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Special Relativity in a Universe of Flowing Time

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ABSTRACT

By eliminating the need for an absolute frame of reference or ether, Einstein resolved the problem of the constancy of light-speed in all inertial frames but created a new problem in our understanding of time. The resolution of this problem requires no experimentation but only a careful analysis of special relativity, in particular the relativity of simultaneity. This concept is insufficiently relativistic insofar as Einstein failed to recognize that any given set of events privileges the frame in which the events occur; relative to those events, only the privileged frame yields the correct measurement. Instead of equally valid frames occupying different times, one frame is correct and all others incorrect within a shared present moment. I conclude that; 1) Time is a succession of universal moments and 2) In the context of flowing time, time dilation requires absolute simultaneity, whereas relative simultaneity predicts a nonexistent phenomenon here dubbed time regression.

Keywords: Relativity simultaneity, time dilation, time travel, Space-time

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INTRODUCTION

According to Albert Einstein's principle of the relativity of simultaneity, events that are simultaneous in one inertial frame of reference are successive in another frame. What is present from one perspective might be past or future from a perspective in motion relative to the first, rendering the flow of time incoherent. Physicists typically regard time as a static sequence of instants, any of which can be defined as the present. This view is in stark contrast to our sense of time as duration. Why, if time contains neither flow nor presence, does all human experience derive from present moments that recede into past moments?

At the core of special relativity is the claim that absolute properties of nature, including the speed of light, are uniform across all inertial frames of reference. This means the speed of light, *c*, is always the same regardless of the speed of either the object emitting it or the inertial frame from which it is measured. Einstein's error was to assume that the equivalence of inertial frames in relation to *c* also applies to events. In fact, any given set of events privileges a particular frame, which is preferred not in the sense of a frame at absolute rest, but only *relative* to the events being timed. Relativistic privileging of a given frame of reference is compatible with the twin postulates of relativity: invariance of physical law across inertial frames and the constancy of light-speed *in vacuo*. As Dean Zimmerman observes, "positing contingent phenomena that happen to distinguish one frame from all the others" does not defy special relativity; "but what one cannot do, consistent with SR, is to posit *laws* governing some phenomenon… that *directly invoke* a privileged frame" (Zimmerman, 2011). Inertial frames enjoy full equality under the laws of nature. The fact that we are free to choose any frame of reference to measure the timing of a given set of events, however, does not mean that every answer is we get is equally valid. A set of events is not, after all, a law of nature. Though the invariance of *c* causes measurements of time to differ between inertial frames, the frames themselves do not inhabit different times, as Einstein contended. So long as we reject the positivist substitution of reality with our measurement of it, special relativity neither implies relative simultaneity nor conflicts with absolute simultaneity. Granted, the invariance of c across frames does result in the proven phenomenon of time dilation. In the context of flowing time, however, only absolute simultaneity is compatible with time dilation.

In this article I clear a path beyond the false dilemma of Einsteinian vs. neo-Lorentzian theory. In no way depending on a universal frame of reference, absolute simultaneity simply expresses the absolute nature of temporal presence, for which no spatial equivalent exists. Like acceleration and c, each present moment is invariant across all frames of reference. Were simultaneity actually relative, the high-speed frame would regress in time rather than dilate. Since time does not regress, Kip Thorne's proposed mechanism for time travel is nullified. Additionally, a nagging conflict between special relativity and quantum mechanics is resolved.

THE RELATIVITY OF SIMULTANEITY REFUTED

Einstein's celebrated 1905 paper, On the Electrodynamics of Moving Bodies, begins with an examination of electricity and magnetism (Albert Einstein, 1952). At the time, scientists thought the cause of an electric current in a conductor depended on whether the conductor or the magnet was in motion. If a magnet moves past a conductor, the current is stimulated by an electric field. In the case of the conductor moving past the magnet, the current is stimulated by an electromotive force. Einstein realized the motion of the magnet is entirely relative to the conductor and vice versa, meaning neither one moves in relation to an absolute state of rest. The question of which object is in motion and which one at rest is frame-dependent. Regardless of which frame we chose that of the magnet or the conductor the current is generated through the same mechanism, namely an electromagnetic field.

