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. Using this differentiation and by bringing in infinity, we provide a simple explanation for the constancy of the speed of light. We introduce velocity addition and distance-time equations that are consistent with both postulates of special relativity. Thus, widely accepted derivations, showing that the two postulates necessarily lead to the Lorentz transformations, cannot be correct. 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, and we do not have a time dilation formula that applies between inertial frames. In our theory clock mechanism would play a role; thus, while many clocks would match the special relativity formula, not all clocks will give that exact same time shift. We note that quasars and gamma-ray bursts, which are not showing the needed exact time dilation of special relativity, might be examples of such clock mechanisms. We suggest other Lorentz violation time dilation experiments where special relativity and our theory give different predictions. In particular, we suggest an experiment using atomic clocks and sophisticated quartz clocks – OCXO – together in a high speed vehicle; such space vehicle launches are numerous nowadays. We predict these two clocks will go out of sync, thus providing a controlled and easily replicable violation of special relativity's time dilation.

Keywords: Lorentz violation; Time dilation; Special relativity; Speed of light; Philosophy of time; Actual infinity.

1 Introduction

In recent 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. Theories such as loop quantum gravity [2] suggest a need to abandon continuous space. Other theories that modify relativity include "doubly special relativity" [3], which requires Lorentz-Fitzgerald contraction to not happen at short scales; another model puts restrictions on energy and momentum [4], and variable speed of light theories [5] have gained interest. Some other theories that have gained attention have also been incompatible with the Lorentz transformations [6, 7, 8].

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, and we do this while keeping the postulates exactly as they are. Numerous experimental tests confirming the postulates thus also support our theory.

A popular article explains that Lorentz violation experiments are about "investigating the possibility that relativity's postulates provide only an approximation of nature's workings"[9]. However, we open a new door by showing that a violation of the time dilation equation of the Lorentz transformations would actually not be inconsistent with the postulates. The other theories that seek to modify the Lorentz transformations accept the claim that to change these transformations the postulates need to be modified in some way. In section 8

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we discuss experimental results and propose further experiments. Recent experimental observations of time dilation in quasars and gamma-ray bursts [22, 23] are not perfectly confirming the Lorentz transformations; on the other hand, the results from precision tests of the postulates of relativity show them to continue to pass all of these. Such contradictory experimental results would suggest examining the foundational theoretical conclusion that the postulates necessarily imply the Lorentz transformations. In particular, the time dilation Lorentz violation should be vigorously investigated, experimentally and theoretically.

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.

We believe that the derivation of the Lorentz transformations was based on certain unstated assumptions about the nature of time and velocity, abandoning which allows us to get a new set of equations consistent with both postulates. 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. We introduce velocity addition rules and from these, using the infinity associated with light, we derive the constancy of the speed of light; thus we do not need to postulate this constancy. Our equations lead to different time measurements by observers but they have no time dilation or length contraction formulas that apply between inertial frames. Section 2 has our velocity addition rules and section 5 has the distance-time rules which are derived from the velocity addition rules.

In section 8 we propose an experiment using atomic clocks and sophisticated quartz clocks – OCXO – together in a high speed vehicle; such an experiment can be easily done with today's technology.

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 greater the number of jumps and the smaller the 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 $d(N) = \dfrac{1}{\sqrt{1 + \dfrac{N^2L^2}{c^2}}}$, 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 $v \to c$.

L could perhaps be the Planck length, $L_p = \sqrt{\dfrac{\hbar G}{c^3}}$, where $\hbar$ is the reduced Planck's constant and G is the gravitational constant. In relativity Planck length is subject to Lorentz-Fitzgerald contraction. Various 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.

Unlike the discrete motion of mass, the motion of light through space is continuous. 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 $N'_x = N_x - N_v$ and from N'_x we can calculate d'_x .

