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Einstein's False Interpretation Of The Velocity Addition Law

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1.0 Introduction

One of the fundamental discoveries of Einstein's special relativity that was definitely not borrowed from Lorentz, Larmor, or Poincare is the famous velocity addition law. This law shows that the velocities measured in two relatively moving reference frames do not add linearly, but in a nonlinear manner. This paper shows that the velocity addition law is based on an incorrect interpretation of Lorentz transformation equations and that a correct interpretation of the mathematics of Lorentz transforms upholds the Galilean transformation law for velocities.

Einstein's special theory of relativity is based on two postulates. The first one, the principle of relativity, states that the laws of physics are of the same form when determined relative to one inertial system as when determined relative to any other. The second postulate states that the numerical constant in the light speed equation is the same in all inertial systems. When we consider the Galilean transformation, which implies that velocities defined in two different reference frames add linearly, we find that the principle of relativity does not apply. This is a curious contradiction. If the Galilean transformation is a valid law of physics, then why doesn't it transform in the same form as other laws that are subject to the relativity postulate?

The answer is that special relativity views the velocity addition law as unique result of the new concept of space-time physics that sets it apart from the old physics, which is based on the Galilean law. In this paper, it will be demonstrated that a reinterpretation of the Lorentz transformations means that the Galilean velocity law can be retained in the realm of relativistic physics rather than dispensed with. This preserves the principle that the laws of physics retain their form in relatively moving inertial reference systems.

2.0 Galilean and Relativistic Transformation Laws Of Velocities

Suppose we are given two relatively moving reference frames where the origin of S' moves with the velocity v along the x axis of S. Suppose we measure the velocity of an object relative to the S' frame of coordinates as having the velocity w. The according to the Galilean velocity addition law, the velocity of the same object relative to the S frame of reference is $V=v+w$. There is also a velocity subtraction law, which gives the velocity of an object relative to the moving coordinate system S' if the velocity relative to the system S is known. The velocity relative to S' is $w=V-v$.

Special relativity claims that these laws are invalid for velocities where the ratio v/c is not close to zero. In 1905, Einstein obtained the following velocity addition law: V= v+w/(1+vw/c^2). He deduced further "that the velocity of light c cannot be altered by composition with a velocity less than that of light . For in this case we obtain: V=c+w/(1+w/c)=c."

3.0 Proof That Galilean Addition Law Is Valid In General

This section presents the proof that the Galilean velocity addition law is generally valid for all ratios of v/c up to and including unity, and that the law discovered by Einstein is a special case. The first step of the proof is the correct evaluation of the Lorentz transformation equations.

3.1 Evaluation Of Lorentz Transformation Equations

The mathematical method used here is to first solve the system of Lorentz and inverse Lorentz equations for space and time simultaneously using a specified condition of evaluation. Here the term evaluation is used in the same sense as it is used when a polynomial equation is solved for its roots by setting the equation to equal zero and solving for the indeterminates. The procedure used here is similar. A selected variable is set to zero, and the resulting solutions are obtained. Solutions are obtained by setting one of the following four variables equal to zero, and then solving for the remaining three. The following variables are set equal to zero and the resulting solutions obtained by evaluation: x=x'=t=t'=0, each taken in turn.

The Lorentz transformation equations in a simplified form are assumed as follows:
$x'=\beta(x-vt)$ $t'=\beta(t-vx/c^2)$ $x=\beta(x'+vt')$ $t=\beta(t'+vx/c^2)$ $\beta=(1-v^2/c^2)^{-1/2}$
Here there are four equations which express the simultaneous solutions for the transformation of coordinates. These equations are defined in the usual way in terms of two relatively moving reference frames S and S'. Where the origin of frame S' is in motion with velocity v in the positive x direction of S.

Notice that β is greater than unity when v is greater than zero, and that β^{-1} is less than unity when v is greater than zero. An equation of the form t'=βt results in a dilation of the variable t' with respect to t because t' is greater than t The equation $t=\beta^{-1}t'$ results in a contraction of the variable t with respect to t' because t is less than t'. The definition of β implies that it is always equal to or greater than unity, and can never be less than unity.

The coordinate frames S and S' are assumed to be orthogonal coordinate systems with the requirement that time is defined such that t=t'=0 occurs when the origins coincide; i.e. x=x'=y=y'=z=z'=0 at t=t'=0. The axes for the x, y, and z directions are assumed to be parallel, and the y and z coordinates are assumed to be identical and coincide when the origins coincide at t=t'=0. The purpose of the solutions is to determine the relations governing the transformation of the x and t coordinates according to the Lorentz transform equations.

