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Selleri Theory Not Equivalent to the Special Theory of Relativity and a Related Note on H.P. Robertson 1949 Paper

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Abstract

In the present paper, I dispel the belief that the transformation developed by F. Selleri is equivalent to the Lorentz transformation, thus dispelling the misconception that his alternative theory is equivalent to Einstein's special theory of relativity. In the current paper I present an argument that has not been shown before aimed at settling the dispute. I demonstrate that the Selleri transformation is not equivalent to the Lorentz transformation by reasons of predicting different results for relativistic aberration.

Keywords: special relativity, Selleri transformation, Lorentz transformation, relativistic Doppler effect, relativistic aberration, Robertson 1949 paper

1. Introduction

In a paper published in 1996, F. Selleri (1990) put forward an alternative relativistic theory and derived the transformation equations that bear his name:

$$\begin{aligned} x' &= \gamma(v)(x - vt) \\ y' &= y \\ z' &= z \\ t' &= \gamma(v)t \end{aligned} \tag{1.1}$$

It can be seen that the Selleri transformations imply absolute simultaneity by contrast to the Lorentz transformations that imply relative simultaneity (Einstein, A., 1905):

$$\begin{aligned} x' &= \gamma(v)(x - vt) \\ y' &= y \\ z' &= z \\ t' &= \gamma(v)(t - \frac{vx}{c^2}) \end{aligned} \tag{1.2}$$

Selleri's program was to re-derive from the above transformation the explanation for the canonical tests of special relativity, the Michelson-Morley, Kennedy-Thorndike and Ives-Stilwell experiments and he succeeded in doing just that. The question that I plan to answer in the next section is: does that mean that Selleri's theory of relativity is equivalent to the special theory of relativity modulo the difference in the way simultaneity is being viewed?

2. Two Derivations of Relativistic Doppler Effect and Relativistic Aberration

Unlike his predecessors, Einstein did not consider relativity as a consequence of electromagnetism but rather a fundamental property of nature. The common starting point for the Doppler and aberration derivations for both Einstein and Selleri is the invariance of the phase of the generic planar waves:

$$\Phi = \omega(t - \frac{lx + my + nz}{c}) \tag{2.1}$$

Unlike the wave equation, the wave phase has directional content and this directional content will be reflected in both the Doppler effect and in the aberration. Einstein started with the phase invariance of the planar wave (1905):

$$\Phi = \Phi' = \omega'(t' - \frac{l'x' + m'y' + n'z'}{c}) \tag{2.2}$$

Inserting the Lorentz (Lorentz, H. A., 1904) transformations (1.2) into (2.1) Einstein obtained:

$$\begin{aligned} \omega'(t' - \frac{l'x' + m'y' + n'z'}{c}) &= \omega'[\gamma(t - \frac{vx}{c^2}) - \frac{l'}{c}\gamma(x - vt) - \frac{m'y + n'z}{c}] = \\ &= \omega'\gamma(1 + \frac{l'v}{c})t - \omega'\gamma(l' - \frac{v}{c})\frac{x}{c} - \omega'\frac{m'y + n'z}{c} = \\ &= \omega'\gamma(1 + \frac{l'v}{c})(t - \frac{l' - \frac{v}{c}}{1 + \frac{l'v}{c}}\frac{x}{c} - \frac{m'y/c + n'z/c}{\gamma(1 + \frac{l'v}{c})}) \end{aligned} \tag{2.3}$$

The above needs to hold for any (x, y, z, t), so, by identifying the coefficients of the variables between (2.1) and (2.3), one obtains the formulas for relativistic Doppler effect and for relativistic aberration:

$$\begin{aligned} \omega &= \omega'\gamma(1 + \frac{l'v}{c}) \\ l &= \frac{l' - \frac{v}{c}}{1 + \frac{l'v}{c}} \\ m &= \frac{m'}{\gamma(1 + \frac{l'v}{c})} \\ n &= \frac{n'}{\gamma(1 + \frac{l'v}{c})} \end{aligned} \tag{2.4}$$

