Simultaneity and Synchronization, the Preferred Frame and the Principle of Relativity

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Abstract

In this paper it is considered the physical meaning of simultaneity and synchronization, that has also been addressed in other previous papers, based on the existence of a Preferred Frame where the one-way speed of light is isotropic. Usually in the standard Special Relativity what is considered is the Einstein simultaneity and Einstein synchronization that has been introduced by Einstein in the 1905 article "by definition". In the standard interpretation simultaneity and synchronization are not considered since the Einstein speed of light is considered the speed of light. However, in our previous work we have shown that this is a terminological confusion, a paralogism. Now we explain why this is so with a very simple concise formalism using two clocks in every point of a frame, frame that is moving in relation to the Preferred Frame, a synchronized clock, and a Lorentzian clock. With this approach the solution of the conventionality of simultaneity and synchronization controversy is addressed. This proposed formulation is based on the existence of a gap of "synchronizations" that standard formulation is unable to detect since the Preferred Frame is considered superfluous. The restricted Principle of Relativity emerge since exist two clocks in every coordinate and when we refer two simultaneous events, we mean that we are using two synchronized clocks and not two desynchronized clocks, marking the same number. The non-equivalence of the frames emerge with physical meaning through the analysis of the Lorentz-Fitzgerald contraction and Larmor time dilation mathematical expressions.

Introduction

In previous works [1-17] particularly in "The physical meaning of synchronization and simultaneity in Special Relativity" [1] it is criticized the approach of Einstein [18] based on the postulates of the isotropy of speed light in every frame and the equivalence of every frame. Several works, some very recent, point out the importance of this discussion about the foundations of Mathematics, Philosophy, Relativity, Quantum Mechanics, Cosmology and Biophysics [19-96]. The consequent Principle of Relativity has been also considered in the articles "On the Consistency between the Assumption of a Special System of Reference and Special Relativity" [10] and "The Principle of Relativity and the Indeterminacy of Special Relativity" [12]. In a more recent work "Speakable and Unspeakable in Special Relativity: time readings and clock rhythms" [14] it is referred the consequences of these analysis particularly the physical meaning of time dilation and Lorentz-Fitzgerald contraction mathematical expressions. Also in the works of Fredrik Andersen, Johan Arnt Myrstad, Maurizio Consoli, Alessandro Pluchino, Espen Gaarder Haug, Zbigniew Oziewicz, Georgy I. Burde and Manuel Ricou that are also referred [21, 22, 23-24, 25-27, 33, 37, 38].

The paper is organized as follows.

In section I. Simultaneity and Synchronization, the Preferred frame, and the One-Way Speed of Light after defined the Preferred Frame in Ia. The IST transformation and the Speed of Light we calculate the speed of light.

The Lorentz transformation is obtained in Ib. from a change of coordinates defined by a mathematical expression that we designate intrinsic desynchronization. The notion of Einstein speed and speed are introduced, and it is shown that the Preferred frame is unique.

In section II. The Preferred Frame and Principle of Relativity we obtain the Lorentz transformation between two frames whatever the frames are, whatever the relative movement is. This explain that the Principle of Relativity does not have the equivalence of the frames in lato sensu but only in a stricto sensu as a result of the uniqueness of the Preferred Frame. This is explained based on an existence of a gap of desynchronizations that standard relativity is unable to detect. The gap of desynchronizations is dependent of the speed v_1 , it is not only dependent of $V_E^{\prime}$ the "parameter" that standard relativity consider. We show that the relation between distances is no more given by the Lorentz-Fitzgerald contraction and the relation between rhythms is no more given by Larmor dilation expression except when one of the two frames consider is the PF, when the gap is zero.

I. Simultaneity and Synchronization, the Preferred frame, and the One-Way Speed of Light

Ia. The IST transformation and the Speed of Light.

Consider a frame designated by S as the Preferred Frame (PF), that we designate previously Einstein´s Frame (EF), the frame where the speed of light is *c*, isotropic and independent of the movement of the source of light. This frame is unique (see Ib.). Indeed, in a frame S' moving with speed v_1 in the direction of the x axis of the PF through the *x* axis, the speed of light is no more *c*. Consider also frame S'' with speed v_2. The two-way speed of light based on the experiences of Michelson, Morley and Miller for those frames, it is assumed, is also *c*. if this is so, only for *S* Einstein method of synchronization is effective. The IST (Inertial-Synchronized-Tangherlini) transformation can be obtained with synchronized clocks marking time *t* in EF and *t´* in S' [1, 8, 14, 15]

$$x' = \frac{(x - v_1 t)}{\sqrt{\left(1 - \frac{{v_1}^2}{c^2}\right)}} \quad (1)$$

$$t' = t\sqrt{\left(1-\frac{{v_1}^2}{c^2}\right)} \quad (2)$$

The first equation result from Fitzgerald-Lorentz contraction and the second from Larmor time dilation [20].

