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

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(Received 24 June 2009; accepted 13 July 2010; published online 4 August 2010)

Abstract: In the thought experiment of this paper, we first synchronized the times of clock A and clock B on each end of a rod of length L at rest in a stationary system by Einstein's method using light signals. Next, the rod that was at rest begins moving, and an observer on the rod performed a second time synchronization when constant velocity $\boldsymbol{v}$ is reached in relationship to the coordinate system in which the rod was initially at rest. The purpose of this operation is to ensure that the times of both clocks are the same for the coordinate system of the rod moving at constant velocity. The amount of this time adjustment from the viewpoint of an observer on the rod is sometimes Lv/c^2 (s) and is sometimes not Lv/c^2 (s). According to the special theory of relativity, the same principle of relativity must be upheld in all frames of reference. However, it is not possible to predict the amount of time calibration for the second synchronization of clocks on each end of a rod moving at constant velocity in this experiment, even if its velocity is known. Even though the velocity is fixed, the amount of time calibration is not fixed. This result completely contradicts the principle of relativity. This paper concludes that the reason for this breakdown of the principle of relativity is the failure to consider an unknown velocity vector related to the coordinate system in which the rod was initially at rest. This paper also predicts the existence of an unknown stationary system as the source of this velocity vector. This forces the need to completely revise the special theory of relativity.
 [DOI: 10.4006/1.3474836]

Résumé: L'expérience de pensée proposée dans ce rapport commence par la synchronisation au moyen de signaux lumineux, selon la méthode d'Einstein, d'une horloge A et d'une horloge B, placées aux deux extrémités d'une barre de longueur L dans un référentiel statique donné. L'observateur de cette barre effectue par la suite une deuxième synchronisation, au moment où la barre en arrêt, qui s'est mise en mouvement, atteint la vitesse constante $\boldsymbol{v}$ par rapport à son référentiel de départ. Cette manipulation vise à synchroniser les horloges dans le référentiel de la barre en mouvement uniforme. L'heure indiquée par les horloges après ce réajustement correspond dans certain cas à Lv/c^2 mais dans d'autres cas non. La théorie de la relativité restreinte affirme que tous les référentiels galiléens répondent aux mêmes lois physiques. Or, notre rapport montre qu'on ne peut prévoir la valeur de l'heure après le deuxième réglage des horloges placées aux extrémités de la barre en mouvement uniforme, quand bien même la vitesse de cette barre est connue. La vitesse est définie mais l'heure réajustée ne l'est pas. Ce résultat est en complète contradiction avec le principe de relativité. Nous concluons dans ce rapport que l'échec du principe de relativité est dû au fait qu'il néglige l'existence d'un vecteur-vitesse inconnu opérant dans le référentiel de départ. Dans le même temps, nous conjecturons dans ce rapport l'existence d'un référentiel statique inconnu à l'origine de ce vecteur-vitesse. Une révision complète de la théorie de la relativité restreinte est de ce fait requise.

Key words: Special Theory of Relativity; Definition of Simultaneity; Time Adjustment of Clocks; Relativity Violation.

I. INTRODUCTION

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

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

On the other hand, Lorentz was convinced of 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 $\boldsymbol{v}$ 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) pub-

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lished in 1905, Einstein insisted that physics does not require an "absolutely stationary system" provided with special properties, and that there be no such things as "especially-favored" coordinate systems to occasion the introduction of the ether-idea.[3] Einstein's aim at the time was not to explain the reason, like Lorentz and Poincaré, the expected results were not observed in the Michelson–Morley experiment, but to instead derive a conversion equation between coordinate systems in order to resolve the asymmetry apparent in electromagnetism.

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. 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.

This paper presents a thought experiment that attempts to resolve this question.

II. TIME ADJUSTMENT OF CLOCKS IN A MOVING COORDINATE SYSTEM

In order to explain why the Michelson–Morley experiment did not detect the expected result, presented here are the two different interpretations of Michelson and Lorentz.

Considering these two interpretations from the perspective of propagation of light, in the coordinate system for Earth as envisioned by Michelson, light propagates isotropically away from the light source (this kind of coordinate system is referred to as "Michelson's coordinate system," hereafter referred to as "coordinate system M").

However, for the case of Lorentz in a laboratory on the surface of Earth which is moving through an ether, light propagates anisotropically (this kind of coordinate system is referred to as "Lorentz's coordinate system," hereafter referred to as "coordinate system L").

However, Einstein believed that it was impossible to tell the difference between coordinate system M and L through experimental methods.

So, Einstein proposed to synchronize both clocks in order to make it possible to state that a light signal emitted from the middle of a train will arrive at the same time at clocks affixed to walls at each end of the train moving at constant speed. (Einstein does not address whether the times of light's arrival as shown on clocks at each end of the train are absolutely the same time or not.)

Following Einstein's approach, light will arrive at the same time to clocks on both walls of the laboratory even in "coordinate system L."

Therefore, observers in both coordinate systems M and L would conclude that light is propagating isotropically in their own coordinate systems. By synchronizing the proposed clocks, Einstein rendered it physically meaningless to attempt to differentiate between these two types of coordinate systems.

