East African Scholars Journal of Engineering and Computer Sciences
Abbreviated Key Title: East African Scholars J Eng Comput Sci
ISSN: 2617-4480 (Print) & ISSN: 2663-0346 (Online)
Published By East African Scholars Publisher, Kenya

Volume-6 | Issue-4 | Aug-2023 | DOI: 10.36349/easjecs.2023.v06i04.002

Review Article

The Many Flaws of the Lorentz Transformation

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Article History
Received: 10.07.2023
Accepted: 16.08.2023
Published: 22.08.2023

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: The Lorentz transformation (LT) is one of the most revered set of relationships in modern physics. Overlooked in this broad assessment are a number of clear inconsistencies in its predictions, however, as will be discussed herein. For example, it makes three predictions which are not consistent with one another: Lorentz-FitzGerald length contraction (FLC), time dilation (TD) and light-speed equality for observers in relative motion to one another. Einstein's light-speed postulate (LSP) is shown to be unviable by considering a case in which a light source passes by a stationary observer at the same time that it emits a light pulse in the same direction. It is found that, in contradiction to the LSP, that the classical velocity (Galilean) transformation (GVT) is applicable when two observers in relative motion deduce the speed of a light wave from their different perspectives. The LT also stands in violation of the Law of Causality because it fails to recognize that inertial clocks can never change their rate spontaneously; thus its two clocks must always measure elapsed times in the same ratio (Q), contrary to the LT prediction of space-time mixing. The Newton-Voigt transformation (NVT) is consistent with the Law of Causality because it assumes space and time do not mix. It is nonetheless also consistent with the relativistic velocity transformation (RVT) and also with Einstein's mass-energy equivalence relation $E=mc^2$. The ratio Q of clock rates for two inertial rest frames S and S' is required input for the NVT. Experimental data obey the Universal Time-dilation Law (UTDL) which states that the measured time Δt obtained by an inertial clock for a given event is inversely proportional to $\gamma(v)= (1-v^2c^{-2})^{-0.5}$, where v is the speed of the clock relative to a specific rest frame referred to as the objective rest frame ORS. The Uniform Scaling method employs Q as a conversion factor between the units of time in the two rest frames. It is found that the conversion factors for all other physical properties are integral multiples of Q. Kinetic scaling of the properties insures that the laws of physics are the same in each inertial frame, as required by Galileo's Relativity Principle. The Universal Scaling method uses a set of conversion factors for the effects of gravity that is analogous to those for kinetic scaling.

Keywords: Lorentz transformation (LT), Law of Causality, Newton-Voigt transformation (NVT), Time dilation (TD), Lorentz-FitzGerald length contraction (FLC), Uniform Scaling method.

I. INTRODUCTION

The Lorentz Transformation (LT) was introduced independently by Larmor [1] and Lorentz [2] in the late 19th century. It was taken over without change by Einstein as the lynchpin for his Special Relativity Theory which he introduced in his landmark paper of 1905 [3]. To have general validity, it is essential that any such theory be free from any logical inconsistencies. It also must be free of any predictions which stand in contradiction to accepted Laws of Physics. In the following discussion it will be shown that the LT fails to satisfy the above criteria in three well-defined instances.

II. Space-time Deductions of the LT

The results of the Michelson-Morley interferometry experiment [4] had a huge impact on the way physicists understood the relationships between space and time. For example, it led FitzGerald [5] and Lorentz [6] independently to conjecture that the lengths

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of objects contract as they are accelerated, and by varying amounts depending on their orientation to the observer. One of the interesting findings in Einstein's 1905 paper [3] is that it derives exactly the same relationships about the variation of the lengths of objects, referred to as FitzGerald-Lorentz Contraction (FLC), directly from the equations of the LT. Consequently, it is predicted that distances measured on a moving object will appear contracted to a stationary observer.

