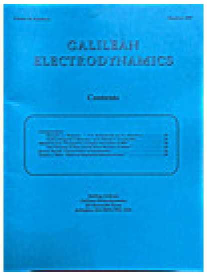

2005 revision of 2001 paper, "The Speed of Time", about the relativity of simultaneity, appearing in the May/June, 2007, issue of [Galilean Electrodynamics] (v.18 n.3), and here by permission of the publisher.

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On the Failure of Simultaneity (2005)

[The Speed of Time]

Kevin J. Parcell
email peoplepower (at) me.com
http://kevinparcell.net

A re-examination of Einstein's argument for the failure of simultaneity identifies the hidden, and false, assumption of [the possibility of] simultaneity for observations from frames in relative motion. Avoiding this error permits a simpler theory of relativity that reveals how both the schism of relativity and quantum theories and the contradictions and paradoxes of flexible space may proceed from the illusion of a common frame. A GPS satellite experiment is proposed to determine which view is correct.

1. Introduction

Inspired by the mystery of how a game of catch was wholly unaffected by the transit of the ship upon which it was played, Galileo proposed that 'rest' is *somehow* conserved with motion so that the two are indistinguishable. Newton left this mystery [of equivalence] unresolved when he proposed his laws of motion. However, these laws established Galileo's enigmatic inertia as the foundation for our scientific investigation of the physical Universe by describing inertial energy, the energy that resists acceleration. Consequently, the puzzle echoes through succeeding theory, most obviously when the remodeling of relativity theory was catalyzed by the perplexing discovery that observers in relative motion must agree on the velocity of light.

Special Relativity Theory (SRT) attempts to reconcile these seemingly conflicting observations by supposing that stationary observers see the rates of moving clocks slowed and moving rulers contracted in the direction of motion in the ratio $1:[1-(v/c)^2]^{-2}$. However, a series of conflicting observations ensues. For example, the supposition of a contraction of space in the same ratio was later appended to this model

because bodies cannot traverse the original distance in a reduced time without increasing velocity; and although subsequent experiments have supported the theory of time-dilation, and hence the implication of reduced distance, contracted frames are not contracted - and so distances are not reduced - if measured with a contracted ruler. Such persistent problems caution us to revisit our basic assumptions.

In Newton's law of conservation of inertia, as in the Galilean principle, the terms *rest* and *uniform motion* have meaning only as perceptions of spatial relationships, implying that inertia and inertial energy are conserved in these relationships. SRT adopts this basic assumption, but rejects absolute space, and instead supposes that bodies are at rest or in motion relative to each other. With this new premise, a comparison of simultaneous observations of the transit of light from frames in relative motion falsifies the assumption of absolute time as well, which is to say the assumption of universal *simultaneity of time.* However, in the discussion that follows, such a comparison is shown to be impossible, as the assumption of *simultaneity of observation* from frames in relative motion is proven to lead to its own falsification. Together with a second experiment, this result is then shown to signify the loss of the underlying common frame both implicit in that assumption and necessary to the conservation of inertia in spatial relationships, and so further leads to a redefinition of the law of the conservation of inertia and a remodeling of relativity theory.

The utility of the Galilean principle suggests that solutions to the mysteries associated with time and motion may accompany an understanding of inertia sufficient to reveal why rest and uniform motion are indistinguishable. This redefinition of the principle of failure of simultaneity will be shown to allow that understanding and deliver that result, but at the cost of the common frame we've curved space to preserve. Thus, to resolve the contradictions and paradoxes of relativity theory, we must not only revisit our basic assumptions, we must also accept some astonishing implications.