The following equations give the values of the component velocities as observed by Other in terms of those observed by You:

$$u'_x = (N_x - N_v)d'_x = \frac{N_x - N_v}{\sqrt{1 + \dfrac{(N_x - N_v)^2}{c^2}}}$$

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

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

(Note that when $N_x = \infty$ we have $\infty \cdot 0 = \frac{\infty}{\infty} = c$; for $u_x = c$ we will have $u'_x = c$ and all y and z velocities will be 0)

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. A key reason is seen in section 5.1, where we derive a relation between time measured by the two observers. We can do this using x direction or y and z directions. The chosen u'_y and u'_z formulas give the same time relation which we get using u'_x.

3 Cantor's actual infinity has made its first appearance within the natural sciences by providing a mathematical explanation for constancy of the speed of light

We refer to the motion and velocity addition rules in section 2 above. Georg Cantor fought the authorities and dogmas of his time and brought actual infinity into mathematics. (Potential infinity or infinity as a limit was previously accepted, but not the concept of an actual infinite). Cantor biographer Joseph Dauben explains the Aristotelian challenges to infinity faced by Cantor:

> "As the inspiration for centuries' worth of opposition to the actual infinite, Aristotle required explicit confrontation ... A typical argument used by Aristotle and by the scholastics involved the 'annihilation of number.' Were the infinite admitted, it was said that finite numbers would be swallowed up by any infinite number or magnitude. For example ... their sum $a + b$ ... if b were infinite, no matter what finite value a might assume, $a + \infty = \infty$ ... It was in this sense that any infinite number was thought to 'annihilate' any finite number." [11]

Was Aristotle wrong in claiming such annihilation would be caused by actual infinity? No. His annihilation argument is perfectly valid. Aristotle particularly pointed to such annihilation as being physically "absurd." But such annihilation by infinity actually forms our explanation for the constancy of the speed of light. We explain above the addition of infinite number of jumps associated with light and finite number of jumps that the observer makes. When You are observing light we have $\infty \pm$ 'finite value' $= \infty$. No matter what the finite value, the infinite annihilates the finite number. The speed of light annihilates the speed of the observer in that the speed of the observer does not matter when looking at light. This basic annihilation property of actual infinity, understood since ancient times, provides the long-missing explanation for the constancy of the speed of light.

$\infty \cdot 0 = c$ is also an equation involving actual infinity, with the continuous motion of light having number of jumps per time $N = \infty$, with jump length $d = 0$.

It would be expected that physics would be the first natural science where Cantor's actual infinity appears.

4 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 conceptual 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.

5 Distance-time rules and their physical interpretation

5.1 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 that result in any contraction or dilation. 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 and we do not have a time formula that applies between two inertial frames. 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 canceling in the cases $N_x - N_v = 0, \infty$) we get $\dfrac{t'}{t} = \dfrac{d_x}{d'_x}$. 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.

We have the below set of distance-time rules:

$$x' = t(N_x - N_v)d_x = t(N_x - N_v)\sqrt{1 - \frac{u_x^2}{c^2}}$$

$$y' = y$$

$$z' = z$$

$$t' = t(\frac{d_x}{d'_x}) = t\sqrt{\frac{c^2 - {u_x}^2}{c^2 - {u'_x}^2}}$$

(Note that when $N_x = \infty$ we have $\infty \cdot 0 = c$; for the time formula, in the case of $\frac{0}{0}$ the 0s cancel)

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.

5.2 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.

Our philosophy of time is in line with that expressed by Leibniz, and by others before him. We believe that change (such as that represented by velocity) is associated with the very existence of time rather than time flowing as an independent physical entity, and that philosophy affected our choice of what we start with: velocity (change) or time. Thus we begin with velocity addition rules and from these get our time equation.

Einstein's philosophy of time takes the "$t' = t$" of Newtonian physics to be a "flow of time" and relativity's time dilation modifies that to state that *motion affects the flow of time.*

For simplicity, let us discuss time by looking at motion in 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 i.e. going beyond counting number of jumps to distance covered by these jumps, they measure different times and the time ratio for such motion depends on the ratio of jump lengths. 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 physical 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.

6 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 m is actually changing with velocity.

From momentum we can go on to force and energy.

7 Transformations derived from the two postulates of special relativity

7.1 Counterexample to the Derivation showing that the Lorentz transformations are the only equations that follow from the postulates

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, stated in sections 2 and 5, respectively, are also consistent with the two postulates, and thus are a counterexample to the statement that the two postulates necessarily lead to the Lorentz transformations.

