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On the Impossibility of Hybrid Time in a Relativistic Setting

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Abstract

There are two rival theories of time: static and dynamic. The Special Theory of Relativity is one of the strongest arguments for static time. However, the defenders of dynamic time claim that their approach is also possible in a relativistic setting. This debate supported the third theory: the hybrid theory of time. The aim of this paper, however, is to argue that the hybrid theory (combining both static and dynamic elements) is against the nature of the Special Theory of Relativity. The argument is motivated by H. Stein's attempt to separate definite past from indefinite future by timelike and lightlike relations in and on the past pointing light cone. The paper shows that this approach leads to restricted and extremely unintuitive notion of co-presence. This is considered as a serious objection against the animation of static time in a relativistic setting.

There are two opposite aspects of time: static temporal order and dynamic temporal passage. Since these aspects are opposite, we naturally ask which of them the fundamental one is. This paper looks at a philosophical project with the ambition to incorporate both aspects into the hybrid theory of time. Firstly, we will look at McTaggart and his famous proof of unreality of time. The purpose is to clarify the concepts of static and dynamic time. The rest of the paper deals with the notion of hybrid theory and its plausibility within the framework of the Special Theory of Relativity (STR). Although it has been discussed in the philosophy of science for decades, STR has become a topic of metaphysics relatively recently. It is argued that STR eliminates temporal passage from the description of the world. If that is true, then the notions of past, present and future refer to anthropomorphic features having no place in science and metaphysics. This consequence is rejected by several philosophers whose agenda, in my opinion, is not time primarily. As will be explained later, elimination of past, present and future reduces reality to static, eternal distribution of events in four-dimensional manifold and thus introduces fatalistic picture of the world. It seems that it is an attack on fatalism and its consequences that are primal motives for developing hybrid theories of time. We can't ignore the best scientific theories but we still want to be sure that we can change our future and thus being able to talk meaningfully of moral responsibility, free will, etc. However, this problem has also its broader aspects. The theoretical machinery of physics attributes properties (from topology, metric, etc.) that naturally exclude the notion of passage. As a consequence, some philosophers conclude that this is one of the reasons why the time in physics is not a genuine time since passage is considered as an essential property of time. This dispute, however, is not the focus of our attention here. The aim of this paper is to argue that temporal passage and related notions (e.g. the notions of absolute past, present and future) are not compatible with STR which calls into question the possibility of the hybrid theory of time incorporating both STR and temporal passage. It is upon the reader to decide weather it automatically questions the notions of moral responsibility, free will and other related issues.

1 The A-series

The dynamic theory of time is often said to be a "folk theory of time" as it accommodates our everyday intuitions about time. This, however, questions the label *theoretical*.[1] We should rather

*Most of the ideas presented in this paper were developed during my Fulbright scholarship at the University of California, Davis. I am in debt to Ladislav Kvasz for helpful comments and discussions on this paper and Josh Parsons for introducing me to the topic.

[1] A theoretical approach requires atemporal attitude toward the entity being studied whereas dynamic concept of time requires the very opposite. Even the etymology of *the-*

say *dynamic concept* or *approach* to time instead of *theory* but, as a matter of tradition, we will use the term *theory* too. There are two prominent and interrelated aspects of dynamic time: one is that time passes and the second is its consequence, the existence of absolute past, present and future. It is natural to suppose that the time you are reading this sentence is your present. Call it T. Once you have finished reading the sentence, the very same moment T is in your past. It is also plainly true that when you started reading this paper, T was in your future. T was approaching you from the remote future to the near future, then to the present, near past and is going to finish in the remote past. The change of monadic properties of present and different degrees of pastness and futurity are the fundamental ideas of the dynamic theory of time. Temporal moment T is constantly changing these properties and this is what makes us believe that time passes. However, this temporal aspect of time is a basis of a famous proof of unreality of time proposed by J. M. E. McTaggart in [4]. He introduces two ways how to order temporal events: the dynamic A-series which orders events in the way described by the example of T, and the static B-series which orders events by the relations of "simultaneous with", "earlier than" and "later than" and their grammatical equivalents. Positions in the B-series never change. Once an event is in a certain position in the B-series, it remains in it forever.[2] This is not true of the positions in the A-series. They permanently change as a consequence of their dynamic nature. Le Poidevin reformulated McTaggart's proof as follows [3, 131-32]:

