it be avoided? In Lorentz's Newtonian space-time, the Fitzgerald contraction looks like the work of forces shrinking objects in the direction of motion when they move rapidly relative to "the ether" — an entity that, in Lorentz's theory, has become indistinguishable from absolute space. From the point of view of these rapidly moving things, objects at rest in the ether will look to be contracted and clocks to be temporally dilated, although this would be an illusion. As Callender sees it, the Lorentzian "introduces unexplained coincidences: why do those rods and clocks keep contracting and dilating, respectively? As a kinematical effect in Minkowski space-time, Minkowski space-time is a common cause of this behavior, which is otherwise brute in the Lorentzian framework."[112] It is simpler and more elegant to be able to regard the Lorentz invariance of laws governing many different kinds of forces as stemming from the same source, namely the structure of space-time.

But this the presentist can do, so long as she insists upon the fundamentality of the Minkowskian metrical structure of her manifold. Its structural features — the straightness and space-time lengths of light-like and inertial paths, in particular — provide the kinematical background upon which dynamical theories are to be erected. The location of the A-theoretically privileged slicing is supposed to be a contingent matter; where it falls is a further interesting fact beyond the Minkowskian metric; but the latter can play its role in explaining the shapes of the paths taken by particles, no matter where the A-theorist's present may lie.

Choice of a single frame by the wave of becoming does give one set of distance relations among objects a special status, metaphysically; and Callender will no doubt feel that this "introduces otherwise unnecessary unobservable structure to the theory".[113] But that is a different objection from the one to which I am responding here: that the presentist is unable to explain the Fitzgerald contraction as "a kinematical effect in Minkowski space-time", unable to regard a Minkowskian manifold as "common cause" of all frame-relative spatial contractions and time dilations. If the presentist insists that the Minkowskian metrical structure of her manifold is the real subject matter of SR, the presentist is in the same position as Maudlin's quantum theorist with a quantum-theoretically privileged foliation: the "old" Minkowskian explanations of various phenomena do not become inapplicable, merely because some additional structure has been posited.

Could SR Really be a Discription of the Presentist's Manifold?

It might be objected that the metrical properties the presentist ascribes to her four-dimensional manifold simply cannot be the same as those ascribed to Minkowski space-time by relativistic physics. After all, the latter is a theory about space-time; the presentist's manifold may be four-dimensional, but the fourth dimension is not exactly that of *time*. It is distance in the direction of light-like and inertial accessibility, but that is not a temporal direction. The presentist cannot give the same kinds of scientific explanations of motion as would be given by a Minkowskian B-theorist, if she is not even talking about the same metrical relations among points.[114]

It must be granted that the presentist has to give the structural properties of her manifold a metaphysical gloss somewhat different from that of the ordinary B-theorist. Still, all three presentists with a manifold — empty box, ghostly box, and one-slice —have the means to talk

about every formerly occupied point; all three can ascribe properties to sets of them in virtue of which they satisfy the Minkowskian metrical description, and they can construe this metrical structure as relevant to the motion of particles through the manifold in a way that certainly *sounds* just like the kind of relevance a B-theorist would ascribe to the properties of his Minkowskian manifold. If there is a difference in their explanations of physical phenomena, it is not apparent in the words (and equations) they use.

Whatever differences there are between the way presentist and B-theorist understand the ontology of the manifold and the nature of the relations between points that give it metrical structure, I do not think they should be called *scientific* differences. It would be a stretch to insist that the laws of physics can only be interpreted as laws about the relations within a B-theorist's block; and that the trajectories in the A-theorist's manifold are clearly *not* what relativistic physics is describing.

The unfairness of such an accusation becomes apparent when one considers other cases of metaphysical disagreements about things that are governed by scientific laws. In such circumstances, the laws articulated by the relevant science provide relatively abstract descriptions of the entities about which there is metaphysical disagreement; philosophers haggle over the best metaphysical scheme for classifying these entities; but, at least in many cases, the laws will stand as accurate descriptions of their behavior no matter which party is right about the metaphysics. For example, some metaphysicians believe that at least some objects with mass are "enduring things" — that is, things that last through time but do not need temporal parts in order to do so. Other metaphysicians believe that *everything* that lasts through time is, automatically, a "perduring thing" — something wholly constituted at each time it exists by a different instantaneous stand-in or temporal part. Physical laws about massive objects — for example,

Newton's laws of motion — will be given different metaphysical glosses by the two sorts of metaphysicians. The "endurantist" metaphysicians will say that Newtonian laws are really constraints upon the possible histories open to a single thing, provided that the thing has mass; the friends of temporal parts will regard the laws as describing the possible ways in which a series of massive-object-stages, each causally dependent upon earlier ones, can be spatiotemporally arranged. I suppose an endurantist who accepts Newtonian physics could try to refute perdurantists by arguing along these lines: Newton's laws only mention objects with mass; they do not require the existence of instantaneous object-stages; therefore these laws of motion are about enduring massive objects, not about series of object-stages; and so the laws of motion would be *overturned* if perdurantism were true — perdurantists are anti-scientific!

Newtonian perdurantists would be unimpressed by such an argument; and rightly so. Granted, if the endurantists are right, the laws about the behavior of massive objects are not laws about self-perpetuating chains of object-stages. But the perdurantists can plausibly turn around and claim that, if *their* metaphysics is correct, the physicists were in the business of giving laws about object-stage propagation *all along*. A modest sort of externalism about the natural kind, *object with mass*, will yield this result. If perdurantists are right about massive objects, the theory of motion would not be falsified, even if all the physicists who developed the theory had believed that objects endure.

The response I have offered the perdurantist can be used by our (hypothetical) presentist who wants to accept SR, and explain everything that it explains by means of Minkowskian metrical structure. If this A-theorist is right about the structure of the manifold, SR would not be false; rather, SR (whenever it was advanced "realistically", intended as an objectively correct description of the physical universe) was always a theory about the metrical properties of the

trajectories constituting the A-theorist's manifold, whether or not the proponents of SR were card-carrying A-theorists and would have accepted this description of their theory.

