

Violation of the special theory of relativity as proven by synchronization of clocks

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Abstract

This paper provides for the categories of “primary stationary system” and “conditional stationary system” for inertial frames of reference, which Einstein believed were all equivalent.

The “primary stationary system” is a coordinate system in which all clocks are in sync, in absolute terms, even if clocks were not synchronized as proposed by Einstein.

The “conditional coordinate system,” on the other hand, is a coordinate system in which an observer in this coordinate system, in order to be able to state that light propagates isotropically from a light source in his coordinate system, must use the clock synchronization method proposed by Einstein to synchronize with the time of the clock in his coordinate system.

This paper considered the coordinate system of rod 2, moving at constant velocity relative to a “conditional stationary system” (Einstein’s inertial frame of reference), as considered in this paper as equivalent to inertial frame of reference of the special theory of relativity. Then, it was shown that, the actual time adjustment made by an observer in this coordinate system to synchronize two clocks at each end of a rod by using Einstein’s method is not the same as the value predicted by the special theory of relativity.

The reason for the discrepancy between experimental values and theoretical values is due to the unknown velocity v which is related to “conditional stationary systems,” the

existence of which Einstein denied.

This paper therefore concludes that Einstein was incorrect in considering all inertial frames of reference to be equal when developing the special theory of relativity.

Key words: Special Theory of Relativity; Definition of Simultaneity; Time Adjustment of Clocks; Relativity of Simultaneity; Primary Stationary System; Conditional Stationary System; Relativity Violation.

1. Introduction

At the end of the 19th century, most physicists were convinced of the existence of ether as a medium that propagates light. Further, they thought ether to be “absolutely stationary.”

Michelson and Morley attempted to detect Earth’s motion relative to the luminiferous ether, i.e. the absolute velocity. However, they failed to detect the effect they had expected.¹ In order to explain why they failed to detect the effect they had expected, Michelson concluded that the ether was at rest relative to the earth in motion (i.e. it accompanied the earth).

On the other hand, Lorentz was convinced of the earth’s motion relative to the “preferred frame.” He made a stopgap solution by proposing a hypothesis that a body moves through space at the velocity v relative to the ether contracted by a factor of $\sqrt{1-(v/c)^2}$ in the direction of motion.²

Michelson believed that light emitted from a laboratory on earth propagated isotropically, while light propagated anisotropically in the interpretation of Lorentz.

However, in his special theory of relativity (STR) published in 1905, Einstein insisted physics not require an “absolutely stationary system” provided with special property, and that there be no such things as “specially-favoured” coordinate systems to occasion the introduction of the ether-idea.³ Einstein’s aim at the time was not to explain the reason why, like Lorentz and Poincaré, the expected results were not observed in the Michelson-Morley (MM) experiment, but to derive a conversion equation between coordinate systems in order to resolve the asymmetry apparent in electromagnetism.³

Then, as he was building his STR, he determined through definition that light traversing two paths of equal length would arrive at a reflector at the same time.³ Therefore, Einstein did not provide an answer the question of whether two beams of light arriving at the reflectors was absolutely at the same time or not.

Incidentally, through new experimental techniques made available through the 20th century, Brillet and Hall have improved the accuracy of MM experiment by a factor of 4000.^{4,5}

Also, the Kennedy-Thorndike (KT) experiment examined whether light speed changes according to the speed of the laboratory by creating two light paths of different lengths using an interferometer.⁶

Modern descendents of the MM experiment more strictly limits the anisotropy of light speed. The most accurate limit today is thought to be that provided by the group from Humboldt University of Berlin, Germany.

Müller *et al.* performed a modern MM experiment that compared the frequencies of two crossed cryogenic optical resonators subject to Earth's rotation over more than one year.⁷ The limit they obtained on the isotropy-violation parameter within the Robertson-Mansouri-Sexl framework is about three times lower than that from the experiment of Brillet and Hall.⁴

Furthermore, they obtained limits on seven parameters from photonic sector of the standard model extension,⁸ at accuracies down to 10^{-15} , which is about two orders of magnitude lower than the only previous result.⁹ They collected data for about a year and established a limit for variations in light speed of $\Delta c/c \leq (2.6 \pm 1.7) \times 10^{-15}$.^{7,10} This is compatible with zero within the accuracy of the experiment.¹¹

The laboratory velocity $\nu(t)$ relative to the hypothetical preferred frame of reference Σ has contributions from the motion of the Sun through Σ with a constant velocity $v_s=369\text{km/s}$,¹² Earth's orbital motion around the Sun (orbital velocity $v_e=30\text{km/s}$), and Earth's daily rotation (velocity $v_d \approx 330\text{m/s}$ at the latitude of Konstanz).¹¹

Although no specific grounds are provided, this is $v_d/c \approx 10^{-6}$, even when assuming that only the earth's rotation, the smallest velocity here, contributes to breakdown in the isotropy of light propagation. Therefore, if the motion of the earth were causing a

change in light speed, it should be possible to easily detect such a change with current technology, but no such change has been actually observed.