3.2 Results for x=0 (Specification of an evaluation at the same place in S)

To consider the role of evaluation in space, we determine the simultaneous solution of the four equations when we specify the condition that x=0. The results are as follows:

(1) $x'=\beta(x-vt)=-\beta vt$

(2) $t'=\beta(t-vx/c^2)=\beta t$

(3) $x=\beta(x'+vt')=0$, Therefore $x'=-vt'$

(4) $t=\beta(t'+vx'/c^2)=\beta t'(1-v^2/c^2)=\beta^{-1}t'$

Notice that equation 4 is the inverse of equation 2, so they are the same solution. Equation 4 is solved by substitution with the result from equation 3. Therefore, from equations 2 and 4 we have the following solution for the condition x=0: $t'=\beta t$. The solutions for equations 1 and 3 give the results $x'=-\beta vt=-vt'$, from which we conclude that $t'=\beta t$. A result which is the same as obtained from equation 2 which is the primary result for the condition x=0.

3.3 Results for x'=0 (Specification of an evaluation at the same place in S')

To consider the role of evaluation in space, we determine the simultaneous solution of the four equations when we specify the condition that x'=0. The results are obtained as follows:

(5) $x'=\beta(x-vt)=0$, Hence $x=vt$

(6) $t'=\beta(t-vx/c^2)=\beta t(1-v^2/c^2)=\beta^{-1}t$

(7) $x=\beta(x'+vt')=\beta vt'$

(8) $t=\beta(t'+vx'/c^2)=\beta t'$.

Notice that equation 6 is the inverse of equation 8, so they are the same solution. Equation 6 is solved by substitution with the result from equation 5. Therefore, from equations 6 and 8 we have the following solution for the condition x'=0: $t=\beta t'$. The solutions for equations 5 and 7 give the results $x=vt=\beta vt'$, from which we conclude that $t=\beta t'$. A result which is the same as obtained from equation 8 which is the primary result for the condition x'=0.

3.4 Results for t=0 (Specification of an evaluation at the same time in S)

To complete the analysis of evaluation, we now consider the role of evaluation in time. We determine the simultaneous solution of the four equations when we specify the condition that t=0. The results are as follows:

(9) $x'=\beta(x-vt)=\beta x$

(10) $t'=\beta(t-vx/c^2)= -\beta vx/c^2$

(11) $x=\beta(x'+vt')=\beta x'(1-v^{2/}c^2)=\beta^{-1}x'$

(12) $t=\beta(t'+vx'/c^2)=0$, therefore $t'=-vx'/c^{2.}$

Notice that equation 11 is the inverse of equation 9, so they are the same solution. Equation 11 is solved by substitution with the result from equation 12. From equations 9 and 11, we have the following solution for the condition that t=0: $x'=\beta x$. The solutions for equations 10 and 12 give the results $t'=-\beta vx/c^2=-vx'/c^2$ from which we conclude that $x'=\beta x$. A result which is the same as obtained from equation 9 which is the primary result for the condition t=0.

3.5 Results for t'=0 (Specification of an evaluation at the same time in S')

To consider the role of evaluation with the opposite condition, we determine the simultaneous solution of the four equations when we specify the condition that t'=0. The results are as follows:

(13) $x'=\beta(x-vt)=\beta x(1-v^{2/}c^2)=\beta^{-1}x$

(14) $t'=\beta(t-vx/c^2)=0$, therefore $t= vx/c^2$.

(15) $x=\beta(x'+vt')=\beta x'$

(16) $t=\beta(t'+vx'/c^2)= \beta vx'/c^2$.

Notice that equation 13 is the inverse of equation 15, so they are the same solution. Equation 13 is solved by substitution with the result from equation 14. From equations 13 and 15 we have the following solution for the condition that t'=0: $x=\beta x'$. The solutions for equations 14 and 16 give the results $t=\beta vx'/c^2=vx/c^2$ from which we conclude that $x=\beta x'$. A result which is the same as obtained from equation 15 which is the primary result for the condition t'=0.

3.6 The Equations Define The Measurement Scale Change Laws

The most obvious and clearly fruitful interpretation is that the equations resulting from the process of evaluation give the basis and coordinate transformation laws between the reference frames S and S'. This interpretation is different from the traditional interpretation given to the evaluation equations in Einstein's theory, where the solutions are interpreted as real changes in the physical state of space and time between reference frames. This interpretation follows from the assumption in special relativity that the measurement units are the same in frames S and S'. The new interpretation views the transformation equations as measurement basis and coordinate scale changes between reference frames. Hence, the transformation of the units of time measurement, the time scale, for time in S into the units of time measure in S' is given by equation 2. The transformation from S' into S is given by the inverse of equation 2 as in equation 4. These are bijective transformations that are one-to-one and onto between the reference frames. Since the transformations of Einstein relativity are not bijective, paradoxes, inconsistencies, and contradictions are eliminated.

