the general science journal

The Synchronized Transformation[1] and the Inertial Transformation[2] with the Lorentz-Einstein Transformations in Hand

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Abstract. It is shown that the Lorentz transformations for the space-time coordinates of the same event, consequently applied lead to all the relativistic equations derived by those who believe in the ether theory.

Special relativity is a very flexible chapter of physics. The fact that the Lorentz-Einstein transformations (LET) for the space-time coordinates of the same event could be derived in many different ways and that the formulas which account for relativistic effects could be derived without using the LET produces a large number of papers devoted to the subject. The usual trend in teaching special relativity theory is to start with the LET

$$x = \gamma(x' + Vt'_E) \tag{1}$$

$$t_E = \gamma(t'_E + \frac{V}{c^2}x') \tag{2}$$

and with the inverse ones

$$x' = \gamma(x - Vt_E) \tag{3}$$

$$t'_E = \gamma(t_E - \frac{V}{c^2}x) \tag{4}$$

where (x,t_E) and (x',t'_E) represent the space-time coordinates of events $E(x,t_E)$ and $E'(x',t'_E)$ detected from the inertial reference frames I and I' in the standard arrangement, with I' moving with constant speed V in the positive direction of the overlapped OX(O'X') axes. The two events take place at the same point in space when the clocks C(x) and C'(x') of the two inertial reference frames located at that point read t_E and t'_E, respectively. These clocks are synchronized following the clock synchronization procedure proposed by Einstein; $\gamma=(1-V^2/c^2)^{-1/2}$ represents the Lorentz factor.

In the literature on the subject we find the transformation equations

$$x' = \gamma(x - Vt) \tag{5}$$

$$t' = \gamma t \tag{6}$$

the inverse of which are

$$x = \gamma^{-1}(x' + \gamma^2 Vt') \tag{7}$$

$$t = \gamma t'. \tag{8}$$

with $\gamma=(1-V^2/c^2)^{-1/2}$.

According to Abreu and Guerra[1] these equations represent the "synchronized transformations," whereas Selleri[2] calls them "inertial transformations." Abreu and Guerra[1] derive them using the formulas that account for the length contraction and time dilation effects, which could be derived without utilizing the LET[3].

The purpose of our paper is to show that the nonstandard transformation equations (5)-(7) could be derived knowing the LET (1)-(4) and considering that the clocks of the I frame (stationary) are synchronized following Einstein's clock synchronization procedure and that the clocks of the I' reference frame (moving) are synchronized using a signal that propagates with constant speed c_f in the positive direction of the overlapped OX(O'X') axes.

2. Transformation equations for nonstandard synchronized clocks.

Consider the clocks C'(x') located at the different points of the I' inertial reference frame. When the ticking clock $C'_0(0)$ located at the origin O' reads t'=0, a synchronizing signal is emitted from O' in the positive direction of the OX(O'X') axes. The signal propagates with speed $c'_f = c/n$; (n>1, $c'_f < c$). A clock C_1(x') is stopped and fixed to read

$$t'_n = nx'/c\,. \tag{9}$$

When it arrives at the location of this clock, the synchronizing signal starts it and from that very time, clocks $C'_0(0)$ and $C'(x')$ display the same running time and are nonstandard synchronized **(??)**. A clock $C'_2(x')$ located in front of clock $C'_1(x')$ defined above but standard synchronized **(??)** would read

$$t'_E = x'/c\,. \tag{10}$$

Combining (9) and (10) results in

$$t'_E = t'_n + \frac{x'}{c}(1-n)\,. \tag{11}$$

Equation (11) enables us to express the LET (1) and (2) as a function of t'_n, with the result

$$x = x'\frac{[1+\frac{V}{c}(1-n)]}{\sqrt{1-\frac{V^2}{c^2}}} + t'_n\frac{V}{\sqrt{1-\frac{V^2}{c^2}}} \tag{12}$$

and

$$t_E = \frac{t'_n}{\sqrt{1-\frac{V^2}{c^2}}} + \frac{x'}{c}\frac{(1-n+\frac{V}{c})}{\sqrt{1-\frac{V^2}{c^2}}}\,. \tag{13}$$

In order to obtain the synchronized (inertial) transformation equations we impose the condition that the transformation (13) become x'-independent i.e.