This paper cannot explain why anisotropic properties of light propagation were not detected in the experiment of Müller *et al.* Even though the earth is in motion, light propagates isotropically relative to a fixed laboratory on the earth.^{1,6,7,11}

Incidentally, according to the kinematical analysis of Robertson¹³ as well as Mansouri and Sexl,¹⁴ STR follows unambiguously from experiments establishing the isotropy of space (MM experiment [1]), the independence of light speed from the velocity \mathbf{v} of the laboratory relative to Σ (KT experiment [6]), and special relativistic time dilation (Ives-Stilwell (IS) experiment [15]).¹¹

In this paper, based on this IS experiment and Einstein's "principle of constancy of light speed,"³ a thought experiment is performed.

2. Why is a thought experiment necessary?

The STR has survived a century of arguments and criticisms challenging this theory. Many modern experiments are also being performed to search for relativity violations, but no clear evidence has yet been found. Under these conditions, if a thought experiment of this paper is to be performed, it is necessary to explain why it is possible to prove a relativity violation from only a thought experiment.

An experiment was considered in the introduction that attempted to detect the anisotropic propagation of light. Many highly advanced modern experiments of this kind are also being performed in a variety of fields, from atomic physics to cosmology.

Incidentally, since Enrico Fermi, effective field theory has been widely used in particle physics. In the framework of this theory, the violation of Lorentz invariance is caused by background fields. The effective field theory approach to Lorentz violation was advocated by Kostelecky (Indiana University) and coworkers.¹⁶ If a uniform background vector \mathbf{b} exists, \mathbf{b} defines a preferred direction in space and so violates Lorentz invariance.

The effective field theory predicts that it should be possible to observe a relatively violation from not just a change in light speed but also from a change in the nuclear spin

precession frequency, or from astrophysical observations.

In 1960, Hughes and coworkers and, independently, Drever conducted a different kind of Lorentz invariance test.¹⁷ With the rotation of the earth, the direction of magnetic field rotation in an experimental chamber changes relative to a galactic reference frame, and in this experiment, they measured the effect of the change in magnetic field on the nuclear spin precession frequency of lithium-7.

Modern descendants of the Hughes-Drever experiments provide very strict constraints on the many possible Lorentz-violating parameters. In these experiences, a Lorentz violation would be manifested as a change in the nuclear spin precession frequency, and this change would be thought to be caused by a rotation of the magnetic field relative to the preferred direction as defined by vector \mathbf{b} .

In cosmic theory, quintessence is being seriously regarded as a new field that permeates the universe as a possible candidate for recently-discovered dark energy. Because a quintessence field φ is constantly changing within time and space, it is hoped that these interactions between time space and matter might be manifested as an apparent breaking of Lorentz symmetry.

In the experiments introduced by Pospelov and Romalis in Reference [5], the reference frame defined by the cosmic microwave background Σ , background vector \mathbf{b} , and quintessence field φ are presumed. Whatever the true origin of Lorentz breaking, no hopeful results have been observed in any of these experiments until now. If an expected result is observed in these experiments, this would mean the discovery of one of Σ or \mathbf{b} or φ , as expected by this experiment.

A discovery of a relatively violation is generally accepted to be the same as a discovery of proof of the existence of a stationary system. However, in this experiment, it is presumed that it is possible to discover a condition in which Σ or \mathbf{b} can be discovered from a relativity violation, but that a relativity violation itself can occur even in conditions where Σ or \mathbf{b} are not found. The reason for taking this position in this paper is described in the discussion of Sec. 5.

Ultimately, because the objective of this discussion is not to search for possible candidates for this stationary system, this differs from the objective of modern advanced

experiments attempting that challenge STR (Reason 1).

Therefore, even proof of a relativity violation in this discussion is not the same as discovering proof of Σ or \mathbf{b} .

In this thought experiment, there are observers of two coordinate systems that can be thought to be stationary systems from the perspective of STR, and these observers apply STR to predict the result of an experiment performed in a different coordinate system. Under these conditions, different values are predicted by each of the two observers, but it is not possible for both observers to be correct in this thought experiment. Therefore, a relativity violation must have occurred in one of the frames of reference.

