Space is discrete for mass and continuous for light

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Abstract

Space is discrete for a moving mass and continuous for an electromagnetic wave. We introduce velocity addition rules for such motion, and from these we derive the second postulate of special relativity — namely, that each observer measures the same value of the speed of light. We contrast the distance-time implications of our velocity addition rules with the Lorentz transformations. Our theory leads to different time measurements by observers and to special relativity's momentum-energy formulas. However, in our theory, length of an object remains invariant. Our equations also serve as a counter-example to the statement that special relativity's two postulates necessarily lead to the Lorentz transformations.

KEY WORDS: Special relativity, Lorentz invariance, speed of light, length contraction.
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1 INTRODUCTION

In the last few years alternatives to special relativity [1] (hereafter "relativity") have begun to be seriously considered and many experiments to test for possible violations of relativity are being performed. Many theories suggest a need to abandon continuous motion, considering it to be incompatible with quantum theory. Theories such as "doubly special relativity" [2], which require Lorentz-Fitzgerald contraction to not happen at short scales, are currently drawing attention. Some other recent theories, particularly in the field of quantum gravity, are also incompatible with the Lorentz transformations [3, 4].

Our removing continuity of space for motion of mass allows us to unite the two postulates of relativity with the discrete nature of quantum theory. Various experimental tests confirming the postulates thus also support our theory.

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Our simple velocity-addition and distance-time rules clearly establish that the Lorentz transformations are not necessarily the only equations that follow from the postulates. Thus widely accepted derivations, a cornerstone of relativity, showing that the two postulates necessarily lead to the Lorentz transformations, cannot be correct.

In relativity, as in our theory, the speed of light effectively acts as an infinite velocity. However, unlike relativity, in the mathematics of our theory an actual infinity corresponds to the speed of light.

2 MOTION AND VELOCITY ADDITION RULES

2.1 Motion of mass and light

Mass moves through space discretely, "jumping" from one point to another without passing through the points in between. For mass travelling at constant velocity the "length jumped" is constant. The higher the velocity the smaller this jump length. In a unit time a mass particle with constant velocity would have made N jumps (N need not, of course, be a whole number). Each jump length is Ld where L is a length that is a constant for space and d is a function of N, given by $d(N) = \frac{1}{\sqrt{1 + \frac{N^2L^2}{c^2}}}$, where c is the speed of light in matching units of distance and time. We can think of d as a function that causes "shrinkage" of the jump length.

The distance the particle travels in unit time will be $v = NLd$ (the magnitude of its displacement per time to be precise, given the nature of the movement). As the velocity of the particle increases, we have $N \to \infty$, which gives $d \to 0$ and $v \to c$.

We propose that L is the Planck length, $L_p = \sqrt{\frac{\hbar G}{c^3}}$, where $\hbar$ is the reduced Planck's constant and G is the gravitational constant. In relativity Planck length is subject to Lorentz-Fitzgerald contraction. Many theorists have expressed a desire, citing different reasons, that such a fundamental constant be observer-independent, as it is in our theory. For convenience, let us choose units that give $L = 1$, thus $v = Nd$. Just as L becomes the longest length that any mass jumps, we also propose that there exists a constant representing the smallest number of jumps per unit of time, N being an integer multiple of this constant.

In a unit time a point mass particle moving at constant velocity will physically only be at a finite number of points and will travel a total distance of Nd; in this time light will travel continuously over all points in its path, thus having $N = \infty$ and $d = 0$. Mathematically, while we can take the limit of the product of two functions with individual limits of ∞ and

0, the actual product of ∞ and 0 is deemed to be indeterminate. However, for motion in space this indeterminate is fixed and we have $\infty \cdot 0 = c$. All continuous motion in space is at this speed.

2.2 Velocity addition rules

Given a velocity with magnitude v we can compute the jumps per unit time, N, using $N = \dfrac{v}{\sqrt{1 - \frac{v^2}{c^2}}}$ (it would be $NL = \dfrac{v}{\sqrt{1 - \frac{v^2}{c^2}}}$ if we did not assume $L = 1$ and used $v = NLd$).