The phenomenon of "time dilation (TD)" is also predicted on the basis of the LT. It asserts that a moving clock will be found to run slower than its identical counterpart at rest. The amount of the decrease in rate increases with the speed v of the clock relative to the rest frame of the observer and is proportional to $\gamma(v) = (1-v^2c^{-2})^{-0.5}$ ($c = 299792458\ ms^{-1}$ is the speed of light in free space). Derivations of both the FLC and TD can be found in Jackson's book on electrodynamics [7], as well as in Einstein's original work.[1]

Consider the following application in which a train passes a station platform with constant speed v. A passenger R on the train wishes to measure the speed of light by passing a light pulse between the ends of metal bar of length L m. He finds that the elapsed time for this to occur is T s and verifies on this basis that the speed of the light pulse is equal to c = L/T. According to SR and the LT, a stationary observer P on the platform must find the same value for the speed of the light pulse in the rest frame of the train. Assume that the metal bar is oriented perpendicular to the direction of the train. According to the FLC, observer P must find that the length LP of the bar is also equal to L in this orientation. Because of time dilation on the train, observer P's clock runs faster than that used by R. The LT therefore predicts that the corresponding elapsed time TP measured for the passage of the light pulse on the train is equal to $\gamma(v)T$. The platform observer must therefore find that the speed of the light pulse is $cP = LP/TP = L/\gamma(v)T = c/\gamma(v) \neq c$, in clear violation of the light-speed equality condition of the LT.

If the metal bar is assumed to lie in the parallel direction of the train's motion, the FLC claims that $LP = L/\gamma(v)$. In this case the light speed deduced for the platform observer is $LP/TP = L/\gamma^2(v)T = c/\gamma^2(v)$, which is in even greater disagreement with the SR light speed equality condition. The unavoidable conclusion from this example is therefore that the LT is not a valid space-time transformation and is therefore not a physically acceptable component of relativity theory. More details concerning this negative evaluation of the LT and SR can be found in an earlier publication of the author [8].

III. Problems with Einstein's Light-speed Postulate (LSP) and Remote Non-simultaneity

In formulating his version of relativity theory [3], Einstein agonized [9] over the definition of a postulate which correctly described the observation of light-speed constancy. He concluded that the speed of light in free space has the same value c for all observers independent of their state of motion as well as that of the source of the light. It will be shown in the following how this postulate leads directly to the conclusion that the lightning strikes on a train could not possibly be simultaneous for both an observer there and one who is stationary on the platform.

A basic part of the theory has to do with how different people perceive how fast an object is moving. Just take the following simple example. You are standing on a street corner as a car passes you with a speed of v=50 km/h. The car driver reports that he sees a train moving in the same direction with speed w=30 km/h away from him. You can safely assume on this basis that the train is moving with speed v+w=80 km/h relative to you as you stand on the corner. It is all very easy to understand.

Now change the example so that there is a light pulse instead of a train. The light pulse moves with speed w=c away from the car. So the relative speed of the light to you on the corner will be v+c according to the above example using a train. Einstein did not agree with this conclusion, however. He assumed [10] instead (light speed postulate LSP) that the speed of light is *independent* of the speed of the observer or light source. He claimed that the procedure used above in the car-train example (the Galilean velocity transformation GVT) is only valid at low speeds much less than c.

There is a simple way to test Einstein's assumption, however. Just consider how far the light travels in a given time T relative to the car/light source on the one hand and relative to the street corner/origin on the other [11]. According to Einstein's LSP in both cases the value of the distance of separation from the light pulse is found to be cT. *This result is clearly unacceptable,* since it is impossible that the light pulse could be the same distance from both *since their two positions are not coincident at time T;* they are separated by a distance of vT now, whereby T can have any value. For example, T could be as great as one year, so the distance separating the light source from the origin/street corner would be 1.0 light year (ly) in that case. This proves beyond any shadow of a doubt that Einstein's LSP in untenable.

The same procedure (*distance* reframing [11]) can be put to good use in another way in this example. The distance moved by the light source relative to the origin is vT, while that moved by the light pulse away from the light source is cT. The total distance separating the light pulse from the origin is obtained by simply adding these two values, with the result vT+cT=(v+c)T. (Note that the addition of distances is commonplace in everyday activities such as measuring the width of a room, whereas there is no such intuitive principle for the addition of velocities).