Currently, no proof has been discovered for the existence of Σ or \mathbf{b} or φ , and the task of discovering these is left up to other experiments. The objective of this paper is limited to the discovery of a relativity violation. In this case, a relativity violation can be decisively proven from only a thought experiment (Reason 2).

Modern experiments challenging STR do so by presuming the existence of Σ or \mathbf{b} or φ , and if these are discovered, predict that it could be possible to discover a relativity violation.

However, in this discussion, because it is possible to present conditions in which the experiment results predicted by applying STR are different for observers of two coordinate systems that can be considered stationary systems, it is possible to prove the existence of a frame of reference in which a relativity violation has clearly occurred.

This paper does not presume to resolve all of the questions left unresolved by the many existing experiments challenging STR. However, based on the above reasons, it seems possible to assert the validity of the thought experiments of the next sections as well.

3. “Principle of constancy of light speed II” and isotropicity of light propagation as derived from Einstein’s proposed “clock synchronization”

In building a new theory of physics, Einstein did not believe it necessary for there to be a special, absolutely stationary system. Einstein also asserted that because there is no

way to detect the absolute velocity to such an absolute coordinate system even if it existed, that physics should not be built around the presumption of the existence of such a virtual coordinate system.

Einstein then derived the STR based on the velocity relative to this inertial frame of reference, without considering absolute velocity relative to such a coordinate system, and when doing so proposed to determine the time of two clocks in an inertial frame of reference using light signals.

In this section, we first verify the importance of the role of the “definition of simultaneity” as Einstein built his STR.

Let us imagine a case in which two clocks A and B are accurately ticking at the same tempo at two locations in space, A and B. Einstein stated that if we define that the time required for a ray of light to reach B from A is equal to the time required for the ray of light to reach A from B, it is possible to compare the time of the two clocks.³

In other words, if a ray of light is emitted in the direction of B from A at the time t'_A of clock A, reaches and is reflected at B at t'_B of clock B, and the light returns to A at time t'_A of clock A, then this time relationship can be represented by the following two formulas.

$$t'_B - t'_A = t'_A - t'_B. \quad (1)$$

$$\frac{1}{2}(t'_A + t'_A) = t'_B. \quad (2)$$

Einstein determined that if these formulas are true, the two clocks on this coordinate system represent the same time by definition.

Let us imagine a rod placed in a stationary system. Next, we synchronize clocks placed at each end of this rod while stationary, according to Einstein’s method. Then, this rod begins moving at constant velocity relative to this stationary system. This will result in the requirement for an observer in the coordinate system of the rod to adjust the clocks on both ends of the rod to ensure they are in sync with the time of the moving system.

Unless the time here is recalibrated, it is not possible to state that the principle of constancy of light speed will be true for the coordinate system of the rod, nor will the

observer be able to state that a ray of light propagates isotropically from a light source in his coordinate system.

Einstein felt that because all relativistically moving inertial frames of reference are equal, observers in any inertial frame of reference may consider their coordinate system to be the stationary system. However, in order to assert that one's own coordinate system is the stationary system, an observer in that coordinate system must have calibrated clock times, as proposed by Einstein.

Here, this paper separates inertial frames of reference into the "primary stationary system" and "conditional stationary system," from the perspective of an observer in that coordinate system.

Considering first the "primary stationary system," clock times in this coordinate system are in sync, in absolute terms. Therefore, in this coordinate system, it is not necessary to calibrate clocks as introduced by Einstein. Light propagation in this sort of coordinate system is called "a priori" isotropic propagation, which is separated from isotropic propagation as used when later explaining "principle of constancy of light speed II." In general terms, we are able to assert that a ray of light propagates isotropically in all inertial frames of reference is based on our calibrating clocks in that coordinate system based on Einstein's method. "Relativity of simultaneity" as proposed by Einstein does not assert that the times of two synchronized clocks in an inertial frame of reference are absolutely in sync. "Primary stationary system" as defined in this paper is the coordinate system in which a ray of light propagating from the point of origin on the x axis of the coordinate system arrives at absolutely the same time to the points $x = \pm L$. Therefore, the "primary stationary system" includes not only Σ and ϕ , which are candidates for an absolute stationary system, but also coordinate systems on earth thought to show a priori light propagation from the perspective of the previous section, (however, in the case of earth, we cannot completely excluded the possibility of being a completely "primary stationary system" nor an approximate "primary stationary system," but this is not important here).

"Conditional stationary system" refers to the coordinate system which is moving at constant velocity relative to this "primary stationary system."

