Relativity and the Moving Spotlight*

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1 Introduction

The moving spotlight theory of time is usually introduced as follows. The theory combines eternalism—the doctrine that past, present, and future times all exist—with "objective becoming." The claim that there is objective becoming has two parts. First, facts about which time is present are non-relative. That is, even if in some sense each time is present relative to itself, only one time is *absolutely* present. That time, and only that time, glows with a special metaphysical status. And second, which instant is absolutely present keeps changing. The NOW moves along the series of times from earlier times to later times.

There are lots of objections to the moving spotlight theory. But one objection to the theory looks particularly devastating. The objection is that the theory is incompatible with special relativity.

Whatever the force of the other objections to the moving spotlight theory, I do not think that this one is good. My goal in this paper is to explain how to formulate the moving spotlight theory so that it is compatible with special relativity.

Before proceeding I want to make a remark about the moving spotlight theory's place in the philosophy of time. There are two types of theories about the nature of time: A-theories and B-theories. Roughly speaking, A-theorists say that there is some absolute (that is, non-relative) distinction between the past, present, and future. B-theorists deny this. The moving spotlight theory is one version of the A-theory of time. But it is not the most popular. Instead, most A-theorists prefer presentism—the view that everything that exists is present. (In fact, while

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many people defend presentism, I do not know of any contemporary defenders of the moving spotlight theory.)

Now presentism, like the moving spotlight theory, appears to be incompatible with special relativity. So if what I say in this paper is correct, A-theorists may want to reconsider the merits of the moving spotlight theory. Presentists often concede that their view is incompatible with special relativity, and go on to defend the propriety of adding a notion of absolute simultaneity to special relativity. But putting a moving spotlight into special relativity does not require any such funny business. It does not require making any additions to the geometrical structure of flat relativistic spacetime. So whatever you think of the other relative merits of the two theories, the moving spotlight theory is at least easier to reconcile with the physics.[1]

2 Moving Spotlights in Classical Spacetimes

It is easy to think about the moving spotlight theory from the "space + time" point of view, where points of space and instants of time are distinct kinds of things. The theory is a theory about a *spotlight* because the light shines on just a single moment of time, and we picture instants of time as extensionless points. But even in the context of pre-relativistic physics we are better off looking at things from the spacetime point of view, where points of spacetime are basic, and spaces and times, if they exist at all, are just special regions of spacetime. So, before explaining how to reconcile the moving spotlight with relativity, I want to say more about how the moving spotlight works in pre-relativistic spacetimes.

In classical spacetimes (like Newtonian spacetime, neo-Newtonian (or Galilean) spacetime, and Leibnizian spacetime) there is a relation of absolute simultaneity on points of spacetime, and the instants of time are just the fusions of the equivalence

[1]Two examples of presentists defending the addition of absolute simultaneity to relativistic spacetime are [Prior 1996] and [Zimmerman forthcoming].

I should say that this is not the only way to try to reconcile presentism with special relativity. A presentist could say that only one spacetime point exists (the "point model"), or say that the only spacetime points that exist are the points on the back light cone of some one point ("the cone model"). Mark Hinchliff 2000 discusses both but thinks presentists should not use the point model.

classes of this relation. So times are just special regions of spacetime; and, according to the moving spotlight theory, the NOW moves from one such region to another. But how are we to make sense of this talk about the NOW's motion? According to the (non-relativistic) moving spotlight theory, which time is NOW keeps changing. But the status of this claim is difficult to get a grip on. On one model for evaluating talk of change, talk of change can be only be evaluated from a perspective within (space)time. On this model, when I say that my sister is getting taller, I mean that (or, at least, my utterance is true just in the case that) at times before my utterance, my sister is less tall than she is at time after my utterance. But we are not supposed to use this model to evaluate talk of the NOW's motion.[2] When Moving Spotlight theorists say that the NOW is moving into the future, we are not to take this to be true just in case at times before their utterance, the NOW is at earlier times, and at times after their utterance, the NOW is at later times. For that presupposes that a given time is NOW *relative to* some times (times before their utterance) but not others (times after their utterance). But (on this theory) the property of being NOW is absolute; it is not had relative to times.[3] So how are we supposed to evaluate talk of the NOW's motion?

