Einstein's Hidden Postulate

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The present Note calls attention to an undeclared assumption in Einstein's derivation of the Lorentz transformation (LT). In subsequent discussions of the special theory of relativity (SR), the practice has been to claim that the relativity principle and the postulate of the constancy of light in free space are the only two assumptions required for a unique specification of the desired kinematic relationships between space and time variables. A review of this derivation shows on the contrary that it is also necessary to make an additional assumption in order to fix the value of a *normalization function* that appears in the most general form of the transformation that leaves Maxwell's equations invariant and also satisfies the light-speed postulate. *This means that a large list of claims based on the LT, primary among them the belief that two clocks can each be running slower than the other at the same time, actually rest on the shaky ground of this undeclared and unproven assumption in Einstein's SR.* The relativistic velocity transformation (VT) also derived in Einstein's original work does not depend on the choice of the normalization function and thus is not affected by the above assumption. It is pointed out that the experimental results that

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have been traditionally claimed as verification of the LT are actually predicted on the basis of the VT alone, and thus leave open the possibility of an alternative space-time transformation that still satisfies both relativity postulates but makes use of a different assumption regarding the normalization function than that employed in Einstein's original derivation.

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I. Introduction

The Lorentz transformation (LT) [1] is the cornerstone of the special theory of relativity (SR). It leads directly to the condition of Lorentz invariance which plays an integral role in many areas of theoretical physics. It is also responsible for the concept of space-time mixing which represented a fundamental break with classical Newtonian physics and the Galilean transformation. The predictions of Fitzgerald-Lorentz length contraction and time dilation are derived in a straightforward manner from the LT. In both cases Einstein argued that measurement has a distinctly symmetric character whereby observers in relative motion must disagree as to whose clocks are running slower and whose measuring rods are shorter in length. Moreover, the amount of length contraction must vary with the orientation of the moving object to the observer according to the LT. Most surprising of all, it had to be concluded that events do not occur simultaneously for different observers as a consequence of the aforementioned space-time mixing predicted by the LT. Indeed, it is

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often claimed that this non-simultaneity characteristic is the central feature of Einstein's theory.

The derivation of the LT is consequently of supreme importance in fully understanding the foundations of Einstein's special theory. The first few pages of most texts dealing with relativity are consequently devoted to this topic and go to great lengths to show the inevitability of the predictions of SR that follow from the two postulates he employed to obtain his space-time transformation. There is general agreement that assumptions of homogeneity and isotropy of space and also the independence of the object's history are also implicit in his derivation [2]. However, there is another aspect that is easily overlooked in this discussion and this will be the subject of the following section.

II. Lorentz's Normalization Function

After introducing his two postulates of relativity, Einstein wrote down the following general equations to define the space-time transformation under consideration [1]:

$$t' = \gamma\varphi\left(t - \mathrm{v}x\mathrm{c}^{-2}\right) \tag{1a}$$

$$x' = \gamma\varphi\left(x - \mathrm{v}t\right) \tag{1b}$$

$$y' = \varphi y \tag{1c}$$

$$z' = \varphi z \tag{1d}$$

In these equations, x, y, z and t are the space-time coordinates of an object as measured by an observer who is at rest in inertial system S, whereas the corresponding primed symbols correspond to the measured values for the same object obtained by a second observer who is stationary in another inertial system S' which is moving along

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the common x, x' axis at constant speed v relative to S [c is the speed of light in free space and $\gamma = \left(1 - \mathrm{v}^2\mathrm{c}^{-2}\right)^{-0.5}$]. The emphasis in the present discussion is on the function φ in the above equations.

Einstein was following Lorentz to this point in the derivation, who had published [3] the same set of equations in slightly different notation in 1899 (he used ε instead of φ, for example [4]). Lorentz pointed out that there is a degree of freedom (normalization function) in defining the transformation that was not specified by the requirement that it leave Maxwell's equations of electricity and magnetism invariant. This is also obviously the case if no other condition needs to be satisfied than the light-speed postulate; the function φ merely cancels out when velocity components are formed by dividing x', y', z' by t' in eqs. (1a-d).