According to Einstein's "principle of constancy of light speed," because light speed does not depend upon the velocity of the light source and is always constant ("Principle of constancy of light speed I").

In other words, even when the velocities of light emitting sources are different, the light of one source will not overtake the other.

The "principle of constancy of light speed I" applies to the propagation of a ray of light in a "conditional stationary system" moving at constant velocity relative to the coordinate system of an observer in the "primary stationary system." Thus, because light propagates isotropically in an a priori fashion relative to the "primary stationary system" in which this observer stands, he judges that light is propagating anisotropically in the "conditional stationary system" that is moving relative to his coordinate system ("Relativity of simultaneity").

However, even for a coordinate system that begins moving, if an observer in this system adjusts the clocks in this coordinate system so that the light signal reaches clocks A and B in this coordinate system at the same time, he can assert that light propagates isotropically even in this coordinate system. The principle which endures by adjusting time in this fashion is called the "principle of constancy of light speed II."

Ultimately, an observer in the "primary stationary system" explains anisotropic propagation of light in a moving system through the "principle of constancy of light speed I," while an observer in a moving coordinate system explains isotropic light propagation in his coordinate system through the "principle of constancy of light speed II." These two principles can coexist without conflict due to the clock adjustments in these coordinate systems as proposed by Einstein.

The "conditional coordinate system," is a coordinate system in which an observer in this coordinate system is stationary in his own coordinate system, and must use the clock synchronization method proposed by Einstein to synchronize clocks in his own coordinate system in order to assert that light propagates isotropically from a light source in his coordinate system.

In this way, the "principle of constancy of light speed II" should be understood as a principle created by humans that cannot endure unless an observer adjusts the clock in

his own coordinate system when there is a change in velocity of a moving system.

Next, the rod which has had its clocks at both ends calibrated in advance while stationary in one of the types of coordinate systems of this paper begins moving at constant velocity.

Then, the observer in the coordinate system of the rod compares the time actually set for the clock with the value that the observer predicts according to the STR.

This paper presents a thought experiment in which these two times do not match.

Incidentally, the “principle of constancy of light speed” normally is used to express three different meanings. We are not normally cognizant of these, but it is important this discussion so we shall review these below.

Let us imagine a light signal emitted from a light source located at the center of a train moving at constant velocity on surface of the earth and expanding outward both to front and rear of the train. Let us also imagine a stationary observer on a ground platform observing this light propagation.

The platform observer applies the “principle of constancy of light speed I” to the light propagation for the train’s coordinate system and determines that a ray of light arrived first to the rear of the train, which is moving closer to the point in the stationary system where the light was emitted, and then arrived later to the front of the train.

However, an observer aboard the train who considers his own coordinate system as the stationary system would apply the “principle of constancy of light speed II” and therefore see that the ray of light arrived at the front and rear of the train simultaneously. Or, because the onboard clocks at each end of the train would be adjusted as required to be able to assert that the ray of light has reached the front and rear of the train at the same time, the “principle of constancy of light speed II” would hold true in the train’s coordinate system.

Lastly, to consider the “principle of constancy of light speed III,” we imagine light emitted from a light source situated at the center of an experimental apparatus, propagating away from the light source and arriving simultaneously at two mirrors A and B placed vertically at equal distances from the light source, and returning simultaneously. If L is the distance from the light source to the mirror (arm’s length) and

t is the time required for the light to make one round trip, then we can use $2L/t$ to solve for light speed c , and this value is always a constant (“Principle of constancy of light speed III”).

However, there is no currently available method to verify whether the ray of light in this experiment arrived at mirrors A and B at the same time in absolute terms, or arrived only at the same time for that coordinate system as defined by Einstein; that is we cannot verify whether that coordinate system is the “primary stationary system” or the “conditional stationary system.”

The educational material created for students by the California Institute of Technology (Caltech) is extremely helpful to understand this situation.¹⁸

It should be emphasized that in the below thought experiment of this paper, the light propagation condition, rod contraction for a bar moving at constant velocity, or time dilation within moving coordinate systems are all predictions made based this educational material.

After verifying the above, we actually synchronize clocks following Einstein’s directions.

4. Time adjustment of clocks in a moving coordinate system

Let there be a given stationary rigid rod of length L as measured by a ruler which is stationary, and its axis moving in parallel in the positive direction of the stationary system x axis at constant velocity v (see Fig.1).