We evaluate it using a device familiar from discussions of presentism: primitive tense operators (see, for example, chapter 1 of [Sider 2001]). If it is NOW time t, then to say that the NOW moves from the past to the future is to say that *it was the case that* a time before t was NOW, and *it will be the case that* a time after t is NOW. But "It will be the case that t' is NOW" does not mean the same as the claim that (and is not true just in the case that) at a time later than this utterance, t'

[2]Moving Spotlight theorists may say that we should not use this model even for ordinary talk of change.

[3]Much of my paper is inspired by Howard Stein's 1968 paper, "On Einstein-Minkowski Spacetime." But his theory is flawed as a defense of the A-theory exactly because it focuses on what the temporal facts are *from perspectives within spacetime.* Objective becoming, whatever exactly it is, is something that is manifest from a perspective outside of spacetime. (Callender [2000: S594] also makes this complaint.) The same flaw appears in discussions of "worldline-dependent becoming" (several such proposals are discussed in [Clifton and Hogarth 1995]). In the theory I present, objective becoming is not relative to observers or points of spacetime.

is NOW.

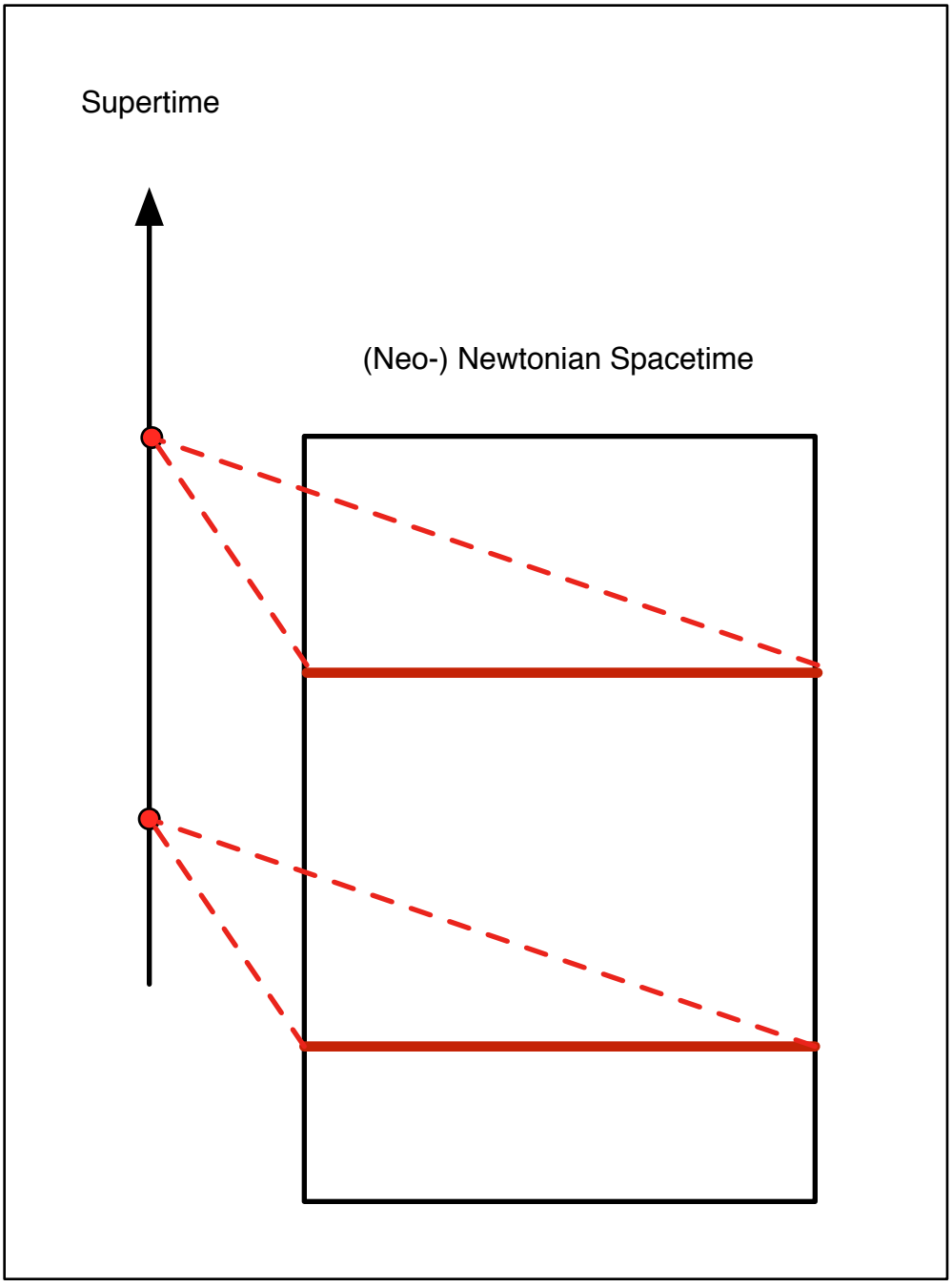
So the official formulation of the (classical) moving spotlight theory makes use of primitive tense operators. But to understand the transition to the relativistic theory it will help to have another presentation of the theory. This second presentation makes sense of the motion of the NOW using a fictional device: supertime. Supertime is a dimension similar to time, but distinct and disconnected from it. Supertime provides a perspective on spacetime from which we can make sense of the motion of the NOW. From the perspective of each point of supertime, just one time is NOW. But from different perspectives in supertime, different times are NOW. This is illustrated in figure 1, where the property of being NOW is represented by a red glow.