Fortunately, then, the presentist who adds a foliation to space-time but affirms its fundamentally Minkowskian metrical structure retains the right to draw the line between kinematics and dynamics exactly where it belongs on orthodox versions of SR; and this provides a sense in which "the content of Relativity is not being rejected at all" — to borrow Maudlin's description of the parallel case of the added quantum-theoretically privileged foliation.

But who is this presentist, forced to choose between Callender's two options: (i) a Lorentzian return to absolute space, and (ii) a Minkowskian manifold with an added foliation? It turns out that she is an entirely hypothetical philosopher who inhabits a world quite unlike ours — one in which SR seems otherwise adequate. Why should we actual-world A-theorists think that *our* fortunes are in any way tied to *hers*? That is the question to which I now turn.

The Plight of Some Merely Possible Presentists

Now that the prospects for reconciling presentism and SR have been explored, it is time to consider the extent to which the difficulties that have turned up (such as they are) should be taken to undermine presentism.

As Bradley Monton has emphasized, there is something decidedly odd about arguments like Putnam's and Sider's: the actual falsity of the A-theory is inferred from SR or GR, despite widespread agreement that SR is false, and that GR is inconsistent with quantum theory and therefore likely to undergo serious revision, at the very least. Just what are these authors assuming about SR that justifies accepting its (alleged) implications as true, despite the theory's falsehood?

When philosophers make use of SR in this way, they must be assuming that, although SR has been superseded by GR, the features of SR that conflict with presentism are preserved in GR. But it is not obvious that this is so. Saunders provides one reason to think that the prospects for presentism might look different, in GR.

> 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. [115]

Saunders is not claiming that, if our world satisfies GR, presentists would inevitably want to choose his example ("York time") as coincident with the wave of becoming. His point is that it is the sort of thing that *could* be thought to coincide with the A-theoretically privileged foliation. And GR has served up other physically interesting candidates. William Lane Craig, Peter Forrest, and J. R. Lucas, for example, suppose that "cosmic time" — "the fundamental frame of the cosmic expansion"[116] — "*contingently* coincides with metaphysical time", i.e., the A-theoretically privileged foliation.[117]

In short, the presentist's situation with respect to GR is much like it was with respect to SR: In some possible worlds, GR and presentism can be true together, because the laws governing the passage of the present make use of a foliation that is distinguished by the manifold

and its contents. Indeed, assuming GR, likely shapes for our manifold would allow a couple of ways to link the wave of becoming to a physically unique foliation. However, if one describes a sufficiently hostile (and probably *merely* possible) combination of manifold-plus-material-contents, no such laws can be formulated. A presentist who, unlike us at the present state of knowledge, found herself in such a universe, would face more pressure to add space-time structure beyond the metric of a GR manifold. Here is the similar argument such a presentist would face: According to her, the history of the universe includes facts about which events were truly simultaneous, and these facts select a series of slices that constitute a complete foliation. Is this wave of becoming acting in a regular way, obeying some law? Given a universe chosen for its hostility to the physical privileging of any particular foliation, either the evolution of the wave of becoming is insanely indeterministic, or it is governed by a law that could only link the present to some extra feature of the manifold itself.

But there is reason to worry about the relevance of GR to presentism, as well. An argument from GR to the falsehood of presentism would seem to require, not only that our universe be one of those with contents hostile to all physically privileged foliations; but also that GR be *true*. Quantum mechanics, however, is an even more impressively confirmed theory than GR; the two theories appear to be in conflict; and some of the most promising ways to iron out the conflict turn out to be quite friendly to the A-theory, since they reintroduce a privileged foliation of the manifold.[118] According to Monton, presentists should be encouraged by these developments: "general relativity is incompatible with quantum mechanics, so our most fundamental physics can be found in the nascent theories of quantum gravity, which attempt to resolve the incompatibility. It turns out that there are some theories of quantum gravity, which are compatible with presentism. Thus,…presentism is unrefuted."[119] A successful argument for

inconsistency with GR, at this point in time, would only show that the A-theorist *may or may not* have to posit either an additional layer of space-time structure (which could, as in the case of SR, leave the explanatory role of a substantival GR manifold intact) or admit massive indeterminism about the successive locations of the present. Why get worked up about the possibility of having to concede this, when things could look very different once quantum theory and gravity are successfully put together? I am not qualified to have an independent opinion about Monton's claims concerning the current live options for a unified theory of quantum gravity. But I find them confirmed by reliable sources — including the staunchly B-theorist philosophers of physics who serve as my main informants on such matters.[120] It is too early for presentists to begin hand-wringing.

Can one grant the falsehood of SR and the shakiness of GR, but still find inconsistency with SR or GR relevant to the truth or falsehood of presentism? I am at a loss to see how, and I find no suggestions in Putnam, Sider, or other B-theorist critics who emphasize the (alleged) inconsistency of SR and the A-theory. Perhaps inconsistency with SR is thought to show that, whatever the actual world is like, we are *not too far* from worlds in which SR could truly and completely describe all space-time structure — were it not for that pesky wave of becoming, and the laws governing its progress. Is that enough to undermine the A-theory's credibility, even if *our* space-time manifold turns out, in fact, to be friendlier to presentism?

There is something of an opportunity to make A-theorists uncomfortable here, since most of us reject the very possibility of worlds with temporal phenomena but lacking a wave of becoming — we think the A-theory is necessarily true, if true at all. So, if some possible worlds are temporal but have no A-theoretic foliation, this would show that the A-theory is not necessary and therefore not true.

It seems to me to be completely fair for the A-theorists to point out that: (a) all that has been shown is that, in these supposedly "nearby" worlds, more structure would have to be added to space-time than is supplied by a Minkowskian metrical description; and (b) this additional structure would not rob the presentist of the most important explanatory resources of SR, for reasons rehearsed above. We A-theorists should *not* admit that, in these (allegedly) nearby worlds, the A-theory would be false. What's more, the sense of "nearby" seems largely epistemic, and only dubiously relevant. The nearness consists in the fact that, had our evidence been only slightly different, we would have been justified in accepting SR as the final word about space-time structure. But, from a less anthropocentric, more objective point of view, one should say that the actual metrical features of our manifold are radically different than they would be in a Minkowskian universe. Granted, if GR is right, the world looks more Minkowskian as one looks at smaller and smaller patches of it; but a curved space-time with black holes and other radical deformities is very different from the infinite flat manifold of SR; and who knows whether it will look more or less Minkowskian when gravity and quantum theory are united? So the "nearby" Minkowskian worlds may well be far away from us, by objective measures.

