Review of: "How Many Postulates Are Needed to Derive the Lorentz Transformation?"

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In his interesting paper, Ma presents a mathematical and logical approach to the derivation of the Lorentz transformation. The author shows that, besides the two main postulates --- 1) the principle of relativity; and 2) the constancy of the speed of light --- at least two more postulates are necessary to derive it. According to Ma, without the third and the fourth postulates as constraints, an infinite number of space and time transformations satisfy the constancy of the speed of light and the principle of relativity.

We believe that, from the mathematical and logical perspective, the approach of Ma is correct. In fact, even from a physical and empirical perspective, we are met with an infinite number of Lorentz transformations (LT), as shown and derived by Mansouri and Sexl (MS) in 1977 [1]. MS determine some of the coefficients empirically, but the time transform is a function of the synchronization parameter ε, which is arbitrary as clock synchronization is, and thus the one-way light speed is conventional. The main difference between the LTs of Ma and that of MS has to do with the problem of distant clock synchronization and whether the one-way speed of light is measurable or otherwise. With ε=v, the LTs of Ma and of MS coincide and are the standard ones based on relative simultaneity. With ε=0, simultaneity is conserved (absolute simultaneity) and the transformations are denoted as LTA. According to MS, the LTs --- for any allowed value of ε --- agree with all the experiments supporting standard special relativity. Hence, we are still within the context of special relativity as a relativistic theory. The conventionalist approach of MS is in line with the criticisms made by epistemologists [2]-[4] of Einstein synchronization, pointing out that although the average light speed c from A to B and back can be measured, there is an indeterminacy in the theory because the one-way speed from A to B may be different from the return one-way speed from B to A.

According to Ma, “…Einstein argued that it is impossible to measure the one-way speed of light in inertial systems and postulated the constancy of the speed of light…”. Then, “… the theory of relativity has to face the awkward situation that the one-way speed of light can be measured in non-inertial systems (Sagnac 1913; Wang et al. 2003; Wang, Zheng, and Yao 2004; Wang 2005) and there is no inertial system in the universe.” Furthermore, Ma writes, “General relativity cannot assume the constancy of the speed of light because the one-way speed of light can be measured in non-inertial systems … using the Lorentz transformation as the primary principle can avoid the contradiction between special relativity and general relativity”

It is important to deal with the central arguments of Ma in a wider context that includes the experimental verification of the LT, which we consider below. Moreover, it would be more rigorous to consider the difference between the global light

speed c and the local, differential one-way light speed d**x**/dt. In any case, Ma's comments are significant because they are related to the interesting and fascinating controversy on the foundations of special relativity, which has been taking place between the supporters of Sagnac with light speed variance and the supporters of a conventional one-way light speed.

Schematically, with reference to the empirical validity of the standard LT (ε=v), we point out the following results:

According to several authors [5]-[23], the description of the Sagnac effects (circular and linear (Wang)) can be made without problems within inertial frames in flat spacetime, and thus there is no need to introduce General Relativity. The result is that the standard LTs fail in the interpretation of these optical effects. This point has been recognized also by conventionalists Kassner, Lee, Klauber, and many other relativist physicists. In fact, if the invariant one-way light speed is locally c = dx/dt along the contours where light propagates, light can cover a fraction of the contour only in the observed time interval, leading to a violation of spacetime continuity. However, spacetime continuity is not violated by adopting the LTA based on absolute simultaneity (ε=0) [5]-[18] with the variant local speed c ± v determined experimentally in the Sagnac effects.

The contention of conventionalists is that, although the LTs fail, they are not disproved because, due to the arbitrariness of synchronization, the LT and the LTA are physically equivalent [21]-[23]. Nevertheless, we believe that the claim of the equivalence between relative and absolute simultaneity does not make sense from the epistemological and physical viewpoint. In any case, to show that in general the LT and LTA are NOT physically equivalent, we mention the following examples listed in the Appendix, discussed also in Ref. [18]. As a final remark, we highlight that essentially all the paradoxes of standard special relativity (particularly the equilibrium paradoxes of electrodynamics) based on the LT with relative simultaneity are immediately solved with special relativity based on the LTA with conservation of simultaneity.

We are aware that the claim that the LTs fail in describing the optical experiments of the Sagnac type can be shocking for physicists adhering to the current paradigm of light speed invariance. However, similarly, Michelson and Morley (MM) and the physicists adhering to the Newtonian view, including Poincaré, were utterly shocked when the MM experiment provided an astonishing unexpected null result. However, historically, there has been general agreement that, in physics research, emotions, prejudices, and personal beliefs should be left out in favor of the traditional scientific rational approach and empirical verification.

In conclusion, we deem that the inclusion of phenomenological considerations, related comments, and references will improve and provide more general validity to Ma's paper and any inferences that can be drawn from it. Indeed, keeping within a rational approach, Ma's suggestion of "… using the Lorentz transformation as the primary principle…" could be viable only after the LTs are shown to account for a consistent interpretation of all known experiments, including the Sagnac effects and the several paradoxes of the theory.

APPENDIX

Some physical situations where the LT and the LTA foresee different observable results.

1- Sagnac effects (circular and linear). If the one-way light speed is c in the laboratory frame, for a consistent

interpretation, the local light speed in the clock's moving frame must be $\simeq c \pm v$.

2- GPS (Global Positioning System). According to GPS engineers, to achieve clock synchronization while using Einstein synchronization in the GPS and maintaining accuracy, the GPS must apply to the light signals a velocity correction that corresponds to the Sagnac effect. If the local speed of light is c in the Earth Centered Inertial (ECI) frame, the local light speed must be $c \pm v$ on the rotating Earth surface.

3- The reciprocal linear Sagnac effect. The analysis by Spavieri and Haug [21], [22] of the reciprocal linear Sagnac effect shows that the LTA and LT foresee different results. Hence, the two transformations are not equivalent and represent different physical realities.

4- The Thomas precession. Unlike the LT, the LTAs do not foresee the Thomas precession. In fact, the two transformations have different inherent symmetries. For the LTA, the spin-orbit interaction is explained with the Dirac equation and its nonrelativistic limit without the need to introduce the classical Thomas precession.

5. The synchronization procedure with entangled simultaneity proposed in Ref. [18] differs from Einstein's. By adopting the new procedure, the LT and LTA foresee different results and thus are not equivalent. It follows that, contrary to the conventionalist view, at least in principle, the one-way light speed can be measured and the Lorentz invariance can be tested.

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