2. The Relativity of Simultaneity

To attain this improved understanding of inertia while building upon the successes of existing theory, we first adopt as postulates the two stated principles of SRT: Galileo's enigmatic equivalence of inertial frames, such that the laws of physics apply equally to all coordinate systems; and the constancy of the speed of light detected in empty space, contrarily independent of the relative motion of its source. With this beginning, we may now imagine two identical clocks A and B at rest in the same frame, and also adopt SRT's criterion for determining that they are synchronous or, in other words, for determining simultaneity of time at a distance. Here we understand that "The 'time' of an event is the reading obtained simultaneously from a clock at rest that is located at the place of the event" [1]:

"The [common time] can now be determined by establishing *by definition* that the 'time' required for light to travel from A to B is equal to the 'time' it requires to travel from B to A. For, suppose a ray of light leaves from A for B at 'A-time' t_A, is reflected from B toward A at 'B-time' t_B, and arrives back at A at 'A-time' t'_A. The two clocks are synchronous by definition if

$$t_B - t_A = t'_A - t_B."$$

The principle of the failure of simultaneity - the foundation of the paradigmatic shift of relativity theory - is derived from an imagined experiment that follows these definitions, in which the rest system of two identical clocks is set in uniform motion at velocity v relative to the rest frame of a third identical clock. This experiment requires that we suppose that the three clocks remain synchronous as observed from the system that remains at rest, and it then tests if the two moving clocks are also synchronous with each other as observed from their moving frame [1]:

"We further imagine that each clock has an observer co-moving with it, and that these observers apply to the two clocks the criterion for the synchronous rate of two clocks. Taking into account the principle of the constant velocity of light [Einstein uses V; today we use c], we find that

$$t_B - t_A = r_{AB} /(V-v),$$

and

$$t'_A - t_B = r_{AB} /(V+v),$$

where r_{AB} denotes the [distance between the clocks] measured in the rest system. Observers co-moving with the [clocks] would thus find that the two clocks do not run synchronously, while observers in the system at rest would declare them to be running synchronously.

"Thus we find that we cannot ascribe absolute meaning to the concept of simultaneity; instead two events that are simultaneous when observed from some particular coordinate system can no longer be considered simultaneous when observed from a system that is moving relative to that system."

Now, to achieve a more complete understanding, we must recognize that observations are themselves events, and so an event and its observation are then two simultaneous events (allowing, of course, for signal delay). Consequently, Einstein's principle oddly forbids that observers in relative motion can simultaneously observe any event, including the departure, reflection, or return of the light in this experiment. However, since the three clocks are assumed to be synchronous as observed from the stationary frame, an assumption that these events are in fact observed simultaneously from the two frames is obviously required if we are to suppose, as Einstein does, that the observers agree on the times of the events. Thus, a tacit assumption of the simultaneous observation of the same event from frames in relative motion is necessary to generate the conclusion that forbids it, and so that assumption fails through *reductio ad absurdum*.

Considered for a century to a be a proof of the failure of simultaneity of time, Einstein's imagined experiment is now shown to generate a proof by contradiction of the failure of simultaneity of observation. This failure is, as we have discovered, a failure of simultaneity of events, a physical reality, rather than merely a perception. But then, how are we to comprehend this result when it contradicts our perception that observers in relative motion do simultaneously observe events?

To clarify the physical meaning of this new understanding of the relationship between time and motion and examine its implications for inertia we imagine a second experiment: Let clocks *A* and *B* again be at rest in the same frame and synchronous. The two clocks are then set in uniform relative motion by simultaneously subjecting them to forces that are identical except opposite in direction. Having thus avoided the possibility of establishing a preferred frame, our premise of the equivalence of inertial frames requires that the rates of progression of values on these clocks (or *speed of time*), as seen by the co-moving observers on their own clocks, must remain identical to each other. We compared the times on clocks at relative rest in their common frame; where we measure this identical conservation of inertial energy with relative motion will soon emerge as a telling point.

After some time has passed, we subject clock *A* to a second force that brings it again to rest relative to clock *B*. Consistent with our experience, and independent of the time-transformation equation, we know that a time lag on Clock *A* is seen by both observers now that Clock *A* has decelerated again to rest. As a result, if there are simultaneous observations by these observers of the identical time on their co-moving clocks in the instant before deceleration, and upon deceleration the observation of a time lag on clock *A*, then the observer with clock *A* must find that it returns to rest before it decelerates (supposing, of course, that the duration of deceleration does not exceed the time lag).

