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Symmetry Experiment to the Lorentz Transformation

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Abstract

The result of the Lorentz Transformation on a classical formula is that an observer in reference frame A observes the same phenomena in reference frame B like an observer in reference frame B observing the phenomena in reference frame A. Is that true? In this article I demonstrate at the Doppler effect that this is valid even for 'absolute' velocities belonging to a reference frame outside of A and B. I suggest to test whether the geometric means of frequencies belong to the frames A and B or to a reference frame outside of A and B by an experiment at CERN. In the latter case this would have significant implications in space-time modelling.

Keywords: Lorentz-transformation; Doppler effect; Frequency; Galilean transformation

Introduction

The Relativistic Doppler Effect as a Geometric Mean

The Lorentz Transformation (LT) applied to the classical Doppler Effect at a Lorentz boost provides the formula for the Relativistic Doppler Effect (RDE), e.g. if sender and receiver move to each other in x-direction [1]:

$$f = f_0\sqrt{(1+\beta)/(1-\beta)} = f_0(1/\gamma)(1-\beta) = f_0\gamma(1+\beta) \qquad (1)$$

with $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$

The observer in A gets the same frequency as the observer in B.

The RDE is a symmetric formula concerning the observations of A and B. But one can see at one glance that the formula of RDE is a geometric mean of the two classical Doppler Effect formulas for the observer A in rest and B moving to A [2]

$$f_B = f_0/(1 - \beta) \qquad (2)$$

and the system B in rest and A moving to B

$$f_A = f_0\,(1 + \beta) \qquad (3)$$

where f_B and f_A

are not symmetric to each other.

This is no accident. In my former paper I demonstrated the deduction of Lorentz-transformation by three completely different methods, each having the same result: The transformed variable is a geometric mean as a result of simultaneous movement of frames A and B in opposite directions [3].

The geometric mean might be useful if the observers in A and B cannot measure their own velocities related to a fixed point but only the relative velocity between A and B. However, in this case formula (1) gets another meaning because the velocities v_A and v_B referring to an outside reference frame of A and B (e.g. the air for sound) determine the results of (2) and (3). One can get the relative velocity v in all variations of

$$v = v_A - v_B \qquad (4)$$

e.g. v = 900 – (- 100) = 1000, or v = 800 – (- 200) or v = 500 – (- 500) = 1000 km/h.

Therefore, there is no classical formula of Doppler effect with the relative velocity between A and B.

If $|v_A| \neq |v_B|$ there is no more symmetry in observations though v has the same value in all cases and the physical meaning is different as well, because (2) can only be derived from a rest frame C outside of A and B, where the light propagates isotropically with constant speed c (also valid without a medium). An observer in A or B cannot derivate the classical Doppler effect formulas from their own system because he/she cannot see the changed wavelength by the velocity of the sender. This is possible only for an observer in C outside of A and B where the velocities v_A and v_B to a common fixed point in this frame can be measured and only such a person can anticipate which frequencies can be measured in the systems A and B.

But there is a problem: To which system should the reference frame C belong to? To the surface of Earth, to the center of Earth, to the space over the sun, to the space over our galaxy or galaxy clusters, or to the space of the Universe?

From experiments we know that atomic clocks go slower in a system that moves with high speed. If e.g. v_A = 1000 km/h and v_B = -100 km/h, an atomic clock in A goes slower than in B. This was detected in the Hafele-Keating experiment (by the way: without symmetry between the times of clocks in the aircrafts and the ground clock), where the reference frame was the center of Earth and not the clock on the ground [4]. But the formulas of the STR determine the time to go slower by the same factor γ in the observed system that moves with the relative speed v to the own system. An experiment could perhaps reveal which interpretation of formula (1) is correct.

Let's regard the situation with an example where A and B move to each other at the same altitude and take aim with a laser beam at each other. If an observer in B measures the frequency shift he/she will get in the first step by the classical Doppler-formula

$$f_B = f_0\,(1 + \beta_B) / (1 - \beta_A), \text{ and an observer in A: } f_A = f_0\,(1 + \beta_A) / (1 - \beta_B) \qquad (5)$$

It is evident, that these formulas are not symmetric, except for $|v_A| = |v_B|$. On the other hand, we should take account of the Hafele Keating experiment. The results show that the time t = N/f and

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therefore the frequency must be corrected by a γ-factor. But in this case we don't know the amount, because we don't know to which system the reference frame C is allocated to. We get, as (5) is the product of the frequencies (2) and (3),

$$f_{BA} = f_0\,[\gamma_B/\gamma_A]\,(1 + \beta_B) / (1 - \beta_A) \tag{6}$$

In B the atomic clock goes more slowly. Therefore, B gets in its own time – observed from the space over the North Pole- more impulses from A and hence a higher frequency. Then, the correction must be the multiplication with γ. In A, the atomic clock goes more slowly too. Therefore, the sender sends less impulses and hence a lower frequency. Then, the correction must be the division by γ. This is a new ansatz where classical physics is combined with the experimentally found effects at high velocities in which it is unproved whether the gammas really follow the formula

$$\gamma_A = 1/\sqrt{(1-\beta_A^2)}$$

If an observer in A measures the frequency-shift, he/she will get

$$f_{AB} = f_0\,[\gamma_A/\gamma_B]\,(1 + \beta_A) / (1 - \beta_B) \tag{7}$$

If we assume that $\gamma_A = 1/\sqrt{(1-\beta_A^2)}$ and $\gamma_B = 1/\sqrt{(1-\beta_B^2)}$ (inserted in (7)),

$$\begin{aligned} f_{AB} &= f_0\{\sqrt{[(1+\beta_B)^2/(1-\beta_A)^2][(1+\beta_A)/(1-\beta_A)/(1+\beta_B)(1-\beta_B)]} = \\ f_{AB} &= f_{BA} = \sqrt{f_B * f_A} = f_0\sqrt{[(1+\beta_A)/(1-\beta_A)]*[(1+\beta_B)(1-\beta_B)]} \end{aligned} \tag{7a}$$

At low speeds (<1000 km/h) they would show the same value as f. This gamma-correction results in the geometric mean of the frequencies, measured in A and in B (which move to each other) as well, like at formula (1). If $v_B = 0$ then $f_{BA} = f$, the Lorentz-transformed formula (1) of the RDE.