There is a mirroring between the temporal structure of spacetime on the one hand, and the structure of supertime, on the other. Spacetime has a temporal metric and a temporal orientation (says the moving spotlight theory). Similarly, supertime comes equipped with a metric: there are facts about the distance between any two points. It also comes equipped with an orientation: there is an asymmetric relation on supertime, which we can call ">," and the points of supertime are linearly ordered by this relation. When $p > q$, where p and q are points of supertime, I will say that p is "After" q, though we should be careful about using this word. Supertime is not time, so whatever exactly it means to say that one point in supertime is After another, it does not mean the same as any claim about the order of things in (ordinary) time (such as the claim that my death is after my birth). Still, the ordering of points in supertime is not entirely unrelated to the ordering of instants in time. So the use of a common word for both orders is not entirely misleading. To keep them distinct I spell the name of this relation (and all relations) on supertime with a capital letter.

Using the orientation on supertime, we can say that at *Later* points in supertime, later times are NOW. That, then, is what the claim that the NOW moves into the future amounts to.

Again I want to emphasize that this talk of supertime is not to be taken literally. Taken literally, the story about supertime is not consistent with the rest of the moving spotlight theory. The property of being NOW is supposed to be absolute,

Figure 1:



and so not had relative to times. But on this picture it is still had relative to points in supertime, so is not absolute. I said above how to express in non-figurative language the propositions that the story about supertime expresses in metaphor. I can say a bit more about the relationship between the two formulations of the theory. If we pretend there is such a thing as supertime, then we can pretend to analyze the primitive tense operators that appear in the first presentation of the theory in terms of quantification over points in supertime: "It will be the case that t' is NOW" is analyzed as "At a Later point in supertime, t' is NOW." But this is all pretend; outside of the pretense, the tense operators are still primitive.

Why have I given both a literal and a metaphorical presentation of the classical moving spotlight theory? Because it is easier to explain the transition to the relativistic theory using the metaphorical presentation. It is also easier to understand the relativistic theory when it is presented in metaphorical terms. So in the following sections I will rely on that presentation of the theory.

