On spontaneous changes in the speed of light

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April 2, 2011

Summary

The central claim of this article, from which all other conclusions are derived, is:

"It is impossible by any means, in the physical universe described by Special Relativity, to devise an experiment that can detect any change in the speed of light."

In opposition to this is the self-evident observation that investigators using reliable measuring instruments (with corrections for gravitational fields) will announce that this universal constant of nature has indeed changed…

Introduction

In the description of the universe supplied by Special Relativity, time is another geometrical dimension, interchangeable with 3 others in a 4-dimentional Minkowski geometry. Lorentz transformations based on a value v, the velocity, transform time freely into space, allowing one to

move from one reference frame to another. In these frames geodesic motion is always in straight lines, with an upper limit on velocity given by c. Physicists often replace the measured value of c by a simple "1". This sometimes simplifies calculations and eliminates what is deemed, theoretically, a mere coefficient of proportionality between duration and length.

Imagine, then, what would happen if employees at the Bureau of Standards were to discover that, by their calculations, the speed of light has increased by, say, 1000 miles per second? Right away one asks: what other constants of nature have also changed? In any event, one is looking at a fundamental shift in the relationship of time and space.

But this is contrary to treating time as a spatial dimension! What would someone think who lives in a room of dimensions, say, 50 x 80 feet (A big room), who comes home one night to discover that, by using a standard tape measure, the room is now 50 x 50 feet! This can't possibly be. It is a fundamental assumption that space is completely homogeneous. Without the presence of a warping force, say gravitation, a sphere remains a sphere. But if time is really a spatial dimension, then the shape of a surface in 4-space given by $(ct)^2 - x^2 - y^2 - z^2 = k^2$ also can't change.

If I move my ruler at right angles to its initial position, its length doesn't change. This may, for some, be in conflict with the theory of an expanding universe. Note, significantly, that we claim to be able to see this because of measurements on the red shifts of distant galaxies. Such measurements are not made with rulers but with frequencies of photon emissions, which are the domain of Quantum Theory and not Special Relativity. This will be discussed further on in more detail.

In some sense, of course, the "speed of light" is an arbitrary number and depends upon one's choice of a value for the duration of a second. A speed of 186,000 mps can be changed to 187,000 mps by extending the currently accepted second in the ratio 187/186.

However within the context of Special Relativity, which is a kinematic theory without forces, and only inertial motions and inertial frames are treated, it is the constancy of the speed of light that *determines* the length of the second. Once this has been decided upon it cannot be capriciously changed; if there is a real change it must come from outside the theory.

The initial candidates are the vibrations of the atoms of the elements, most notably the cesium atom, or the motions of pendulums based on the strengths of gravitational fields. It is naturally assumed that all of these will come to an agreement about the length of a unit second;

but what would happen if they didn't? Some juggling would then by necessary among the fundamental constants of nature, particularly those that enter into the two coupling constants, that of gravitation and that of the Coulomb force. Provided they, also, do not decide to change!

What this means is the following: The Special Theory of Relativity implies, not only that the speed of light is constant, but that it can *never* change! Which is absurd. It is a measurable constant of nature and can do what it likes!

Does General Relativity successfully rescue Special Relativity from this absurdity? What it seems to do is to set up an inter-relationship between the speed of light and the gravitational constant, and argue that *this* can never change. Ultimately one constructs the gravitational coupling constant, a pure number given by:

$$\alpha_G = \frac{Gm_e^2}{\hbar c} = \left(\frac{m_e}{m_P}\right)^2 \approx 1.7518 \times 10^{-45}$$

Can this change? Will that cause geodesic domes to warp into ellipsoids? Along which axes? The same axes everywhere? Will protons also be distorted? Or range-free chicken eggs?

Perhaps the error lies right at the beginning, that is to say, treating time as another spatial dimension.