1. If time is real, then there is an A-series (the A-series being the most fundamental kind of temporal series).

2. Different A-series positions are mutually incompatible, so no event can exhibit more than one of them.

3. If there is an A-series, then, since the A-series positions of events change, all events have all A-series positions.

Therefore

4. If there is an A-series, then any event both has only one A-series position *and* has them all. But this is absurd.

Therefore

5. There is no A-series.

Therefore

6. Time is unreal.

McTaggart' proves, in the form of *reductio*, that the A-theory is inconsistent and so is the very notion of time. However, one of the assumptions of the proof is that if there is time, there must be the A-series. We don't have to agree with that and we are free to say that the proof is the proof of unreality of the A-series and not of time itself. As a matter of fact, premise 3 can be reformulated within the framework of the B-theory: every event has different A-series positions but has them successively [3, p. 132]. Temporal moment T is not past, present and future simultaneously but successively. It eliminates the source of paradox as stated in premise 4 of the proof. However, it naturally leads to the B-series. The B-series is the series of successive temporal moments and so the B-theory is immune to McTaggart's paradox.[3]

2 The B-series

Static time, or the B-series, is also part of our everyday experience. There is something static about time, something that corresponds to atemporal order of events. This idea is implicitly

oretical refers to this feature and it might also be considered as yet another indirect proof that science must exclude temporal passage from its concepts. I owe this idea to Ladislav Kvasz.

[2] However, as a consequence of STR, T is a member of various, frame-dependent, B-series.

[3] Another way out of the paradox is presentism. Presentists reduce the A-series to only one position: the present. There is no past and future, there is only present. If that is true, then the premises 2 and 3 are not true and so is the rest of the proof. However, presentism is rather unattractive alternative to the B-theory as it faces serious ontological and conceptual difficulties.

present in the notion of different degrees of futurity and pastness of the A-series too. What tells us that T is in the near or remote past? It is its position in temporal order, that it is earlier, later or simultaneous with some other temporal events. However, the consequences of the B-theory are less intuitive: there is no absolute future, present and past; every position in the B-series, every event, is ontologically equal, they are all equally real; there is nothing special about our present, etc. Such view of the world is fatalistic. If that is true, then our ontological commitments include temporal moments and their inhabitants both in the past and future. From this perspective, both Napoleon and the first president of the European Union (suppose there will be one) exist. They exist in the same sense as you and myself. In order to avoid these consequences, some B-theorists started introducing some elements that lead to the process of making static time pass. They are trying to introduce certain structures to the B-series that will put a perspective on it: dividing it into the past, present and future. This is supposed to exclude future events from our ontological commitments and thus make sense of our everyday experience. There are two principal sources of the arguments how to animate the B-series: the first alternative utilizes *a priori* argumentation typical for traditional metaphysics, the second alternative utilizes scientific knowledge and is typical for naturalistic metaphysics. We will look at the second alternative, specifically at STR.

3 Putnam versus Stein

It was a debate between H. Putnam and H. Stein in the late 60s of the 20^{th} century that introduced STR to metaphysics. Putnam, in his paper *Time and Physical Geometry* [5], came with a proof that future events, according to STR, are as real as the present ones. It meant that STR implied static time. Before looking at the debate in detail, let me explain the theoretical context of the poof. As has already been stressed, the A-theory is not a scientific theory. Traditionally, physics, with its "geometrical" approach to time, has been working with what we now call "the B-series" for centuries. On the other hand, in pre-relativistic physics, this does not prevent us from identifying absolute present and separating past from future. This is no longer possible within the framework of STR and this is the agenda behind Putnam's proof. If he is right, then the dynamic A-series and its consequences are in trouble. There are two assumptions in Putnam's argument:

1. Relativistic assumption that there are no privileged observers.
2. The relation "being co-present with" (CP) is transitive.

