BACWARD-LIGHT-CONE SIMULTANEITY, WITH SPECIAL APPLICATION TO THE TWIN PARADOX

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ABSTRACT

In an earlier publication (Ben-Yami 2006) I argued against Malament's claim (Malament 1977) that, given the causal theory of time and some additional minimal constraints, Einstein's standard definition of simultaneity is the only acceptable simultaneity definition in the Special Theory of Relativity. Among other things I have shown there that if we adopt Malament's approach, the definition of all events on a given event's backward light cone (BLC) as those simultaneous with that event is at least as acceptable as Einstein simultaneity. In this paper I show how BLC simultaneity has some conceptual advantages over Einstein simultaneity, I present kinematics with BLC simultaneity, and show how it resolves the Twin Paradox.

First, according to Einstein simultaneity, one and the same event can occur more than once relative to the same observer, if that observer is not inertial. This result shows that nothing much is left of our concept of temporal order if we adopt Einstein simultaneity. Secondly, if we understand by a system 'an organized or connected group of objects' (OED), and if we should aspire that all parts of a system would ascribe roughly the same coordinates to the same events, then, I argue, BLC simultaneity does that better than Einstein's. Thirdly, I show that BLC simultaneity reduces the gap between the scientific image of the world and its manifest image. Fourthly, I show that while coordinates that rely on BLC simultaneity express a *fact* about the world—how things really appear to observers—coordinates using Einstein simultaneity do not represent any observable fact but serve only as middle terms between observables. In this sense any exposition of Special Relativity should include the results obtained with BLC simultaneity, but not *vice versa*.[1]

I then present the results for length and time change in a moving body according to BLC simultaneity. I limit myself here to the one-dimensional case: a body moving towards or away from an observer. If a body's velocity is positive when it moves away from the observer, then the length of a body moving with velocity v is:

$$L_v = L\,(1 - 2v/c)^{1/2}$$

The time interval that a clock moving with velocity v would show, compared with that shown by the observer's clock is:

$$\Delta t_v = \Delta t(1 - 2v/c)^{1/2}$$

[1] BLC simultaneity has other advantages too, which I have no space to mention here. I discuss them in (Ben-Yami 2007), where all the results mentioned in this paper are also proved.

We get not only length contraction and time dilation, but, if the body and clock are moving towards the observer, length expansion and time acceleration. These are the changes of length and time that would actually be seen by the observer, and not their Einstein equivalents.

I next proceed to apply these results to the Twin Paradox. I first argue that according to Einstein simultaneity a paradox, or at least a puzzle, still remains. This is because the situation, according to Einstein simultaneity, is by and large symmetric. Einstein simultaneity also forces us to consider the astronaut's acceleration as absolute in order to account for the astraonaut's dilated clock relative to the Earth's clock when they meet again. In contrast, if we describe the situation by means of BLC simultaneity, the symmetry is canceled and the paradox does not arise. Acceleration in Special Relativity can still be considered relative from a kinematical point of view. The paradox was a result of an artificial symmetry imposed on the description of the situation by Einstein simultaneity.

Bibliography

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