The velocity V' is given by

$$V' = \frac{dx'}{dt'} = \frac{\frac{dx}{dt}\frac{dt}{dt'} - v_1\frac{dt}{dt'}}{\sqrt{\left(1-\frac{v_1^2}{c^2}\right)}} = \frac{v_2 - v_1}{1-\frac{v_1^2}{c^2}} \quad (3)$$

Therefore V' is *c* when v_2 tend to *c* for $v_1 = 0$. For $v_1 \neq 0$ V' tend to

$$\frac{c - v_1}{1-\frac{v_1^2}{c^2}} = \frac{c}{1+\frac{v_1}{c}} \quad (4)$$

Frame *S* is unique. Only for $v_1 = 0$ the one-way of light is *c*.

Ib. The Lorentz transformation and the Speed of Light.

The Lorentz transformation (LT) can be obtained introducing an intrinsic desynchronization defined by [1, 37]

$$t_L' = t' - \frac{v_1}{c^2}x' \quad (5)$$

At x'we have a Lorentzian clock marking t_L' and a synchronized clock marking t'. Only at $x' = 0$ both clocks mark the same number. For other coordinate x' the clocks are desynchronized, does not mark the same number. Therefore, Lorentzian clocks at two different coordinates x´ are also desynchronized between each other, does not mark the same number. Einstein synchronization is a desynchronization except for the Preferred Frame, Einstein frame [6, 8]. When $v_1 = 0$ $t_L' = t' = t_L = t$. It is independent of *x*. With a change of coordinate time given by (5) we obtain LT.

Indeed from (1) and (2) introducing (5) with $\gamma_1 = 1\Big/\sqrt{\left(1-\frac{{v_1}^2}{c^2}\right)}$

$$t_L^{'} = t' - \frac{v_1}{c^2}x' = {}^{t}\!/_{\gamma_1} - \frac{v_1}{c^2}x' \quad (6)$$

we obtain

$$t_L^{'} = {}^{t}\!/_{\gamma_1} - \frac{v_1}{c^2}x\gamma_1 + \frac{{v_1}^2}{c^2}t\gamma_1 \qquad (7)$$

$$t_L^{'} = t\left({}^{1}\!/_{\gamma_1} + \frac{{v_1}^2}{c^2}\gamma_1\right) - \frac{v_1}{c^2}x\gamma_1 \quad (8)$$

$$t_L^{'} = t(\frac{1 + \frac{{v_1}^2}{c^2}{\gamma_1}^2}{\gamma_1}) - \frac{v_1}{c^2}x\gamma_1 \qquad (9)$$

$$t_L^{'} = t(1 + \frac{\frac{{v_1}^2}{c^2}}{(1 - \frac{{v_1}^2}{c^2}})\frac{1}{\gamma_1} - \frac{v_1}{c^2}x\gamma_1 \quad (10)$$

$$t_L^{'} = t(\frac{1 - \frac{{v_1}^2}{c^2} + \frac{{v_1}^2}{c^2}}{(1 - \frac{{v_1}^2}{c^2}})\frac{1}{\gamma_1} - \frac{v_1}{c^2}x\gamma_1 \quad (11)$$

$$t_L^{'} = (t - \frac{v_1}{c^2}x)\gamma_1 \quad (12)$$

$$x' = \frac{(x - v_1 t)}{\sqrt{\left(1 - \frac{{v_1}^2}{c^2}\right)}} \quad (13)$$

Eq. (12) and (13) are the LT between the Preferred frame and S'.