The proof can be stated in the following form:
Suppose that

3. Event x is co-present with event y ($xCPy$) in x's frame of reference.
4. Event y is co-present with event z ($yCPz$) in y's frame of reference.
5. Z is in the future of x in x's frame of reference.

Therefore

6. If CP relation is transitive, then from premises 3 and 4 follows that z is co-present with x ($xCPy, yCPz \vdash xCPz$).

The conclusion says that x's future event z already co-exists with x, which suggests that future is equally real. There is no problem if we are confined to a particular frame of reference. There exists absolute separation of past, present and future. However, if we keep to the relativistic principle that there are no privileged observers, then the separation is necessarily relative and cannot satisfy the A-theorists. What was Stein's response in his paper *On Relativity Theory and Openness of the Future* [9]?

Before answering this question, we shall look at one potential source of misunderstanding between Putnam and Stein. There is a problem with CP relation. CP is not *just* transitive. CP is also reflexive (every event is co-present in respect to itself) and symmetric (if x is co-present with y, then y is also co-present with x). As a result, CP relation is an equivalence relation and that is

in harmony with our pre-relativistic intuitions of co-present and co-existing entities. Putnam explicitly mentioned transitivity but implicitly also symmetry: "At least one other observer is real, and it is possible for this other observer to be in relative motion to me" [5, p. 240]. Reflexivity was possibly considered as a trivial feature. Anyway, symmetry of CP is the issue. Putnam implicitly assumed that (1) symmetry is necessary feature of CP but (2) it is not possible to define it within the relativistic framework. Stein agrees with (2) but disagrees with (1). Stein considered symmetry of CP as something that should be dismissed in the relativistic world. His CP relation is deprived of its symmetric character and this is the real source of disagreement between Putnam and Stein. The following paragraphs should give us the details.

Stein's reply to Putnam's argument consists of two proposals. The first proposal is to identify an event's present by an event itself:

> "[...] in Einstein-Minkowski space-time an event's present is constituted by itself alone. In this theory, therefore, the present tense can never be applied correctly to "foreign" objects. This is at bottom a consequence (and a fairly obvious one) of our adopting relativistically invariant notion of simultaneity" [8, p. 15].

This solution doesn't satisfy our definition of CP. It is just reflexive and that is not enough. Could Stein have overlooked this difficulty? I think he couldn't have. The quotation goes on to suggest an idea that spacetime of STR is quite different from pre-relativistic space and time and this enables us to dismiss some of our pre-relativistic intuitions in the relativistic world. We are dismissing symmetry of CP in this case. Once again, this is one of the most serious difficulties in the philosophical discussions over STR. Arguments are often constructed in the language that contains both relativistic and pre-relativistic notions. The debate is often conducted in the following manner: (1) some proposal says that relativistic counterpart of everyday notion Z is XY, (2) a critic replies that XY is not in accord with our everyday intuitions associated with Z and (3) the final response is that we are in a relativistic world and we had better forget some everyday intuitions. The final response is partly true but it doesn't mean that everything goes in the relativistic world. This point has been developed by C. Callender [1, p. 592]. For Callender, Stein's proposal doesn't satisfy the weakest condition for a relation that wants to be the CP's counterpart within the relativistic framework. It is non-uniqueness principle that we have already assumed in relation to CP's symmetric nature: "This condition says merely that at least one event in the universe shares its present with another event's present" [1, p. 592]. This principle is not satisfied even by Stein's second proposal. The second proposal introduces the notion of becoming to STR. The notion of becoming is a tool for separating definite past from indefinite future. If something has already become, it has come into existence, it is already there, either in the present or in the past. It is definite which is in contrast with open future. Stein elaborated the second proposal later, in his paper [9] so we will look at that source. However, full exposition presupposes that the reader is familiar with some basic features of Minkowski spacetime and so we leave this topic here and return to it later.

4 Present, past and future in STR

Geometrical separation of past, present and future in Minkowski spacetime cannot be based on frame-dependent structures and notions since any result will be confined to a particular frame of reference. This is in contrast with absolute notions of past, present and future of the A-theory. We must look at invariant, frame independent structures of Minkowski spacetime. The obvious candidate is a light cone structure. The speed of light is constant and every observer will agree what spacetime locations are illuminated by the light spreading from a particular spacetime point. If we suppress two spatial dimensions, Figure 1 depicts the way the light spreads from a spacetime location O.[4]

There are two light cones: past and future. Past

[4] Savitt's entry in *Stanford Encyclopedia of Philosophy* [7, p. 10] has been an inspiration for the Figure 1 and subsequent characteristics of Minkowski spacetime.

