Review of: "The Sagnac-Wang Interferometers and Absolute vs. Relative Simultaneity"

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Potential competing interests: No potential competing interests to declare.

Dear Justo, thank you for discussing our view of standard special relativity (SR) in relation to the interpretations of the effects of the Sagnac type. I hope that an interchange of opinions can help to reach a convergent view on this important issue. If you convince me, I'll become a fan of the Lorentz transformations (LT). If I convince you, perhaps we may write an interesting joint paper on this subject.

Still, I think that you are missing the crucial point in the interpretation of the (Wang) linear effect, as I show below. Thus, my present (can be changing) appreciation of your article with a limited number of stars reflects the missing point, but not your competence in the subject area, which I consider superior to that of many other physicists. So, my compliments for your paper.

1- Regarding your sentence,

"Without discussing their empirical adequacy, the most evident problem with the LTA is that it lacks theoretical and conceptual support",

let me explain why the theoretical and conceptual support of the LTA (Lorentz transformations based on absolute simultaneity) is the same as that of the LT.

Through more than a century, the original second postulate of Einstein has been evolving together with the interpretation of SR [1]. Currently, according to the many articles by relativists in mainstream journals, what is constant in Einstein's second postulate, is no longer the one-way light speed, but,

"The "observable" round-trip speed of light (i.e., the average light speed c during the round-trip from clock C* to a distant point X and then back to C*)."   (Current Second Postulate)

The change is due to the non-observability of the one-way light speed (considered conventional) with Einstein two-way synchronization procedure [1]-[11]. Therefore, the transformations considered by Mansouri and Sexl [2],

$$t' = t/\gamma - \varepsilon x/c^2 \quad x' = \gamma(x-vt) \quad y' = y \quad z' = z \tag{1}$$

$$c'(\varepsilon) = c/(1 + v/c - \varepsilon/c),$$

which, for different values of the synchronization parameter ε, satisfy (such as the LT and LTA) [1], [7]-[11], the Current

Second Postulate, possess the same theoretical and empirical support. In fact, without being aware of it, you are using the LTA in your approach with General relativity (GR), when you change synchronization (or desynchronization).

The use of the LT ($\varepsilon = v$) with light speed invariance is theoretically possible but limited to the case when the light speed is indetermined because measured by two spatially separated clocks arbitrarily synchronized [1], [2].

The well-known failure of Einstein synchronization and the LT [4]-[11] when applied to closed moving contours such as, for example, the Sagnac experiments, is due to the fact that, for closed contours, the one-way light speed can be measured by a single clock, where Sagnac found it is c+v or c-v. Hence, the corresponding synchronization parameter is determined and is $\varepsilon = 0$, requiring to adopt the synchrony of the LTA [1], [4]-[11] and ruling out the LT and other synchronies.

Thus, the historical support you attribute to the LT is somewhat "obsolete".

2- You state, after Eq. (3) where T = 2L/(c+v),

"We shall prove that an observer comoving with the clock C finds the same value (3) applying relativity theory."

I do not understand why you need to prove it; we all agree with it!

Our objection to the LT is about their inconsistency, and not the resulting T, which is the same for the LT and LTA, in this case. Our claim is that, at the local speed c, the photon cannot cover the whole path of length 2L in the interval T [1], [7]-[11]. Even a high school student can understand this kinematical result. Just consider your own results derived with the LT:

$$T = T_{out} + T_{ret} = L/c + (L/c)(1- 2v/c),$$

where Tout is measured by a clock C co-moving with the fiber lower section, and Tret > 0 is measured by a clock C co-moving with the fiber upper section from t = 0 to t = Tret at the arrival of the photon. Then, for the counter-propagating photon, we have:

Path covered in the out trip at speed c: $L_{out} = c\, T_{out} = L$

Path covered in the return trip at speed c: $L_{ret} = c\, T_{ret} = L(1- 2v/c)$

Total path covered in the round-trip interval T: $L_{tot} = L_{out} + L_{ret} = 2L – 2(v/c)L.$

But the total path to be covered is 2L and, therefore, according to the LT, the photon does not cover the "missing path" 2(v/c)L, implying a spacetime discontinuity related to relative simultaneity [1], [7]-[11].

Instead, according to the LTA, in the example considered, the photon covers the whole path of length 2L (spacetime continuity) at the average speed c +v, being c the local speed in the out trip, and c+2v in the return trip [1].

Hence, we have a big problem with the LT, but no problem with the LTA.

Sorry, Justo, but I think that you missed the critical point in your linear Sagnac effect interpretation.

You mention circular reasoning on my part, but the results of the LTs are derived by you, not by me. I just calculate the resulting path covered by light according to your results. Because of the spacetime discontinuity involved, the conclusion is that SR with the LT appears to be incomplete. Instead, there are no problems with the LTAs, which preserve spacetime continuity [1].

3- Passing to the circular Sagnac effect, you give up interpreting it with standard SR and use General Relativity (GR).

Considering that GR has nothing to do with the linear effect and the circular Sagnac effect is completely equivalent to the linear effect, why do we need GR to interpret the circular effect?