I could even grant that my justification for *believing* the A-theory would, in fact, be undermined had I been in a world where, so far as physics is concerned, SR is adequate as a theory of the manifold; while nevertheless affirming that the A-theory is necessarily true in any world with temporal goings-on. Given the sense in which the presentist need not reject the explanatory virtues of SR, I do not think that the A-theorist should grant even this much. But, for the sake of argument, let it be granted. How much should that affect my convictions about the actual truth of presentism? For any interesting fact, including many necessary ones, it is

relatively easy to cook up circumstances in which the fact is *true* but the evidence misleadingly points away from it. And, given the actual falsity of SR, the presentist need not admit that the B-theorist has done any more in this case: We have been asked to imagine a world in which we might be misled into thinking there is no A-theoretically privileged foliation.

Would the Rejection of Relativity for Physical Reasons "Only Make Things Worse"?

In the actual world, quantum-theoretic phenomena raise difficulties for Relativity, and these difficulties may well require the introduction of a preferred foliation of one sort or another. I agree with Monton that A-theorists should be encouraged by this development. One would have to look closely to see what role a given foliation plays in the physics before reaching a judgment, but there will sometimes be reason to think that it coincides with the A-theorist's — as is the case in the examples to be discussed here: Bohmian quantum gravity and GRW.

Some "interpretations" of quantuam mechanics require non-local causal influences; in fact, it looks as though *most* require non-locality, once one sets aside "many worlds" versions of quantum theory.[121] Two much-discussed proposals — Bohm's theory and GRW, a theory with instantaneous collapses of the wave function — posit a foliation of the manifold unknown to Relativity.[122] Their viability might seem to provide aid and comfort to the presentist — indeed, I believe it does. But Callender argues that they would only make things worse!

Following Callender's discussion, I shall focus mainly on Bohm's theory, which implies that the outcome of the measurement of a particle can depend upon whether another particle, arbitrarily far away (anywhere within the first particle's "bow-tie" region), is measured *first*; but I believe similar morals could be drawn in the case of GRW's instantaneous collapses.[123] The natural development of a Bohmian theory in a Minkowskian manifold would simply add a

foliation, not found in the metric, that marks the line between "before" and "after" for quantum measurements. If we could determine the precise locations of pairs of particles as they go off into measurement devices, Bohm's theory predicts that we would discover the exact shape of the quantum-theoretically privileged foliation. But the theory also implies that we *cannot* determine precise locations. Does this constitute an implausible "conspiracy" in nature, a fiddling with the laws that feels like it was carefully designed to hide the shape of the series of quantum-theoretically privileged presents? Maudlin thinks not: 'the only reason we can't "see" the foliation is because we can't "see" the local beables [i.e. particle locations] with arbitrary accuracy (without disturbing the wavefunction), and the reason in turn for this is given by the structure of the basic dynamical laws that govern all physical interactions.'[124]

> When trying to formulate a Bohmian theory in a Relativistic domain, there is an evident need for some structure that will give rise to non-locality, and the postulation of a foliation is the simplest, most natural way to be able to write down non-local dynamical laws. *And once the foliation is postulated, no particular effort or adjustment of parameters is made with the purpose of hiding the foliation*. Rather, one writes down the simplest dynamical equations that look like versions of the non-Relativistic equations, and it then *turns out* that foliation will not be empirically accessible. Once the equations are in place, all the rest is just analysis.[125]

Maudlin argues for a similar conclusion with respect to the instantaneous collapses posited by a quite different version of quantum theory, GRW: The theory needs a foliation to be added to the manifold, if it is to be developed in an otherwise Minkowskian setting. Because it makes slightly

different empirical predictions than more orthodox versions of quantum theory, GRW's additional foliation would be, in principle, detectable — but only by means of experiments we lack time or technical ability to carry out.[126]

Should the presentist be at all encouraged by the fact that a few philosophers of physics and theoretical physicists working on the foundations of quantum theory feel the need to add a foliation to an otherwise relativistic manifold? Should we hope that they are simply discovering a use for the foliation the A-theorist has been positing all along (thereby vindicating Arthur Prior's prediction that, eventually, scientific opponents of the A-theory would come slinking back to make use of his tense logic)?[127] Callender says, No. He describes what a Bohmian would say about the case of measurements of a two-particle system made at space-like separation by two characters, A and B. The precise details of the set-up are irrelevant for present purposes; what is important is that the Bohmian will say that it makes a big difference which one of them *measured first*. If A measured first, then A determines the outcome of B's measurement; if B measured first, the reverse is the case. To make sense of non-relative facts about relations of temporal priority among events at space-like distances, the Bohmian needs a preferred foliation that settles facts about which event-locations are earlier than which, for quantum-mechanical purposes.

Callender denies that Bohmianism would make a happy home for the presentist:

> There is an in principle irresolvable *coordination problem* between the two preferred foliations, the metaphysically preferred foliation posited by the [A-theorist] and the physically preferred one by Bohmian mechanics. There is simply no reason to think the two are the same. Only blind faith leads one to expect that the two are coordinated. In

> our above experiment, A might measure first and then B measure second according to the Bohm frame, yet according to the temporal becoming frame B measures first and A second. Assuming the becoming frame is primary, we would say B really happened before A; meanwhile fundamental physics would say that A happened before B. Since it would be a miracle if the two frames coincided exactly, with near certainty this will be the case for *some* pairs of events. *Hence the tenser is committed to asserting that with near certainty fundamental physics gets the order of some events the wrong way round.* Far be it from quantum mechanics saving tenses, the tenser merely trades one conflict with fundamental physics for another.[128]

Is it only "blind faith" that could convince the A-theorist that the two foliations coincide? That depends upon whether it could only be "blind faith" that makes (9), above, or the slightly weaker principle (9*), seem plausible:

> (9*) For any events e^1 and e^2, e^2 is causally dependent upon e^1 only if, when e^2 was happening, e^1 was happening or had already happened.