As in relativity, we consider two observers, You and Other. We consider You to be at rest in a coordinate frame S and observing a moving object. We consider Other to be at rest in frame S', with parallel axes, which is moving with a velocity of v in the $+x$ direction relative to frame S and observing the same moving object. Given the velocity of an object as observed by You, we calculate the velocity as observed by Other.

Let us first consider motion in one dimension. Suppose You see an object moving in the $+x$ direction with some velocity u. How will Other see this object to be travelling? From u and v we calculate N_u and N_v respectively. Adding we get $N'_u = N_u - N_v$. From this we can calculate d'_u and then get the velocity as observed by Other to be $u' = N'_u d'_u$.

Again considering one dimensional motion, You see light moving in the $+x$ direction with $u = c$. For light we get $N_u = \infty$; from Other's v we get a finite value N_v. Adding we get $N'_u = N_u - N_v = \infty$. Then we calculate $d'_u = 0$ and get the velocity seen by Other to be $u' = N'_u d'_u = c$.

We note that, given N, the corresponding velocity magnitude v is the value of the function $f(N) = N \cdot d(N) = \dfrac{N}{\sqrt{1 + \frac{N^2}{c^2}}}$. You see an object to be moving with velocity u and component velocities u_x, u_y, u_z, with u_x in the $+x$ direction. From u_x we calculate N_x and from Other's velocity v we calculate N_v. We have $N'_x = N_x - N_v$. The following equations give the values of u'_x, u'_y, u'_z, the component velocities as observed by Other.

$$u'_x = f(N'_x)$$

$$u'_y = u_y \sqrt{\frac{c^2 - {u'_x}^2}{c^2 - {u_x}^2}}$$

$$u'_z = u_z \sqrt{\frac{c^2 - {u'_x}^2}{c^2 - {u_x}^2}}$$

There is no purely mathematical reason, based on any previous statements of our theory of velocity, that leads us to arrive exclusively at these formulas for u'_y and u'_z. Keeping close to Newtonian (we take this term to also include Galilean) physics, from u we can calculate N and then get $N' = \sqrt{{N'_x}^2 + N^2 - {N_x}^2}$ from which we could have proposed $u'_y = u_y\sqrt{\dfrac{(f(N'))^2 - {u'_x}^2}{(f(N))^2 - {u_x}^2}}$ and $u'_z = u_z\sqrt{\dfrac{(f(N'))^2 - {u'_x}^2}{(f(N))^2 - {u_x}^2}}$. However, for physical reasons we choose the other formulas.

3 COMPARISON WITH EQUATIONS OF SPECIAL RELATIVITY

We consider the same observers, You and Other, as in the previous section, except that we add the following conditions: at $t' = t = 0$ the origins of S and S' coincide and a moving particle is at this common origin with its u_x in the $+x$ direction. You observe the particle and measure positions x, y, z, and time t whereas Other measures x', y', z', and time t'. Relativity obtains the Lorentz transformations:

$$x' = \frac{x - vt}{\sqrt{1 - \dfrac{v^2}{c^2}}}$$

$$y' = y$$

$$z' = z$$

$$t' = \frac{t - \dfrac{vx}{c^2}}{\sqrt{1 - \dfrac{v^2}{c^2}}}$$

From the Lorentz transformations we get the following *relativistic velocity transformations* (we will use this term to distinguish these formulas from our "velocity addition rules" stated previously) expressing the velocity components of the particle as observed by Other in terms of those observed by You.

$$u'_x = \frac{u_x - v}{1 - \dfrac{vu_x}{c^2}}$$

$$u'_y = \frac{u_y\sqrt{1 - \dfrac{v^2}{c^2}}}{1 - \dfrac{vu_x}{c^2}}$$

$$u'_z = \frac{u_z\sqrt{1-\dfrac{v^2}{c^2}}}{1-\dfrac{vu_x}{c^2}}$$

We consider the setup commonly referred to as a "light clock" to look at relativistic time dilation. We have a photon as seen by You to be moving along the y-axis ($x = 0, z = 0$) and oscillating between two parallel mirrors from $y = 0$ to $y = Y$ and back to $y = 0$ with $u_x = 0$, $u_y = \pm c$, $u_z = 0$. From the relativistic velocity transformations, Other will see $u'_x = -v$, $u'_y = \pm c\sqrt{1-\frac{v^2}{c^2}}$, $u'_z = 0$. Consider the time for the event of half an oscillation (from $y = 0$ to $y = Y$). From the Lorentz time dilation equation, Other sees this event to take a longer time by the factor of $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$, and for this event this time dilation also follows from the smaller y-velocity measured by Other (as indeed it must since the relativistic velocity transformations are derived from the Lorentz transformations).