The dismissal of a fixed frame of reference spanning the universe is among Einstein's greatest achievements. Disposing of the need for an absolute state of rest, he inferred that all frames are equally valid regarding the timing of events. Yet this is true only in the abstract. In every actual instance, one frame is preferred, specifically the one at rest with respect to the events in question. If we wish to measure the timing of the electric current, the fact that the current is located in the conductor privileges the conductor frame over the magnet frame in our measurement. Instead of equally valid frames occupying different times, we have one valid frame and one invalid frame sharing a present moment. Einstein illustrates the problem of simultaneity with a train traveling on an embankment (Einstein, 1961). Lightning occurs at points A and B along the embankment. At point M midway between A and B, the flashes of lightning register simultaneously. Point M' is also midway between A and B. However, M' is on the train and therefore in motion towards B and away from A. For this reason, at M' the lightning that strikes at B appears to precede the lightning at A. "Events which are simultaneous with reference to the embankment," writes Einstein, "are not simultaneous with respect to the train, and vice versa." He concludes that "each frame has its own particular time" (Einstein, 1961).

His mistake is to grant equal validity to both frames despite the fact that only one of them, the frame of the embankment, is at rest with respect to the lightning. In motion relative to the lightning, M' registers the timing of the flashes incorrectly. Since the frames must occupy different times only if both are equally valid in their measurement of the timing of the flashes, the relativity of simultaneity collapses.

If the light from paired lightning strikes could somehow reach M and M' instantaneously, both points would register the strikes as simultaneous. Only the lapse in time between the source and destination of the light distinguishes the reading at M' from the reading at M. The limitation of c distorts measurement in whatever frame is in motion relative to a given set of events. To fully appreciate this point, consider a complementary scenario in which a light flashes within one of the cars comprising the train. If the source of light is fixed to the center of the car, the light reaches its front and back walls simultaneously. From the embankment, however, the forward motion of the train causes the light to appear to reach the back of the car prior to reaching the front. Rejecting the extraordinary claim that each frame occupies a distinct time, we conclude that the view from the train yields the correct measurement of the timing of events while the limitation of c distorts the measurement from the embankment. In the absence of an absolute frame of reference, all frames seem equally valid. In practice, however, any given set of events privileges whichever frame is at rest with respect to those events. In Einstein's lightning scenario, the frame of the embankment is preferred. In the alternative scenario of a light flashing within the train, the train is the preferred frame in which to measure the timing of events. A given frame is preferred not absolutely or universally but only relative to a given set of events. By assuming the absolute equivalence of inertial frames with respect to events, Einstein is insufficiently relativistic in his analysis. No frame of reference is always preferred in relation to other frames. What Einstein overlooks is that the inverse is also true: *all frames of reference are always preferred in relation to themselves*. Because the measurement of the timing of events is correct for the frame in which the events occur and incorrect for other frames, we have no need to posit different times for different frames. Einstein's proposal for synchronizing clocks at a distance by the use of light-signals traveling between them yields the correct timing of events that take place in the frame in which the clocks are synchronized but fails with respect to events occurring outside that frame (Albert Einstein, 1952). Though Einstein is correct that synchronized clocks in different frames measure different timings of the same set of events, this means only that the limitation of c fools clocks as readily as subjective observers. Since the mistaken measurement in a non-preferred frame follows from a property of light, relative simultaneity is a special case of optical illusion. Whereas ordinary optical illusions depend on organic processing in the human visual system, the mirage of relative simultaneity arises from the transmission of light itself. What differs from one frame to another is not time itself but only the readings of clocks. This is why Mario Bacelar Valente refers to the relativity of simultaneity as the relativity of synchronization (Valente, 2012). Far from nullifying a universal present moment or preferred foliation, the relativity of synchronization merely prevents observers in one frame from precisely measuring the present moment in other frames, thereby insulating the relativity of simultaneity from falsification via measurement. Though eluding precise measurement, a succession of present moments encompassing both inertial frames is implicit in Einstein's thought experiment. At the exact moment an observer on the train registers the lightning flash at B, an observer on the embankment has seen neither flash. At the moment the passenger registers the lightning at A, the embankment observer has already noted both flashes. In order to make conflicting observations at any given moment, both observers must occupy that moment. Einstein highlighted the discord across inertial frames while neglecting the underlying accord. If an event is observed at different times in different frames, different events must be observed at the same time in those frames. To deny this claim is to assume from the outset that the phrase, at the same time, cannot apply to different frames. Yet this is precisely what Einstein ostensibly demonstrates with the relativity of simultaneity. We cannot assume at the outset the very thing we seek to prove. If different frames actually occupied different times, that is, if the present moment of one frame differed from the present moment of another frame, they could not detect each other at all, as we perceive only what is present to us, not what is past or future. This is not to deny that by observing a galaxy two million light years away, for instance, we see its state two million years prior. Nonetheless, we see only what was present at that point in time. While we do not know what is happening now in a distant star system, we have no reason to doubt that the present moment on Earth is also the present moment at that remote location.