This untenable result indicates that the observers cannot simultaneously see identical times on their co-moving clocks in frames in relative motion. However, neither can they simultaneously observe different times, because this would imply that different clock rates have proceeded from the same cause, violating our premise of the equivalence of inertial frames. In contrast, as we have seen, SRT presumes the possibility of the simultaneous observation of the same event from frames in relative motion, an error that

requires that observers in relative motion either simultaneously observe identical times or simultaneously observe different times.

Correctly understood then, these two experiments discover a complete failure of simultaneity itself, rather than merely a failure of simultaneity of either time or observation of the same event, such that there is no possibility of a direct correspondence of times in frames in relative motion. Lacking the direct correspondence of temporal coordinates implicit in the assumption of simultaneity, we have no basis for a direct correspondence of spatial coordinates, and so our difficult but inescapable conclusion is that the frames of bodies in relative motion are fully separate and distinct: Moving bodies transit no points in rest frames.

The *common frame* gains physical meaning through our definition of the 'common time', or simultaneity of time at a distance: We can agree at relative rest on the temporal and spatial coordinates of events, rather than merely perceive agreement. With this complete failure of simultaneity, no such direct correspondence of coordinates is possible, and the common frame, as physically real as time and motion, is lost. And so space-time - the common frame where at rest we measured the speed of time of our two clocks - is lost with motion, and the clear consequence of this is that we are forced to abandon the assumption that inertia is conserved in spatial relationships. In its place, we must be careful to offer nothing more than what remains and is necessary to provide meaning to our assumption of the equivalence of inertial frames; namely, that inertia is conserved in an identical manner in the separate and distinct relationship between each body and time.

This new understanding of inertia immediately accounts for the equivalence of rest and uniform motion while disposing of the problem of superluminal inertial phenomena. And since both the law of conservation of inertia and current relativity theory presume the common frame that we now see gives rise to the enigma of inertia, we will remodel them so as to discover if this is indeed the deeper understanding that resolves the many contradictions and paradoxes accompanying descriptions of time and motion. To distinguish our new understanding from Einstein's, we will refer to this separate and distinct experience of time that forbids simultaneous observations from frames in relative motion as *the complete failure of simultaneity*.

3. Transformations of Time, Mass, & Extension

A. Inertial Frames

The considerations above should suffice to demonstrate that the correct inertial transformation equations, which must describe the relationships between observations made from a stationary frame of rest and moving systems, have not and cannot be derived through SRT's comparison of observations made from systems in relative motion. However, we may now derive the correct equations utilizing only observations from a stationary frame by employing the essential and difficult change in our understanding of the physical Universe that is the complete failure of simultaneity. For the separate and distinct experience of time that it describes signifies that observers in relative motion do not observe the transit of light in an underlying common frame, and so we have no a priori argument requiring stationary observers to measure the velocity of light as c relative to moving bodies. Instead, to preserve our assumption of a constant velocity of light, a stationary observer must only find that the velocity of light varies from c relative to the source with the source's velocity when measuring with the clock and ruler in the stationary frame.

Now, because of this requirement a stationary observer must also find that light suffers a loss of inertial energy in the stationary system corresponding to that associated with the velocity of its source. Considering the equivalence of inertial and kinetic energies, and that kinetic energy varies with the square of velocity, if we describe this transformation factor for light energy as l, then

$c^2 l = c^2 - v^2$, **so**

$l = (c^2 - v^2)/c^2$, and so
$l = 1-(v/c)^2$.