The Principle of Spatial Homogeneity

1. Under the assumption that the objects chosen to serve as rulers abide in the same Euclidean 3-dimensional space as all other objects, it is clear that no spontaneous changes in spatial lengths or proportions can be detected. If all lengths in all directions suddenly double, one's instruments for spatial measurements also double their lengths in all directions. Changes may be in fact be occurring observable in h, γ, and ε, the Coulomb force, but these would not be detectable by a static ruler without moving parts, that is to say, some material object that can be moved about from without, but with no internal motions.

(2) Even if all lengths were to double in only a single direction, one could not detect any change. A turned ruler would expand in that direction as it was turning, and no change would be detectable.

***Principle Of Spatial Homogeneity*: No universal alteration in the relative size or length of any physical objects is detectable by static measuring devices, by which is meant that they, when at rest, have no internal motions.**

If there does exist a privileged class of objects accepted as standard rulers, then one can speak of contractions or expansions of other objects. If for or example, streets spontaneously doubled in length, while the cars

in them were unaffected, then one could take the length of a specific car as a standard unit, and record the increase in street length. If streets were to be taken as the standard, one would conclude that all the cars had contracted in length.

Clocks Versus Rulers

2. The metrization (quantification and measurement) of time is essentially different from that of distance. Durations are measured by clocks, and clocks are *machines*. Being such, they are subject to the same laws of dynamics that govern the motions of particles, waves, masses, radiation. Comparing clock measurements with ruler measurements opens up several possibilities. Systemic or universal changes in velocities or speeds could be detected:

(i) Some of them by all constructible clocks

(ii) Some by certain clocks operating in accordance with one list of physical principles, but not by others

(iii) Or be intrinsically undetectable like homogeneous alterations in length.

(iv) There is yet another possibility: ***different kinds of clocks may register different changes in velocity in the same universal phenomenon*****!**

As I intend to show, this sort of thought experiment is not idle when applied to the most notorious universal speed in nature, that of light.

The Speed of Light

3. At the present time, reliable measurements are showing that the speed of light, c, in the neighborhood of every point of space-time, and in every reference frame, is a universal constant. The speed of light is a physical quantity, neither some arbitrary designation, nor a pure mathematical constant like π. c is observable and measureable. There is no reason whatsoever to assume that it must remain invariant through all time. The theories of Relativity are based on this experimental evidence. One must emphasis that it is ***experimental*** **evidence. Therefore one cannot assert that it** ***must never*** **change!**

To a first approximation, it takes 8 minutes for sunlight to reach the earth. Let's take this as an absolute figure: there is some location near the sun from which it takes exactly 8 minutes for sunlight to reach the earth.

Then the distance to this location from here is L = 480x186,000 miles, where we use this approximation to represent the speed of light. Supposing that the speed of light has increased by 1,000 miles per second, one computes T'= 480x (186,000/187,000), which is about 447 seconds. Thus sunlight will appear to arrive here 33 seconds earlier.

One might also argue for a spontaneous contraction of the distance from the sun to us. However this is in violation of the Homogeneity Principle: there can be no spontaneous contraction of length in one direction, without that contraction affecting all lengths uniformly throughout the universe, including such things as rulers, sextants, astrolabes, parallaxes (with adjustments for gravity) , and all other methods for measuring distances. As we speaking of a *universal* increase in the speed of light, no such contraction can be detected. The reduction in the time it takes light to reach the earth can, under these assumptions, only be due to an increase in the speed of light.

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4. A spontaneous alteration of the speed of light as a constant of nature would implies the existence of an independent, autonomous time dimension. From the assertion in Special Relativity, that one cannot devise any experiment to detect one's own motion, one goes directly to the kindred assertion that it is impossible to devise any experiment to detect a change in the speed of light.

(a) As Relativity has banished "simultaneity", the possibility of a simultaneous spontaneous change in the speed of light in all reference frames is ruled out. But such change would have to be simultaneous in order that the fundamental concept underlying relativity be fulfilled: it is impossible by any means to conduct an experiment to detect one's own velocity.