By definition, the speed of the light pulse relative to the origin is obtained by dividing the above value by the elapsed time T, which upon cancellation gives v+c. This is exactly the value that is obtained when the GVT is applied directly. In summary, the *distance reframing procedure* contradicts the long-held position of the physics community that the motion of the light pulse relative to two different rest frames is governed by Einstein's LSP, while at the same time verifying that the GVT is totally accurate in this example as well as in any conceivable variation involving other moving objects than light.

Relegation of the GVT to the realm of low-energy physics has its price, however. Belief in the LT and Einstein's LSP forces one to accept the doctrine of remote non-simultaneity (RNS). Accordingly, two events which occur simultaneously for an observer in one rest frame may not necessarily be simultaneous for someone who is in motion relative to him. Einstein was aware that there is no experimental verification for RNS [12], even though what Poincaré [13] had to say on the subject is just as true, namely that there is also no proof from experiment that all events must occur at the same time for all observers in the universe.

In order to deal with his own uncertainty on this subject, Einstein came up with an example [10] which should demonstrate without doubt that RNS is a fact of nature. He asked his readers to consider the case in which two lightning strikes occur on a passing train. They are measured to occur simultaneously for an observer O_p who is at rest on the station's platform. He argued that if the two strikes occurred on opposite sides of the position M on the platform which both were separated by a distance of L from O_p, then light emanating from them would necessarily arrive at M simultaneously. The time T_p required for this to occur is L/c, where c is the speed of light in free space.

He further assumed that the passing train was moving at a constant speed v relative to the platform as the lightning strikes occurred. On the basis of his LSP, an observer O_t who is at rest on the train at the same position M when the two lightning strikes occur, cannot find that they would also occur simultaneously for him. This is because O_t must find that the light pulse moving in the opposite direction as the train would move a distance of cT toward him at any time T while he has moved a distance of vT during the same period. The light would therefore arrive at O_t's momentary position at time $T_1=L/(v+c) < T_p$. Meanwhile the light pulse travelling in the opposite direction would also move a distance of cT by virtue of the LSP, whereas O_t would have moved a distance of vT away from this pulse. The time required for this light pulse to "catch up" with O_t is thus $T_2= L(c-v)>T_p$. Clearly, $T_2>T_1$, so the light pulses do not arrive simultaneously for O_t when the LSP is used, as Einstein wished to show [10].

Let us now consider how the substitution of the GVT for the LSP in Einstein's example of two lightning strikes changes the result. Assume as before that the light from the two strikes reaches the observer O_p located at the midpoint M of the platform simultaneously at time $T_p=L/c$. After time T has elapsed, *the sources of the strikes* have moved to positions 2L+vT and vT, respectively, that is, by taking account of the speed of the train relative to the platform. The speed of the first light pulse relative to O_t is c+v in the negative direction according to the GVT, so at time T this pulse is located at 2L+vT–(v+c)T=2L-cT. Note that this is exactly the same trajectory for this light pulse as from the vantage point of O_p.

Meanwhile, the speed of the second pulse toward O_t is c-v according to the GVT. As a result it is located at vT+(c-v)T=cT at time T. The trajectory of this one is also identical to that measured by the stationary observer O_p on the platform. Therefore, the two light pulses will also meet for O_t when 2L-cT = cT. The corresponding time is $L/c=T_p$, the same as for O_p on the platform. In summary, the arrival time is simultaneous for O_t as well as for O_p when the GVT is applied. It is thus clear that there is no RNS in this procedure using the GVT, contrary to what one must assume when the LSP is assumed instead.

IV. The Law of Causality and Space-time Mixing

Einstein [3] used time dilation to make his famous energy-mass equivalence prediction ($E=mc^2$). This was at first received with considerable skepticism [14], including from Einstein himself, but over time it has proven to be of considerable consequence in the history of scientific investigation. It explained the fact that the sum of masses is not conserved in nuclear reactions. It is the underlying theoretical basis for both nuclear reactors and weapons such as the atomic bomb and is therefore beyond dispute.

The fact that there have been so many confirmations of Einstein's Special Relativity (SR) does not prove that it is a truly reliable theory, however. The rule for any theory is to maintain faith in it so long as no contradictory evidence is found, but never to stop trying to improve it by removing any clear inconsistency in its predictions. With this in mind, it is important to consider possibly relevant information that can produce a new variant which continues to deal successfully with past accomplishments of the old theory, but while at the same time broadening the range of applicability of the new one.

