Review of: "Zeno and Einstein"

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This is a very interesting paper. Ted Dace begins by making a parallel between Zeno's paradox, that aims at ``demonstrating" the impossibility of motion, and what he names ``Einstein's principle of the relativity of simultaneity", which states that the notion of simultaneous events depends on the reference frame.

Zeno's paradox consists essentially in considering some specific infinite series of successive instants that may be defined within the duration of a finite motion, and in saying that the fact that this number is infinite makes that very motion impossible. The standard resolution of the paradox simply notes that the infinite series of the time intervals between those specific instants has a finite sum --- namely, the duration of the motion. In contrast with the author, I see no problem with this resolution, even though, as emphasized by him, both the statement of the paradox and its resolution are ``abstract": after all, this is the way in which the analytic thought works. Moreover, to criticize Salmon's exposition of the standard resolution, the author states that it amounts to say ``that a given interval of time is actually constructed from an infinity of zero-duration instants". This is incorrect. As I wrote hereabove, what is used in the standard resolution (including its exposition by Salmon) is that the sum of the time intervals between those zero-duration instants is finite and provides the length of the given interval of time --- and that is true.

According to Ted Dace, Zeno’s paradox and the relativity of simultaneity are ``equally absurd". In my opinion, this is not the case for the following reason: Zeno's paradox wants to contradict the very possibility of the motion, that is yet observed everywhere and at any time. Whereas the notion of distant simultaneous events, while apparently obvious to our consciousness, is not easy to define. On the other hand, I do agree that the relativity of simultaneity is shocking for the common sense. However, it has a very solid status within the framework of standard special relativity, being a straightforward consequence of the Lorentz transformation, that is central in special relativity. (Thus, the relativity of simultaneity is not a ``principle" but rather a theorem of special relativity.) Also, it cannot be qualified as absurd, because, as first noted by Poincaré: ``Not only have we no direct intuition of the equality of two periods, but we have not even direct intuition of the simultaneity of two events occurring in two different places." The point is that physics needs operational definitions. Currently, the best operational definition of simultaneity is the one deduced from synchronizing the time by exchange of light signals, as described by the author. This definition has been first introduced by Poincaré and has been ``rediscovered" by Einstein. It has as a consequence the relativity of simultaneity, that (I repeat) is also implied by the Lorentz transformation.

Thus, in my opinion, the relativity of simultaneity is an inescapable consequence of special relativity --- or more exactly, of its standard (Einstein-Minkowski) interpretation. However, there is an alternative interpretation: the Lorentz-Poincaré

interpretation, which sees the relativistic effects as following from the ``true" Lorentz contraction of all objects in their motion through the ether. In this interpretation, there is a preferred reference frame (the ether), even though it cannot be detected in the physical situations that are correctly described by special relativity. The time in that reference frame, synchronized by exchange of light signals, is then considered as the ``true time", and the simultaneity thus defined in the ether frame is regarded as the ``true simultaneity". This interpretation is physically fully equivalent to the standard interpretation, and (precisely for that reason) its difference with the Einstein-Minkowski interpretation may be qualified as ``metaphysical", as long as the ether remains undetectable.

However, special relativity does not include gravitation. Gravitation is currently described by general relativity, which reduces to special relativity when gravity can be neglected. But no physical theory is final. From the logical point of view at least, it could be the case that a more correct extension of special relativity to the situation with gravitation would be a preferred-frame theory, in which the ether would be detectable, and that would reduce to special relativity in the absence of a gravitational field. In that case, the relativity of simultaneity would not apply any more to the general situation with a gravitational field.

Ted Dace's appeal to quantum mechanics in Section 4 is interesting, though it contains several passages that I find unclear. E.g. the author's negative considerations about ``the mathematical continuum of Galileo, Descartes, Leibniz and Kant" look unclear and unconvincing to me. The mathematical continuum in question is just the real line. It is difficult to describe it as problematic, in my opinion. Good physics needs good mathematics: to deprive oneself from the real line would make nearly impossible to do physics. Anyway, Section 4 about ``Special Relativity in Light of Quantum Mechanics" does not appear to solve the relativity of simultaneity inherent in special relativity. (Note that, generally speaking, quantum mechanics makes our understanding of physical reality more difficult, rather than more easy.)

The author insists that real events have a finite duration, not zero duration. In my opinion this may be argued in the classical world as well, if one considers real bodies or particles, that have a non-zero spatial extension and are deformable; so that the digression about quantum mechanics does not seem crucial to the author’s argument. As he notes, this non-zero duration of real events allows one to associate any (finite-duration) event with a reference frame: ``Only by occupying a certain duration can an event participate in the motion of a given frame and thereby be identified with that frame". Okay, although in physics we are accustomed to consider the useful simplification of zero-duration events. Now, this analysis would lead one to define that two non-zero-duration events taking place in the same frame are ``absolutely" simultaneous if they are simultaneous in that frame. But this tells nothing about the general case of two non-zero-duration events taking place in two different reference frames. Thus, this interesting remark of the author leaves us unable to define an observer-independent notion of the present time, which in my opinion is really the trouble with the relativity of simultaneity.

In summary: I find that this paper is very interesting and that his author is a cultivated one, and I agree with him that the relativity of simultaneity is very difficult to accept for the common sense. However, I disagree with his criticism of the standard resolution of Zeno's paradox, as well as with his statement that the relativity of simultaneity can be put aside from special relativity in its standard interpretation.