In order to completely specify the transformation, Einstein [1] made the following assertion (see p. 900 of ref. 1): "… and φ is a temporarily unknown function of v." He therefore removed from consideration the real possibility that φ might depend on some other variable than v in his derivation. He gives no justification for this conclusion. Indeed, he does not even declare that it is an assumption at all. He then proceeds on the basis of symmetry to show that the only possible value for φ consistent with this assumption is unity, and then upon substituting this value in eqs. (1a-d) he obtains the LT directly.

There are many predictions of SR that are direct applications of the LT. As discussed in the Introduction, these include Lorentz invariance, space-time mixing [see eq. (1a) with φ = 1], Fitzgerald-Lorentz length contraction (FLC) and its anisotropic character, time dilation and the symmetric nature of both time and length measurements, remote non-simultaneity of events for observers in

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relative motion, and the impossibility of $\mathrm{v} > \mathrm{c}$ speeds (because that would open up the possibility that the two observers can disagree on the time-order of events). Except for time dilation, none of the above effects has ever been observed experimentally, despite the unwavering belief of most physicists in their existence. *If Einstein's normalization assumption is not correct, it is clear that such faith is greatly misplaced.* At the very least, there is compelling reason to examine the many other *verified* predictions of his theory to see if the LT is essential for any of those. To investigate this question, it is important to take a closer look at the other key transformation of Einstein's paper, the relativistic velocity transformation (VT).

III. Simultaneity and the Velocity Transformation

The derivation of the VT does not depend in any way on the choice of the normalization function φ in eqs. (1a-d). One merely has to divide the spatial equations with the corresponding result for t', in which case φ simply cancels out in each case. The result is:

$$u_{x'} = \left(1 - \mathrm{v}u_x \mathrm{c}^{-2}\right)\left(u_x - \mathrm{v}\right) = \eta\left(u_x - v\right) \tag{2a}$$

$$u_{y'} = \gamma^{-1}\left(1 - \mathrm{v}u_x \mathrm{c}^{-2}\right)^{-1} u_y = \eta\gamma^{-1}u_y \tag{2b}$$

$$u_{z'} = \gamma^{-1}\left(1 - \mathrm{v}u_x \mathrm{c}^{-2}\right)^{-1} u_z = \eta\gamma^{-1}u_z \tag{2c}$$

where $u_{x'} = \dfrac{x'}{t'}$, etc. and $\eta = \left(1 - \mathrm{v}u_x \mathrm{c}^{-2}\right)^{-1} = \left(1 - \mathrm{v}xt^{-1}\mathrm{c}^{-2}\right)^{-1}$.

Einstein's light-speed postulate is satisfied by the VT and thus many of the confirmed predictions of SR can be traced directly to this set of equations. This is a key fact in the present context because it impacts directly on the question of whether such effects as the aberration of starlight at the zenith also serve as verifications of the LT. The discussion in the previous section makes clear that any choice for φ in the general Lorentz transformation of eqs. (1a-d) leads to the correct predictions in all such cases, not just the value of unity assumed for Einstein's LT. In short, *simply verifying the VT does not necessarily prove anything about the validity of the LT.*

To expand on this point, it is helpful to consider eqs. (2b,c) of the VT. One of the consequences of the LT is that the two observers must agree on the values of distances measured perpendicular to their direction of motion ($y = y'$ and $z = z'$) since $\varphi = 1$ in this case. The VT states that the corresponding velocity components are not generally equal, however, because of the factor $\eta\gamma^{-1}$ in both of the above equations. One can just as well assume that $\varphi = \eta\gamma^{-1}$ in the general Lorentz transformation of eqs. (1a-d) and still satisfy Einstein's second postulate and remain consistent with all the successful predictions of SR that require only the use of the VT in their justification. The resulting alternative Lorentz transformation (ALT [5]) is thus [recall that $\eta = \left(1 - \mathrm{v}u_x c^{-2}\right)^{-1} = \left(1 - \mathrm{v}xt^{-1}\mathrm{c}^{-2}\right)^{-1}$]:

$$t' = \gamma\varphi\left(t - \mathrm{v}x\mathrm{c}^{-2}\right) = \gamma\eta\gamma^{-1}\left(t - \mathrm{v}x\mathrm{c}^{-2}\right) = \eta\left(t - \mathrm{v}x\mathrm{c}^{-2}\right) = t \qquad \text{(3a)}$$

$$x' = \gamma\varphi\left(x - \mathrm{v}t\right) = \gamma\eta\gamma^{-1}\left(x - \mathrm{v}t\right) = \eta\left(x - \mathrm{v}t\right) \qquad \text{(3b)}$$

$$y' = \varphi y = \eta\gamma^{-1} y \qquad \text{(3c)}$$

$$z' = \varphi z = \eta\gamma^{-1} z\ . \qquad \text{(3d)}$$

Although it is just as consistent with his two relativity postulates, *the ALT is qualitatively different from Einstein's LT.* This is most easily seen from eq. (3a) for which one has the Galilean-like simplicity of equal time measurements for the two observers (t'=t).