For example, the Law of Causality has played a key role in the development of science through the ages. It basically says that nothing happens without something causing it to occur. Newton's First Law of Kinetics [15] (Law of Inertia) is a prime example. It states that a body will continue in a straight line at constant speed until it is subjected to an unbalanced external force. By extension, each of the physical properties of the same object such as a clock will remain constant indefinitely *unless some outside force is applied*. Accordingly, it seems unavoidable to conclude that the rate of such a (inertial) clock will not change unless it is acted upon by some outside force (Clock-rate Corollary [16]). That being the case, one must conclude that the *ratio* of the rates of any two such clocks will be a *constant.* In other words, when these clocks are used to measure an elapsed time, their different values Δt and Δt' will always be found to be in the same ratio, i.e. $\Delta t' = \Delta t/Q$, where Q is the rate ratio.

The LT makes use of inertial clocks in two different rest frames. One of its main characteristics is that the elapsed time Δt' measured on one such clock will depend on the relative speed v of the two rest frames and the location Δx of the object in one of the other rest frames. as well as the time Δt measured on that clock, i.e. $\Delta t' = \gamma(v)\ (\Delta t - v\Delta x/c^2)$, where $\gamma(v) = (1-v^2/c^2)^{-0.5}$ and c=299792458 m/s. It can be seen that if both v and Δx have non-zero values, then Δt' will not be proportional to Δt. This characteristic of the LT is known as *space-time mixing*. It stands in direct contradiction to the $\Delta t' = \Delta t/Q$ relation required by the Law of Causality. *This shows that the LT is not consistent with the Law of Causality.*

As stated in Sect. III, one of the consequences of the space-time mixing of the LT is that it allows the two observers mentioned above to disagree on whether two events occurred simultaneously or not [3]. This is clear from the same LT equation mentioned above. Again, if both v and Δx are not equal to zero, it follows that when Δt=0 (note that Δt=0 means that the two events did occur simultaneously for the one observer), it cannot be that Δt'= 0 as well, i.e. that the two events were also simultaneous for the other observer. This situation is referred to as remote non-simultaneity (RNS). The distinction between the LT and the $\Delta t' = \Delta t/Q$ condition required by the Law of Causality is quite clear because in the latter case when Δt'=0, so must also Δt. For this reason the latter proportionality relation is referred to as *Newtonian Simultaneity.* This is in recognition of the historical fact that Newton was a firm believer in absolute simultaneity, that is, that if two events occur simultaneously, they will also be found to be simultaneous in any other pair of rest frames throughout the universe.

The choice for physicists is clear. Either you give up on the ancient Law of Causality in order to preserve your faith in Einstein and the LT and RNS, or you accept the conclusion of the former that Newtonian Simultaneity explains why the ratio of the rates of any two inertial clocks must have a constant value. The latter conclusion is essential for the operation of the Global Positioning System (GPS) navigation methodology [17]. In summary, the fabulous success of GPS in our everyday lives serves as an undeniable verification of Newtonian Simultaneity and its prediction that clock rates in different rest frames are always strictly proportional to one another.

The relativistic velocity transformation (RVT) is used extensively in the analysis of particles emitted by rapidly moving sources, and is therefore also an essential ingredient of relativity theory. For example, consider the case [18] in which a Σ^0 hyperon decays to a photon plus Λ particle. The variables which are to be inserted in the RVT in one example are defined as follows: v is the speed of the Σ^0 particle in the laboratory rest frame, u_x' is the speed of Λ in this rest frame and u_x is the final speed of Λ after the decay has occurred. There is a collimating effect such that the higher the value of v, the more the particles get beamed forward in the laboratory rest frame. The RVT was originally derived by Einstein from the LT [3], but it can also be obtained from other space-time transformations such as that introduced by Voigt [19] in 1887. In other words, it exists independently of the LT. The same is true for the mass-equivalence relation.