Given (9*), the Bohmian's privileged foliation could not cut across the A-theorist's. The Bohmian foliation is introduced precisely to answer questions about causal dependence; whether the outcome of one measurement depends upon the outcome of another measurement, or vice versa, is determined by which of the two occurred first, according to the Bohmian ordering. In Callender's example, the fact that measurement B came out a certain way is causally dependent upon the fact that measurement A was made first (relative to the Bohmian foliation); but, if the

A-theoretically privileged foliation could cut across the Bohmian one, there will be measurement situations like this in which B is happening, but A has not yet happened — a combination ruled out by (9*). No doubt Callender noticed that cross-cutting of the foliations would force an A-theorist to accept that an event can be causally dependent upon one that has not yet happened. He must, then, think that a presentist has no reason to believe principles like (9*), and could only accept them on "blind faith".

Suppose the presentist really has no right to appeal to (9*). If even this mild causal assumption is unwarranted, I had no right to use (9) in my argument about the current shape of the present. If there is no presumption that presently occurring events are caused by events that have already happened, then it should be "up for grabs" whether presently occurring events at locations other than my own include ones inside or on the surface of my rearward or forward light-cone. The only reasons I can find to rule them out are the sort I rehearsed above: the rearward ones may already have affected me, and so must already have occurred; and the forward ones could be affected by me, and so cannot yet have occurred. It would be strange to grant the presentist this much use of (9), while denying her the right to use similar reasoning in the case of the Bohmian foliation. If the presentist is justified in supposing that what is happening now does not include a dinosaur's death or the death of the sun, she is also justified in judging that the Bohmian and A-theoretic foliations coincide.

Callender argues that the Bohmian's foliation would be of no use to the A-theorist; but his argument requires that (9) and (9*) be utterly unmotivated for a presentist. The presentist is bound to disagree: she will regard such principles as extensions of something known to be true with respect to causal dependencies among events in her own life. The presentist needn't

produce an indubitable a priori proof of these intuitively plausible and inductively confirmed generalizations in order to believe them on the basis of something more than blind faith.

V. Conclusion

Summing Up

The main problems for presentism discussed in this paper were: (1) Sider's argument that presentists lack adequate grounds for physically important cross-temporal relations involving motion; and (2) objections based on inconsistency with Relativity, especially those based on alleged inconsistency with SR. My main conclusions can be summed up as follows:

(1) Sider's problems about cross-temporal relations require that presentists take manifold structure seriously. In a Galilean or Relativistic universe, physically fundamental cross-temporal relations force the presentist to admit the existence of formerly occupied points, or find some kinds of surrogates for them in the present. The simplest strategy would be to adopt a growing-manifold presentism; but I suggested a way to maintain a one-slice presentism with persisting trajectories that passed through no-longer-existing points.

(2) I tried to show that the conflict with Relativity is not so deep as one might think, while also calling into question the relevance of conflict with SR or GR. If we inhabited a manifold that appeared to have the metrical properties of Minkowski space-time or of some foliable manifold satisfying GR, those of us who are presentists would not automatically be forced to reject SR or GR, because we would not automatically have to posit laws involving additional intrinsic space-time structure. The present might march in step with some physical phenomenon, and so obey laws that do not directly appeal to manifold structure going beyond

the metric. Even if the presentist were forced to posit such additional structure, she would not be radically scientifically revisionist, so long as she accepts the existence of the manifold and recognizes the fundamentality of its structure in scientific explanations. Furthermore, the relevance of whatever conflict there might be between presentism and either form of Relativity remains uncertain. SR is false, and GR is challenged by quantum theory. Although most physicists who are looking for a theory of quantum gravity are trying to get by without imposing a preferred foliation upon space-time, some think we need to do so. I lack the expertise to hazard an informed guess about the relative chances of these two kinds of theories. But some of the reasons proposed for introducing a physically distinguished foliation would play right into the presentists' hands. So long as we are allowed to appeal to principles like (9) or (9*), we would have good reason to suppose that physics had come around at last, and found a use for genuine simultaneity after all.

Pushing Back

Metaphysicians — including the numerous theoretical physicists and philosophers of physics who moonlight as metaphysicians — should naturally like to be able to invoke the prestige of physics in settling disputes. After all, scientific questions actually do get settled occasionally, unlike so many of the larger questions of metaphysics; it would be nice if stable results in physics could provide some leverage on the slippery problems of metaphysics. And this metaphysician, at any rate, agrees that physics simply *must* be relevant to many of the metaphysician's central concerns. What part of metaphysics is more exciting than the attempt to locate ourselves — thinking and feeling human agents — in the physical world? Since physics

represents our best efforts to describe the fundamental nature of that world, metaphysicians cannot ignore advances in physics if we are serious about this project.

However, when appealing to findings from empirically well-grounded disciplines, philosophers face a strong temptation to overstate their case — especially if their philosophical opponents can be relied on to be relatively innocent of new developments in the relevant science. I fear that some B-theorists have succumbed to the temptation, judging by the relish with which they often pronounce a verdict based on Relativity. They can practically hear the *crunch* of the lowly metaphysician's armor giving way, as they bring the full force of incontrovertible physical fact down upon our A-theoretically-addled heads.[129] But what actually hits us, and how hard is the blow? SR is false; GR's future is highly uncertain; and the presentist's conflict with either version of Relativity is shallow, since the presentist's manifold can satisfy the same geometrical description as a B-theorist's manifold, and afford explanations of all the same phenomena in precisely the same style. In these circumstances, how could appeal to SR or GR justify the frequent announcements that the A-theory–B-theory dispute has been "settled by physics, not philosophy"?

