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Review of the Lorentz Factor

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Abstract: **The Lorentz factor is a special factor of the theory of special relativity (TSR). Its derivation and involving in physics is not easily understandable, as is, for example, the buoyancy force in fluids. This paper will review the physics of this factor and the way of its entering in the science of physics. The review will be done with analysis and comparison of the results of several interest works in which the Lorentz factor appears. The conclusion of this paper is that the Lorentz factor has no sustainable basis in physics.**

Keywords: **Lorentz factor, velocity of light, special relativity.**

1. INTRODUCTION

Lorentz factor is derived as attempt to explain the relative motion. The simplest Galilean relative motion is represented in Fig. 1. We have an inertial reference frame K and another similar frame K', which moves relative to the first with velocity v (Fig. 1). Within frame K', a light signal with velocity (c) is issued. The conditions for the existence of relative motion are fulfilled, because an event (motion of light) in K' can be observed from two different observers, which are resting at origins O and O'.

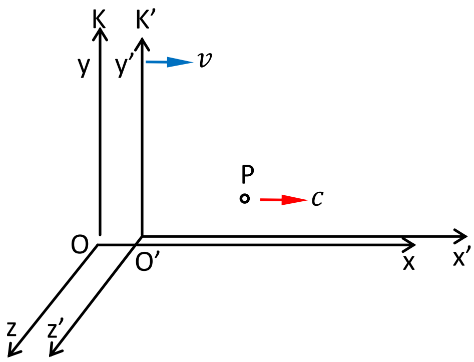

Fig. 1: Motion of light signal in frame K', which moves relative to frame K with velocity$v$

The Lorentz factor is defined as:

$$= \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (1)$$

Where γ the most is frequent note of this factor; v is the relative velocity between inertial reference frames and c is the velocity of light in vacuum. Galileo in 1632 explained the relative motion without the Lorentz factor [1]. Also Doppler explained the relative motion in 1842 without the Lorentz factor [2]. Nowadays we call that explanation the Doppler's effect. One of the evidences that the Doppler's effect is typical Galilean motion (as in Fig. 1) is the equation for the redshift, which has wide use in physics and astronomy [3]. The first work about relative motion, in which the Lorentz factor appeared (although, not in quite explicit form) is The Relative Motion of the Earth and the Luminiferous Ether by

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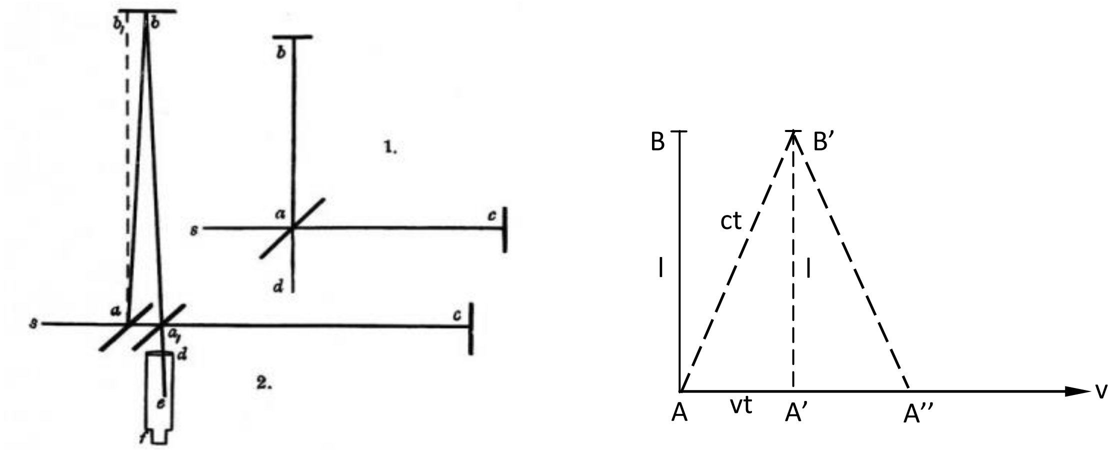
Michelson in 1881 [4]. In an explicit form this factor appeared in Voigt's paper Über das Doppler'sches Prinzip in 1887 [5]. After Voigt, Heaviside derived the deformation of electrostatic fields in motion in 1888 [6] using an implicit form of Lorentz factor. Then by FitzGerald (in 1889) and Lorentz (in 1892) the length contraction was postulated exactly as the Lorentz factor [7, 8] to explain the negative outcome of Michelson experiment. Lorentz, whose name bears the factor, since 1892 included this factor in all his works that deal with relative motion. In 1897 Joseph Larmor derived the Lorentz transformation in nowadays form [9], which means he also derived the Lorentz factor. Poincare in 1905 named as the Lorentz transformations equations containing the Lorentz factor [10]. In same year Einstein also derived the Lorentz transformation [11] and since this time the physics became familiar with Lorentz factor. Familiarity was more in books and theory than in practice.