In his thought experiment involving a space fleet launched from the Andromeda galaxy, Roger Penrose explains relative simultaneity in terms of the differing perspectives of two pedestrians passing each other (Penrose, 1989). From one perspective, the space fleet has already set sail for Earth. From the perspective of the person walking the other direction, the decision to launch has yet to be made. Rather than negate a shared present between Earth and Andromeda, however, this conflict only highlights the inaccuracy of one or both perspectives. Since the correct frame for judging the Andromedean space launch is that of the space fleet itself, we must ascertain if either pedestrian's frame is equivalent to it. Even at a distance of two million light years, velocities that match up constitute a single frame. Of course, if neither pedestrian occupies the same frame as the Andromedeans, both are mistaken about the timing of the launch. Either way the paradox of multiple times dissolves. The relativity of simultaneity applies only in a temporal vacuum, a world devoid of actual events that would privilege particular frames over others. As Einstein's positivist left hand reduces time to its measurable properties, his idealist right hand places abstraction ahead of actuality.

OBJECTIONS

1. A shared present moment implies a third reference frame in addition to the train and the embankment. A frame of reference, by definition, extends across space. Though any given present moment applies equally in all frames, a moment is not itself a frame. Presence is universal not in the sense that it extends ether-like across all space but because the universe lawfully obeys it. So too the fact that the speed of light is universal does not mean c itself, in addition to lawfully propagating light, extends across space.

2. An event occurs not in a frame of reference but at a point in space-time. The implication here is that an event is instantaneous in the sense of occupying no duration. If this were the case, however, Einstein's thought experiment would break down, as the train's measurement of the timing of the lightning flashes would not differ from the embankment's measurement. Only if the flashes occupy a certain interval is the motion of the train relevant, since only during the interval of the flashes does the train’s motion distinguish its measurement from that of the embankment. Moreover, points in space-time do exist in frames. As Einstein puts it, "Let M' be the midpoint of the distance A to B on the travelling train. Just when the flashes of lightning occur, this point M' naturally coincides with the point M, but it moves… with the velocity of the train" (Einstein, 1961). Here Einstein assigns space-time point M to the embankment frame and M' to the train frame. This procedure is to be expected, for any points that do not adhere to a particular reference frame would therefore constitute the fabled ether.

3. Events cannot be localized to one frame or another but belong equally to both. If a light comes on in a steadily moving train, clearly it does so in the train frame. To deny this is to separate the frame from the object whose motion defines it. In Einstein’s thought experiment, lightning takes place in the embankment frame, whereas the train is in motion relative to the flashes. We know this because at point M, which is equidistant from the flashes, they are simultaneous. This is why Einstein invokes a pair of lightning strikes: we can all agree they seem to be simultaneous. What Einstein fails to grasp is that they actually are simultaneous when measured correctly, that is, from the frame in which they occur. That the timing of the same events can be measured incorrectly from a different frame has no bearing on the nature of time.