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There is no space-time mixing as occurs in the corresponding eq. (1a) of the LT. *At the very least, this shows that the century-old assertion that such coordinate mixing is the inevitable consequence of Einstein's postulates is specious.* Moreover, one can easily take account of the observed fact that clock rates in different inertial systems are generally not equal (time dilation). If one assumes that there is a strict proportionality between the two rates [6] as long as the relative velocity of the two inertial systems is constant ($t = \mathrm{Q}t'$), this condition can easily be satisfied by setting $\varphi = \eta\left(\gamma\mathrm{Q}\right)^{-1}$. A more general version of the ALT that takes time dilation into account is thus:

$$t' = \mathrm{Q}^{-1} t \tag{4a}$$

$$x' = \eta \mathrm{Q}^{-1}\left(x - \mathrm{v}t\right) \tag{4b}$$

$$y' = \eta\left(\gamma\mathrm{Q}\right)^{-1} y \tag{4c}$$

$$z' = \eta\left(\gamma\mathrm{Q}\right)^{-1} z\,. \tag{4d}$$

The ALT differs from the LT in another significant way. It does not predict that time dilation is symmetric, i.e. that observers in motion will each think it is the other’s proper clock which is running slower. Einstein had therefore predicted on the basis of the LT that a red shift must always be observed for light waves emanating from a source that is in motion relative to the detector [1]. By contrast, Hay et al. found [7] on the basis of transverse Doppler measurements using the Mössbauer effect *that a frequency shift to the blue results when the detector is located closer to the rim of a rotor* and a red shift when the opposite is the case. Sherwin [8] pointed out that this result could only be explained by assuming that an accelerated clock is

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slowed relative to a stationary one, and therefore that there was "no ambiguity" of the type expected from the LT. He went on to conclude that one should only base predictions on the LT when both the detector and the light source are "in uniform motion." Some ten years later Hafele and Keating [9] found that there is also no ambiguity as to which of two atomic clocks on circumnavigating airplanes is running slower [6]. The ALT does not require any new assumptions to be consistent with these experimental results. The proportionality constant Q in eq. (4a) guarantees that one clock must be slower than the other when there is time dilation; if $Q > 1$, the clock in S' is slower and the opposite is true if $Q < 1$, i.e. the clock in S is slower. In short, *the subjective character of measurement in SR caused by its reliance on the LT is replaced by a completely objective theory when the ALT is used instead.*

What about non-simultaneity in relativity theory? Again, the standard argument is that it is impossible to satisfy the relativity postulates and still conform to the principle of simultaneity of events for two observers who are moving relative to one another. This conclusion is also based on the assumption that $\varphi = 1$ in eq. (1a) that leads to the LT, in which case the following relation holds between time differences Δt and $\Delta t'$ between the events as observed in S and S', respectively:

$$\Delta t' = \gamma \left(\Delta t - \mathrm{v} \Delta x \mathrm{c}^{-2} \right). \tag{5}$$

Accordingly, if $\Delta t = 0$ but $\Delta x \neq 0$, it naturally follows that $\Delta t' \neq 0$, i.e. the two events in different locations occur simultaneously for the observer in S but not for his moving counterpart in S'. Einstein's two postulates are satisfied just as well by the ALT and eq. (4a), however, resulting in the simple alternative to eq. (5):

$$\Delta t' = \mathrm{Q}^{-1} \Delta t\,. \tag{6}$$

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According to this equation, it is seen that the elapsed times of any two events will differ by the same factor Q as in the ALT. Remote simultaneity of events is therefore guaranteed since Δt must vanish whenever $\Delta t'$ does, regardless of the relative speed of S and S′ or the distance separating the two events [5, 6, 10].