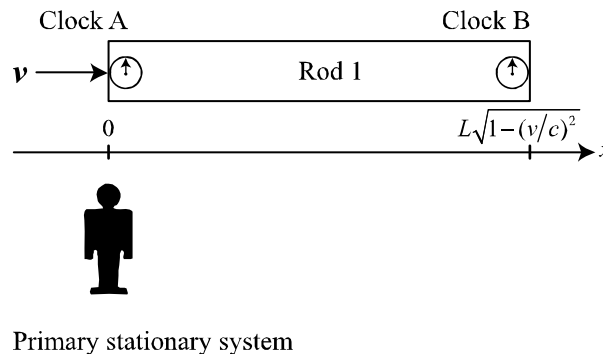


Fig1

Fig.1 Rod 1 is moving at constant velocity v relative to “primary stationary

system.” Clocks A and B are set up at A and B at each end of this rod, and the times of each of these clocks are synchronized while the system is stationary.

However, let the velocity of the rod considered in this paper to be moving at such a high velocity to require the application of STR.

Let us imagine that clocks A and B are set up at A and B each end of this rod 1, and the times of each of these clocks are synchronized while the system is stationary.

In this study, we first attempt to adjust time of each of these clocks, such that we achieve simultaneity in a moving coordinate system.

Let us imagine that a ray of light departs the trailing end of A in the direction of the leading end of B at time t'_A of clock A of the coordinate system of rod 1, arrives at B at time t'_B of clock B, and returns to A at time $t'_{A'}$ of clock A. Let us imagine that times $t'_A, t'_B, t'_{A'}$ of this moving system corresponds to times $t_A, t_B, t_{A'}$ of the stationary system.

Einstein’s paper is cited here as it sets the guideline for the thought experiment of this discussion.³

“We imagine further that at the two ends A and B of the rod, clocks are placed which synchronize with the clocks of the stationary system, that is to say that their indications correspond at any instant to the “time of the stationary system” at the places where they happen to be. These clocks are therefore “synchronous in the stationary system.”

We imagine further that with each clock there is a moving observer, and that these observers apply to both clocks the criterion established in § 1 for the synchronization of two clocks. Let a ray of light depart from A at the time t_A , let it be reflected at B at the time t_B , and reach A again at the time $t'_{A'}$. Taking into consideration the principle of the constancy of the velocity of light we find that

$$t_B - t_A = \frac{r_{AB}}{c - v} \quad \text{and} \quad t'_{A'} - t_B = \frac{r_{AB}}{c + v}$$

where r_{AB} denotes the length of the moving rod—measured in the stationary system.”

* “Time” here denotes “time of the stationary system” and also “position of hands of the moving clock situated at the place under discussion.”

The wording of his section is somewhat vague. However, it should be noted that measurement performed in this time space is done not by the observer in the moving system, but instead by the observer in the stationary system. It is important to also note that these times t_A , t_B , t'_A are not times of clocks in the moving system but instead are times as measured by clocks in the stationary system. From this it is clear that the delay in time for clocks in the moving system have not been accounted for in $(t_B - t_A)$ and $(t'_A - t_B)$. This paper continues as follows:

“Observers moving with the moving rod would thus find that the two clocks were not synchronous, while observers in the stationary system would declare the clocks to be synchronous.”

Ultimately, even when two clocks are synchronous when located at each end of a rod which is at rest, they are no longer synchronous in a moving system when that rod begins moving at a constant velocity. The clocks must be re-calibrated for both clocks to be synchronous in the moving system. This discussion presents the predicted adjustment amount that would actually be required to synchronize the clocks, based on Einstein’s paper as cited above.

Incidentally, according to the STR, because rod 1 contracts by a factor of $\sqrt{1-(v/c)^2}$ in the direction of motion, the time required for a ray of light to reach B from A as measured from stationary system clocks $(t_B - t_A)$, in seconds, is

$$t_B - t_A = \frac{L\sqrt{1-(v/c)^2}}{c-v} \text{ (sec.)}, \quad \text{where, } r_{AB} = L\sqrt{1-(v/c)^2}. \quad (3)$$

In Eq. (3), doesn’t the principle of constancy of light speed prohibit $c-v$?

In building the STR, Einstein proposed the following “principle of constancy of light speed.”³

“Any ray of light moves in the “stationary” system of co-ordinates with the determined velocity c , whether the ray be emitted by a stationary or by a moving body.