$$1-n+\frac{V}{c}=0 \quad (14)$$

or

$$n=1+\frac{V}{c}. \quad (15)$$

where the synchronizing signal propagates with speed

$$c'_f=\frac{c}{1+\frac{V}{c}}. \quad (16)$$

The transformation equations we are looking for are

$$x=x'\sqrt{1-\frac{V^2}{c^2}}+t'_n\frac{V}{\sqrt{1-\frac{V^2}{c^2}}} \quad (17)$$

$$t_E=\frac{t'_n}{\sqrt{1-\frac{V^2}{c^2}}} \quad (18)$$

recovering **(??)** the transformation equations (7) and (8) which lead to the transformation equations (5) and (6) obtained by Abreu and Guerra[1] and by Selleri from other starting premises.

Defining the speeds

$$u_E=\frac{x}{t_E} \quad (19)$$

and

$$u'_n=\frac{x'}{t'_n} \quad (20)$$

we obtain that they add as

$$u_E=\frac{u'_n[1+\frac{V}{c}(1-n)]+V}{1+\frac{u'_n}{c}(1-n+\frac{V}{c})} \quad (21)$$

which, in the case of the synchronized (inertial transformations), becomes

$$u_E=u'_n(1-\frac{V^2}{c^2})+V \quad (22)$$

the inverse of which is

$$u'_n=\frac{u_E-V}{1-\frac{V^2}{c^2}}. \quad (23)$$

If $u_E=c$ then, in accordance with (23), the synchronizing signal propagates relative to I' with speed

$$c'_{+,n}=c\frac{1-\frac{V}{c}}{1-\frac{V^2}{c^2}} \quad (24)$$

in the positive direction of the overlapped axes and with speed

$$c'_{n,-} = c\frac{1+\frac{V}{c}}{1-\frac{V^2}{c^2}} \tag{25}$$

in their negative direction. These equations satisfy the invariance of the round trip of the speed of light[4]

$$\frac{2}{c} = \frac{1}{c_{n,+}} + \frac{1}{c_{n,-}} \tag{26}$$

a postulate in Reichenbach's[4,5] approach to special relativity theory.

In accordance with (17) the origin O of I (x=0) moves relative to I' according to

$$x'_O = -\frac{V}{1-\frac{V^2}{c^2}} t'_n \tag{27}$$

and with speed

$$V' = -\frac{V}{1-\frac{V^2}{c^2}} \tag{28}$$

relative to I.

In this case, the starting equation in our derivations (11) becomes

$$t'_E = t'_n + \frac{Vx'}{c^2}. \tag{29}$$

In this way we have derived all the results obtained by Abreu and Guerra[1] using the LET; our equations show the clocks displaying the times that appear in the derived equations the corresponding times have E and n as indices.

3. Links to those who believe in ether theory

Those who believe in the ether theory start with the following assumptions[1,2]

(i) Space is homogeneous and isotropic and time homogeneous, at least if judged from I;
(ii) In the isotropic system I the velocity of light is "c" in all directions, so that clocks can be synchronized in I and one-way velocities relative to I can be measured;
(iii) The origin of I', observed from I, is seen to move with velocity V<c parallel to the +OX axis, that is, according to the equation x=Vt.
(iv) The axes of I and I' coincide for t=t'=0;
(v) The two-way velocity of light is the same in all directions and in all inertial systems;
(vi) Clock retardation takes place with the usual velocity-dependent factor when clocks move with respect to the isotropic reference frame I

Comparing these assumptions with our approach, we see that they have (i),(ii) (iii) and (iv) in common as a consequence of the LET with which we started; assumption (v) is a natural consequence in our approach.

4. Conclusions

The important conclusions of our approach are:

(i) Ether theory and Einstein's relativity theory are equivalent;
(ii) The LET consequently applied lead to all the results obtained by those who believe in ether theory (theories) and so it is not necessary to reinvent them.

It is important to emphasize the fact that the ether frame is arbitrary. Just choose any inertial observer and define an inertial frame using the Einstein synchronization convention, and derive all the other Selleri frames from that. The fact that a privileged ether frame is postulated, but we are free to choose any such frame, seems a philosophical deficiency compared with Einstein's formulation of special relativity.

5. References

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