Our theory is velocity-centric and we start with velocity addition rules and from those derive distance-time rules. Einstein's derivation first obtains distance and time formulas — the Lorentz transformations; from these follow the relativistic velocity transformations [1]. 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. Other theories that seek to modify relativity[2, 3, 4, 5, 6] accept that the postulates necessarily imply the Lorentz transformations. Thus these theories accept that to change the Lorentz transformations the postulates need to be modified in some way, and that experimentally confirming the two postulates is equivalent to confirming the Lorentz transformations. Our theory preserves both postulates exactly as they are but has equations that are different from the Lorentz transformations

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" [12]. Einstein ever doubted that the postulates of relativity were true, but he seems to have realized that removing the foundation of continuity could have consequences. We have shown how we get a different set of equations by preserving both postulates but assuming space to be discrete for motion of mass but continuous for motion of light. 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.

7.2 The relativistic velocity transformations are consistent with two sets of transformations, not just the Lorentz transformations

In examining the foundations of Einstein's derivation of the Lorentz transformations we note that there are two possible sets of transformations that are consistent with the postulates and the relativistic velocity transformations, not just one as assumed by Einstein [1]. This possibility is not generally known or realized, as evidenced by examination of numerous other published versions of the derivation of the Lorentz transformations. This technical point is not a part of our counterexample to the derivation, but goes to the issue of rigor in reaching conclusions.

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 methodology we get the below *alternative transformations*. (Using $y' = y$, $z' = z$ to obtain a time relation would give us the Lorentz transformations).

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

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

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

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

But our physical interpretation, which seeks to avoid transformations between coordinates that result in a dilation or contraction, 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.

Between the Lorentz transformations and these alternative transformations there is no purely mathematical reason to prefer one over the other; the alternative transformations have to be rejected 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.

8 Time dilation experimental tests

8.1 Our theory keeps the postulates exactly as they are, while removing the requirement that all clocks have the exact same time dilation

Our theory, though yielding equations different from the Lorentz transformations, is consistent with relativity's two postulates and its momentum-energy formulas, keeping them exactly as they are. Numerous experiments have tested and confirmed the postulates and momentum-energy equations. Thus these experiments would also be confirmations of our theory. Highly sensitive experiments looking to test new theories which suggest modifications of the postulates have failed to find any violation of the postulates [7, 8, 10, 24, 25].

No experiments aimed at directly testing the relativistic velocity 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 give the same results as our velocity addition rules. These two directions were used in the setup of Michelson-Morley experiment [13].

In special relativity time *itself* dilates. This means that all individual clocks in the same relatively moving frame, no matter what their mechanisms and other properties, would necessarily record the exact same dilation. Again, in our theory time itself does not dilate, and therefore diverse clock mechanisms, as well as differentiating properties between individual clocks with the same mechanism, may cause them to have different time effects. This theoretical path is consistent with the emerging reality of the postulates continuing to test to be perfectly correct but the time dilation equation facing continuing experimental controversies regarding their precision correctness.

As discussed earlier, there is wide acceptance among physicists of Einstein's derivation which showed that the postulates necessarily imply the Lorentz transformations. In line with that, the other theories that seek to modify the Lorentz transformations accept the claim that to change these transformations the postulates need to be modified in some way. Lorentz violation experiments based on theoretical modifications of the special relativity postulates have not shown any of the suggested deviations. Our theoretical breakthrough is in showing that alternative time equations are possible without any modification of the postulates. The theoretical and experimental focus regarding possible modifications of special relativity has mainly been on a violation of the postulates. However, it is the time dilation Lorentz violation that particularly needs to be thoroughly and rigorously examined, both experimentally and theoretically.

It is commonly stated that a single replicable experimental observation that contradicts a physics theory's prediction is enough to prove the theory wrong. We give below experiments to test time dilation further, including a key experiment in section 8.4 based on comparison of flying two commonly available clocks which have diverse mechanisms.