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[*] In my work on the topic of this paper, I have incurred many debts; I feel sure I will fail to acknowledge some who helped me over the years, and I had better apologize in advance. My greatest debt is to Tim Maudlin, whose seminars, papers, and books have taught me whatever I know about Relativity. In addition, Tim provided all kinds of useful advice and criticism, helping me to avoid many mistakes (though he was not, in the end, able to save me from the biggest mistake, namely, defending presentism!). I also owe a great deal to conversations or correspondence with: Frank Arntzenius, Yuri Balashov, Craig Callender, Robin Collins, William Lane Craig, Tom Crisp, Shamik Dasgupta, Kit Fine, John Hawthorne, Hud Hudson, Barry Loewer, Peter Ludlow, Ned Markosian, Bradley Monton, Alan Rhoda, Jeff Russell, Steve Savitt, Ted Sider, Zoltan Szabo, and Timothy Williamson. I learned much from questions and conversations after talks at the University of Georgia, NYU, Western Washington University, Oxford, and Rutgers; and in the Rutgers philosophy of religion and metaphysics reading group.

[1] J. McT. E. McTaggart (1927: 10).

[2] Dolev (2007), for example, rejects the current A-theory–B-theory debate altogether; he advocates an anti-metaphysical approach to questions about the past, present, and future, hoping to bypass all the traditional metaphysical issues. For less radical forms of skepticism about the A-theory–B-theory distinction, see Lombard (1999, forthcoming), William (1998), and Callender (2000).

[3] B-theorists who affirm that Relativity provides the deepest, most objective description of the relations between events will want to fiddle with McTaggart's B-relations; outmoded conceptions of *being earlier than* and *being simultaneous with* must give way to the more fundamental relations of spatio-temporal distance encoded in the metric of the manifolds of Special or General Relativity. Objective (i.e., not-merely-relative) temporal precedence

relations remain, though they only hold between events one of which could reach the other by a flash of light or slower means; and simultaneity is at best a relative affair.

[4] Although it seems that most philosophers who take a position on the matter are B-theorists; nevertheless, A-theorists have made up a significant proportion of the metaphysicians actually working on the A-theory–B-theory debate during the past ten or fifteen years. We A-theorists might be inclined to explain this as a case in which the balance of opinion among the experts diverges from that of the hoi polloi. There is an alternative explanation, however. I have the impression that there is a much larger proportion of incompatibilists (about free will and determinism) among those actually writing on free will than among philosophers more generally. A similar phenomenon may be at work in both cases: The B-theory and compatibilism are regarded as unproblematic, perhaps even obviously true, by a majority of philosophers; they seem hardly worth defending against the retrograde views of A-theorists and incompatibilists. Philosophers sympathetic to A-theories or incompatibilism, on the other hand, are more likely to be goaded into defending their views in print precisely because they feel their cherished doctrines are given short shrift by most philosophers.

[5] See Hinckfuss (1975), Lucas (1989), Lowe (1998: Ch. 4), Bigelow (1996), Merricks (1999), Markosian (2004), Crisp (2004, 2003), Smith (1993); Bourne (2006), Monton (2006), Cameron (2008), Craig (2000), McCall (1994), Ludlow (1999), Schlesinger (1980, 1994), Adams (1986), Forrest (2004, 2006), and Nicholas Maxwell (2006). See also Zimmerman (1996, 1997, 2006a), and Gale (1968) (though Gale has since repudiated the A-theory). Tooley (1997) sounds like an A-theorist, although I am not so sure that, in the end, he is one; for discussion of the question, see (Sider, 2001: 21-5).

[6] See Broad (1923) [an excerpt in which Broad defends an A-theory is reprinted in (van Inwagen and Zimmerman, 2008: 141-9)], Prior (1970, 1996, 2003), Chisholm (1990a, 1990b, 1981), and Geach (1972). Charles Hartshorne is another famous 20th century A-theorist (Hartshorne, 1967: 93-6).

[7] See Frege (1984: 370) and Russell (1938: Ch. 54).

[8] See Williams (1951), Quine (1960: §36), Grünbaum (1967: Ch. 1), Smart (1963: Ch. 7; and 1987), Lewis (1976, 1979, 2002, 2004), Mellor (1981a, 1981b, 1998), Horwich (1987), Sider (2001), Le Poidevin (1991), Oaklander (1991), Savitt (2000), and Sattig (2006).

[9] Sider (2001: Ch. 2) gives a litany of serious objections; for a useful strategy presentists might use to respond to certain kinds of objections, see (Sider, 1999).

[10] Sider (2005) discusses the prospects for carrying out such a project using binary, undirected tense operators.

[11] See also Jill North's chapter in this volume for discussion of the closely related topic of "Time in Thermodynamics".

[12] The strategy can be found in Lombard (1999, forthcoming), Williams (1998), Callender (2000), Dorato (2006), and Savitt (2006) — though Savitt tries to salvage some kind of disagreement that could occur in the context of certain scientific theories about space-time.

[13] See Zimmerman (2005, 2006a), and also Sider (1999, 2006), and Crisp (2004). See also Mozersky, "Presentism", in this volume; and Ludlow (2004).

[14] See Keller (2004), Armstrong (2004: Ch. 2), Lewis (1999a), Sider (2001), Tooley (1997), and Mozersky, this volume.

[15] Examples include Crisp (2007a), Bourne (2006), Cameron (2010), and Rhoda (forthcoming). Although I have some sympathy with the idea that the demand for truthmakers is illegitimate, I have also argued that defenders of

truthmaker arguments must admit that Rhoda's proposed truthmakers are adequate to the task; see Zimmerman (2009).

[16] For example, Merricks (2007: Ch. 6), and Kierland and Monton (2007).

[17] Broad (1923: 66).

[18] Prior (1959, 1996).

[19] For B-theoretic replies to Prior's argument, see Mellor (1981b), MacBeath (1983), and Hardin (1984).

[20] See Braddon-Mitchell (2004) and Bourne (2002) for statements of this objection to the growing block.

[21] Merricks (2006).

[22] As I read Adams (1986), he holds a version of this view; Forrest (2004) develops a related view, according to which the past changes in such a way that consciousness disappears. For more discussion, see Zimmerman (2008: 212-216).

[23] Chisholm (1970, and 1976: Ch. 4).

[24] Bennett (1988) provides a subtle analysis of the systematic differences in these two ways of talking about events.

[25] I should not want to put too much weight on our initial inclination to disbelieve in explosions and games that do not occur, given that contexts can be created in which it seems fine to talk about such things; for example: "In 2005, a grenade was thrown at George Bush in Tbilisi, Georgia; the explosion of the grenade was prevented by a

malfunction of the firing mechanism." Perhaps the use of certain kinds of names for events can create a tacit restriction of the domain of quantification to *events that occur*.