(b) Within a single frame, there would have to be an *actual moment* in which the speed of light made the leap. This moment cannot be predicted by Special Relativity, thus lies outside the "flat" Minkowski Space-Time of Relativity in the absence of gravitation.

A Celebration of Clocks

5. Measurements of speed depend on both clocks and rulers. The pulsing of clocks depends on the dynamical laws that govern the construction of the time-keeping instruments at one's disposal. These may not be all the same for all instruments.

In the remainder of this paper I will be examining the response of several clocks, each based on a different dependence on universal laws and constants of nature. It will be argued that, depending on the way their readings are interpreted, ***they might indeed yield different numerical values*** **of an increase in the speed of light.**

These clocks are:

(1) The light clock

(2) The photon clock

(3) The inertial clock

(4) An idealized pendulum clock.

(5) The rotation of the earth about the sun.

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1. *The light clock*

Consider two mirrors set apart at a flat distance of, say, 500 miles. A light beam bounces back and forth between these mirrors. A counter

registers 186 complete circuits and uses this as the "standard second" for all other measurements.

Such an instrument, by definition and construction, can never detect a systematic alteration of the speed of light through the universe. By the Principle of Homogeneity, the 500 miles between the two mirrors also cannot change by some universal contraction or expansion. Increases and decreases in the time needed, for example, for the arrival of sunlight will be accompanied by corresponding increases and decreases in the speed of the beam going between the two mirrors; they will therefore be undetectable.

2. The photon clock

Light has the remarkable property of containing two equally dependable clock mechanisms in its composition. The constancy of the speed of light allows one to construct the mirror clock described above. Incorporated in the emission of light there is a second clock defined by the frequencies and wave lengths of the specific photons that go into the composition of the beam. Take as the standard a monochromatic beam of electro-magnetic radiation, composed of photons of the same frequency. One counts the number of cycles of, say, the H-α line of hydrogen, (656.28 nm) that make up a second, then declare this as the official definition of the standard second, at least for the present. (*In another*

article on Ferment Magazine, I argue for the existence of a photon of maximum frequency and minimum wave-length, as the "natural clock" of the universe. If this were found to exist it would be more fundamental even than the speed of light in determining the length of the second. Go to www.fermentmagazine.org/essays/barrier.pdf .)

By comparison with the pulsing of some standard photon, , one could detect a change in the speed of light by observing that an H-α beam will be able to travel a longer distance in this standard second (defined by counting cycles), than it did in the past.

The person using the light clock, who believes that the speed of light can never change, will correspondingly conclude that there has been a systemic loss of energy through the universe, leading to the "false identification" of a second by the observer of the photon clock.

The important point to bring out here is that each clock regulates the other! Through its structural formation as a composite clock system, an intrinsic relativity between its two clocks sets up a comparison between two definitions of time-reckoning, that is to say of time itself, which can allow for special events outside the frame work of relativity to occur. Note that a systematic increase in the frequencies of all wave phenomena in the universe is equivalent to a substantial change in the value of h!

3. The inertial clock

A cylinder of length L encloses a perfect vacuum in which is placed a massive particle that moves back and forth along its length in this chamber, with a speed v, and kinetic energy $E_k = \frac{1}{2}Mv^2$. Its collisions with the walls at the two ends are "perfectly elastic". Ideally it neither loses nor gains energy, not even when one counts the number N of trajectories required to produce the "standard second" s = NL/v.

Assertion (Not quite a Theorem):

Changes in the speed of light cannot be detected by any clock built on inertial principles.

Imagine that an inertial clock, (in an approximation of the real world in which General Relativity is not operative) based on the velocity of a material particle were to record a change in the speed of light .This immediately brings in several problems:

(1) The "light clock" and the "inertial clock" will each give different readings, thereby rendering Special Relativity inconsistent. Special Relativity does not allow these two kinds of clock to be inconsistent. It

follows that a change in the speed of light requires a fundamental alteration of Special Relativity itself.