Einstein velocity $V_E^{'}$ is defined by [6, 8, 12]

$$V_E^{'} = \frac{dx'}{dt_L^{'}} = \frac{\frac{dx}{dt}\frac{dt}{dt_L^{'}} - v_1\frac{dt}{dt_L^{'}}}{\sqrt{\left(1 - \frac{{v_1}^2}{c^2}\right)}} = (v_2 - v_1)\frac{dt}{dt_L^{'}}\gamma_1 \quad (14)$$

From (12)

$$\frac{dt_L^{'}}{dt} = \left(1 - \frac{v_1}{c^2}\frac{dx}{dt}\right)\gamma_1 = \left(1 - \frac{v_1 v_2}{c^2}\right)\gamma_1 \quad (15)$$

Therefore

$$V_E^{'} = \frac{(v_2 - v_1)}{\left(1 - \frac{v_1 v_2}{c^2}\right)} \quad (16)$$

As expected, independently of the value of v_1 $V_E^{'} = c$ for $v_2 = c$.

II. The Preferred frame and the Principle of Relativity

From (12) and (13) we obtain

$$x = \left(x^{'} + v_1 t_L^{'}\right)\gamma_1 \quad (17)$$

$$t = \left(t_L^{'} + \frac{v_1}{c^2}x^{'}\right)\gamma_1 \quad (18)$$

Since

$$x^{''} = (x - v_2 t)\gamma_2 \quad (19)$$

and

$$t^{''} = \left(t - \frac{v_2}{c^2}x^{'}\right)\gamma_2 \quad (20)$$

Substituting eq. (17) and (18) in (19) we obtain

$$x^{''} = \left[(x^{'} + v_1 t_L^{'})\gamma_1 - v_2(t_L^{'} + \tfrac{v_1}{c^2}x^{'})\gamma_1\right]\gamma_2 \qquad (21)$$

$$x^{''} = \left[x^{'}(1 - \tfrac{v_2 v_1}{c^2}) + (v_1 - v_2)t_L^{'})\right]\gamma_1\gamma_2 \qquad (22)$$

$$x^{''} = \left[x^{'} - \frac{(v_2 - v_1)}{1 - \frac{v_1 v_2}{c^2}}t_L^{'}\right]\gamma_1\gamma_2\left(1 - \frac{v_1 v_2}{c^2}\right) \qquad (23)$$

From

$$V_E^{\prime} = \frac{(v_2 - v_1)}{\left(1 - \frac{v_1 v_2}{c^2}\right)} \quad (24)$$

we obtain

$$\sqrt{\left(1 - \frac{V_E^{\prime\,2}}{c^2}\right)} = [\gamma_1 \gamma_2 (1 - \frac{v_1 v_2}{c^2})]^{-1} \quad (25)$$

Therefore from (23), (24) and (25)

$$x^{\prime\prime} = \frac{x^{\prime} - V_E^{\prime} t_L^{\prime}}{\sqrt{\left(1 - \frac{V_E^{\prime\,2}}{c^2}\right)}} \quad (26)$$

And similarly we obtain

$$t_L^{\prime\prime} = \frac{t_L^{\prime} - \frac{V_E^{\prime}}{c^2} x^{\prime}}{\sqrt{\left(1 - \frac{V_E^{\prime\,2}}{c^2}\right)}} \quad (27)$$

Therefore, similar relations are obtained whith frame S´ when $v_1 = 0$, when $S^{\prime}$ is at rest with the preferred frame. The Principle of Relativity emerge. The frames seems equivalent when Lorentz coordinates are used [12].

Now we can show [1, 2, 3, 12, 14] that although the mathematical expressions of time dilation and Lorentz-Fitzgerald contraction subsist the physical meaning attributed is not the same.

Consider frames S´ and S´´ as previously defined. Consider $x^{\prime} = l_1$ the distance between the origin of S´ and the coordinate $x^{\prime}$. Using eq. (26) we have

$$x^{\prime\prime} = \frac{x^{\prime} - V_E^{\prime} t_L^{\prime}}{\sqrt{\left(1 - \frac{V_E^{\prime\,2}}{c^2}\right)}} = \frac{l_1 - V_E^{\prime}(-\frac{v_1}{c^2} l_1)}{\sqrt{\left(1 - \frac{V_E^{\prime\,2}}{c^2}\right)}} \quad (28)$$

Therefore, the distance $x^{\prime} = l_2$ is

$$l_2 = \frac{l_1(1 + V_E^{\prime} \frac{v_1}{c^2})}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} \quad (29)$$

Eq. (29) correspond to the Lorentz-Fitzgerald contraction when $v_1 = 0$. However, when $v_1 \neq 0$ the mathematical expression subsist and correspond to the coordinate

$$x^{\prime\prime} = \frac{l_1}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} \quad (30)$$