Let us examine the light clock using our velocity addition rules. We have $N_x = 0$, $N'_x = N_x - N_v = -N_v$ which gives $u'_x = -v$, $u'_y = \pm c\sqrt{1-\frac{v^2}{c^2}}$, $u'_z = 0$. In this important case our velocity formulas give the same result as relativity. But in general, our velocity addition rules give results which are different from those of the relativistic velocity transformations and experimental measurements should be able to decide the matter in our favor.

4 DISTANCE-TIME RULES AND THEIR PHYSICAL INTERPRETATION

4.1 Distance-time rules

For observations made by You we have $x = u_x t$, $y = u_y t$, $z = u_z t$. Obtaining velocities by our velocity addition rules and assuming the same initial conditions as in the Lorentz transformations, we calculate distance as measured by Other:
$x' = u'_x t'$
$y' = u'_y t'$
$z' = u'_z t'$

Since in our equations we are observing a moving particle which we take to be at the coinciding origins at $t = t' = 0$, x and x' *represent distances travelled*. If we were observing a rigid object, we would be considering a point on the rigid object as our particle. Whichever point on the rigid object is being observed, You would see each point on the rigid object have the same x and Other would see each point have the same x'. When we talk of x, x', t, t' etc. we are referring to *distances travelled* as measured by the two observers and time for such travel. Thus, in our velocity-centric theory, these distance-time relations are *not* transformations from one set of coordinates to another. If we had a rigid object of a certain shape and size with a certain velocity u as seen by You (and, of course, each point on the object would have this velocity), Other would see the same rigid object with *exactly the same shape and size* but with a different velocity u' as given by the velocity addition rules. Also, in our theory, we do not talk about how observers measure time in general — we can only talk about how they measure time for a specified event. Any observed ratio between t' and t would only be ratio of the times it takes the object to travel the observed distances.

In Newtonian physics we have $u'_x = u_x - v$, $u'_y = u_y$, $u'_z = u_z$ and for $x' = x - vt$ and $y' = y$, $z' = z$ we have $t' = t$. Consider a theory with different formulas for u'_x, u'_y, u'_z. From the formulas for u'_x, u'_y, u'_z, using $x' = x - vt$ or $y' = y$, $z' = z$ we can get a relation between t' and t for that particular motion.

We consider $v < c$. Computing a time relation from $x' = x - vt = (u_x - v)t$ we get $t' = \dfrac{t(u_x - v)}{u'_x}$.
u_x and v are velocities measured by You. This $(u_x - v)$ term denoting simple "linear" addition appears in both Newtonian physics and relativity. In relativity $(u_x - v)$ is not the speed of the object as seen by either observer but is still a linear velocity addition. In our theory velocity addition is not linear. We have $u_x = N_x d_x$ and $v = N_v d_v$. When we add velocities it is not distance per time but number of jumps per time that we add — in such addition no weight is given to the length of the jumps. Then we multiply these resultant jumps per time by the observed jump length (as observed by You, each jump of the object is of length d_x and each jump of Other is of length d_v). Noting that we are comparing with u'_x, the velocity of the object as observed by Other, we choose the appropriate addition and jump length.
$t' = \dfrac{t(u_x - v)}{u'_x}$ is replaced in our theory by $t' = \dfrac{t(N_x - N_v)d_x}{u'_x}$. Putting in $u'_x = N'_x d'_x = (N_x - N_v)d'_x$ (and also allowing cancellation for the cases $N_x - N_v = 0, \infty$) we get $\dfrac{t'}{t} = \dfrac{d_x}{d'_x}$ (for the case $d'_x = d_x = 0$, take $t' = t$). Thus the different jump lengths of the object as seen by the observers is responsible for different time measurements.