[26] Heathwood (2005) makes the point that, if the principle reason for being a growing blocker (rather than a presentist) is to have better truthmakers for statements about the past, this sort of growing blocker is in trouble.

[27] Although this sort of A-theory may never have been held by any historical individual, it is in fact the version of the A-theory McTaggart attacks in his argument against the existence of time; and McTaggart has an (unconvincing) argument to the effect that it is the only potentially sustainable version of the A-theory (McTaggart, 1927: 12-18).

[28] There is a form of the eternalist growing spotlight view that can leave the future radically open. Eternalism requires the existence, already, of every future event and individual that will ever occur or exist, thereby threatening to "close off" other future possibilities. But if every possible future event and individual already exists, though many of them will never occur or be made concrete (as in, for example, Timothy Williamson's densely populated ontology (Williamson, 1999)); then the bare existence of the future history that will, in fact, have occurred could not be thought by anyone to raise the specter of fatalism.

[29] Lewis (2004).

[30] See Prior (2003) for an informal presentation of his tense logic.

[31] Sider (2001: 25).

[32] For objections to use of span operators by presentists, see Lewis (2004) and Sider (2001: 26-27); for attempts to introduce span operators while respecting presentist scruples, see Brogaard (2007) and Bourne (2007).

[33] See Lewis (2004) and Sider (2001: 25-35).

[34] For a variety of strategies presentists might use to tackle various problems of cross-temporal relations, see Chisholm (1990a, 1990b), Markosian (2004), Sider (1999), Szabo (2007), Crisp (2005), Bourne (2006: 95-108), Bigelow (1996), and Zimmerman (1997); for more criticism, see Davidson (2003).

[35] This was the strategy I advocated in (Zimmerman, 1997); Bigelow (1996) defends a very similar idea. Of course some will find these entities too "abstract" (a word with no fixed meaning, but often used as a term of abuse) to serve as causal relata, since they are rather like propositions (indeed, Chisholm held that they simply *were* a certain kind of proposition).

[36] These are terms introduced by Cook Wilson (1926: 713), Stout (1921/22), and Williams (1953).

[37] For discussion of "tropes throughout history", see Mulligan, et al. (1984: 290-93).

[38] Szabo (2007: 414). Szabo points out that the term "resultant states" was coined by Terence Parsons.

[39] Sider (1999) offers presentists a version of this quasi-truth response; Markosian (2004) defends a slightly different one.

[40] Shoemaker (1998).

[41] Maudlin (1993) explains why Newton's space-time and that of SR are more promising contexts for relationalism than are Galilean space-time and the manifolds countenanced by GR.

[42] In Belot's words: "The observation that the structure of Minkowski spacetime is incompatible with the lapse of time and the existence of genuine change would be of limited interest if similar conclusions did not follow in more fundamental contexts", such as "general relativistic cosmology" (Belot, 2005: 263).

[43] Maudlin (1993).

[44] Balashov and Janssen (2003: 340-1) ask whether "the Minkowskian nature of space-time explain[s] why the forces holding a rod together are Lorentz invariant or the other way around". They opt for the first answer, and regard the explanatory power of Minkowski space-time as a reason for realism about its structure and existence. Brown and Pooley (2006) take the second option, and it leads them to declare Minkowski space-time (in the words of their paper's title) "a glorious non-entity". Saunders remarks that, since Brown and Pooley do not follow Lorentz in positing a privileged rest frame, "they suppose that the forces which yield the contraction and dilation effects may be explanatory, even if there is no fact of the matter as to what they really are" (Saunders, 2002: 290, n. 13).

[45] Maudlin (1993: 199); see also Nerlich (1994).

[46] See Norton (1989), and Earman (1989). I should also note that the "hole argument" depends upon a number of highly abstract metaphysical theses that have been called into question by its critics. The argument depends upon a quite technical definition of "determinism", and then assumes that any decent theory of space-time has to be consistent with the possibility of determinism, *in this precise sense*. It also presupposes a kind of haecceitism about space-time points that is not beyond question. For criticism of the "hole" argument, see, e.g., Maudlin (1989).

[47] See Barbour (1999: 165-181). Belot (1999) also champions revival of the relationalism–substantivalism debate in the context of GR; but, again, the relationalism he articulates makes free use of a plenum of point-like entities, and is close enough to substantivalism for my purposes.

[48] One need not regard the "telling" as anything like a causal process. And one need not regard the dispositional characterizations of these relations as fundamental. Perhaps the distance relations are "categorical", and it is a merely contingent fact that they play these roles with respect to the propagation of light and the motion of particles.

Mundy (1986) reconstructs SR on the basis of five physical relations tied closely to the kinds of physical processes Einstein employed in constructing coordinate systems.

[49] For similar reactions, see Prior (1996), and Bourne (2006: 172-76).

[50] Prior (1996), Smith (1993: 225-38), Craig (2001: Ch. 8), and Bourne (2006: 172-176) are examples of A-theorists who charge Einstein with verificationism, and advocate A-theoretically-based notions of simultaneity.

[51] In almost all GR manifolds, there is no slicing of the manifold definable by anything like the Radar method; this might lead one to dismiss it as an unimportant structural feature of the SR manifold as well, if one is thinking of SR as a sort of special case of a GR manifold; see, e.g., Maudlin (2008: 156).

[52] Confronting certain non-foliable space-times discovered by Gödel (1949), Einstein, for example, asked "whether these are not to be excluded on physical grounds" (Einstein, 1949: 688). I take it he was not merely considering whether to exclude them from the category of likely candidates for our space-time.

[53] Crisp (2008: 274) takes the same attitude toward non-foliable GR manifolds. Monton (2006: 274-6) points out that GR is false, anyway; and he speculates that non-foliable manifolds may well turn out to be physically impossible according to whatever theory of quantum gravity supercedes GR.

[54] Gödel's (1949) argument against the reality of time makes use of a particularly oddly shaped GR manifold. For a recent criticism of Gödel's much-discussed argument, see Belot (2005).