Exist a gap of synchronizations [17, 26, 27, 84] given by

$$g = \frac{l_1(1 + V_E^{\prime} \frac{v_1}{c^2})}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} - \frac{l_1}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} = \frac{l_1\left(V_E^{\prime} \frac{v_1}{c^2}\right)}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} \quad (31)$$

In relation of the meaning of time dilation a similar approach can be done. From eq. (27)

$$t_L^{\prime\prime} = \frac{t_L^{\prime} - \frac{V_E^{\prime}}{c^2} x^{\prime}}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} \quad (32)$$

we have

$$dt_L^{\prime\prime} = d\tau^{\prime\prime} = \frac{dt_L^{\prime} - \frac{V_E^{\prime}}{c^2} dx^{\prime}}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} = \frac{dt_L^{\prime} - \frac{V_E^{\prime}}{c^2} V^{\prime} dt^{\prime}}{\sqrt{\left(1 - \frac{V_E^{\prime 2}}{c^2}\right)}} \quad (33)$$

From

$$t_L^{\prime} = t^{\prime} - \frac{v_1}{c^2} x^{\prime} \qquad (34)$$

$$dt_L^{\prime} = dt^{\prime} - \frac{v_1}{c^2} dx^{\prime} \quad (35)$$

Substituting at

$$d\tau'' = \frac{dt' - \frac{v_1}{c^2}dx' - \frac{V_E'}{c^2}V'dt'}{\sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)}} = \frac{dt' - \frac{v_1}{c^2}V'dt' - \frac{V_E'}{c^2}V'dt'}{\sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)}} \quad (36)$$

$$d\tau'' = \frac{d\tau'(1 - \frac{v_1}{c^2}V' - \frac{V_E'}{c^2}V')}{\sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)}} = d\tau' \frac{1}{1 + \frac{v_1 V_E'}{c^2}} \sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)} \quad (37)$$

since from eq. (3) and (16)

$$V' = \frac{V_E'}{1 + \frac{v_1 V_E'}{c^2}} \quad (38)$$

Therefore, the relation of rhythms is not the time dilation expression. However, the time dilation expression continue valid. Indeed from eq. (32)

$$d\tau'' = \frac{dt_L' - \frac{V_E'}{c^2}dx'}{\sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)}} = \frac{dt_L' - \frac{V_E'}{c^2}V_E' dt_L'}{\sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)}} = dt_L' \sqrt{\left(1 - \frac{V_E'^2}{c^2}\right)} \quad (39)$$

Eq. (29) and (37) permit the resolution of the Twin paradox conundrum [15, 16] and solve the paradox proposed by Haug [26, 27].

Conclusion

It is our firm belief that physics should assume itself as the heir of natural philosophy. And thus question, with no fear nor prejudice, the postulates or hypothesis at the origin of each theory. Only in this way is it possible to claim that to understand a physical theory goes much beyond the simple knowledge of how to perform the calculations. Unfortunately, special relativity is presented in most textbooks and papers by passing too swiftly over the discussion of its postulates [12].

It is beyond doubt that different types of clocks synchronization simply provide time coordinates to describe the same reality. In addition, the words “time”, “speed” and “simultaneity”, wich we use to attribute a precise physical meaning, actually refer to different notions when different types of clocks are used. Since different descriptions made with various types of clocks, are mathematically equivalent, this latter issue is mainly a question of language. Nonetheless it is an important one and likely to originates several misunderstandings because the physical concepts underlying each of these descriptions are quite different. Many disputes and hot debates around special relativity are related to the problem of using the same word to designate different concepts. For this reason, it is of major importance to know what kind of clocks one ends up after performing synchronization, p.40 and 41 [12]. This is the conclusion of our article about the meaning of The Principle of Relativity and the Indeterminacy of Special Relativity [12]. This is also the conclusion of another recent experimental article, Misconception Regarding Conventional Coupling of Fields and Particles in XFEL Codes, p.11 and 12 [28, 31].

Therefore, perhaps it is now clear what is happen with standard special relativity. Light is moving with one-way speed $c_+^{'}$ and $c_-^{'}$ given by

$$c_{\pm}^{'} = \frac{c}{1 \pm \frac{v_1}{c}}$$

Standard relativity affirms that the one-way speed of light is c for both trips in every frame. Of course, it isn´t. c is the one-way Einstein speed of light, because of its very definition in every frame. End of the mystery.

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