The consequence of the non-inertiality of the clock is negligible in the circular Sagnac effect as in very many experiments and effects taking place on the rotating Earth's surface. Why do we need to use GR now?

Possibly, the need surges because the interpretation of the circular effect without GR gives the same problem we find in the linear effect: In the interval,

$$T = 2\pi r/(c+v) = 2\pi r(1-v/c)/c, \tag{2}$$

and at the local speed c, as measured along the rim of length $2\pi r$ of the rotating circular platform, the path covered is $cT = 2\pi r(1-v/c)$, and we have again a "missing path". Instead, spacetime continuity is maintained with the speed $c + v$ foreseen by the LTA.

To "solve" this simple kinematical problem maintaining light speed invariance, you see the need to use GR. If the local speed is c along the path $2\pi r$ of the circular rim, we easily find the round- trip interval,

$$T = 2\pi r/c, \tag{3}$$

for both counter-propagating photons, which is wrong because against observation. You find the same "wrong" formal GR result in your Eqs. (37) and (43).

To avoid the problem related to observation, some GR physicists say that the differential local speed is $c = ds/dt$, but $dt = ds/c$ is not "integrable" along the curvilinear coordinate "s". You prefer to keep the finite results of your Eqs. (37) and (43) equivalent to my Eq. (3), but then things get more complex and, to agree with observation, you need introducing the desynchronizing effect, different in both directions. However, more problems arise and surges the need of correcting the definition of simultaneity in GR. About this, you point out that "the problem does not resides in the theory but in the incorrect definition of simultaneity…".

RESUMING YOUR APPROACH WITH GR.

With GR you get the wrong result (3) and introduce desynchronization to obtain agreement with experiment. Please, be aware that by changing synchronization you are no longer using the LT, but the LTA. Since the LT and LTA are not equivalent, as shown in Refs. [1], [7]-[11], because they foresee different results for the reciprocal linear Sagnac effect and other physical effects, you are not using standard GR with the LT, but a different theory based on the LTA.

In fact, I do not see the final T calculated with GR, but assume that, after the "desynchronization" and other corrections, it is the usual observable T of my Eq. (2). In this case, after an interesting journey in the GR scenario, returning to the flat spacetime of SR, I still see that, at the local speed c, the path covered is 2πr(1-v/c) and the breach in spacetime continuity persists with the LT. We have to be aware that, to maintain spacetime continuity and obtain the observable T = 2πr/(c+v) as in Eq. (2), we may correctly introduce "desynchronization" (or synchronization), which is equivalent to use the value ε = 0 in the Mansouri and Sexl transformations of Eq. (1). This way, we get agreement with observation, but because we are now using the LTAs that interpret correctly the Sagnac effects.

As far as I can see, the need of "desynchronization" in the approach with GR, confirms that the one-way speed cannot be c along the path 2πr. So, you make my point. With the LT it is not possible to interpret the Sagnac effect, within standard SR or even GR!

4- Let us consider from a conceptual perspective the reason why the need for using GR is surging.

In a nutshell, physicists have shown that, in principle, the approach with "standard" SR, based on the LT and light speed invariance, reveals unexpected problems such that of spacetime discontinuity in the interpretation of these effects.

Our claim is that "standard" SR and the LT fail in this case. The LT and light speed invariance are valid in the limited scenario of Einstein synchronization where "c" represents the two-way average speed in a round trip and the one-way light speed c is non-observable and conventional when measured with two clocks arbitrarily synchronized. Nevertheless, the one-way light speed is observable in the Sagnac effects where it is measured by a single clock that needs no synchronization.

Thus, to solve these problems, physicists allege the need to go beyond the "standard" SR scenario and use a different or more general theory to describe the electromagnetic phenomenon of light propagation along closed moving contours. The need for a different or more general theory, confirms the claim that the LT have limited validity and I agree completely about the need of a theory different or more general than "standard" special relativity.

Where I do not agree is that a complex theory such as GR is required for a consistent interpretation of the simple kinematics involved in these optical effects.

The relativistic theory (much simpler that GR) that solves the problems that arise with the LT, is just special relativity satisfying the Current Second Postulate and adopting the LTA with absolute simultaneity [1]. All the mentioned problems of the LT disappear with the LTA.

Even supposing that the GR interpretation is meaningful (although it does not seem to be such with the LT), please, compare the complexity of your approach with GR with the simpler one of the LTA, where we only have to set ε = 0 in Eq. (1).

Psychologically, we have been taught to believe in light speed invariance as a universal principle that solves and interprets all facets of physical reality. Nevertheless, among the infinite synchronies satisfying the Current Second Postulate, for the consistent interpretation of optical effects nature chooses the LTA with $\varepsilon = 0$.

History indicates that scientific progress is possible because paradigms do change. Thus, we cannot be linked dogmatically to a specific paradigm not supported experimentally. Hence, since physics is supposed to be based on rationality and empirical evidence, we may presume that, as the Galilean transformations have been dismissed by the Michelson-Morley experiment more than a century ago, the effects of the Sagnac type rule out today the Lorentz transformations based on light speed invariance.

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