[55] The argument leading to (8), below, is similar in some respects to arguments that can be found in Sider (2001: 42-52), Savitt (2000), Saunders (2002), and Callender (2000).

[56] For a better description, see Maudlin (2002: 104-108).

[57] Arthur (2006) introduces an interestingly shaped "present" that he calls "the interactive present"; it is defined in terms of the region around a part of a worldline that contains all the places from which there could be "mutual physical connection" between the place and the worldline. In SR, it turns out to be the intersection of the backward lightcone of the latest point on the worldline and the forward lightcone of the earliest part of the worldline. Arthur does not intend his interactive present to provide anything like the objective "shape of the present" required by an A-theorist. According it an objective status would give *r* and some world-line segment including *r* a unique role to play in the evolution of the universe.

[58] Even if Relativity were taken to imply that "what has already happened" is relative to a frame of reference, (9) would not imply that there is anything relative about causal facts, so long as light is an upper limit on the propagation of causal dependency. Events on or within the backward light-cone of another event are earlier than it according to every frame.

[59] William Lane Craig has brought to my attention a paragraph from Bergson in which he argues for a single plane of simultaneity, the same for all, in an analogous way, but based on our experience of "indivisible duration": "Each of us feels himself endure: this duration is the flowing, continuous and indivisible, of our inner life. But our inner life includes perceptions, and these perceptions seem to us to involve at the same time ourselves and things. We thus extend our duration to our immediate material surroundings. Since, moreover, these surroundings are themselves surrounded, there is no reason, we think, why our duration is not just as well the duration of all things. This is the reasoning that each of us sketches vaguely, I would almost say, unconsciously" (Gunter, 1969: 128-9). I do not know whether the durations of which I am aware are supposed, by Bergson, to be measurable using my clocks. If they are, I would reject this argument. Since my state of motion changes, using the Radar method to measure distant simultaneity will yield inconsistent results; and, assuming Relativity is right about the amount of metrical structure that is built into the manifold, some possible distributions of matter will provide no other physical phenomena to ground objective distance relations between slices in the A-theoretically preferred foliation. In that case, I should want to say that there is no objective fact of the matter how much time has passed between the

occurrence of an event in one slice and the occurrence of an event in another. As Crisp (2008: 266-8) points out, one can combine the A-theory with Relativity (Crisp is concerned, in particular, with GR) while denying that the series of co-present slices displays an "intrinsic temporal metric".

[60] Sider (2001: 27-33).

[61] Sider (2001: 32).

[62] Sider (2001: 32-35).

[63] Shamik Dasgupta and Peter Forrest have pointed out to me that, given *supersubstantivalism* (the thesis that material objects are made up out of those points of space-time which we would ordinarily say are occupied by the objects), the independence of our judgments about the existence of ordinary objects and scientific information about the nature of space-time cannot be kept apart so neatly. I must admit that, for someone attracted to supersubstantivalism, these judgments may be less independent than I have portrayed them. But even an empty-boxer supersubstantivalist need not suppose that Bucephalus still exists, just because the space-time points that once made him up continue to exist and bear metrical relations to one another. If they no longer exemplify the material properties they did when they were present, it seems to me that a supersubstantivalist with presentist inclinations should say, *not* that Bucephalus exists but is now an empty region, but rather that the points in this empty region once constituted a horse, but do so no longer.

[64] For a better-informed and more detailed discussion, see Crisp (2007). Crisp reconciles presentism and GR in a way that is neutral between two hypotheses: (i) a one-slice metaphysics, according to which space is constituted by a different set of points at each time; and (ii) a persisting space metaphysics, according to which space is always constituted by the same point-sized parts. (The neutrality of his theory is not emphasized in Crisp's exposition, which favors (ii); but it is there, upon examination.) Crisp's approach combined with (i) yields a theory positing less complexity in the structure of the physical world, since it abolishes absolute sameness of place; while (ii) retains

absolute location as a physically inert factor. The choice between (i) and (ii) is a delicate one, however, turning on subtle questions about the weightings of different theoretical virtues. (ii) introduces physically idle objective facts about sameness of region, which I should count as a major strike against it, if an alternative is available. On the other hand, if the presentist finds herself forced toward an empty box or ghostly box with four-dimensions, a three-dimensional persisting space might seem preferable. But whatever costs would be incurred under (ii) by positing the formerly-filled space-time points, in addition to presently filled ones, it is eliminated if points can be constructed out of trajectories instead of the reverse.

[65] There is a quite different approach to lining up snapshots due to Barbour. Barbour's "best matching" technique is designed to take a collection of "Nows or 'instants of time'" (Barbour, 1999: 177), three-dimensional slices of a relativistic manifold corresponding to one of its foliations, and to put them back together in the right order and with the cross-temporal geometry intact. His method works particularly well in the context of GR (Barbour, 1999: 167-77). Barbour may think of the procedure as "eliminating" time, but the A-theorist need not.

[66] Smart (1963: 136) gives an argument against the A-theorist along these lines.

[67] See Putnam (1967), Sider (2001: 42-52). Mellor (1998: 55-57) endorses the objection, although he does not regard it as his main argument against the A-theory.

[68] Putnam (1967: 247); a similar argument for a slightly different conclusion can be found in Rietdijk (1966).

[69] Sider (2001: 42).

[70] Putnam (1967: 240-1); Putnam does not, in his argument, emphasize the need for symmetry in the "real-for" relation; but, as Saunders (2002: 282-3) points out, Putnam pretty clearly does, and should, assume its symmetry.

[71] Putnam (1967: 241).

[72] Putnam (1967: 242-3).

[73] Stein (1968); see also Stein (1991).

[74] E.g., Dickson (1998), and Clifton and Hogarth (1995).

[75] Callender (2000), Saunders (2002), and Savitt (2000) provide insightful (and, to my mind, decisive) analysis of the Putnam–Stein debate, and its confusing aftermath. See also Peacock (2006: 248-50).

[76] Sider (2001: 47).

[77] Sider (2001: 52).