2. THE PHYSICS OF LORENTZ FACTOR

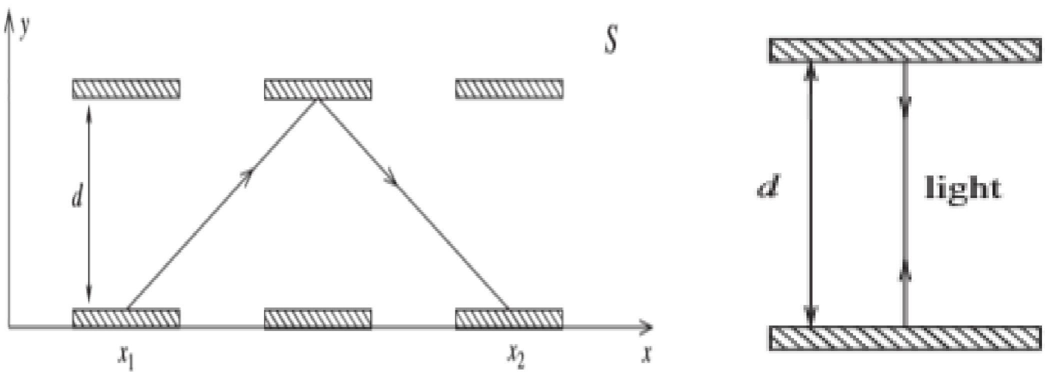
The physics of the Lorentz factor will be analyzed with the comparison of three different presentations of Michelson experiment. Michelson and Morley in 1887 repeated the experiment of 1881, to find the impact of the Earth's motion on velocity of light [12].



a *b*

Fig. 2: Michelson experiment (*a*) [12]; Born's interpretation of Michelson experiment (*b*) [13].

It is very important to note that Michelson and Morley were aware that they have to do with relative motion, and this can be seen from the titles of two papers [4, 12]. Even more important is to note that Michelson and Morley knew and manipulated only with the principle of Galileo.



a **b**

Fig. 3: Light-clock [14].

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Nowadays there is a very widespread idea (may be the only idea) for explanation of time dilation physics. Here we will mention only two sources [14 and 15]. Fig. 3 is taken from the source [14]. It is the light-clock. Fig. 3a shows how the observer from the origin of the reference frame S sees the light-clock in moving reference frame S' with velocity v relative to frame S. If we look closely, the figure of Michelson and Morley (Fig. 2a) holds the same light-clock. In Fig. 2b we see the light path in Michelson experiment (only in perpendicular arm of interferometer relative to direction of Earth motion) and from this view we can see better the Michelson's light-clock [13]. Fig. 3a shows the path of light as it is seen by the observer resting in the frame S, as in Fig. 2a and 2b reflect the path of light as seen by the hypothetical observer resting in frame that is not shown in Fig. 2. This missing observer in Fig. 2a and 2b can be seen in Fig. 4, in hypothetic reference frame in space (S). We consider that in Fig. 4 is presented the full scheme of Michelson experiment [16].