Since only the velocity of the particle or the frequency of its associated wave can signify this energy, our assumption of the constant velocity of light requires that the relative motion of the source is observed from the rest system to result in the transformation of light frequency. Where kinetic energy varies with the square of velocity, the frequency of waves varies directly with velocity, hence the equation for the transformation of light frequency with source motion, separate from the Doppler effect, is the known equation $f' = f\,[1-(v/c)^2]^{-2}$, where f' and f are the frequencies of the light observed from the stationary system when the source is in motion and at rest, respectively. So, although the time observed in a moving system is indeterminate to observers in the stationary system, the stationary observer must find that because wave frequency can serve as a clock the speed of time of a moving system appears slowed by this same ratio relative to the stationary system.

We also must then find that uniformity of light frequency detected from a source at rest or in uniform motion signifies that the speed of time, although slowed by motion, is uniform. Since light frequency corresponds as well to the inertial energy of its source, this allows us to simply and meaningfully describe the conservation of inertia in the relationship between bodies and time while eliminating the artificial distinction between rest and uniform motion: Absent the application of an external force, a body will remain at rest in time. So that we may discuss it, we will refer to this redefinition of the law of conservation of inertia as *the law of conservation of time*.

It is well understood that such transformations of time and frequency require inverse transformations of both the mass of the moving source and the wavelength of its light, to preserve momentum and the constant velocity of light, respectively. However, since the radius of a light source is a multiple of the wavelength of the light it emits, just as the meanings of the terms time and frequency require that the speed of time be observed to dilate with light frequency, it is tautologous that the radii of bodies in motion be observed to expand with the expansion of wavelength. This must then be described by the equation $r'=r/[1-(v/c)^2]^{-2}$, where r' and r are the radii observed from the stationary system when a body is in motion and at rest, respectively.

The principle of the complete failure of simultaneity signifies the loss of the underlying common frame that had required agreement by observers in relative motion on instantaneous locations of bodies and rays of light, and so allows us to replace the theory of the contraction of bodies in the direction of motion with that of a uniform expansion of moving bodies. This expansion also accords with the distances that the bodies are observed to traverse, for the expanded rulers must measure this as exactly the lesser distance that can be traversed in the reduced time at the observed velocity. In fact, the contraction of distances traversed is in the ratio $1:[1-(v/c)^2]^{-2}$, which - as pointed out in our introduction - is incorrectly ascribed to the transformations of SRT. This then disposes of the need for a transformation of space while recovering the successes of *The Electrodynamic Part* of SRT that are accomplished through that theory's transformations.

B. Arbitrary Frames

The equation for escape velocity, $V_e=(2GM/R)^{-2}$, is derived from a consideration of the equivalence of kinetic and gravitational potential energies; and the considerations above tell us that the equations $t'=t[1-(V_e/c)^2]^{-2}$ and $m'=m/[1-(V_e/c)^2]^{-2}$ describe the reciprocal transformations of time and mass at escape velocity. Again considering the equivalence of inertial and kinetic energy, an equal application in arbitrary frames of our assumption that inertia is conserved in an identical manner in the separate and distinct relationship between each body and time requires that these second and third equations must also describe the conservation of the equivalent gravitational potential energy through this scaling. The expression $t'=t[1-(2GM/Rc^2)]^{-2}$ is in fact the equivalent and experimentally supported equation describing

the transformation of time in gravitational frames, and the equation $m'=m/[1-(2GM/Rc^2)]^{-2}$ must then describe the inverse transformation of mass necessary to conserve momentum.

Thus, our new model of relativity successfully describes the transformations of time and mass in gravitational frames as the conservation of energy in the relationship between bodies and time, rather than attributing them to the equivalence of acceleration and gravity. Unlike Einstein's equivalence principle, this changed understanding is consistent with the fact that these gravitational transformations occur regardless of whether a body is in the accelerated frame of gravity or instead in the inertial frame of free fall.

General Relativity's gravitational transformations of bodies, space, time, and light extend SRT's now disallowed transformations to arbitrary frames. In point of fact, General Relativity's deceleration of light in gravitational frames, as distinguished from deflection and associated transit delay, has never been observed in otherwise empty space, even as neither observation nor experiment have ever verified the contraction of bodies or space in any frame. Alternatively, the gravitational slowing of clock rates required by our new model is both experimentally verified and immediately seen to completely account for the observed gravitational shift of light frequency, again signifying an expansion of rulers, but requiring no transformations of light or space.