Hence

$$\text{velocity} = \frac{\text{light path}}{\text{time interval}}$$

Namely,

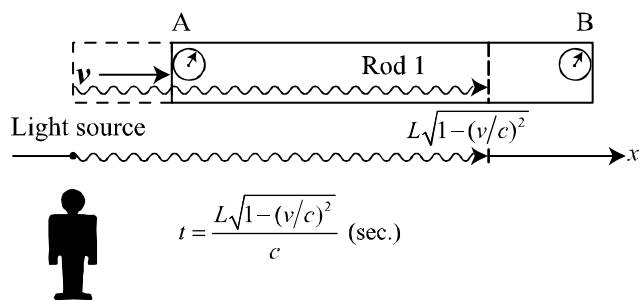
$$\frac{2 AB}{t'_A - t_A} = c,$$

to be a universal constant — the velocity of light in empty space.”

Of this principle, the first portion is related to the definition of “principle of constancy of light speed I.” Hence, the following is related to the definition of “principle of constancy of light speed III.”

A ray of light emitted from the rear point A on the rod propagates at the same speed as a ray of light emitted from a light source in the stationary system (“Principle of constancy of light speed I”).

To an observer in the stationary system who sees this ray of light propagation, it will appear that B is moving further away from the stationary system light source during the time that it takes for the ray of light to travel from the rear of the rod to B at the front of the rod (see Fig.2).



Primary stationary system

Fig2

Fig.2 If a ray of light is emitted at the same time from a light source in front of a stationary observer and from point A on the rear end of a rod moving at constant velocity, each will propagate at constant velocity c because light speed is not dependent on the velocity of the

source from which the light is emitted. When this ray of light arrives at the position $x = L\sqrt{1-(v/c)^2}$ after $L\sqrt{1-(v/c)^2}/c$ seconds according to the clock of the observer in the stationary system, point B on the front of the rod is no longer at that location but has moved ahead in space.

Therefore, the time required for a ray of light to pass by both ends of a rod of length $L\sqrt{1-(v/c)^2}$ is not necessarily $L\sqrt{1-(v/c)^2}/c$ when measured from the watch of an observer in the stationary system.

Ultimately, an observer in the stationary system will measure the time required for a ray of light to travel from A to B ($t_B - t_A$) as longer than the time required for it to return from B back to A ($t'_A - t'_B$).

The term $c - v$ of Eq. (3) does not imply that the light speed is affected by the speed of the light source. The light speed holds as c . Therefore, $c - v$ of Eq. (3) does not represent changes in light speed.

Because Eq. (3) is from the cited paper of Einstein, there should be no disagreement regarding this equation. However, to avoid any misunderstanding, the validity of Eq. (3) was shown above.

Also, because time passes more slowly in the moving system,¹⁵ during the passage of ($t_B - t_A$) seconds in the stationary system, the passage of time in the moving system ($t'_B - t'_A$) as observed by an observer in the stationary system can be written as follows.

$$t'_B - t'_A = (t_B - t_A)\sqrt{1-(v/c)^2} \quad (\text{sec.}) \quad (4)$$

From these two formulas, the following formula can be derived.

$$t'_B - t'_A = \frac{L(c+v)}{c^2} \quad (\text{sec.}) \quad (5)$$

Similarly, the passage of time ($t'_A - t'_B$) in the moving system for light to return to A from B as observed by an observer in the “primary stationary system.”

$$t'_A - t'_B = \frac{L(c-v)}{c^2} \quad (\text{sec.}) \quad (6)$$

For the sake of simplicity, these two formulas can be written as follows when t'_A is zero.

$$\frac{1}{2}t'_A = t'_B \quad (7a)$$

$$= \frac{1}{2} \left[\frac{L(c+v)}{c^2} + \frac{L(c-v)}{c^2} \right] \quad (7b)$$

$$= \frac{L}{c} \quad (\text{sec.}) \quad (7c)$$

While the observer in the “primary stationary system” would judge that the passage of time of the clocks on both ends of the rod for the time for a ray of light to reach B from A is $L(c+v)/c^2$ seconds, when this light reaches B, by definition, the time shown on clock B must be L/c seconds.

However, since $L(c+v)/c^2 > L/c$, the time at clock B must be later than the time at clock A to resolve this discrepancy. Thus, if the time adjustment to make the actual time at clock B later is Δt_1 , it should be possible to take the difference between the two as this time. Namely,

$$\Delta t_1 = \frac{L(c+v)}{c^2} - \frac{L}{c} \quad (8a)$$

$$= \frac{Lv}{c^2} \quad (\text{sec.}) \quad (8b)$$

Through this procedure, the two clocks achieve simultaneity in the moving system, and we verify that the thought experiment until now is simply a training exercise that applicable to existing theory.