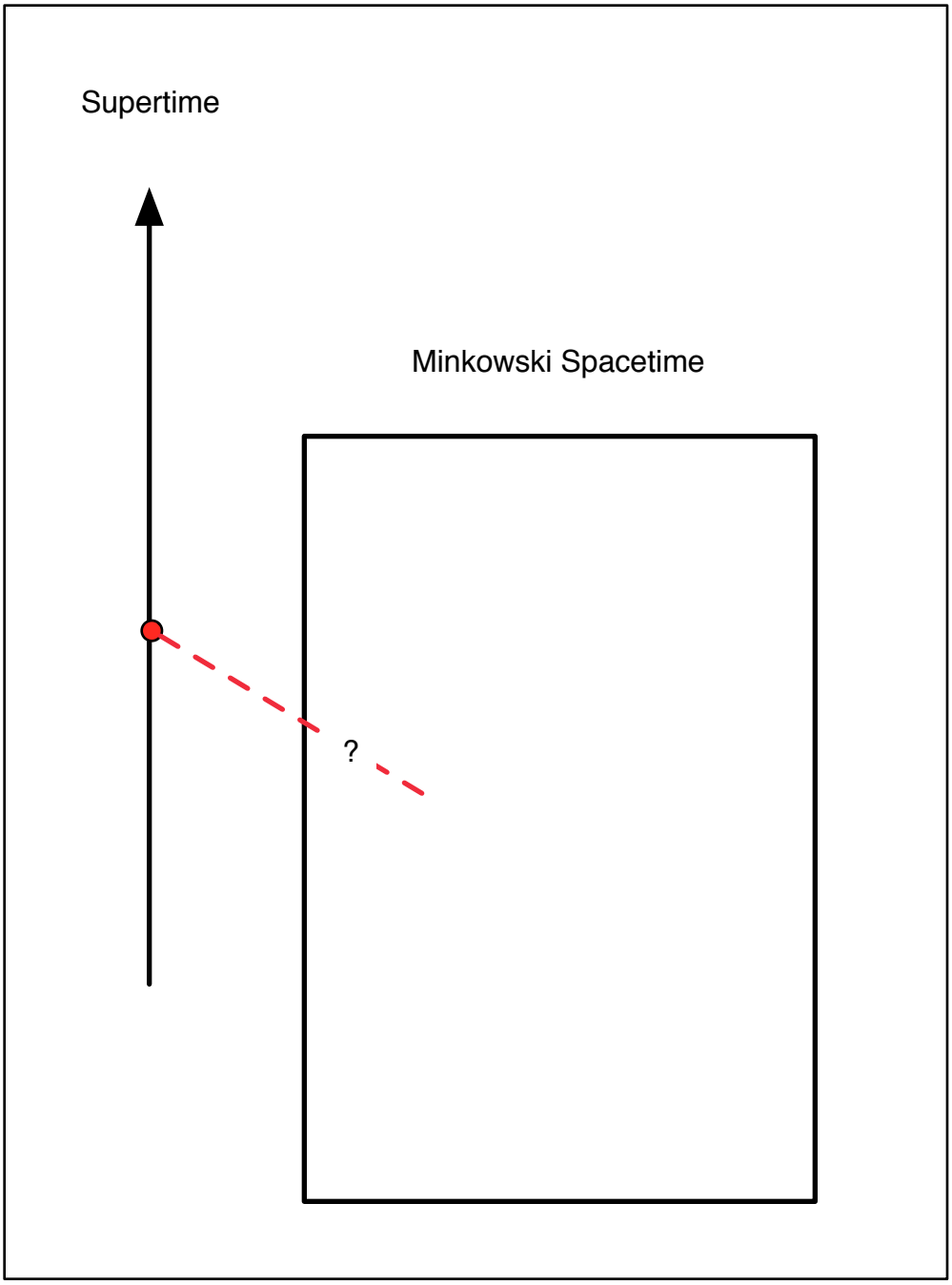
3 The Challenge from Relativity

Why think that the moving spotlight theory conflicts with relativity? The problem is this. (Flat) relativistic spacetime has no relation of (absolute) simultaneity on points of spacetime. So in this spacetime there are no such things as instants of time. But then there are no things to instantiate the property of being NOW, and no things to provide a dimension along which the NOW can move. So the moving spotlight view seems to make no sense relativistically.

I have a solution to this problem. To appreciate the solution, it helps to dwell a little longer on how the problem arises. To make the move to relativistic spacetime, we have taken the scenario pictured in figure 1, and replaced (Neo-) Newtonian spacetime with Minkowski spacetime. Figure 2 pictures this revised scenario. Now, which region of Minkowski spacetime is supposed to "light up" from the perspective of a given point in supertime? The problem is that there does not seem to be any way for moving spotlight theorists to answer this question.