C. Preferred Frames

A large percentage of the muons created in the Earth's upper atmosphere are known to survive long enough to collide with the Earth. According to SRT, this is consistent with observations from the Earth's frame, in which the muons' velocities dilate time, sufficiently extending their brief lifetimes. However, the reciprocity of SRT requires that an observer at rest in a muon's frame may simultaneously observe the reverse temporal relationship, requiring that the Earth can rarely arrive before the muon decays; and so, the actual behavior of muons signifies an unexplained preference for observations from the Earth's frame.

A similar problem arises with the imagined barn/pole paradox, in which a farmer sees a pole moving toward his barn at near-light speed. Since the farmer knows that the pole is the same length at rest as the barn and SRT informs him that the pole is contracted by its relative motion, he arranges for the front and back door of the barn to be closed for just the instant that the pole is due to pass through, momentarily enclosing it within. However, from the pole's perspective it is at rest while the barn's motion contracts the barn, so closing the doors must result in a collision.

This paradox is supposedly avoided because of the failure of simultaneity described by Einstein: If the farmer closes the doors simultaneously from his point of view, then an observer in the pole's frame must find that the back door is open when the front door is closed. But again, SRT's reciprocity requires that the co-moving observers must disagree about the times that correspond with their meeting. Hence, a preferred frame is again required to avoid an observation from the pole's frame, for example, that the barn's clocks lagged just enough that the back door closed on the pole as it was passing through.

Our new model retains the transformation of time but proposes that all observers see bodies expand with motion, requiring that collisions with the pole and muons are seen from the barn's and Earth's frames. However, by eliminating simultaneous observations from frames in relative motion, and so also the infinite temporal regressions they generate, our new interpretation of relativity disposes of the problem of preferred frames: The collisions seen from the barn's and Earth's frames decelerate the pole and muons at times before co-moving observers in the pole's and muons' frames can observe the alternate outcomes.

4. The Speed of Time in a Cosmological Model

The currently accepted cosmological model supposes that the observation of cosmological redshift signifies an expansion of space, but agreement is lacking on a cause for this expansion. Our new

understanding permits an alternative model that may account for gravitational acceleration as well as this observation of redshift: The universal acceleration of the speed of time.

The term *speed* meaningfully relates the idea of rate of change with respect to time because of the observable difference in the rates of progression of time on clocks in relative motion or in gravitational wells. However, we cannot consider time per se to have a speed without a universal standard from which to measure such a rate of change. The theory introduced here is that the rate of the progression of values on all clocks is accelerating self-referentially, providing that standard.

To illustrate the speed of time cosmological model we may visualize light as a sine wave moving between two bodies at rest in the same frame. Using a Cartesian coordinate system and the methods of Euclidean geometry, our new model of relativity informs us that if time accelerates universally, then the Cartesian frame (i.e. space), the coordinates of the bodies, and the sine wave remain unchanged while the bodies contract. So, for observers with the two bodies, the velocity of light measures as constant while its frequency redshifts with the increasing distance between them, and so space itself appears to expand.

The currently accepted expansion model is founded on the General Theory of Relativity, in which the acceleration of time with increasing height in gravitational wells is accompanied with the expansions of bodies, space, and lightwaves, rather than accompanied with the contraction of bodies described by our new model. Consistent with General Relativity's transformations, a universal acceleration of clock rates would coincide with light frequency being observed to decrease with greater source distance, but the expanding rulers that must accompany this would measure no change of co-expanding space and light wavelength, requiring that the speed of light also appear to decrease with greater distance. Consequently, given our assumption of the constant velocity of light, a universal acceleration of the speed of time is incompatible with the expandable space of General Relativity. However, in both the expansion model and the speed of time model, the observation of cosmological redshift must be equivalent to the observation of time-dilation. The speed of time model preserves the assumption that a constant velocity of light is observed from a time-dilated source by accompanying this observation of temporal transformation with the observation of a compensating uniform expansion of the source. The expansion cosmological model does not account for how observers receding from each other in the manner supposed by that theory agree on the velocity of the light transiting between them.