The distinction between eqs. (5) and (6) is also relevant to the recent controversy over superluminal neutrino motion. From eq. (5) of the LT it is seen that $\Delta t'$ should differ in sign from Δt whenever $\frac{\mathrm{v}\Delta x}{\Delta t} = \mathrm{v}u_x > c^2$. If the speed u_x of the neutrino or other object exceeds c, it is possible to satisfy this inequality even though the observers' relative speed v is less than c. This would be a violation of Einstein causality since the time-order of events would be different for the two observers. Traditionally, it has been assumed that such a situation is impossible and therefore that the $\mathrm{v} \le \mathrm{c}$ condition is sacrosanct. The ALT and eq. (6) make no such connection because it can safely be assumed that clock rates are always positive and therefore that $\mathrm{Q} > 0$ in all cases. Superluminal motion is also not ruled out by the VT in eqs. (2a-c). Closer inspection shows that it simply demands that all observers must agree on whether the object's speed is greater than c, just as they also must agree when it is less than c (and also when it is exactly c, of course). In this connection, it should be noted that there is earlier experimental evidence [11] that the speed of photons in otherwise transparent media exceeds c in wavelength regions near absorption lines (anomalous dispersion), causing the group refractive index to be less than unity. *The only theoretical argument against superluminal motion in either case rests totally on the LT and therefore on Einstein's normalization condition in eqs. (1a-d).*

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Another key property of the LT is the condition of Lorentz invariance. The general invariance condition based on eqs. (1a-d) is:

$$x'^2 + y'^2 + z'^2 - \mathrm{c}^2 t'^2 = \varphi^2 \left(x^2 + y^2 + z^2 - \mathrm{c}^2 t^2 \right). \tag{7}$$

Einstein's assumed value for the normalization function of $\varphi = 1$ leads to the highly symmetric form that is so familiar to theoretical physicists. Most important, this version of eq. (7) satisfies the relativity principle since it looks exactly the same from the vantage point of both observers. It is less obvious how any other choice of φ can satisfy the latter requirement, and this is one conceivable justification for adopting the value of unity in deriving the LT. Specifically, the question arises as to whether the choice of $\varphi = \eta (\gamma \mathrm{Q})^{-1}$ that leads to the ALT is also consistent with the relativity principle. Substitution in eq. (7) gives the following alternative condition of invariance:

$$x'^2 + y'^2 + z'^2 - \mathrm{c}^2 t'^2 = \eta^2 (\gamma \mathrm{Q})^{-2} \left(x^2 + y^2 + z^2 - \mathrm{c}^2 t^2 \right). \tag{8}$$

To satisfy the relativity principle, it is necessary for the inverse of eq. (8) to have the same form from the vantage point of the observer in S:

$$x^2 + y^2 + z^2 - \mathrm{c}^2 t^2 = \eta'^2 (\gamma \mathrm{Q}')^{-2} \left(x'^2 + y'^2 + z'^2 - \mathrm{c}^2 t'^2 \right). \tag{9}$$

In this equation η' must be obtained from $\eta = \left(1 - \mathrm{v} u_x \mathrm{c}^{-2}\right)^{-1} = \left(1 - \mathrm{v} x t^{-1} \mathrm{c}^{-2}\right)^{-1}$ in the standard way by exchanging corresponding primed and unprimed values and changing v to $-\mathrm{v}$, i.e. $\eta' = \left(1 + \mathrm{v} u'_x \mathrm{c}^{-2}\right)^{-1} = \left(1 + \mathrm{v} x' t'^{-1} \mathrm{c}^{-2}\right)^{-1}$. The value of γ remains the same because it is a function of v^2, and the value of

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$Q' = Q^{-1}$ is fixed by forming the inverse of eq. (4a), i.e. $t = Q'^{-1}t' = Qt'$.