8.2 Light clock, horizontal light clock and traincar-and-platform setup

Relativity's time dilation formula has been experimentally confirmed in certain cases such as atomic clocks, and with increasing accuracy [14]. According to our theory, a full understanding of the mechanism of a particular clock would explain why that moving clock gives the specific time dilation.

In section 4, we examined the light clock where light is moving in a direction perpendicular to the direction of relative motion between source and observer. For the light clock we have $u_x = 0$ and $u_y = c$. We showed there that in the case of the light clock both theories correctly give the same time result.

As noted in section 5.1, in clocks where motion of light is the clock mechanism, for the case of $u_x = c$ our theory predicts that we will have $t' = t$ and thus there will be no time dilation observed whatsoever. A horizontal light clock fits this requirement. In a horizontal light clock the photon bounces between two mirrors in a direction that is parallel to the direction of relative motion between source and observer. Here we have $u_x = c$. In our theory there is no length contraction, and thus the photon will travel the same length as measured by both observers and we will have $t' = t$. A similar situation occurs in the famous traincar-and-platform thought experiment commonly used to illustrate the implications of special relativity. This thought experiment consists of one observer midway inside a speeding traincar and another observer standing on the platform as the train moves past. A flash of light is given off at the center of the traincar just as the two observers pass each other. The observer onboard the train sees the front and back of the traincar at fixed distances from the source of light and as such, according to this observer, the light will reach the front and back of the traincar at the same time (simultaneously). The observer standing on the platform, on the other hand, sees the rear of the traincar moving (catching up) toward the point at which the flash was given off and the front of the traincar moving away from it. As the speed of light is finite and the same for all observers, the light headed for the back of the train will have less distance to cover than the light headed for the front. Thus, special relativity notes, the observer on the platform will see the flashes of light strike the ends of the traincar at different times (and the event of light striking the ends will appear non-simultaneous to this observer). Again, in our theory, different observers can measure different times but not in this specific case. Here the light will be seen by both to strike the ends of the traincar simultaneously because here we again have a case of light moving along the direction of relative motion between source and observer. We have $u_x = c$ and thus we will have $t' = t$.

We believe a replication of such a traincar-and-platform experiment can, using today's technology, actually be implemented in a tabletop form. The tabletop traincar will not have to travel at extraordinarily high speed because the other devices in the experiment can be cameras, and high speed cameras today can take pictures at very high number of frames per second.

8.3 Individual cosmic clocks are not all showing the same time dilation; quasars and GRBs show substantial individual variances

Time dilation in cosmic clocks has had an interesting observational history. A 2010 result [15] showed quasars to be showing no relativistic time dilation whatsoever. A 2012 paper [19] questioned that conclusion. A 2013 result [16] has gamma-ray bursts (GRBs) also not showing time dilation. However, other GRBs results, in 2013 [20] and 2015 [21], found GRBs to be showing time dilation, with the 2013 result showing a high match with the relativity prediction.

A 2022 paper on GRBs shows that there is time dilation but it does not very closely match the relativity prediction. The paper lists individual GRB measurements to highlight the high deviations:

> "Therefore, we concur with [20], that GRBs show evidence for cosmological time dilation only in a statistical sense, but not on a per-GRB basis. . . . Therefore, the values of B are significantly different from that expected from cosmological time dilation ($B = 1$)."

A 2024 study shows quasars having $n = 1.28 \pm 0.29$, which does include the $n = 1$ value predicted by relativity, but is not centered near it.

Type 1A supernovae have historically been giving time dilation results that are far better relativity matches, with a 2024 result giving $n = 1.003 \pm 0.005$.[17]

Again, in relativity time itself dilates and thus all *individual* clocks in the same relatively moving frame, no matter what their mechanisms and other properties, should show the exact same time dilation; time dilation is not a statistical group property. Results from cosmic bodies suggest that comparing pairs of *individual* clocks having diverse properties or mechanisms may be the experimental Achilles' heel that brings down special relativity.

Given such multiple emerging failures of relativistic time dilation some cosmologists who are addressing contradictory time dilation observations in cosmic bodies are discussing the serious need for clear resolution [18]. Many have proposed unlikely scenarios regarding changes to fundamental cosmology as a possible explanation. Why do cosmologists and astrophysicists come up with such novel possibilities rather than suggest the Lorentz transformations being wrong as the explanation for time dilation failures?