Finally, two observers could move toward each other to compensate for the recession redshift of the light transiting between them, but such a compensation could not conserve rest in time (i.e. inertia) as time accelerates, since there can be no preferred direction relative to time in isotropic frames. In contrast, the temporal anisotropy of a gravitational well may signify such a direction and so allow for the conservation of inertia through a body's instantaneous acceleration in the direction of the slower time of the well. If so, absent an external force, the law of conservation of time requires this acceleration. Even as our new understanding immediately accounts for the equivalence of rest and uniform motion while disposing of the problem of superluminal inertial phenomena, so it also accounts for the equivalence of both rest and free fall and of inertial and gravitational mass while disposing of the problem of superluminal gravitational phenomena if bodies in free fall are at rest in time.

5. Solutions

Just as SRT emerged from the universal perception that observers in relative motion can simultaneously observe the same event, so our new relativistic model emerges from the principle of the complete failure of simultaneity. The Global Positioning System (GPS) presents a means of physically testing these opposing views. Before launch, GPS satellite clocks are synchronized and the number of transitions of cesium atoms in the definition of one second is adjusted to compensate for expected relativistic affects of gravity and motion. Then, with continual adjustments for anomalous divergences, the clocks remain synchronous as observed from Earth [2]. Consequently, as with Einstein's principle, an assumption of simultaneous observations from frames in relative motion signifies that observers with any two satellites that share a common orbit must find that their co-moving clocks are asynchronous in that inertial frame. The

observation of synchronous rates would then falsify that assumption, as well as Einstein's principle, and so verify our contrary principle of the complete failure of simultaneity.

In Newton's Universe, all clocks read the same time simultaneously, while Einstein's model has all times occurring simultaneously. Our new model proposes a third way: The complete failure of simultaneity such that the time in moving frames is indeterminate. This approach disposes of the assumption of a common frame, or absolute space, which obviously underlies modeling the Universe as an expanding system that we all inhabit simultaneously. In its place, we offer the assumption of the conservation of inertia in an identical manner in the separate and distinct relationship between each body and time.

Our new model retains the experimentally supported principles and transformations - and so retains the general utility - of current relativity theory while allowing a beginning to the resolution of the difficulties associated with it. Perhaps most interestingly, the preferred frame paradoxes addressed above, including the double values of velocity associated with both the relativistic contraction and the cosmological expansion of space, may now be comprehended as proceeding from the original preferred frame paradox: the relativity of rest and uniform motion. And so, not surprisingly, resolving the enigma of inertia by identifying the common frame as an illusion has led us to this simpler view, one in which the single additional assumption of universally accelerating time may at last rid us of the contradictions and paradoxes of flexible space.

This approach opens other promising avenues for inquiry beyond the scope of our brief treatment. Perhaps the most compelling are those that might further unravel the Gordian knot of gravity, light, and ether, such as the relationship between entropy and the transformation of potential energy to kinetic energy that must accompany the universal acceleration of time, and the relationship between wave-particle duality and the separate and distinct frames described by the complete failure of simultaneity. However, the clarifying power of our new model is most persuasively illustrated through an immediate resolution of the most insistent of the fundamental mysteries of time and motion confronting physics: Quantum theory unaccountably forbids simultaneous knowledge of velocity and location, or time and energy, of Einstein's light quanta - knowledge that is required by Einstein's relativity theory and seemingly part of our common experience with macroscopic bodies. The complete failure of simultaneity also explicitly disallows such knowledge, since there are no corresponding temporal or spatial coordinates for frames in relative motion. But our new approach both explains our perception and permits the derivation of the experimentally supported transformation equations. Thus, the complete failure of simultaneity accounts for indeterminacy, even while extending it to all bodies, by forever dislodging us from a common frame.

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