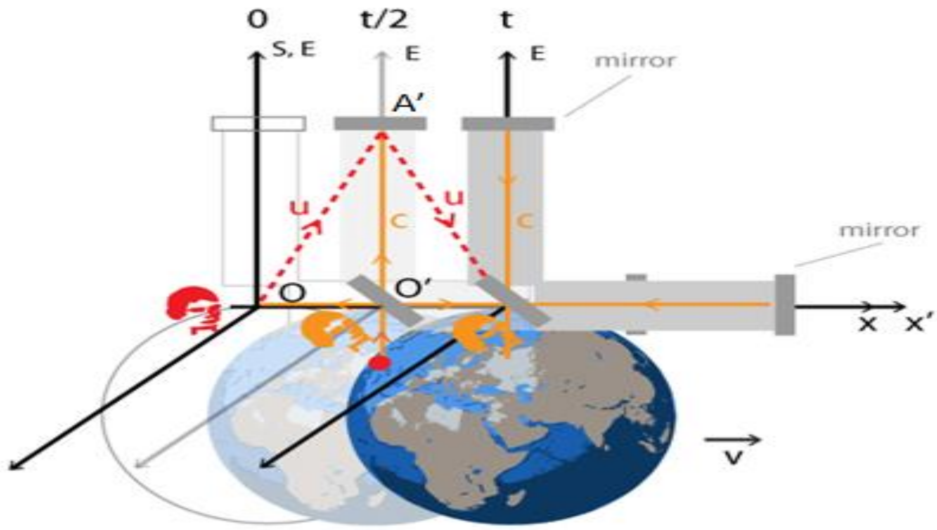

Fig. 4: Full view of Michelson experiment [16]

The common thing in all three cases is the triangle built with light roads and the length vt, about which everyone agreed (Fig. 5).

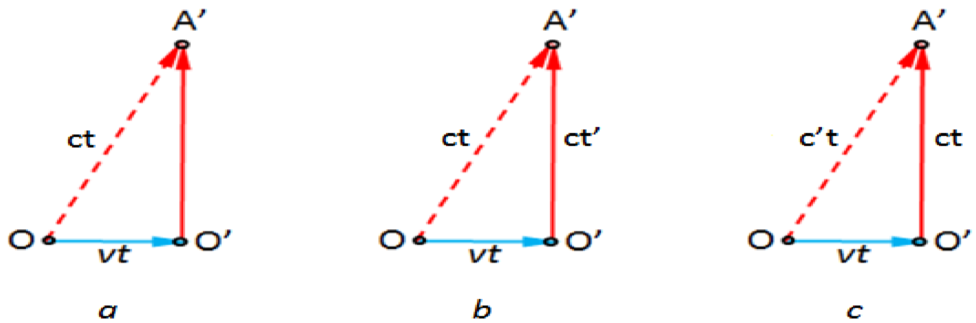

Fig. 5: The problematic triangle created to the Michelson experiment; the Born's notes (a), notes by work [14], notes by paper [16]

The solutions in these three works about the above mentioned triangle will be given below. In the paper [12] the authors find only the length of the hypotenuse and they do not explicitly declare about the value of hypotenuse expressed through production between the velocity and time. So, with the help of Born [13], for the triangle in Fig. 5a is obtained:

$$t = t'\sqrt{1 + \frac{v^2}{c^2}}. \qquad (2)$$

The solution of problematic triangle according to work [14] is:

$$t = t'\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (3$$

And represents the explicit form of Lorentz factor. In work) [16], by applying faithfully the Galileo principle is obtained:

$$c' = \sqrt{c^2 + v^2} \qquad (4)$$

Where c' is the velocity of light on the hypotenuse, which shows that the relative velocity c' is greater than the velocity of light? Michelson experiment, as well as some other experiments (for example Doppler's effect) show that the velocity of light in relative motion obeys to the linear addition of velocities. Subsequently, and in relative terms a sum of two velocities can exceed the velocity of light.