(2) A new speed of light c′, fundamentally alters the "relativistic addition formula" for compounding velocities. Suppose that we've selected a "standard clock", using a particle that moves with a velocity conventionally set to "1". A change in c will alter the expression

$$v(-)1 = \frac{v-1}{1-\frac{v}{c^2}} \quad \textbf{to} \quad v(-)1 = \frac{v-1}{1-\frac{v}{(kc)^2}}$$

This totally upsets the structure between all velocities in a non-linear fashion.

(3) As v moves towards the new speed of light, measurements at those higher would have to converge to the former value of c, to conform to the reading on the "light clock", which has detected no change.

(4) Getting down to the specifics: consider two inertial clocks, C_1 and C_2. C_1 counts the cycles of a particle moving at a velocity v_0 which is very slow. To an observer remaining in the same reference frame, C_2 counts the cycles of a particle moving at a huge velocity v_1 a fraction less than the speed of light.

If the observer of C_1 records an increase in the speed of light to c′, then the observer of C_2 will have to record a velocity still very close to the old value , c , to be consistent with the light clock.

However, lets' say that the observer of C_2 moves to a reference frame, relative to which C_2 appears to pulse at the velocity v_0. Then his observations *will* record an increase from c to c′. But the Principle of Relativity allows for only one value for the speed of light. This inconsistency spells the overthrow of Special Relativity.

The very structure of Special Relativity rules out the possibility that any change in the speed of light could be detected by clocks built on purely inertial principles. At the same time one must allow for the *possibility* that the speed of light can change, otherwise it becomes a "Platonic quantity", a pure number, and not something that can be measured by real physical instruments. The necessary existence of a time dimension in which a change in the speed of light is a possibility frees time from the grip of geometry!

4. The Pendulum Clock

It is another subtlety of our physical universe that, although the equivalence of gravitational and inertial mass is the cornerstone of General Relativity, the actual measurement of mass only seems possible because of the existence of the gravitational force.

What I mean by that is the following: A scale for weight based on inertia alone would have to rely on collisions to determine mass. Given masses M_1 and M_2 moving towards each other with velocities v_1 and v_2 relative to a fixed observer, the velocities v_1^* and v_2^* after the collision are modified by the ratios of the masses, that is to say their relative rather than their actual values.

However, if one measures the gravitational force between them, one sees that doubling the mass of each leads them a doubling of the acceleration of each relative to their center of gravity. Another way of putting this is to say that the gravitational constant γ allows one to define the unit of mass completely in terms of time and space! This is a significant distinction between inertial and gravitational mass.

In detail: The gravitational constant is given by

$\gamma = 6.67300 \times 10^{-11} m^3 (kg)^{-1} s^{-2}$ **in the cgs system. One can therefore solve for the kilogram to get** $1\ kg = 6.67300 \times 10^{-11} m^3 s^{-2} \gamma^{-1}$ **As γ is a universal constant, one can take it to be "1" (until further notice!).**

Because this is so, one can measure mass (dynamically, by weighing machines, springs, balances, etc.) in terms of motion through space.

All of this is preliminary to our discussion of the pendulum clock.

Let's set up a pendulum clock on the earth's surface, at a place where the local gravity coincides with the earth's gravitational constant. The distance between the point of suspension and the bob of the pendulum is L. If set in motion through an infinitesimal arc, in the absence of friction, it moves back and forth in a cyclic period given by:

$T = \sqrt{\frac{L}{g}}$ **The "standard second" is defined as 1 *sec* =*NT*, where N is some integer that doesn't change as long as the pendulum is accepted as the official time keeper. Or one can incorporate L by extending L to the length NL.**

The constancy of L is guaranteed by the homogeneity of space. Any change in T must therefore be due to a change in g. Since an increase in T will measure an increase in the speed of light (and all speeds measured by clocks which are not linearly dependent on the inverse of g) , a reduction in the value of g may be involved.