We should be clear about what the answer is in the classical case. Even there the moving spotlight theory does not answer the question, which region of

Figure 2:



spacetime is NOW relative to location p in supertime? Exactly one instantaneous slice of spacetime is NOW relative to p, but the theory by itself does not tell us just which slice that is. Instead, the theory places a constraint on the relationships between the perspectives of different locations in supertime. The constraint law is this:

(1) If p and q are points in supertime, and p is r units Later than q, then the time that is NOW from the perspective of p is r units later than the time that is NOW from the perspective of q.

(This constraint guarantees that the mapping from points of supertime to their NOWs in spacetime is an isomorphism.)

We cannot ask more from a relativistic spotlight than we do from a classical one. So a relativistic version of the moving spotlight theory need only provide constraints of a similar kind. The form of the relativistic constraint law will resemble the form of the classical constraint law. It will say: given that perspective p and perspective q stand in such-and-such relation, the region of spacetime that is "lit up" from perspective p stands in such-and-such relation to the region that is "lit up" from perspective q.

Now we see what the relativistic theory has to do. But how does it do it? The relevant relation on locations in supertime is the relation *p is Later than q.* So, it seems, the relativistic law has to fill in the blanks in the following statement:

(2) If p and q are point in supertime, and p is r units Later than q, then the BLANK-1 from the perspective of p is BLANK-2 than the BLANK-1 from the perspective of q.

BLANK-1 holds the place for the kind of region that is "lit up" from perspectives in supertime, and BLANK-2 holds the place for the relation that those regions stand in. But there appears to be no way to fill in these blanks. As I said above, there appears to be no way to fill in BLANK-1 because there are no instants of time in Minkowski spacetime. And, for similar reasons, there is no way to fill in BLANK-2. Whatever goes in the place of BLANK-2 must, it seems, be a relation on times that corresponds, in some way, to the $>$ relation on supertime. And if there are no

times then there is no such relation on times. That, in more detail, is the problem facing the relativistic moving spotlight theory.

4 Responding to the Challenge

Opponents of the spotlight have saddled spotlight theorists with a hybrid view: spacetime has a relativistic structure, but supertime remains classical. This is the source of the view's problems. Moving spotlight theorists can respond by going more thoroughly relativistic. Let the set of perspectives on spacetime *also* have a relativistic structure. Replace supertime with *Minkowski Superspacetime!* With their theory revised in this way, defenders of the relativistic moving spotlight can reject as illegitimate the demand to fill in the blanks in (2). The relevant relation on perspectives is not *p is r units Later than q*; it is, instead, *the Interval between p and q is r*. The Interval on superspacetime corresponds to the spacetime interval on spacetime: both endow the spaces on which they are defined with a Minkowski geometry, with its familiar light-cone structure. (As before, I spell the names of relations on superspacetime with capitals to distinguish them from corresponding relations on spacetime.)

I am just about ready to say what the constraint is on the relationships between the perspectives of different locations in superspacetime. But first I need to say which kinds of regions are "lit up" from perspectives in superspacetime. I say: from the perspective of any given point of superspacetime, just a single point of spacetime is lit up. For advertising purposes, I also propose that the relativistic moving spotlight theory include a terminological reform: where the classical theory called the lit-up region "the region that is NOW from the perspective of p," the relativistic version calls it "the region that is PRESENT from the perspective of p." (The use of "NOW" suggests that the theory requires some notion of absolute simultaneity. But, as Stein [1991: 159] points out, there are ordinary uses of "PRESENT" on which it means the here-now—a single spacetime point.) The constraint law, then, is

(3a) If p and q are points in superspacetime, and the Interval between p and q is r, then the spacetime interval between the point that is PRESENT from the

perspective of p and the point that is PRESENT from the perspective of q is r.

In addition, as in the classical case, both spacetime and superspacetime have temporal orientations. So there is a second constraint requiring that these orientations mesh:

(3b) If p and q are points in superspacetime that are Timelike related, and p is to the Future of q (that is, lies in the Future Light Cone of q), then the point that is PRESENT from the perspective of p is timelike related to[4] and to the future of the point that is PRESENT from the perspective of q.

(As with the classical case, these constraints guarantee that the mapping between points in superspacetime and their PRESENTs in spacetime is an isomorphism.)