As been noted before, triangles in Fig. 5 and the results (2), (3) and (4) apply to the motion of light in interferometer arm, which sits normal to the direction of Earth motion, i.e. the vector of the velocity of light in moving frame (velocity in path O'A' in Fig. 5) with the vector of Earth velocity close an angle of 90°. These three results will be obtained without problem even if we apply the vectorial calculation. The problem becomes even more interesting if we apply the same procedure for another interferometer arm (that is parallel to the direction of Earth motion). And we repeat the calculations for three cases. The light path on interferometer arm and the interferometer path are shown in Fig. 6.

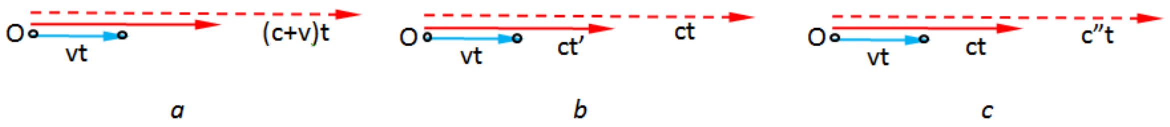

Fig. 6: The light-clock in parallel interferometer's arm to direction of Earth's motion.

These paths are taken from Fig. 3b, if the light-clock is put parallel to *x*.

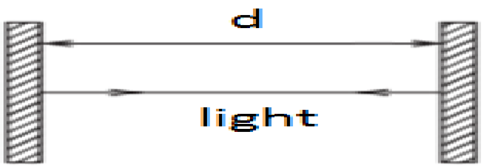

Fig. 7: The light-clock taken from [14] and rotated by 90°.

Let us see the solutions. The authors in paper [12] found this solution:

$$t = \frac{l}{c+v}. \qquad (5)$$

More interesting is to see the solution in spirit of work [14]. Physicists use light-clock from Fig. 3 only as the sand-clock, i.e. only vertically according to the direction of frame's motion. What happens if we put this light-clock in the same direction of frame's motion? From Fig. 6b, summing vectors of paths and knowing that the angle between the direction of the velocity c and v is zero, is obtained:

$$t = t'\frac{1}{1-\frac{v}{c}}. \qquad (6)$$

So, we see that in this case there is no Lorentz factor. We have time dilation, but not in the same rate as in equation (3). This is in contradiction with the result of Michelson experiment.

In the paper [16] is obtained:

$$c'' = c + v. \qquad (7)$$

Where c'' is velocity of light on the interferometer arm parallel to the Earth motion?

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3. DISCUSSION OF RESULTS

Equations (2) and (5) represent Michelson and Morley's solutions. It is known that these results contradict the experiment conducted by them. The calculations of these authors would not be in contradiction to the outcome of the experiment if they had applied faithfully the Galileo principle.

Equations (3) and (6) are interpretations of the theory of special relativity, which have broad consensus. However, as seen only equation (3) gives the Lorentz factor, while equation (6) is not in accordance with this. The most important fact about this interpretation and these two results is that they contradicted the results of experiment.

We consider that equations (4) and (7) represent the right explanation of Michelson experiment; and, what is the most important, they are fully consistent with the results of the experiment. Their compliance with the outcome of the experiment can be seen if we transform the left sides of equations (4) and (7), expressing the velocities c' and c'' by the ratio between the road and time, which are elaborately made in paper [16] (calculating with intensity of magnitudes) and in paper [17] (calculating with vectors of magnitudes).

4. CONCLUSIONS

Lorentz factor is a special part of the Lorentz transformations and it is widespread in physics. In physics it has entered due to the confusing calculations in the Michelson paper in 1881 and wrong interpretation of the results of Michelson experiment. With the right explanation of Michelson experiment it is proved that the Lorentz factor has no basis in physics.

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