4. As static points in space-time, events do not occur. Therefore no meaning can be assigned to the term, the frame in which events occur. Though we can reword the offending statement as the frame in which the events are spatio-temporally located, this compromise is unnecessary since the basis for the reduction of flowing time to static space-time points is none other than the relativity of simultaneity. Having disposed of relative simultaneity as an objective phenomenon, we are free to refer to events as occurring or happening.

5. In the case of a set of events extending across more than one frame of reference, no single frame would provide the correct measurement of the timing of events. Multiple frames must occupy multiple times only if more than one frame provides the correct measurement of the timing of events. In this case the number of correct frames would be zero.

RAMIFICATIONS

The restoration of absolute simultaneity completes our understanding of time dilation, undermines apparent justification for travel to the past and eliminates a source of incompatibility between special relativity and quantum non-locality.

TIME DILATION

Einstein's investigation of relativity famously began with a question: what happens to our perception of light when we travel alongside it? His question is of course unanswerable. No matter how fast the fastest rocket soars, radiant waves of electromagnetism still outrun it by the speed of light. In order for this to be the case, time must slow for the object in high-speed motion. Indeed, time dilation has been demonstrated by way of clock-slowing relative to low-speed frames and clock-gain relative to high-speed frames (Hafele & Keating, 1972). Yet the slowing of time appears nowhere in Einstein's account of time dilation. If my frame of reference is traveling at one-half the value of c, according to common sense the speed of light should appear to drop to one-half c. The simplest way to keep my measurement of the speed of light at c is for my half-second to stretch or dilate so as to equal a complete second of time outside my frame. As far as light is concerned, I am now as motionless as I was prior to accelerating to one-half c, and I naturally measure the speed of light at c.

By adopting the term, time dilation, Einstein treated time in a spatial manner. Instead of conceptualizing time as a line and then stretching that line, we accept the reality of temporal flow and surmise that its rate drops in the high-speed inertial frame relative to low-speed frames. But slowed time should cause the high-speed frame to regress to a relative past. If I undergo five seconds and you undergo ten seconds, I should wind up five seconds in your past. This is, after all, the nature of time. In the absence of flowing time, Einstein's account is perfectly suitable. High-speed motion dilates the interval of the journey of a previously accelerated inertial frame relative to low-speed frames, thereby preserving the measurement of the speed of light at c in the high-speed frame. In a universe where time flows, however, Einstein's account breaks down. High-speed motion reduces the rate of temporal passage of the accelerated frame, causing it to regress to a relative past and thereby negating the correction of the measured speed of light. In a universe of flowing time, preserving the speed of light at c requires not only that the accelerated frame undergo duration-slowing but that it remain in the same present as all other frames. If time flows, just as it seems, time dilation is duration-slowing in the context of absolute simultaneity. Because all frames must share the same present moment, none can regress to a previous moment relative to other frames. The only possible outcome for a frame that slows in time yet remains present to other frames is interval-stretching, i.e. time dilation. Einstein rejected absolute time without considering that time is absolute only in presence and not, as Newton believed, in both presence and flow. Though time dilation is incompatible with the equable flow of time across frames, it also depends on the invariance of temporal presence across frames. In contrast to the proven phenomenon of time dilation, the relativity of simultaneity is strictly symmetrical: from the point of view of each inertial frame, the clock in the other frame seems to be running slow. Since only one frame's clock can run slower than the other's, clearly there is no actual effect. What makes time dilation real is precisely its asymmetry, which results from the inertia-breaking effect of acceleration. Having previously accelerated, the clock in the high-speed inertial frame really does run slow relative to the clock in the low-speed frame, and this is because both frames, despite their differing speeds, must measure c the same. Unlike time dilation, the relativity of simultaneity depends on the *absence* of knowledge. If we do not know which inertial frame is traveling faster, that is, closer to c, the mathematical apparatus of the Lorentz transformation tells us merely how our measurements will differ between frames. Only when the high-speed frame is specified does the Lorentz transformation indicate actuality as opposed to appearance, namely that the high-speed frame dilates in time and contracts in the direction of its motion relative to the low-speed frame. Returning to Einstein's thought experiment, if the train is moving east and therefore in conjunction with Earth's rotation, then the speed of the train, not the embankment, is closer to c. If the train is moving west and therefore against Earth's rotation, the embankment is the high-speed frame. By neglecting to specify which frame moves faster, Einstein establishes a principle of nature on the basis of no actual effect and then appears to confirm this bogus principle with the genuine phenomenon of time dilation. A slower-ticking clock in a high-speed frame indicates not relative simultaneity but time-slowing in the context of absolute simultaneity. In no way does time dilation follow from relative simultaneity, as no actual phenomenon can be derived from a merely apparent phenomenon.