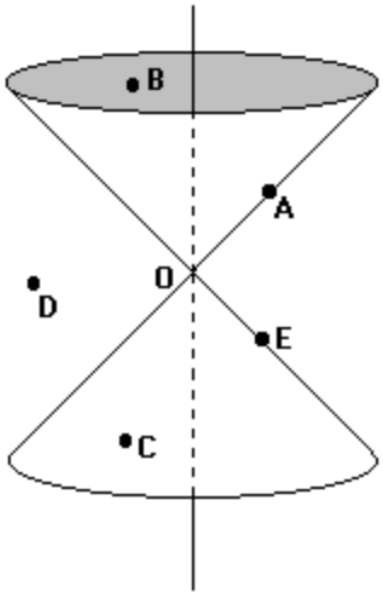

Figure 1

light cone is an area from which photons can reach O (lower light cone with C in it) and future light cone is an area to which photons can be sent from O (upper light cone with B point).

This invariant structure introduces three basic relations of STR: spacelike, lightlike and timelike separations. Two locations are lightlike separated if a photon can travel from location of one event to the location of another (A, on the surface of the future pointing light cone, and O are lightlike separated; the same is true of O and E). In the case of timelike separation, a material particle traveling with a speed less than the speed of light can travel from one location to another (relation between O and B and the relation between O and C are the instances of timelike separation). If no signal, including the light signal, can travel from one location to the other, then these locations are spacelike separated (this is the relation between O and D). Is it possible to identify events and their locations in Minkowski spacetime that are co-present with O? In another word, is there any equivalence class of spacetime locations that includes O? It is time now to return to Stein's second proposal that was supposed to identify events that are already definite, events that are already settled, as opposed to unsettled ones in the open future. If it is possible, then we are able to separate absolute past from absolute future in frame-independent way. This will prove that the hybrid theory of time is definable within the relativistic framework. Locations in the past light cone are natural candidates for the settled past:

> "If R is a reflexive, transitive relation on a Minkowski space... and if Rab holds for some pair of points (a, b) such that ab is a past-pointing (timelike or null) nonzero vector, then for any pair of points (x, y), Rxy holds if and only if xy is a past-pointing vector" [9, p. 149].

Stein's R is our CP and the expression *timelike* refers to timelike separation in the past light cone. Expression *null* refers to the lightlike separation on the surface of the past light cone. It is obvious that the relation between O and any location inside its past light cone is not symmetric. If we use Stein's vocabulary, C is already settled, already existing for O but O is in C's future. Stein is well aware of that but he is not aware of another important fact: both timelike and lightlike relations are not *necessarily* transitive. Focus on E on the surface of O's past light cone. E and O are lightlike separated. However, there exists possibility of another light cone, with different source of its origin, that makes E lightlike separated from a location that is not lightlike separated on the surface of the light cone originating in O. Call this location F. Light signal connects O with E (on the surface of one light cone), E with F (on the surface of some other light cone) but O is not lightlike connectable with F. Lightlike separation is transitive only for locations on the surface of the *same* light cone but we can't prevent situations where we have to take into consideration different light cones that distribute new lightlike relations on the locations in Minkowski spacetime.[5] Similar scenario can also show that timelike relation is not necessarily transitive either. Regardless of its philosophical motivation, Stein's notion of becoming (something that already became real with respect to something else) is not an adequate relativistic counterpart of our CP. Relations that establish it, lightlike and timelike relations in the

[5] I owe this important idea to Ladislav Kvasz.

past pointing light cone are neither symmetric nor necessarily transitive. However, there is a lot more to learn from Putnam - Stein debate but before doing that, we are going to summarize our current results in the search for CP in the relativistic framework.