Figure 3 captures the picture behind the relativistic moving spotlight theory.

That completes my presentation of the relativistic moving spotlight theory. My presentation of the theory makes use of a metaphor: superspacetime. When I presented the classical theory I explained the literal truth behind the supertime metaphor. So what is the literal truth behind the superspacetime metaphor? I am not sure I really need to answer this question. It is at least sometimes legitimate to use a fiction to express some proposition, even when you cannot articulate sentences that, understood literally, express just what the story expresses fictionally. In fact, this is sometimes legitimate even when *there are no* sentences that, understood literally, express just what the story expresses fictionally. (Yablo [1998] claims that this is the situation mathematical fictionalists are in.) Still, I think it may be possible to spell out the literal truth behind the superspacetime metaphor. It could be done using complicated primitive tense-like operators that are adapted to the structure of relativistic spacetime. But I do not think it is worth going through in detail how it all would work, because I think the presentation of the theory using superspacetime is easier to understand.

[4]This part of the constraint just follows from (3a).

Figure 3:

5 Remarks on the Theory

The existence of the theory I have presented shows that the moving spotlight theory of time is perfectly consistent with special relativity. (And I suspect that the strategy I used to produce the theory can easily be used to produce a version that is consistent with general relativity.) In this final section I want to make some remarks on the theory and address some objections.

First a small remark. On the original version of the classical theory, we pictured instants of time as extensionless points. So from the perspective of any point in supertime, the spotlight shone on an extensionless instant of time. But in the spacetime version of the classical theory, times are *three-dimensional hypersurfaces* in spacetime, and the spotlight shines on them. It is not much of a *spot*light anymore. It has become a moving floodlight. The relativistic version restores the original picture. Once again, the spotlight is a focused beam, shining on just one point.

Second, a remark about motion. What has happened to the picture of the spotlight *moving*? I do not think there is anything to worry about here. If the nature of the motion of ordinary rocket ships is different in relativistic spacetimes, it is only to be expected that the nature of the motion of the PRESENT is as well. In the classical theory, I understood the motion of the NOW using supertime (a fictional device): as ones moves from Earlier to Later points in supertime, one will see the NOW move from earlier to later instants in spacetime. The same goes for the relativistic theory. As one moves from Earlier to Later points along any timelike curve in superspacetime, one will see the PRESENT move from earlier to later points along a corresponding timelike curve in spacetime.

Third, a remark about the past and the future. I have said how the moving spotlight theory captures the idea that the NOW, or the PRESENT, is special. But there is also a way to extend the theory so that it captures the idea that the future is open, "not yet determined," in a way that the past is not.

Whether or not the future is open has nothing to do with whether or not the laws of physics are deterministic. Even if the laws are deterministic, and so given the past there is only one physically possible future, there is still a sense in which

the future is open. Here is how one can add an "open future" to the classical version of the moving spotlight theory. The idea is to combine the moving spotlight theory with some ideas from the "growing block universe" theory of time. I have said that, according to the classical spotlight theory, different time-slices of spacetime are NOW from different perspectives in supertime. But we need not say that this is the only way in which the views from different perspectives in supertime differ. Let us also say that they differ over what the material contents of spacetime look like. From any particular point in supertime, the only regions of spacetime in which there are any material goings-on are regions to the past of the NOW. The regions to the future of the NOW are blank, empty, ready for things to happen in them. (Of course, a region that is empty from one perspective in supertime may be occupied from a Later perspective in supertime, if the NOW passes through that region as one passes from the Earlier perspective to the Later one.) That is a way to incorporate into the classical moving spotlight the idea that the future is open.

Adapting this story to the relativistic theory is easy. From any particular point in superspacetime, the only regions of spacetime in which there are any material goings-on are regions to the (absolute) past of the PRESENT—that is, regions in its back light cone. The regions outside its back light cone are blank, empty, ready for things to happen in them. That is a way to incorporate into the relativistic theory the idea that the future is open.

(I said above that the relativistic moving spotlight theory was compatible with general relativity as well as with special relativity. I should note that this extension of the theory is not. It makes no sense in models of general relativity—like models containing closed timelike curves—in which some spacetime point is in its own back light cone.)