There is another way to invert eq. (8) that also needs to be taken into account, namely to simply divide both sides by $\varphi^2 = \eta^2(\gamma Q)^{-2}$, with the result:

$$x^2 + y^2 + z^2 - c^2t^2 = \eta^{-2}(\gamma Q)^2\left(x'^2 + y'^2 + z'^2 - c^2t'^2\right) \qquad (10)$$

Both equations must be equivalent in order to satisfy the relativity principle, hence $\eta^{-2}(\gamma Q)^2$ in eq. (10) must be equal to $\eta'^2(\gamma Q')^{-2}$ in eq. (9). By using the ALT to eliminate the primed variables in the definition of η', the following identity is obtained:

$$\eta\eta' = \gamma^2. \qquad (11)$$

As a result, eqs. (9) and (10) are seen to be equivalent since $Q' = Q^{-1}$. *The choice of* $\varphi = \eta(\gamma Q)^{-1}$ *in the general Lorentz transformation of eqs. (1a-d) to define the ALT therefore satisfies both of the relativity postulates just as well as Einstein's* $\varphi = 1$ *value does for the original LT.*

IV. Distance Relationships and the Clock Riddle

In the previous section the emphasis has been on the measurement of elapsed times by different observers and how the predictions of SR are altered by making another assumption about the normalization function φ in eqs. (1a-d) than in Einstein's original work. Predictions about distance comparisons of the two observers in S and S′ also depend on the choice of φ. The LT with $\varphi = 1$ leads to Fitzgerald-Lorentz length contraction (FLC) with the following relationships between measured spatial and time results for the same event by the two observers: $t' = \gamma^{-1} t$, $x' = \gamma x$, $y' = y$ and $z' = z$ [1] [note that the inverse of eq. (1a) is used with $x' = 0$ and $\varphi = 1$ to obtain the above relation between t and t', while eq. (1b) is used with $t = 0$ and $\varphi = 1$ to obtain the corresponding x / x' relation]. In summary, when the clocks in S′ run slower ($\gamma > 1$), the observer in S should measure length contraction along the direction of relative motion ($x' = \gamma x$), while distances in a perpendicular direction should be the same as measured in S′. However, *it is important to note that there has never been a confirmed verification of the FLC.* Belief in its validity rests squarely on the LT.

There is another way to measure distances using relativity theory, namely to measure the elapsed time for light to pass from one endpoint to the other and multiply with c. According to Einstein's second postulate, the observers in S and S′ must agree on the value of the speed of light even though their proper clocks run at different rates due to time dilation. This consideration leads to a different set of results in the case where the clocks in S′ again run slower by a factor of γ: $t' = \gamma^{-1} t$, $x' = \mathrm{c}t' = \mathrm{c}\gamma^{-1} t = \gamma^{-1} x$, $y' = \gamma^{-1} y$ and $z' = \gamma^{-1} z$. *Comparison with the above results stemming from the FLC and the LT shows clearly that something is amiss.* This is what has been referred to as the "clock riddle" in previous work [12]. Use of the second method for measuring distances leads to the conclusion that lengths in S′ must *expand* rather than contract ($x' = \gamma^{-1} x$ as opposed to $x' = \gamma x$ from the FLC). Furthermore, the change must be *isotropic* since clock rates are clearly independent of direction. The reason that an observer in S′ using this method measures consistently smaller values for the dimensions of the same object is because his unit of time is *larger* than that used by his counterpart in S. The

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modern definition [13] of the meter is the distance traveled by light in free space in c^{-1} s, for example, so it follows that the slower the proper clocks in a given rest frame, the longer will be the meter standard therein. The relativity principle simply demands that observers are never able to notice a change in either the standard unit of time or distance based on their purely *in situ* measurements. On this basis, Einstein's version of the relativity principle [1] needs to be amended to: *The laws of physics are the same in all inertial systems but the units in which they are expressed may vary in a systematic manner from one rest frame to another.*

Moreover, the LT demands that the opposite relationships should occur when roles are reversed in applying the FLC: $t = \gamma^{-1} t'$, $x = \gamma x'$, while still having $y' = y$ and $z' = z$ [note that eq. (1a) is used directly with $x = 0$ and $\varphi = 1$ to obtain the above relation between t and t', while the inverse of eq. (1b) is used with $t' = 0$ and $\varphi = 1$ to obtain the corresponding x / x' relation in this case]. It is typically argued that the apparent discrepancy between the two sets of comparative distance results stemming from use of the LT can be understood from the fact that the respective measurements by the observers in S and S′ are carried out at different times (remote non-simultaneity). *The expected symmetry explanation breaks down, however, when the wavelengths of excited atomic states are the object of the measurement since their values are obviously time-independent for each observer as long as his state of motion does not change.* The most important result of the clock riddle is the contradiction it exposes between the results of the two different ways of making distance comparisons. *The key point is that only assumptions of SR are employed to obtain these two contradictory sets of results.* In the first case, Einstein's FLC is assumed, which in turn is derived from the LT. In the second case, only the light-speed postulate is assumed.