On the other hand, inserting the Selleri transformation (1.1) into (2.1) one obtains:

$$\begin{aligned} \omega'(t' - \frac{l'x' + m'y' + n'z'}{c}) &= \omega'[\gamma(v)t - \frac{l'}{c}\gamma(v)(x - vt) - \frac{m'y + n'z}{c}] = \\ &= \omega'\gamma(v)(1 + \frac{l'v}{c})t - \omega'\frac{l'}{c}\gamma(v)x - \omega'\frac{m'y + n'z}{c} = \\ &= \omega'\gamma(v)(1 + \frac{l'v}{c})(t - \frac{l'}{1 + \frac{l'v}{c}}\frac{x}{c} - \frac{m'y/c + n'z/c}{\gamma(v)(1 + \frac{l'v}{c})}) \end{aligned} \tag{2.5}$$

By identifying the coefficients of the variables between (2.1) and (2.5), one obtains the following consequences of the phase invariance under the Selleri transformations:

$$\omega = \omega' \gamma(v)(1 + \frac{l'v}{c})$$
$$l = \frac{l'}{1 + \frac{l'v}{c}}$$
$$m = \frac{m'}{\gamma(1 + \frac{l'v}{c})} \quad (2.6)$$
$$n = \frac{n'}{\gamma(1 + \frac{l'v}{c})}$$

The Selleri derivation of the relativistic Doppler effect is correct but the relativistic aberration formula is not correct as I can see by comparison with Einstein. There is an obvious difference in the cosine for the x direction. Today, I know that Selleri transformation would pass the Ives-Stilwell experiment that tests the transverse Doppler effect (Saathoff, G., Karpuk, S., Eisenbarth, U., Huber, G., Krohn, S., Horta, R. M., Reinhardt, S., Schwalm, D., Wolf, A., & Gwinner, G., 2003; Müller, H., Herrmann, S., Braxmaier, C., Schiller, S., & Peters, A., 2003; Müller, H., Herrmann, S., Braxmaier, C., Schiller, S., & Peters, A., 2003; Müller, H., Braxmaier, C., Herrmann, S., Peters, A., & Lämmerzahl, C., 2003), but it would give an incorrect prediction for all experiments involving relativistic aberration. In addition, Selleri's transform give the wrong answer for the speed composition formula:

$$\frac{dx'}{dt'} = \frac{dx - vdt}{dt} = u - v \quad (2.7)$$

The above means that the Selleri theory gives the wrong prediction for the Fizeau experiment as well as for all Michelson-Morley experiments in refractive (non-vacuum) media (Sfarti, A., 2011).

According to H.P. Robertson's seminal paper, (1949) Selleri's theory should be equivalent with the special theory of relativity since it gives the same answers for the canonical tests of special relativity, the Michelson-Morley, Kennedy-Thorndike and Ives-Stilwell experiments. Yet, I see that the answers diverge when it comes to the tests of relativistic aberration. This brings us to the realization that the three canonical tests are necessary but not sufficient in establishing the equivalence between the special theory of relativity and alternative interpretations, tests of relativistic aberration need to be added to the set. This conclusion follows naturally from the fact that the Michelson-Morley experiment deals with space transformations, the Ives-Stilwell experiment is an expression of time transformation (time dilation) while the Kennedy-Thorndike experiment is an expression of both time and space transformations while aberration is an expression of angle transformation, so it is not covered by any of the three tests mentioned by Robertson and this is how he missed the issue.

3. Conclusion

I have proved that Selleri's theory is not equivalent with special theory of relativity. As a by-product I have discovered that the three canonical tests are necessary but not sufficient in establishing the equivalence between the special theory of relativity and alternative interpretations, the tests of relativistic aberration need to be added to the list.

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