(1) It is obvious that future light cone (locations inside it) is not, intuitively, location where to place CP in regard to the origin of the light cone. This area represents absolute future. However, the situation on the surface of the future light cone is a bit more complicated and we shall return to it later in the paper.

(2) Less obvious case is with the locations that are spacelike separated but it is a bit paradoxical. In respect to the origin of the light cone, what is neither in the past nor in the future must be co-present. This is commonsense reasoning but it is against our strategy to place CP in the frame-independent structure of Minkowski spacetime. Spacelike separated events are the events whose temporal ordering is the subject of frame-dependent relativity. On the other hand, the fact that B is in O's future and C in O's past is frame-independent. Every observer will agree with that. Frame-dependent differences concern only spacelike separated events. There will be no absolute agreement between observers, who are in relative and inertial motion in respect to each other, about the temporal ordering of spacelike separated events. This is also the reason why the position of one and the same temporal moment varies from one frame of reference to another. There are many, frame-dependent, B-series of spacelike separated events. Spacelike relation is not a candidate for relativistic co-presence relation since it identifies past, present and future in a frame-relative way.

(3) If we locate CP at the origin of the light cone (O is co-present with itself) we face, what S. Savitt calls, "temporal solipsism" [6, p. 567]. This solution violates, what has been called "the thinnest requirement of CP", that is, at least two different entities must co-exist in order to use CP properly and not trivially. However, it is almost impossible to eliminate certain forms of "solipsism" of CP within the relativistic framework and this idea will also be elaborated further in the paper.

(4) Only past pointing light cone remained. As has already been stated, timelike and lightlike relations in the past pointing light cone are neither symmetric nor necessary transitive. But CP is an equivalence relation that is unlikely to be deprived of these properties.

The results are not optimistic so far. However, we are balancing between two limiting points: on the one hand, there is a CP relation and its pre-relativistic, commonsense definition as an equivalence relation; on the other hand, we are not in a pre-relativistic world anymore. This enables us to apply the principle of charity and try to reformulate (1)-(4) differently in order to come as close as possible to pre-relativistic use of CP. It seems also necessary to dismiss some of the pre-relativistic features of CP but still work with interesting and fruitful notion of CP. However, which ones to dismiss? Stein dismissed symmetry. Was he right? We can't do it arbitrarily in the style "everything goes". It looks that the best candidate for relativistic counterpart of pre-relativistic CP is lightlike separation relation on the surface of the past pointing light cone for several reasons. Try to apply the principle of charity to it:

a) It is a topological fact of Minkowskian geometry that the spacetime interval (which is also an invariant structure of Minkowski spacetime) between two lightlike separated events is 0. Such events must be topologically co-present, co-existing and that is a serious fact.

b) Here comes the principle of charity: to ensure that this relation is necessarily transitive, it is sufficient to limit lightlike separation to a surface of the one and only one light cone. This is, in fact, what Stein does.

c) Here comes the principle of charity again: if we reduce our perspective to a single location within the spacetime, as stated in b), it is

> not necessary to end up with "temporal solipsism". It means, however, to make lightlike relation symmetric and make events on the surface of the same past pointing light cone co-present. This can be achieved only and only in Minkowski spacetime that is not time oriented. Suppose there is a past pointing light cone with its origin in location Z with X and Y locations on its surface. Normally, in time oriented structure, we would say that Z can receive a light signal from X and Y but not *vice versa*. Lightlike separation is asymmetric. If the structure is not oriented, it is possible that X and Y can receive a light signal from Z too and this makes lightlike separation symmetric.

If Minkowski spacetime is not time-oriented and if we reduce our perspective to a single location with its lightcone structure, then the lightlike separation is both symmetric and transitive. Formally, this makes it a good relativistic counterpart of CP. Moreover, this fact is also supported by the topology of Minkowskian geometry. However, there are several objections to this conclusion and S. Savitt proposed two of them. If what has been said is true, then we are co-present with events that are far older then us. Savitt mentions the example of Cosmic Microwave Background Radiation that originated 300,000 years after the Big Bang which, by our criteria, must be our present because we are receiving it in a form of light signals [6, p. 566]. Again, we have to find a balance between pre-relativistic notions and a relativistic world. This is Hinchliff's position:

> "The objection derives its force from the "fact" that Cosmic Microwave Background Radiation originated 15 billion years ago. This "fact" comes from outside the special theory. The special theory is silent on this matter. Indeed, according to the special theory, there is no fact of the matter concerning how long ago this event happened. If we think it is a fact that this event happened 15 billion years ago, we must think there is a distinguished inertial frame which assigns events their "correct" dates.... If we think there is no distinguished inertial frame, then we cannot appeal to alleged facts like the radiation's originating 15 billion years ago in objecting cone presentism" [2, p. 581].