Often, testing between two competing theories drives experimentation. Testing for time dilation has not had such a driving force because no theory has previously existed whereby the postulates are maintained and shown to be consistent with a time formula that can give different results for different clocks. Physicists and cosmologists are not aware of any competing theory that predicts such unexpected time dilation failure, while preserving both the postulates of relativity. They wrongly believe that any modification of the Lorentz transformations would need a modification of the postulates; such modification would, of course, be a problem because the postulates continue to pass all precision tests. Astrophysical observations have emerged as a tool to test the predictions of theories that seek to modify relativity [24, 25] and, given our theory, time dilation should now be a key pursuit among these tests.

8.4 Key experiment: Placing an atomic clock and an OCXO quartz clock together in a high speed vehicle to see if they stay in sync

The 1971 Hafele-Keating experiment [26] was a successful test of time dilation of special relativity (and general relativity) and was based on comparing an atomic clock carried in a plane with its twin clock on the ground. Their atomic clocks had an accuracy of about 1 second in 3000 years, and were flown on regular scheduled airliners going at a speed of about 800 km/h.

Our suggestion is to carry out a test using a pair of on-board clocks having diverse mechanisms, and seeing if they stay in sync, as required by special relativity's time dilation, or go out of sync. The major requirement for an on-board clocks time dilation experiment is a high speed vehicle. Today's high speed space vehicles have rockets with far higher speeds than those employed in the Hafele-Keating experiment. Further, high speed space vehicle launches are numerous nowadays.

The atomic clock obeys the special relativity time dilation formula precisely, as numerous experiments show. On Earth, the most common clocks in use today have an oscillating quartz crystal cut in the shape of a tuning fork. Tuning forks produce vibrations with fixed frequencies that depend only on the dimensions and properties of the material. Let us use these quartz tuning fork clocks to examine special relativity's time dilation. Time period, T, formula of the tuning fork clock shows T depending on: (1) dimensions, (2) density and (3) elasticity.

Dimensions of the tuning fork will undergo special relativity's length contraction parallel to the direction of motion. Density depends on volume which would be affected by length contraction in special relativity. But T' must somehow always come to vary to exactly match the time dilation of special relativity. If orientation relative to direction of motion is changed then dimensions and density will be variably affected, which is an additional problem. Elasticity is a property of the material and would not be varying substantially on motion, and certainly not in a specific formulaic way involving velocity that would be a requirement to make the formula conform to the needs of special relativity. How can dimensions, density, and elasticity necessarily change in sync to give the needed T'? We cannot sweep the matter under the rug by saying that the T' formula stops being applicable when the tuning fork is at high speed, because T' must similarly change for low and medium speed too, so as to precisely match special relativity's time dilation equation. We do not see any possible path for the needed relationship between T and T' emerging from the time period formula of this clock. Again, because time itself dilates, all tuning fork clocks, with varying properties, must end up having the same time dilation. And this is not our invented thought clock but is actually the clock that is most common today. Sophisticated quartz clocks − OCXO − now have an accuracy of 1 second in 600 years, with various manufacturers listing their nanoseconds accuracy. Such accuracy is enough to get a time dilation reading, given the high speeds available now. The higher the speed the greater the time effect available for measurement; the larger measurement value means that uncertainty resulting from the limitation of the accuracy of the clock becomes less significant.

With high speed space vehicle travel linking with height, time dilation of general relativity would also be involved, as it was in the Hafele-Keating experiment. However, our experiment is simpler in that one need not make individual measurements for effects of special and general relativity equations on each clock. The aim of our clock pairs experiment is simply to test whether the atomic and quartz clocks pair stay in sync, as required by both special and general relativity. Unlike conflicting cosmic clocks time dilation results which are based on years of observational data, this clock pairs time dilation controlled experiment can be easily replicated at will.

We predict that the quartz OCXO clock will go out of sync with an atomic clock if they were placed together in a high-speed craft. If that happens then this would be one of the most important experiments in the history of science.

We note that our theory has broad implications.

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