Absolute Simultaneity and the Principle of Stable Causality

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Abstract

Einsteins relativity of simultaneity had a deep impact on the pilosophy of time. A first conclusion is that there is no such thing as absolute time. Furthermore according to relativity of simultaneity there is no present in which an open future could come into existence and then pass into a fixed past. According to relativity of simultaneity there is no becoming in a three-dimensional space. There are just changes in a four-dimensional world, often called "block universe". Although many authors refuse this static interpretation of space-time, there is little doubt in the relativity of simultaneity. This is astonishing, because in the present cosmological models the relativity of simultaneity is not valid and the work of Hawking and Ellis has shown that there is good reason to refuse this principle.

1 Absolute Simultaneity and Absolute Time

Herman Weyl stated that Einstein was the first to notice that absolute simultaneity is a special assumption and

... in freeing us from this dogma lies the greatest achievement of Einstein in the field of knowledge and this is what makes us rank his name with that of Copernicus (Weyl 1922 p.164 translation M.W.).

That absolute simultaneity is indeed a special assumption can be seen easily if one looks at Newton's space and time from a four dimensional point of view. The Newtonian spacetime consists of layers of simultanous events.

We will name the afore-mentioned assumption, through which the world is given a structure, which is represented in our figure by the congruence of parallel horizontal planes and that of vertical straight lines - one could describe them as a layering connected with a bunch of transverse fibres - as the asumption of *absolute time* and *absolute space* (Weyl 1922 p.144 translation M.W.).

In the latter I will take the foliation of spacetime M into layers of simultaneous events to be the assumption of absolute simultaneity and absolute time should mean that a global time function f on M exists, which gives every event $x \in M$ a time $t \in \mathbb{R}$. Clearly both statements are equivalent because a hyperplane of simultaneous events consists of events $x \in f^{-1}(t)$ for a chosen t. Relativity of simultaneity in contrast is the assumption that a global time function f, or absolute time, does not exist. Ordinarily something slightly different is understood by relativity of simultaneity:

Each such cleavage plane is a substratum of the events simultaneous for the corresponding observer, but - unlike in the Newtonian spacetime - none of them possesses a priviliged, objective character. This is the meaning of the relativity of simultanity (Capek 1966 p.507).

The cleavage planes Capek meant are defined in a coordinate system by the condition $t = const$. The stronger version "no global time function exists" is of greater importance for the following. The weaker version may not exclude the existence of an absolute time function, because one is not obliged to define simultaneity by $t = const$. (For a more detailed discussion see Wüthrich (2011)). Our present cosmological models contain a global time function and therefore there is absolute simultaneity and absolute time in them.

From this state of affairs, in view of the fact that some of the known cosmological solutions seem to represent our world correctly, James Jeans has concluded that there is no reason to abandon the intuitive idea of an absolute time lapsing objectivley. I do not think that the situation justifies this conclusion and I am basing my opinion chiefly on facts and considerations (Gödel 1949b p.456):

2 Stable Causality and Gödelian Time Travel

To my knowledge Gödel was the first to give an even mathematically correct argument that a global time function might not exist.

There exist cosmological solutions of another kind than those known at present, to which the afore mentioned procedure of defining an absolute time (Jeans 1935) is not applicable, because the local times of the special observers used above cannot be fitted together into one world time. ... *This state of affairs seems to imply an absurdity. For it enables one e.g., to travel into the near past of those places where he has himself lived.* ... As for the conclusions which could be drawn from the state of affairs explained for the question being considered in this paper, the decisive point is this: that for *every* possible definition of a world time one could travel into regions of the universe which are past according to that definition. This again shows that to assume an objective lapse of time would lose every justification in these worlds (Gödel 1949b p. 456).

In order to avoid this absurdity that Gödel mentioned the physicists examined several causal conditions. (See for instance Earman 1992, Hawking and Ellis 1973 or Wald 1984). One of them is the principle of stable causality. It says that there is a smooth non-vanishing vector field t^a on (M, g_{ab}), so that on (M, g'_{ab}) with $g'_{ab} = g_{ab} - t_a t_b$ no causal curves exist. This principle means, that it is possible to widen out the light cone a little and it is still not possible to travel around in time. Stable causality implies strong causality, which means that it is impossible on the original spacetime (M, g_{ab}) to travel around in time and get even close to those places you have been before. Hawking and Ellis proved the following theorem:
Stable causality holds if and even if there is a global time function (Hawking and Ellis 1973 p.198). So it is important where you stand on the existence of absolute time for what you think about the possibility of time travel. If you don't believe in absolute time you can't believe in the principle of stable

causality.