The other objection is related to the surface of the future pointing light cone. Let us take an example of the relation between O and A as shown in Figure 1. O and A are also topologically co-present as O and any other location on the surface of its past light cone. Why not to treat O and A as co-present [6, p. 567]? Hinchliff replies that O cannot receive a light signal from A as Minkowski spacetime is time oriented and thus makes the relation between O and A asymmetric [2, p. 582]. This makes the situation even more difficult. In order to avoid, what Hinchliff calls "the double cone presentism", we must treat lightlike separation as asymmetric but this is exactly what we have been trying to avoid in order to bring lightlike separation as close to pre-relativistic CP as possible. Moreover, if the structure is not oriented than the relations fail to distinguish past from future. Suppose our light cone structure in Figure 1 is not time oriented. Then the adoption of the notions of past and future light cones is relative. A is in the absolute future of O in one direction, but it is in the absolute past from the perspective of the opposite direction. Thus we would be able to identify, via lightlike separated events, absolute present but we would not be able to say where the future and the past are. Even if we are the most charitable persons, it is not possible to introduce absolute past, present and future of the A-theory to STR in a systematic, consistent and independently motivated way.

Surprisingly, we may agree with Stein and Hinchliff with their arguments but it is possible to interpret them differently. I will borrow a metaphor from the beginning of C. Callender's paper *Shedding Light on Time* [1, p. 587]. Imagine that each location in four-dimensional manifold is carrying a lightbulb. We say that event exists when the bulb is on and doesn't exist when the bulb is off. The B-theorists say that each bulb is on, each event exists and that it is useless to say what is present, past and future. Time doesn't

pass. On the other hand, defenders of the hybrid theory of time will say that only some of the bulbs are on and the rest of them are off.[6] The situation is problematical in a relativistic world as every report telling us which bulbs are on and off will also depend on the position and the relative motion of the reporter in the four dimensional manifold. We tried to solve this difficulty by an appeal to invariant structures of the manifold in order to reach frame-independent results. The consequence of this strategy is rather surprising: every lightbulb is on and this is exactly what eternalists, the B-theorists, say. Each event defines its local, perspectival present. This is rather trivial but our effort to enlarge local present to other, as Stein said, "foreign objects", failed. It failed because we reached a rather unintuitive notion of CP. It means that present is trivially defined in every location of four-dimensional manifold and that is important. There is no reason to say that one location is distinguished from the rest. They are all equal:

> "Then each point of spacetime is distinguished as real... and the odd solipsism... is supposedly avoided. Presentism so reformulated collapses to eternalism" [6, p. 568].

5 Conclusion

The search for a reasonable balance between relativistic and pre-relativistic notions of co-presence has failed. Only trivial, solipsistic results can be achieved. If the arguments are correct, they lead to the conclusion that every event exists, every event is present in respect to itself. The search shows that an effort to introduce passage of time (introduce notions of absolute past, present and future) to relativistic universe leads to eternalism, which is one of the consequences of the B-theory of time. In order to get more comprehensible picture of our debate, the reader should also take into consideration the following questions: What is STR about? Is it only theory of light and its features in four-dimensional manifold or is it also a theory of time and space (or rather spacetime)? Even if we manage to define present, past and future in Minkowski spacetime, what is its scientific value? Even if STR proves fatalistic picture of the world, is it really the world that *we* live in? Is it really *our* world? Answers to these questions are relevant to our topic but they would require a separate study.

[6] Why hybrid? They believe in a network of locations with bulbs that is close to our B-series. They are all real but not equally. "Really existing" bulbs are only those that are on, which is a counterpart of the present in the A-series.

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