Stated differently, a measured change in the speed of light can be interpreted as either (i) A real change (ii) A apparent change due to the reduction in the value of $g = \frac{\gamma M}{r^2}$ **, where M is the mass of the earth, and r is the radius. In the same way that an inertial clock cannot detect a change in c, a pendulum clock *taken as the standard* cannot detect a**

change in g. One must compare its readings to those of an atomic clock to register a change in g, as is done in surveys of the earth's local gravity.

If one assumes that γ will not change, nor r (because of spatial homogeneity) , then one must allow that M has been reduced in the ratio $1/k^2$. In other words, the earth becomes lighter. One can measure the "lightening" of the mass parameter in a gravitational field because the gravitational *acceleration* between two masses goes down. *Collisions cannot be used to detect such a phenomenon*. This is a fundamental difference between "inertial mass" and "gravitational mass", which does not, of course, invalidate the Principle of Equivalence.

If there is such a reduction in mass, then the pendulum period will change to T′=kT. That change will not be noticed by those observers that use this pendulum for time keeping, but it will translate into an increase in the observed speed of light.

The result is less problematic in this case because no velocities are involved. As we all know, velocities have special relations in Special Relativity. Yet difficulties still remain in trying to figure out how the velocities of inertial clocks with no gravitational input will appear when measured by the swinging of the pendulum clock.

5. The Orbital Clock

Using the earth's orbit around the sun (or some fraction thereof) as a clock brings in General Relativity. The celebrated formula of Einstein tells us how much the speed of light slows down in the presence of a gravitational potential:

$$c' = c(1 - \frac{\Phi}{c^2})$$

As I've written it, Φ is the *negative* of the gravitational potential, thus a positive number. c′ is always lower than c. However if Φ is the potential of some *anti-gravity force*, then c′ will be larger than c. If one is speaking of a systemic transformation across the whole universe, so that the speed of light changes everywhere in the same amount, then the presence of Φ must be equivalent to the reduction of the absolute value of the gravitational constant, γ. This reduction would not be felt by the inertial clocks, nor, in theory by the light clock, but there is bound to be some interplay between all the fundamental constants by virtue of the gravitational coupling constant and the fine structure constant relationship. Different clocks could therefore in theory give different readings of changes in the speed of light:

(1) The photon clock will not respond to changes in h but can respond to changes in c.

(2) The light ray clock is incapable of detecting changes in c.

(3) The cylinder clock cannot record such a change directly. Only inconsistencies between various inertial clocks and the light clock, ***forcing one to abandon Special Relativity altogether,*** **may indirectly indicate such a change.**

(4) The pendulum clock will not detect a change in g but might detect a change in c

(5) The orbital clock will not detect a change in γ but this might be detectable by the pendulum clock.

(6) Generally speaking, clocks whose functioning depend upon the value of a constant of nature cannot detect changes in that constant (unless there is a ***non-linear*** **alteration everywhere, and it is no longer a true constant of nature.)**

Conclusions

Even Albert Einstein did not have the authority to let "The Good Lord" know that the speed of light must unalterably fixed for all time. It is clear however, that were such a universal transformation as a change in the value of c to occur, the whole cosmos would be thrown into chaos and confusion, (at least for awhile!) New velocities would come into being, more than the former and less than the latter value. These could

be reached through the addition of former velocities and the increased generosity of a new relativistic addition law. Energies could spontaneously rise or fall, weightlessness emerge in certain new situations, while all of the constants of nature would have to change to preserve "pure number invariants" like the coupling constants (if indeed they are *more* "invariant" than the physical constants!)

Special Relativity would be overthrown, causing panic in the Bureau of Standards, and the world would have to await the birth of a new Einstein.

Given all these possibilities, particularly the manner in which the value of the speed of light is so deeply "embedded" in the composition of the cosmos, it seems most unreasonable that time, as we know it, can really be treated as another spatial dimension, homogeneous with the 3 geometrical dimensions of ordinary space.

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