The transformation of the units of the length measurement scale for distance in S into the distance scale in S' is given by equation 9. The transformation of the units of the length measurement scale for distance from S' into S is given by the inverse of equation 9 as in equation 11. These are bijective transformations that are one-to-one and onto between the reference frames. Notice that this interpretation is nicely confirmed by the equations for the motion of the origin of S as viewed from S', equations 1 and 3. Similarly, the synchronization lag equations 10 and 12 are consistent with the scale change interpretation.

3.7 The Scale Change Laws Transform Velocity Invariantly

This section proves the surprising result that application of the measurement scale change interpretation leads to the conclusion that velocity is transformed invariantly between reference frames S and S'. This new approach requires some preparation. Consider the result of the scale change laws. In frame S we measure time and space in terms of units of time and distance measure so that the law x=ct applies. This means that distance and time measurement scales are defined in terms of the light velocity c.

Consider the result of the scale change laws. Equation 9 defines the distance scale in S' in terms of distance measure in S as $x'=\beta x$, and equation 2 defines time in S' in terms of time in S as $t'=\beta t$. The light velocity law transforms as $\beta x=c\beta t$, which is the same as the law in frame S after dividing both sides by the factor β. Hence the Lorentz transformations leave the coordinate measure of light velocity invariant. This is not the same as in Einstein's relativity. In Einstein's relativity, the distances x=ct and x'=ct' are equal; i.e. x=x', because the time and distance measurement scales in S and S' are the same.

3.8 The Scale Change Laws Preserve The Galilean Transformations

Here the fact that the Galilean transformations are preserved by the Lorentz transformations is proved. The proof relies upon converting the Lorentz transforms and the evaluation solutions to differential form. This is easily performed by replacing x with dx, x' with dx', t with dt, and t' with dt'. The Lorentz transform becomes: $dx'=\beta(dx-vdt)$. A velocity defined relative to the frame S' is defined as: $U_x'=dx'/dt'$. Here U_x' means the component of velocity defined in S' which is parallel to the direction of the x' axis of the S' reference frame. A velocity defined relative to the frame S is defined as $U_x=dx/dt$, where this is the velocity component parallel to the x axis of S. Here the velocity addition law is proved by showing that a velocity U_x' defined in S' is given by: $U_x=U_x'+v$, where v is the velocity of the origin of S' relative to S.

The proof is as follows. Given $dx'=\beta(dx-vdt)$, substitute $dx'=U_x'dt'$, and obtain, $U_x'dt'=U_x'\beta dt=\beta(dx-vdt)$. Divide both sides by β : $U_x'dt=dx-vdt$. Rearrange to obtain the result that: $(U_x'+v)dt=dx$, which upon dividing by dt gives: $U_x=U_x'+v$. Hence the velocity addition law holds. The opposite result, the subtraction law, is obtained as follows. Here we are given a velocity defined relative to frame S as U_x. We require the velocity relative to S'; i.e. $U_x'=U_x-v$.

The proof is as follows. Given $dx'=\beta(dx-vdt)$, substitute $dx=U_xdt$ to obtain: $dx'=\beta(U_xdt-vdt)=(U_x-v)\beta dt$. Substitute $dt'=\beta dt$ and divide by dt' to obtain the following: $dx'/dt'=U_x-v=U_x'$, which is the required transformation law. Hence we see that the velocity subtraction part of the Galilean transformation law is preserved.

The significance of this result is that in Einstein relativity, the velocity addition law does not hold in the same form in frames S and S'. But here in this new theory, it is clear that the velocity addition law is the same as the Galilean transform. So the laws of mechanics retain the same form in the new theory but not in Einstein's theory.

4.0 Conclusion

This last point explains the contradiction pointed out in the introduction. In Einstein's version of relativity, the principle of relativity does not apply to the law of velocity addition because he assumed that the units of length and time measure are the same for all relatively moving reference frames. The velocity addition law which he gives is therefore only valid for the special case when the units of measure are the same for frames S and S'. But Einstein's theory has the undesirable side effect that there arise paradoxes and contradictions. In the theory given here, the Galilean transformation law retains its form in accordance with the principle of relativity which Einstein's theory violates. Additionally, in this theory there are no paradoxes and contradictions, as in Einstein's theory. They are avoided because of the different interpretation of the symbols used in the Lorentz transformation equations. This interpretation preserves the form of the Galilean transformation law, but like the light constancy law there is a different interpretation. In the theory given here, the units of measure are not the same in frame S' as in frame S and because of this, there is no contradiction with Einstein's conclusion that c is a limiting velocity.