> The special and the general theories of relativity have both produced conceptual revolutions. The twin paradox and the grandfather paradox help emphasise how radical these revolutions are, but they do not show that these revolutions are not sustainable or contain inherent contradictions (Earman 1992 p.17).

What Earman leaves out in *Recent Work On Time Travel* is that you could take just the opposite position. You could believe in absolute time and the principle of stable causality in perfect agreement with the theory of general relativity. This is what you do, if you believe in the present cosmological models. Even the very hyphothetical Loop Quantum Gravity needs the foliation of spacetime into time and space (Wüthrich 2012 p.317) and therefore Loop Quantum Gravity would rule out the possibility of time travel (Wüthrich 2007 p.206). So what is left over to discuss is why the twin paradox does not imply the relativity of simultaneity.

3 The Twin Paradox and the Lapse of Time

> Common sense, although it recognizes that all things are subject to the conditions of space and time, does not treat time and space in quite the same way. Space appears, by its nature, totally indifferent to things: they undergo no modification as a result of having changed place. It is true that if I took the puppy I hold in my arms to the top of Mont Blanc he would suffer, and if I plunge him in water he would be asphyxiated, but this is the result of a change in the visible material conditions of his surroundings and not the result of mere spatial change. On the other hand, moving forward in time, he will undergo modification by this very fact. If twenty years from now one presented me with a dog resembling this one absolutely and if one tried to make me believe it was the same one, I would not believe it in the least (Meyerson 1925 p.358).

The twin paradox says that the modifications the puppy will undergo from the fact that it moves forward in time do not depend on how many layers of absolute simultaneity the puppy crossed or in other words how far he traveled in absolute time. The age of the puppy will depend on the proper time of his world line $\int_\gamma ds$ with $ds^2 = g_{ab}dx^a dx^b$, defined similar to the length of curves in three dimensional space. The wrong conclusion is that absolute time does not exist. What Meyerson and according to him common sense overlooks, is that the puppy does not age because of moving through time. The puppy does age because of biological, chemical or physical interactions in his body. So the modifications of that puppy do depend in both cases, moving forward in time and moving forward in space, on material conditions. In the same way clocks do not measure absolute time. They count repeatings of periodical processes. Clearly clocks can't (easily) be used to define absolute time. Einstein tried to spread out the proper time a clock actually measures by light signals throughout space. In this definition of time simultaneity depends on the status of motion of the clock the observer used and different observers fail to establish an objective or absolute simultaneity. It's interesting to know that this difficulty appears in the global positioning system GPS. There one takes into consideration that the time a clock shows depends on its state of motion and other relativistical effects **before** one spreads out this time by signals of electromagnetical waves. In this way a "global" time is given to us, which does not depend on the speed of the satellite we use at the moment (Asby 2007). For this paper it might be sufficient to remark that the global time function should be interpreted as an absolute time in the sense of Kantian philosophy and its existence is clearly not ruled out by the twin paradoxon.

4 Conclusions

In the preface of his textbook Hubert Goenner writes *Spezielle Relativtätstheorie und die klassische Feldtheorie*: Einstein's farewell to Newton's *absolute* time was a kind of blasphemy to some persons (against the 'devine' Kant) (Gönner 2004 p.VII translation M.W.). The denial of an absolute time does not just question Kant's philosophy. It has to do with all A-theories such as Arthur Prior's tense logic (Müller 2002). You can divide time theories into two categories: A-theories, which distinguish between past, present and future and B-theories, which simply make a distinction between earlier and later. This classification comes from McTaggart (Mc Taggart 1908). The fundamental difference between A- and B- theories lies in their relationship to the present. B-theories can do without the latter. Massey describes all A-Theories as

> ... ill-advised because grounded in bad physics (found in Müller 2002 p.222).

This article wants to show that one has to add the right condition for the strong version of relativity of simultaneity to hold to statements like these. Massey's criticism to A-theories would be: "All A-Theories are ill adviced because of being grounded in bad physics if the principle of stable causality fails to hold." I agree with Esfeld who wrote

> The tenseless sight of existence is known as the conception of an block universe. Relativity of simultanity in the theory of special relativity is sufficient to establish this philosophical conception (Esfeld 2002 p.34 translation M.W.).

if the stonger version "no global time function exists" is meant. If there is no present, there is just earlier and later and no future or past. But this only has to be true if stable causality is violated. If I could travel into my own past to meet my grandfather I won't kill him simply because I didn't do it then. There is no destinction between past and future any more, so there can't be an open future. But stable causality might not be violated and so relativity of simultaneity might not be true.

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