TIME TRAVEL

Absolute simultaneity guarantees that time slows only in the weak sense that its rate of passage differs between equally present frames, not in the strong sense that a high-speed frame regresses to a relative past. Though displaying an earlier time, the clock in the high-speed frame remains present to other frames. Under the rule of relative simultaneity, however, high-speed motion would cause time regression. Instead of displaying an earlier time, the clock along with its entire frame would regress to that earlier time. This appears to be the reasoning behind Kip Thorne's misguided model of time travel via wormhole.

According to Thorne, a wormhole can in theory be harnessed as a portal to the past by introducing a time differential between its two openings (Thorne, Braginsky, & Ginzburg, 1994). This can be accomplished by accelerating one opening of the wormhole (or towing it to a massive object) but not the other opening. By entering the unmodified opening and exiting the previously accelerated opening, the traveler is left in a moment prior to entering the wormhole.

The only way for this to work, however, is if time dilation is somehow transmuted, in the context of a wormhole, into time regression. In reality, accelerating one opening of the wormhole but not the other would create a clock differential, not a time differential, between the openings. To arrive at a time differential, the wormhole would have to inhabit a universe where time passes but simultaneity is relative. Thorne's error is to revert to an intuitive sense of time while adhering to the relativity of simultaneity.

QUANTUM NONLOCALITY

In accord with Einstein's formulation of special relativity, the instantaneous entanglement of quantum particles across great distances appears to require a unique frame of reference (Bohm & Hiley, 1993). Only within this frame can the entangled particles occupy a shared present moment. With the recognition of absolute simultaneity, no such frame is necessary. Given a universal present moment, particles can be entangled without regard to what frame each particle occupies.

CONCLUSION

No longer satisfied with Werner Heisenberg's advice to stick to the measurements and forget about the nature of reality, many quantum physicists are trying to find out what is "really real"(Merali, 2015). Perhaps the time has come to reevaluate relativity along the same lines. The positivist approach that characterized Heisenberg also gripped Einstein, possibly by way of Ernst Mach (Craig & Smith, 2007). Like the wholly unsatisfactory belief that a particle's properties are determined by our measurements of them, Einstein arrived at the relativity of simultaneity by imprisoning time in its measurement. Despite our imperfect understanding of it, what we call time seems to correspond to something real. Time is not only experienced but constitutes the substrate of experience. An explanation of time dilation that acknowledges the reality of presence and passage is inherently preferable to a model that assumes away the very qualities that make time temporal. The fact that high-speed motion produces length contraction as well as time dilation tells us time and space are related but says nothing of the nature of this relation, let alone rendering time into an appendage of space in a block universe. Since time dilation can be explained according to duration-slowing in the context of absolute simultaneity, evidence for time dilation in no way demotes flowing time to fixed points in space-time geometry. For that we need the relativity of simultaneity, the expulsion of universal presence and the substitution of an evolving three-dimensional world with a frozen four-dimensional world. Yet we have seen that Einstein's argument for relative simultaneity is vacuous. Simultaneity is relative only if all inertial frames are equally valid with respect to the timing of a given set of events. This requires, however, that the events in question never actually occur, for in so doing they cannot help but pick out a preferred frame. If every frame but one is invalid, all can comfortably co-exist in the same present moment. By substituting flowing time with static space-time, Einstein avoided the dilemma of how duration-slowing resolves as time dilation. While this approach streamlines special relativity, it applies only in a universe that literally never happens.

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