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Therefore, it is clear that something is wrong with SR and needs to be corrected. Consequently, if one starts with SR as the basis for further theoretical developments, as for example in the recently published work of Smarandache [14], there is no reason to be certain that the new relationships will be verified by subsequent experiments.

Without the light-speed postulate, a large part of Einstein's relativity theory must be discarded. On the other hand, it has been shown in Sects. II-III that the LT is not the only means of satisfying both of Einstein's relativity postulates. His assumption of $\varphi = 1$ for the normalization function in eqs. (1a-d) leads directly to the LT and the FLC. However, making a different assumption, such as the one that leads to the ALT [5,12] discussed Sect. III, does not lead to the FLC and thus is not consistent with the set of results given first (with $y = y'$, for example). *The ALT is consistent with the second method,* and there is every reason to believe based on practical experience that distances can be accurately measured using atomic clocks by making the assumption that the speed of light has the same constant value for all observers (excluding gravitational effects [9]). The hugely successful Global Positioning System (GPS) technology rests solidly on this principle, for example.

In this connection, it needs to be emphasized that there is a great deal of experimental evidence in favor of the light-speed postulate. Attempts to negate the significance of these experiments generally start with a claim that all such investigations are done with a detector that is at rest in its laboratory. First of all, this position ignores the fact that investigators on the Earth's surface are traveling at 30000 ms^{-1} around the Sun as they carry out their measurements, and that they are typically rotating about the Earth's polar axis at speeds of as high as 440 ms^{-1}. Secondly, while it is difficult to see how such experiments could be done in any other way, it should nonetheless be

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pointed out that the same situation holds for the measurements of the speeds of other objects than light. In those cases it is easily shown that different observers who are moving with respect to each other do not agree on the speed of the object, so one still needs to explain why light pulses represent such a glaring exception to the latter rule. A case in point is the Fresnel light-drag experiment. When a liquid moves through a tube with speed v and light traverses it in the same direction, it is known [15, 16] that the net velocity of light c' in the laboratory is given by:

$$c' = cn^{-1} + \left(1 - n^{-2}\right), \tag{12}$$

where n is the group index of refraction of the medium. Von Laue [15] used the inverse of eq. (2a) of the VT to obtain this result, thus verifying the light-speed postulate ($c' = c$) and demonstrating that the classical result from the non-relativistic Galilean transformation, namely $c' = c + v$, is not valid in the limit of free space ($n = 1$). These facts need to be kept in mind when trying to formulate a theory of electricity and magnetism that rejects Einstein's second postulate.

The underlying problem with SR that is revealed by the above considerations is that the theory fails to recognize that the speed of an object, the distance traveled by it, and the corresponding elapsed time to do so *are not independent quantities.* Once any two of them are known, the third is completely specified. *This observation also holds for relationships involving these quantities.* It therefore defies logic to assert that two observers agree on the speed of light but disagree on the elapsed time of its travel between two points in a perpendicular direction, and then go on to claim that the distance traveled by the light is somehow the same for both ($y = y'$). Einstein's assumption for the dependence of the normalization function in the *general Lorentz transformation* of eqs. (1a-d) forces this conclusion on SR, *even though the light speed postulate and time dilation formula*

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($t' = \gamma^{-1} t$) has already fixed the relationship between all distance values measured by the two observers.

V. Conclusion

There are two basic facts about the LT that need to be underscored. The first is that Einstein made an undeclared assumption in his original derivation [1] about the required "normalization" of the general Lorentz transformation. He claimed without further discussion that the function φ in eqs. (1a-d) *must be a function of* v *alone*, i.e. can only depend on the relative speed of the two inertial systems under consideration. The fact that he made this additional assumption is beyond dispute, as the reader may verify by checking the statement on p. 900 of Ref. 1 in the first line after the definition of β. It is also easy to show that this assumption is essential in arriving at Einstein's LT. As a result, a large number of the key results of SR such as the FLC, the "symmetry" of measurements of time dilation and other quantities, and the remote non-simultaneity of events for observers in relative motion are seen to depend on this assumption and *thus are not the inevitable consequence of Einstein's two relativity postulates*. The same holds true for the condition of Lorentz invariance and the concept of space-time mixing that have traditionally been hailed as great achievements of Einstein's theory that "freed" physics from the supposedly specious ideas of Newton and Galileo and other classical physicists. The same assumption is repeated in numerous derivations of the LT that have appeared over the last century. If Einstein's original statement of the assumption is not used directly, then something equivalent is always employed in its stead. For example, Lorentz invariance is assumed or the supposed equality of distance measurements in a direction perpendicular to that of the relative velocity of the two inertial systems. These are no less

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assumptions that require experimental support for their validity than is the assertion about the functionality of φ that Einstein made.