5. Violation of STR as derived from synchronization of clocks

Let us consider a case in which rod 2, identical to rod 1 from Sec. 4, is moving at constant velocity w (where $w \gg v$). (Like the clocks of rod 1, the clocks of rod 2 are synchronized while they are stationary)

Next, we repeatedly perform the thought experiment for rod 2 according to the same method performed for rod 1 in Sec. 4. Where Δt_2 is the time adjustment to be performed for clock B of rod 2,

$$\Delta t_2 = \frac{Lw}{c^2} \quad (\text{sec.}) \quad (9)$$

Then, rather than moving rod 2 first at constant velocity w , we perform the first experiment when moving at constant velocity v . In other words, in the initial stage rod 2 is moving in parallel to rod 1 at constant velocity v , and at this time the clock B of rod 2 is adjusted the first time by Δt_1 according to the same method as the clock B of rod 1 (see Fig.3).

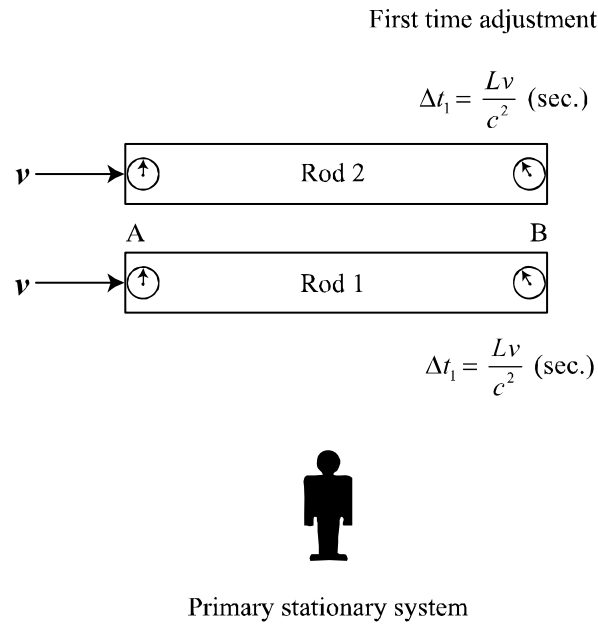


Fig3

Fig.3 Time adjustment Δt_1 of clock B of rod 1 and first time adjustment Δt_1 of clock B of rod 2, as predicted by an observer in the “primary stationary system.”

Then, we accelerate rod 2 until constant velocity w , and we assume that this velocity w is the speed at which the relative velocity between rod 1 and rod 2 is v' .

Therefore, according to the addition theorem for velocities of the STR, this velocity relationship can be represented as follows.

$$w = \frac{v + v'}{1 + \frac{vv'}{c^2}} \quad (10)$$

Here, if the second time adjustment of the clock B of rod 2 when rod 2 reaches velocity w is Δt_3 , then an observer in the “primary stationary system” can determine

that the following relationship exists between these three time adjustments.

$$\Delta t_2 = \Delta t_1 + \Delta t_3. \quad (11)$$

From the above, an observer in the “primary stationary system” can predict Δt_3 as follows (see Fig.4).

$$\Delta t_3 = \Delta t_2 - \Delta t_1 \quad (12a)$$

$$= \frac{L(w-v)}{c^2} \quad (\text{sec.}) \quad (12b)$$

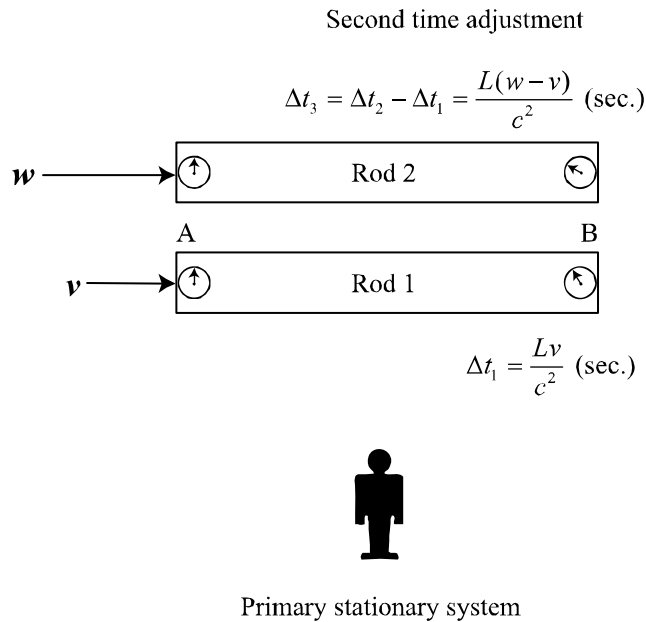


Fig4

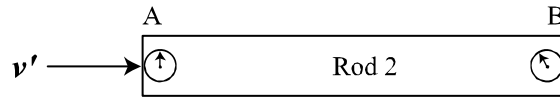
Fig.4 Second time adjustment Δt_3 of clock B of rod 2, as predicted by an observer in the “primary stationary system.”