V. The Newton-Voigt Transformation and the Uniform Scaling Method

The Newton-Voigt transformation (NVT) shown below is the replacement for the LT. The notation used is the same as for the LT; it is assumed that the two inertial rest frames (S and S') are separating from one another with speed v along the mutual x-x' axis.

$$\Delta t' = (\eta/\gamma Q)\ \gamma(\Delta t - vc^{-2}\Delta x) = (\eta/\gamma Q)\ \gamma\ \eta^{-1}\ \Delta t = \Delta t/Q$$
$$\Delta x' = (\eta/\gamma Q)\ \gamma\ (\Delta x - v\Delta t) = \eta\ (\Delta x - v\Delta t)/Q$$
$$\Delta y' = (\eta/\gamma Q)\ \Delta y$$
$$\Delta z' = (\eta/\gamma Q)\ \Delta z.$$

The NVT can be derived by combining the RVT with the Newtonian Simultaneity relation $\Delta t' = \Delta t/Q$, which is the first of its four equations. As such, it is consistent with all the successful predictions previously made with the RVT and is also consistent with the Law of Causality, unlike the case for the LT, as discussed in Sect. IV. The original designation for the NVT was as the Alternative Lorentz Transformation (ALT) [20].

As discussed in Sect. III, there are mutually exclusive applicability ranges for the RVT and the GVT with regard to light [21]. The GVT can be used successfully to compute the distinct measured light speeds made by two observers who are moving with respect to one another. The RVT, on the other hand, is applicable for comparing the light speeds of a single observer under two different conditions, such as occurs in von Laue's interpretation [22] of the light-speed damping in water. The distance reframing procedure discussed in Sect. III allows one to use ordinary vector addition to prove that the GVT is applicable in a given case, such as for computing the angle of stellar aberration from the zenith [21]. This procedure shows that the extra factor of $\gamma(v)$ which was inserted into Bradley's original formula is not correct.

In order to completely define the NVT, it is not only necessary to know the speed v between the two pertinent rest frames described in the equations, but also the value of the parameter Q which connects them. The latter value can be obtained by carrying out explicit timing measurements for the two clocks. For example, Hafele and Keating [23, 24] placed atomic clocks on two airplanes which circumnavigated the earth in opposite directions. As a result of their study, the authors found that the rates of clocks decrease in direct proportion to $\gamma(v)$, where v is the speed of the clock relative to the Earth's center of mass (ECM): $\Delta t' \gamma(v') = \Delta t \gamma(v)$, which has been referred to as the Universal Time-dilation Law [25]. The latter equation can therefore be combined with the Newtonian Simultaneity in the NVT to obtain the following definition of the parameter Q as: $Q = \Delta t / \Delta t' = \gamma(v')/\gamma(v)$. It is helpful to make another definition, namely the rest frame that serves as reference for the speeds of the clocks, namely as the objective rest system ORS [26], which is the ECM in the experiment with circumnavigating clocks.

The Uniform Scaling method takes note of the homogeneity of the time dilation experimental results in the following way. It looks upon the parameter Q in the Newton Simultaneity relation as a *conversion factor* between the unit of time in the object's rest frame (S') and that of the observer in rest frame S. The elapsed time measurement $\Delta t'$ in the UTDL is converted over to the units employed in S by multiplication with Q to obtain the corresponding elapsed time Δt. When viewed in this way, one is led to conclude that the unit of speed/velocity must be the same in both rest frames, since the two observers agree that the speed of light in free space has the same value for both. In order for this to be true, however, it is necessary to assume that *the conversion factor for distances is also equal to Q;* only in this way can the ratio of the distance traveled by the light to the corresponding elapsed time be the same for both observers. Accordingly, the conversion factor for *relative speeds* in general is unity.

The Uniform Scaling method removes the problem with the LT mentioned in Sect. II. The observer in S' finds that the distance travelled by the light pulse (in any direction) is equal to L' and the corresponding elapsed time to be T'. He therefore determines the speed of the light pulse to be L'/T'=c, in agreement with the standard definition. The observer in S deduces the following values for the distance travelled and elapsed time, namely QL' and QT', respectively. The ratio is therefore also L'/T'=c, in agreement with the equal light-speed condition of the theory.