[78] Here, for example, is the endorsement of Ian Gibson and Oliver Pooley: "We take it that relativity rules decisively against both the non-eternalist and the tenser [i.e., against all versions of the A-theory]. … Both presentism and tensed theories of time need an objectively privileged set of subregions of spacetime, each of which can serve as the present as 'time passes' (however this is to be interpreted!). Relativistic physics simply does not provide such a set" (Gibson and Pooley, 2008: 159). (To be fair, it is possible that they mean GR, not SR, by "relativity"; but since the paper concerns persistence in Minkowski space-time, I take them to be agreeing with Putnam and Sider: incompatibility with SR refutes presentism.)

[79] Saunders, after tidying up Putnam's argument, provides a concise summary: "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 does not exist. Everyone knows there is nothing else to replace it — there is no other non-trivial symmetric and transitive relation intrinsic to Minkowski space" (Saunders, 2002: 279-80). Savitt, too, thinks SR is incompatible with supposing that a geometrically undistinguished foliation is special. To choose one hyperplane of

simultaneity as "*the* present" is "a form of inertial chauvinism". Such chauvinism may simply be "a strategy for rejecting special relativity in favor of presentism rather than accommodating presentism in Minkowski spacetime". But Savitt seems to think it would not constitute rejection of SR if the presentist says the A-theoretically privileged foliation is "metaphysically distinguished" but irrelevant for physics. He thinks no presentist should be comfortable holding this sort of view, for reasons discussed below (Savitt, 2000: S570). Monton thinks "presentism is incompatible with special and general relativity" because the manifolds of these theories "do not have a foliation into spacelike hypersurfaces as part of their structure" (Monton, 2006: 267).

[80] Savitt (2000: S572) cites Misner, et al. (1973, 187): "the existence of the gravitational redshift shows that a consistent theory of gravity cannot be constructed within the framework of special relativity."

[81] Saunders (2002: 290-1) and Savitt (2000: S572-3); Savitt is more pessimistic than Saunders about the prospects for presentism in GR.

[82] Saunders (2002: 291), and Monton (2006: 265-66).

[83] Maudlin (2002: 230-31).

[84] Compare Belot's (2005: 262-3) "augmented Minkowski spacetime", with its field of inertial observers at relative rest.

[85] See Maudlin (2002: 203-4).

[86] Maudlin (2002: 194).

[87] Maudlin (2002: 191).

[88] Maudlin (2002: 192).

[89] See Maudlin (2002: 202-4); and Maudlin (2002: 222, n.8): "When a unique center of mass frame does exist, though, one can construct a Lorentz invariant theory" in which a single foliation plays the role of simultaneity for quantum-theoretic purposes. Valentini (2008: 150) makes the same point: "In itself, the mere fact of superluminal interaction is not necessarily incompatible with fundamental Lorentz invariance. For example, the interactions might be instantaneous in the centre-of-mass frame (a manifestly Lorentz-invariant statement)."

[90] Forrest (2008) is after bigger game than just defending the consistency of his A-theory with SR. He means to show that the inflationary Big Bang explanation of the universe's nearly isotropic expansion can generate a reason to think that the A-theoretic foliation roughly coincides with that of "cosmic time"; and thus the A-theorist can acquire empirical evidence for the location of the successive presents in the manifold.

[91] Forrest (2008: 249).

[92] Forrest (2008: 248).

[93] Forrest (2008: 249).

[94] Forrest (2008: 250-2).

[95] Saunders (2002: 280-81).

[96] Saunders (2002: 281).

[97] Peacock (2006: 255-6).

[98] See, e.g., Sider (2001: 52), and Mellor (1998: 57).

[99] Grünbaum (1967: 20).

[100] Callender (2008: 66).

[101] Callender (2008: 67).

[102] Unger (2006: 6-9) outlines the elements of what he sees as the dominant "Scientiphical Metaphysic".

[103] Comparison with epiphenomenalism is explicit in Prosser's (2007) version of a dispensability argument.

[104] Savitt (2000: S570).

[105] Callender (2008).

[106] To be fair, Callender has other things to say against the convictions about past, present, and future upon which the A-theorist relies. He claims that these beliefs "arise solely from ordinary language analysis — a mostly bankrupt enterprise" (Callender, 2008: 67). The real locus of our disagreement seems to me to be this: how much credence should we accord to the beliefs with which we find ourselves before we begin our more systematic inquiries? Reasoning that begins from them yields the kinds of arguments Callender calls "ordinary language analysis", though I should resist the label (except, perhaps, when they happen to be beliefs about language). There are many widely-shared, commonsensical convictions about time that I judge "innocent until proven guilty", while Callender gives the opposite verdict.

[107] Maudlin (2002: 202).

[108] Maudlin (2008: 160).

[109] Callender (2000: S595-6).

[110] Callender (2008: 52).

[111] Callender (2008: 67).

[112] Callender (2008: 67).

[113] Callender (2008: 66).

[114] Here, I am responding to an interesting objection raised by William Lane Craig, in correspondence.

[115] And many A-theorists have taken GR to promise a place for their wave of becoming; Craig, for example, supposes that "cosmic time" — "the fundamental frame of the cosmic expansion" (Craig, 2001: 234) — "*contingently* coincides with metaphysical time", i.e., the A-theoretically privileged foliation (Craig, 2001: 237).

[116] Craig (2001: 234).

[117] Craig (2001: 237). See also Lucas (2008) and Forrest (2008). Swinburne (2008) argues that genuine simultaneity in an expanding universe like ours would correspond to cosmic time.

[118] As Callender puts it, "there are reasons for thinking general relativity and quantum field theory are mutually incompatible and must themselves give way to quantum gravity"; and there are "sketches of theories of quantum gravity that yield a preferred foliation", as well as "sketches of those that do not" (Callender, 2008: 65).

[119] Monton (2006: 265).

[120] E.g., Callender (2008: 65) and Maudlin (2002: 240-2).

[121] For surveys of the range of (mostly) less wild options, see Maudlin (2002, 2008).

[122] Maudlin (2008).

[123] For an accessible presentation of the details of this approach, see Albert (1992).

[124] Maudlin (2008: 163).

[125] Maudlin (2008: 165).

[126] Maudlin (2008: 166-70).

[127] Prior (1996: 51).

[128] Callender (2008: 62-3).

[129] I also suspect that philosophy of physics and metaphysics differ to some degree in the conventions governing writing style and rhetorical pitch.