Computing a time relation from $y' = y$, $z' = z$ we get $t' = \dfrac{t(u_y)}{u'_y} = \dfrac{t(u_z)}{u'_z} = t\sqrt{\dfrac{c^2 - {u_x}^2}{c^2 - {u'_x}^2}}$.
Noting that for a velocity v the jump length is $\sqrt{1 - \frac{v^2}{c^2}}$, we have $\dfrac{t'}{t} = \dfrac{d_x}{d'_x}$. Thus both cases lead to one single time relation, and we have the below set of distance-time rules:

$$t' = (\frac{d_x}{d'_x})t$$

$$x' = t(N_x - N_v)d_x$$

$y' = y$

$z' = z$

In our theory, as in relativity, two events may be simultaneous as seen by one observer but not by the other. However for the case of $u_x = c$ we will have $t' = t$ and relativity's thought experiments centered around this case will fail to create the non-simultaneity predicted by relativity. The case $u_x = c$ is special because of the ∞ that relates to c. It should be possible to set up a clock based on $u_x = c$ to experimentally confirm that $t' = t$.

4.2 Time

While doing away with the concept of "absolute time," relativity presented a new thesis of "relative time flow" between inertial frames. We do not take the absolute time of Newtonian physics to have meant that time itself "flows" as an independent physical quantity — it only meant that the equations worked in such a way that all observers measured the same time for the same event. We could attempt to make a similar statement about observers in different frames and relativity's relative time flow — however, in relativity time is an independent physical quantity and we have actual time dilation.

For simplicity, let us confine ourselves to one dimension. We can consider points in space to be separated by a number of jumps instead of a number of length units. Then whatever statements are made in Newtonian physics about addition of distance per time and the observed time for motion (i.e. object travelling the distance from one point to another) hold in our theory for addition of jumps per time and observed time for jumps. Accordingly, different observers will measure the same time for jumps from one point to another. But when the event is motion they measure different times. Thus if our theory is correct then we cannot talk of the existence of time as an independent physical quantity but can only talk of time for an observed physical event. If $d(N)$ were a constant function, motion would also involve all observers measuring the same time and we would have absolute time as in Newtonian physics.

Experiments such as those confirming time dilation in the case of the "lifetime" of a muon are confirming some process taking a longer time as a result of a velocity involved in the process having a different value by the velocity addition rules. We could similarly talk of one oscillation being the lifetime of the light clock discussed above. Seeking an explanation for the Doppler effect for an electromagnetic wave would suggest that we look at the orthogonal electric and magnetic fields and what is "waving" to which our velocity addition rules would apply. The current wave-model should be changed so as to assign an orthogonal velocity related to this "waving" upon which we can apply the velocity addition rules and get a changed orthogonal velocity and thus a changed frequency. The issue is what empty space is and what the wave nature of light is.

5 MOMENTUM

In Newtonian velocity addition we add the velocities v. In our velocity addition rules it is the jumps per time N on which we perform the addition and which takes the place of v. Similarly, momentum of an object is mN and, for any observer watching a collision, we have conservation of momentum. Since $N = \frac{v}{\sqrt{1-\frac{v^2}{c^2}}}$ this converts to the formula given by relativity. However, there is no possibility of interpreting this formula to suggest that mass is actually changing with velocity.

From momentum we can go on to force and energy.

6 TRANSFORMATIONS DERIVED FROM THE TWO POSTULATES OF SPECIAL RELATIVITY

It is widely accepted that from the two postulates of relativity the Lorentz transformations follow, and that relativity shows how they do. But our velocity addition rules and associated distance-time rules, which are also consistent with the two postulates, are a counter-example to the statement that the two postulates necessarily lead to the Lorentz transformations.