The second fact is equally indisputable. There are two ways of using SR to obtain ratios of the measured values of distances obtained by observers who are in uniform relative motion to one another. It is found that different conclusions are reached depending on whether the FLC is employed for this purpose or one relies instead on Einstein's light-speed postulate and measurements of the elapsed time for light to travel between the same two endpoints. This result is referred to as the "clock riddle [12]," as opposed to the better known "clock paradox." For example, the FLC states that distances measured perpendicular to the direction of relative motion must be the same for the two observers ($y = y'$), whereas the second postulate requires that the observer with the slower clock measure a *shorter* value for such distances than his counterpart with the faster clock. Furthermore, the light-speed postulate leads one to conclude that *isotropic length expansion* accompanies time dilation in a moving rest frame, not the anisotropic length contraction predicted by the FLC [1]. Both of the above conclusions follow directly from SR since a) the light-speed postulate employed in the second method is essential for its justification, and b) the FLC used in the first method is a direct consequence of the LT, which in turn is the cornerstone of SR. Any part of a theory that can be shown to lack internal consistency gives up its claim to legitimacy, and that state of affairs is what the clock riddle exposes in the case of the LT. As a result, it must be concluded that Einstein's assumption about the allowed functionality of φ in the general Lorentz transformation of eqs. (1a-d) is not only undeclared and unconfirmed in his original derivation [1], it is also demonstrably false because it leads unequivocally to a logical contradiction in the resulting theory.

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The only way to avoid the above conclusion about the LT is to show that either of the two facts mentioned above are actually not correct. However, in the search for such a flaw in these arguments, there is another key aspect of the present discussion that needs to be considered. None of the confirmed experimental verifications of Einstein's SR is dependent in any way on the LT. Instead, one finds that they either involve quantities that are independent of space and time such as inertial mass and energy, or actually only require the VT in arriving at the relevant theoretical prediction. *The latter point is crucial in the present context because the VT is independent of the normalization function* φ *and thus is totally unaffected by Einstein's disputed assumption.* As a consequence, all that needs to be done to prevent relativity theory from being self-contradictory is to replace Einstein's original assumption about φ with a different one that is consistent with all experimental findings that have been obtained since he introduced his theory. Specifically, it can be noted that experiments with atomic clocks have invariably found that the rates of clocks in relative motion remain in a constant ratio as long as neither one of them is accelerated or changes its position in a gravitational field. As long as this is the case, it is possible to replace eq. (1a) of the generalized Lorentz transformation with the simple proportionality relation of eq. (4a), $t' = t\mathrm{Q}^{-1}$, where Q is the constant value of the ratio of the two clock rates in question. This amounts to merely making a different choice for φ than Einstein did in his derivation of the LT, and as such, it is completely consistent with the VT and all experimental verifications that have been obtained for it. Accordingly, φ depends on both the relative speed v and also the velocity component u_x of the common object of the measurements of the two observers. Substituting this value for φ into eqs. (1a-d) leads to the alternative Lorentz transformation (ALT [5, 12]) of eqs. (4a-d).

The ALT is consistent with both of Einstein's declared postulates, but also avoids any contradiction associated with the clock riddle [12]. It is consistent with the VT, but no longer predicts that events that occur simultaneously for one observer must be non-simultaneous for others. As the VT itself, the ALT also does not preclude superluminal motion since it does not predict a violation of Einstein causality as the inevitable consequence of such an occurrence, unlike the well-known conclusion that results from applying the LT. The ALT also denies the FLC and the supposed symmetry characteristic in SR that claims that it is impossible to decide which of two proper clocks is running slower when they are in relative motion. It also rejects space-time mixing as a viable characteristic of relativity theory, and it replaces the Lorentz invariance demanded by the LT with the condition given in eqs. (8-9).

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