One may object that my relativistic version of the moving spotlight theory does not forge the right kind of connection between the past and the present: "What is past was once present. The only way from the future to the past is through the present. But on your proposal events are past that were *never* present!"[5] But what

[5]Similar objections appear in [Callender 2000: S594] and [Putnam 1967: 246]; but these objections are directed at a view that is not quite my own. A response to Putnam's objection in the context in which Putnam gave it is in [Stein 1968:

does this objection mean? I can only understand it to mean this: there is a perspective in supertime from which certain events happened in the past (that is, they occur (timelessly speaking) before the NOW), even though there is no Earlier perspective in supertime from which those events are happening NOW. But this objection again presupposes that the relativistic moving spotlight theory is a hybrid theory, with relativistic spacetime but (classical) supertime. The thoroughly relativistic moving spotlight *does* entail that what is past was once present: given a perspective p in superspacetime, for any spacetime point q that is in the (absolute) past of the point that is PRESENT from perspective p, there is a perspective in superspacetime that is in the Absolute Past of p from which q is PRESENT. This follows immediately from the constraint on perspectives (3).

Now for my final remark. I have not tried, in this paper, to present arguments in favor of the moving spotlight theory. I have only tried to show that it is compatible with special relativity. But, one might complain, the features of the classical theory that made it appealing as a theory of time have been lost in the move to the relativistic theory. (Something like this objection appears in [Callender 2000: S594].)

I cannot survey all the motivations philosophers have had for the moving spotlight theory. But the motivation that I like best appeals to the nature of our conscious experience. Of all the experiences I will ever have, some of them are special. Those are the ones that I am having NOW. All those others are ghostly and insubstantial. But which experiences have this special feature keeps changing. The moving spotlight theory explains this feature of experience: the vivid experiences are the ones the spotlight shines upon. As the spotlight moves, there are changes in which experiences are vivid.

If this is why you find the moving spotlight theory appealing, you should find the relativistic version of the theory just as appealing as the classical version. For even in the relativistic version, (there are perspectives in supertime from which) the

15]. As I noted above, these authors are discussing what events are past from a perspective within spacetime (in fact, Putnam is discussing what events are past from the perspective of a particular observer in spacetime), a topic that the moving spotlight theory does not address.

spotlight moves along my worldline, from earlier points to later points, lighting up my experiences as it goes.[6]

In the classical theory the spotlight shines on all people who presently exist, while in the relativistic theory the spotlight shines on at most one person(stage). Is this a problem? Suppose the spotlight shines on me, and so shines on me only. Doesn't this violate the principle that there are no Privileged Observers? Well, I am not sure just what the principle that there are no Privileged Observers is supposed to be. (Putnam [1967] introduced the phrase, but for reasons Stein [1968] points out, it is not clear just what meaning Putnam intended to give it.) But I do not see that the relativistic theory has any problem here that the classical theory did not face already. Perhaps the problem is this: you think the spotlight shines on you, but you are mistaken, because the spotlight shines only on me. But already in the classical case, my past self thinks that the spotlight shines on him, but he is mistaken, because the spotlight shines only on the present. In the classical case, the response to this problem is to note that while my past self *is* wrong, he *was* right, because it was the case that the spotlight shone on him. So it is understandable why he is making a mistake. In terms of the supertime metaphor, the claim is that although from the Current point in supertime, the spotlight does not shine on him, there is a Past point in supertime from which it does. The response in the relativistic case is parallel: we say that while the spotlight does not shine on you, there is a point in superspacetime from which it does. Now, I will not say anything about whether this is an adequate response to the problem in the classical case. But I do maintain that the response in the relativistic case is just as good. So the relativistic theory is doing at least as well as the classical theory.[7]

[6]Of course, by treating the region of spacetime I occupy as one-dimensional, I am idealizing. To remove this idealization we would have to tell a more complicated story. Perhaps we could treat the claim that the spotlight shines on just one point as a matching idealization. Since I actually follow a very thin worldtube, not a worldline, we could let the spotlight be a little bit unfocused, shining on a small region centered on a point. Then it shines on a region large enough to fit my brain.

[7]Thanks to Jonathan Schaffer, Adam Elga, Dean Zimmerman, and students in my Spring 2008 seminar at MIT.

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