Various derivations of the Lorentz transformations have been published, and this link between the postulates and the transformations is a foundation of relativity. Reputable physics textbooks derive the Lorentz transformations, in a claimed mathematically rigorous manner, from the two postulates (assuming homogeneity and isotropy of space). Numerous papers that review or discuss relativity similarly accept that the Lorentz transformations can be derived from the postulates; popular books and articles on the subject repeat this claim. Attempts to unite the postulates with quantum theory have been greatly hampered by this constraint that the postulates necessarily imply the Lorentz transformations. Theories such as doubly special relativity [2], which seek to modify relativity, accept that to change the transformations the postulates need to be modified in some way. The Standard Model Extension (SME) [5], that has been the subject of many recent experiments seeking to test the Lorentz transformations, also assumes that confirming the two postulates is equivalent to confirming the Lorentz transformations. SME-based and other highly sensitive experiments have failed to find any violation of the postulates [3, 4].

Einstein had expressed an intuitive feeling that physics may need to abandon "continuous structures" (though not in the way presented here) and this would cause problems for relativity. In an overly self-deprecating manner he wrote to his friend M. Besso in a 1954 letter: "I consider it quite possible that physics cannot be based on the field concept, i.e. on continuous structures. In that case, nothing remains of my entire castle in the air, gravitation theory included" [6]. We note, however, that removing continuity of motion for mass is not necessary to formulate our set of equations. We could have removed our statement about all continuous motion being at c and then proposed that mass also moves continuously; from v we could calculate N and we would still have these same equations.

Relativity does not have a theory of velocity different from Newtonian, only different formulas for u'_x, u'_y, u'_z.

Let us accept our theory's physical interpretation of distance-time rules and apply its method to construct distance-time formulas from the relativistic velocity transformations. In relativity if we look for a relation between t' and t using $x' = x - vt$ we get a different relation than we would get using $y' = y$, $z' = z$.

Using the relativistic velocity transformations, computing time from the relation $x' = x - vt$, and applying our distance-time rules we get the below *alternative transformations*. (Using $y' = y$, $z' = z$ to obtain a time relation would give us the Lorentz transformations).

$$t' = \frac{t(u_x - v)}{u'_x} = t - \frac{vx}{c^2}$$

$$x' = u'_x t' = x - vt$$

$$y' = u'_y t' = y\sqrt{1 - \tfrac{v^2}{c^2}}$$

$$z' = u'_z t' = z\sqrt{1 - \tfrac{v^2}{c^2}}$$

We emphasize again that, unlike relativity, we do not interpret these to be transformations between coordinates. The quantities represent distance travelled as measured by the observers and time for this travel.

But our physical interpretation, which works with our distance-time rules, will not go far here because length expansion/contraction between coordinates are needed. The problem arises that, in the given time, y' and z' fall short of the requisite distance by the $\sqrt{1 - \frac{v^2}{c^2}}$ factor. To make up for this we will need a "length expansion" along these axes and this would have to be a transformation between coordinates.

Between the Lorentz transformations and these alternative transformations there is no purely mathematical reason to prefer one over the other, the choice was made for physical reasons. If we use the relation between t' and t as given by the Lorentz transformations, the x' length becomes excessive and we need to contract the length.

7 EXPERIMENTAL TESTS

Our theory, though yielding equations different from the Lorentz transformations, is consistent with relativity's two postulates and its momentum-energy formulas. Numerous experiments have tested and confirmed these postulates and momentum-energy equations.

No experiments aimed at directly testing the relativistic velocity transformations, which lead to the Lorentz transformations, have been performed; in general our velocity addition rules give different results. However, for the case of motion of light (1) along the direction of relative motion between two frames and (2) perpendicular to that direction (as seen by one of the frames) relativity's formulas gives the same results as our velocity addition rules, one of these cases having been demonstrated by the light clock example. These two cases were the basis of the Michelson-Morley experiment.

Relativity's prediction of different time measurement by observers has been experimentally confirmed and in certain cases (such as the light clock) our theory gives the same factor relating time measurements as relativity. But the theories differ fundamentally on the nature of time and we have mentioned how to use time measurements to experimentally test between the theories.

Invariance of length of rigid bodies is a key feature differentiating our theory from the Lorentz transformations. No test of Lorentz-Fitzgerald contraction has been performed; experiments can show that it does not happen.

We note that our theory has broad implications.

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