This consideration shows that the Doppler frequencies coming from the opposite system (B or A) have the same value for an observer in A and B. The symmetry of observations is also valid for a reference frame outside of A and B. Hence, an experiment for testing the asymmetry of observations doesn't make sense. One could assume that the STR is verified by this symmetry but on the other hand: Formulas (7) and (1) are different because the geometric means belong to different reference frames.

At which velocity v_B can the difference to formula (1) be detected? The simplest case would be to set $v_B = v_A$ and $v = 2v_A$, because the smaller v_B, the more f_{BA} is related to f. This is really interesting: In order to detect the difference to the Lorentz-transformed Doppler-effect, $v_B = v_A$ seems to be the best approach. In this case the gammas are canceled. Now we compare the two formulas (7) and (1)

$$f_0[(1+\beta_A)/(1-\beta_A) <> f_0\sqrt{(1+2\beta_A)/(1-2\beta_A)} \tag{7b}$$

The rotation of Earth and the other velocities of Earth might increase the gammas (in the STR by the Transversal Doppler effect). But we don't know to which amount as we don't know where the reference system is allocated to. Actually, the gammas must be evaluated by experiments.

The measurements can be done by the frequency-comb technique.

Calculations

Let's calculate these values with an example. The formulas (7) show that a difference between f and f_{BA} cannot be found at low speeds of frames A and B. If e.g. β = 0.000 01 (which corresponds a velocity of about 11 000 km/h) the difference of f and f_A is just about 2 Hz at the 15th digit.

For the ISS, flying with 27.576 km/h = 7.66 km/s and a satellite with the same speed in the opposite direction at the same altitude, we get with the relative velocity v = 15.32 km/s and c = 300 000 km/s = >

β = 5.10666666666666666666666666666667e-5. Inserted in (1):

$$\begin{aligned} f &= f_0 * \sqrt{1.0000510666666666666666666666667 / 0.9999489333333333333333333333} = \\ &f_0 * 1.0000510679706354477379408782 5865 \end{aligned} \tag{10}$$

Blue laser light (e.g. 445 nm) has the frequency in vacuum

$$f_0 = 674\,157\,303\,370\,786.516 \text{ Hz} \tag{11}$$

In this case A and B observe according to formula (1) the same frequency

$$f = 674\,191\,731\,216\,158.748 \text{ Hz} \tag{12}$$

The direct comparison of frequencies in this case is according to formulas (5) expected to be (without the effect by earth rotation or other velocities)

$f_A = f_B = f_0\,(1 + \beta_A) / (1 - \beta_B) = f_0\,(1 + \beta_B) / (1 - \beta_A)$

= 1.0000255333333333333333333333333 / 0.99997446666666666666666666666667 =

= 1.0000510679706021827090651714 64

$f_A = f_B$ = 674 191 731 216 136.302 Hz (reference frame: center of Earth) (13)

f = 674 191 731 216 158.748 Hz (Lorentz-transformed DE)

This experiment is very challenging, because one could detect a difference between f and $f_B = f_B$ at the 14th digit only. For the case that this small difference can be detected reliably the STR is falsified from the mathematical view point.

A better experiment could be performed at CERN where ions and electrons are accelerated to e.g. β_A = 0.1 and are merged for recombination. Could this light ionize other recombined ions which fly in the opposite direction, similar to the experiments of G. Gwinner? By the way: G. Gwinner assumes that there is a preferred cosmological reference frame [5].

$$f = f_0 * \sqrt{1.2/0.8} = 1.224744871391589049098642037353 * f_0$$

$f_A = f_B = f_0\,(1+\beta_A)/(1-\beta_A)$ = 1.222 222 222 222 222 222 222 222 222 222 * f_0

Here the difference could be recognized at the third digit already. If the experiment shows that the result fits better to f_A then the principle of relativity is disproved and the space-time-modelling must be modified.

Conclusion

The proposed very basic experiments above (which are very difficult to do) will hopefully bring clarity into this issue. The experimental results of the Hafele-Keating experiments show that the symmetry of observations is also to be expected if the Doppler-effect is interpreted as a geometric mean of frequencies observed from a reference frame outside of A and B. The gamma-correction results in each case in a geometric mean of frequencies observed in A and B. In this case the mathematical basis of the Theories of Relativity is wrong. Anyway, this experiment should be done to find out if there is a reference frame where the light propagates isotropically with constant speed. If this is found, the assert that the light speed is constant in all frames, would be wrong. Then it would be time to think about physical mechanisms e.g. in the Yokto range (10^{-24} m) with the goal to explain gravitation and quantum phenomena by physical mechanisms (which also can be described mathematically) rather than to describe them mathematically in space-time. In this case the implications on physics and philosophy would be eminent.

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