Incidentally, according to the STR, if there is an inertial system in which objects are in relative motion between each other, then the only important velocity is the relative velocity between coordinate systems. Therefore, an observer on the coordinate system of rod 1 would perceive that his coordinate system was stationary and that the coordinate system of rod 2 was moving at constant velocity v' . Thus, an observer on rod 1 could assert that the time adjustment of clock B of rod 2 would be Δt_4 as follows (see

Fig.5).

$$\Delta t_4 = \frac{Lv'}{c^2} \quad (\text{sec.}) \quad (13)$$

$$\Delta t_4 = \frac{Lv'}{c^2} \neq \frac{L(w-v)}{c^2} \quad (\text{sec.})$$



Observer on Rod 1

Conditional stationary system

Fig5

Fig.5 Time adjustment Δt_4 of clock B of rod 2, as predicted by observer on rod 1 who believes his coordinate system is stationary.

Ultimately, the times predicted by the observer in the “primary stationary system” and the observer on rod 1 are different.

When measuring the length of a moving rod, because the length of objects is a relativistic physical quantity, a difference in the length of the rod occurred depending on the relative velocity of the observer and the rod’s coordinate system. However, because the observer of rod 2 is actually performing the time adjustment in this case, this adjusted time is absolute. In other words, it is impossible that both Δt_3 and Δt_4 are correct.

This paper asserts that Eq. (12b) is the actual time adjustment that the observer on rod 2 would make; but what would be the time adjustment if the observer on rod 2 used the STR to predict the adjustment value?

According to Einstein, the coordinate systems of rod 1 and rod 2 are moving relative to each other and are therefore equivalent. For this reason, it is only natural that an observer on rod 1 using the STR to predict the adjustment time of a clock in the

coordinate system of rod 2 would predict this to be Eq. (13), and an observer on rod 2 would also predict the adjustment value for his own coordinate system to also be Eq. (13).

However, in this thought experiment, the time adjustment value as predicted by the observers using the STR would be equal to Eq. (8b) when adjusting the clock time in the coordinate system of rod 1 moving at constant velocity relative to the “primary stationary system” (the stationary system of Fig.1).

On the other hand, the second time adjustment amount made by the observer in the coordinate system of rod 2 moving at constant velocity v' relative to the “conditional stationary system” (the coordinate system of rod 1 in Fig.1 to 4), is Eq. (12b). This is not equal to Eq. (13), which is the value predicted by the observer based on the STR.

This discrepancy shows the existence of a thought experiment that can differentiate between these two types of stationary systems.

6. Conclusion

This paper considered the coordinate system of rod 2, moving at constant velocity relative to a “conditional stationary system” (Einstein’s inertial frame of reference), as considered in this paper as equivalent to inertial frame of reference of the STR. Then, it was shown that, the actual time adjustment Eq. (12b) made by an observer in this coordinate system to synchronize two clocks at each end of a rod by using Einstein’s method is not the same as Eq. (13), the value predicted by the STR.

As shown here, when a discrepancy occurs between experimental and theoretical values, we can conclude that the coordinate system where we adjusted the time when the rod was initially stationary was the “conditional stationary system;” when the two values match, the initial time adjustment coordinate system for the rod was the “primary stationary system.”

As clearly shown by comparing Eq. (12b) and Eq. (13), the reason for the discrepancy between experimental values and theoretical values is due to the unknown velocity v which is related to “conditional stationary systems,” the existence of which Einstein denied (the coordinate system of rod 1 in this paper).

Let us further imagine the existence of multiple “conditional stationary systems” and multiple rods at the same velocities in each of their stationary systems.

In this case, the time adjustment to calibrate the clocks at both ends of these rods is dependent on the unknown velocity v which is related to that stationary system. Therefore, depending on the size of v , there will be differences in the time adjusted by observers in the coordinate systems of the rods, even if the all rods are moving at equal velocities.

Thus, although it was stated in the explanation of “principle of constancy of light speed III” that there is no currently known method to differentiate between the “primary stationary system” and a “conditional stationary system,” the thought experiment of this paper shows that it is possible to differentiate between these two types of stationary systems.

This paper therefore concludes that Einstein was incorrect in considering all inertial frames of reference to be equal when developing the STR.

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