In this connection, it is also important to note that Bucherer [27] showed that the inertial mass of electrons is proportional to γ (v) in experiments using crossed electric and magnetic fields. One can therefore deduce on this basis that the conversion factor for inertial mass also has a value of Q, i.e. the same as for time and distance. Since every other physical quantity can be expressed as a product of these three fundamental quantities (e.g. in the mks system of units), it therefore follows that the conversion factor for any other quantity must be an integral multiple of Q. All that is necessary to determine its conversion factor is knowledge of its composition in terms of inertial mass, time and distance. More information about the Uniform Scaling method can be found in the original reference [28].

VI. CONCLUSION

It has been proven that the Lorentz Transformation (LT) is not a valid component of relativity theory. It was shown in Sect. II, for example, that time dilation and the FLC, both of which are derived from the LT, are incompatible with the light-speed equality condition that is a key ingredient in the overall theory. The Einstein light-speed postulate (LSP), another key element of the LT, has been demonstrated in Sect. III to be physically unviable by comparing the distances along a straight line separating a light source from both an observer and a light source after some time has passed. The fact that the distance is claimed to be the same for both, even though they are not located at the same point in space shows unequivocally that the LSP is invalid. The same (distance reframing) procedure also proves that the Galilean Velocity Transformation (GVT) is applicable for computing the speed of light emitted from a moving source relative to a given observer, contrary to what Einstein claimed on the basis of the LT. This shows that the speed of light relative to an observer can exceed a value of c in free space.

The space-time mixing characteristic of the LT stands in violation of the Law of Causality. An inertial clock cannot change its rate spontaneously until it is acted upon by an external force.

Two such clocks, such as those foreseen in the LT, must therefore have a constant ratio of rates.

This means that the elapsed times measured on them will always be in the same ratio Q, i.e. $\Delta t' = \Delta t/Q$, contrary to what is claimed to be possible on the basis of the LT. The latter proportionality relationship is referred to as Newtonian Simultaneity. It excludes the possibility of remote non-simultaneity (RNS), as discussed in Sect. IV.

The Newton-Voigt Transformation (NVT) is the replacement for the LT. It can be formed by "melding" the Relativistic Velocity Transformation (RVT) with the above proportionality relationship between the measured times in the two participating inertial systems. The NVT has all the positive advantages known for the RVT in addition to satisfying the requirements of the Law of Causality regarding elapsed times. The equations of the NVT require a definite value for the parameter Q in the Newtonian Simultaneity relation. This is obtained with knowledge of experimental timing relationships between the two rest frames with the help of the Universal Time-dilation Law (UTDL) discussed in Sect. V. It causes the value of Q to always be a ratio of two γ (v) factors.

The parameter Q is conveniently regarded as a *conversion factor* between the units of time in the two rest frames. Note that when the roles of the two observers are reversed, the corresponding conversion factor Q' = 1/Q, i.e. the reciprocal of the latter factor. This reciprocal relationship underscores the nature of the parameter as a conversion factor since it is the same as occurs in everyday life such as when meters are converted to kilometers or pounds to kilograms.

By the same token, the conversion factor for light speeds is unity (Q^0), since the two observers always agree on this value of c regardless of the their relative state of motion.

Consistency requires that if the unit of time increases while that of relative speed stays the same, the corresponding unit of distance must also increase by exactly the same factor as time.

In other words, distances increase as the rates of clocks slow down upon acceleration, and by the same amount in all directions. This conclusion is clearly at odds with what is expected based on the FLC and the LT. This altered relationship between elapsed times and distances travelled solves the problem with the LT in Sect. II. Accordingly, the observer is S deduces the values of time and distance to be QL and QT, so that the ratio is the same as the L/T value measured in S'.

Finally, the Uniform Scaling method enables the corresponding conversion factors for all physical properties to be determined on the basis of the composition of each in terms of the three fundamental properties of inertial mass, distance and time. The factors are always integral multiples of Q. There is an analogous set of scaling factors for the effects of gravity.

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Cite This Article: Robert J. Buenker (2023). The Many Flaws of the Lorentz Transformation. *East African Scholars J Eng Comput Sci*, *6*(4), 50-56.