However, this paper presents a thought experiment that makes it possible to distinguish between these two types of coordinate systems.

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 ("principle of relativity").

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.

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 stationary 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 building the STR, Einstein proposed the following "principle of constancy of light speed."

> "Any ray of light moves in the "stationary" system of coordinates with the determined velocity c, whether the ray be emitted by a stationary or by a moving body."[4] "Let a ray of light start at the "A time" t_{A} from A toward B, let it at the "B time" t_{B} be reflected at B in the direction of A, and arrive again at A at the "A time" t'_{A}.
>
> In agreement with experience, we further assume the quantity
>
> $$\frac{2\mathrm{AB}}{t'_{\mathrm{A}} - t_{\mathrm{A}}} = c,$$
>
> to be a universal constant—the velocity of light in empty space."[5]

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.[4]

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 $t'_{\mathrm{A}'}$, of clock A, then this time relationship can be represented by the following two formulas:

$$t'_{\mathrm{B}} - t'_{\mathrm{A}} = t'_{\mathrm{A}'} - t'_{\mathrm{B}}. \tag{1}$$

$$\tfrac{1}{2}(t'_{\mathrm{A}} + t'_{\mathrm{A}'}) = t'_{\mathrm{B}}. \tag{2}$$

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

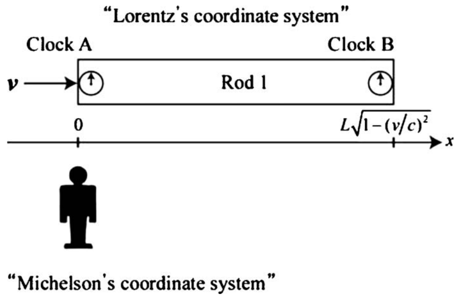

FIG. 1. Rod 1 is moving at constant velocity $\boldsymbol{v}$ relative to Michelson's coordinate system. Clocks A and B are set up at A and B at each end of this rod, and the times of each of these clocks are synchronized while the system is stationary.

Let us imagine a rod placed in a stationary system. Next, we synchronize clocks placed at each end of this rod while it is stationary, according to Einstein's method. Then, this rod begins moving at constant velocity relative to this stationary system (see Appendix A).

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.

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 $\boldsymbol{v}$ (see Fig. 1).

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 $t'_{\mathrm{A}'}$ of clock A. Let us imagine that times t'_{A}, t'_{B}, and $t'_{\mathrm{A}'}$ of this moving system corresponds to times t_{A}, t_{B}, and $t_{\mathrm{A}'}$ of the stationary system.

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

> "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 Sec. I for the synchronization of two clocks. Let a ray of light depart from A at the time t_{A},[1] 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
>
> $$t_{\mathrm{B}}-t_{\mathrm{A}}=\frac{r_{\mathrm{AB}}}{c-v} \text{ and } t'_{\mathrm{A}}-t_{\mathrm{B}}=\frac{r_{\mathrm{AB}}}{c+v},$$
>
> where r_{AB} denotes the length of the moving rod—measured in the stationary system."

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}, and 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 has not been accounted for in $(t_{\mathrm{B}}-t_{\mathrm{A}})$ and $(t'_{\mathrm{A}}-t_{\mathrm{B}})$. 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."[6]

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 recalibrated 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 $(t_{\mathrm{B}}-t_{\mathrm{A}})$, in s, is

$$t_{\mathrm{B}}-t_{\mathrm{A}}=\frac{L\sqrt{1-(v/c)^2}}{c-v} \quad (\mathrm{s}). \tag{3}$$

The numerator $L\sqrt{1-(v/c)^2}$ of the right side of Eq. (3) corresponds to r_{AB} in the previously cited Einstein's equation.

In Eq. (3), does not the "principle of constancy of light speed" prohibit $c-v$?

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).

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.

[1]"Time" here denotes "time of the stationary system" and also "position of hands of the moving clock situated at the place under discussion."[6]

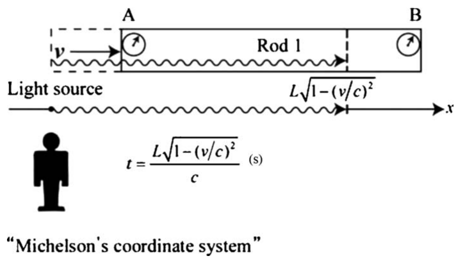

FIG. 2. If a ray of light is emitted at the same time from a light source in front of a stationary observer and from point A on the rear end of a rod moving at constant velocity, each will propagate at constant velocity c because light speed is not dependent on the velocity of the source from which the light is emitted. When this ray of light arrives at the position $x = L\sqrt{1-(v/c)^2}$ after $L\sqrt{1-(v/c)^2}/c$ (s) 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.

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, $c-\boldsymbol{v}$ 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.

Incidentally, among the Lorentz transformations, the following are the transformations for time:

$$t' = \gamma\left(t - \frac{vx}{c^2}\right) \quad \text{with} \quad \gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}. \tag{4}$$

The inverse transformation for Eq. (4) is

$$t = \gamma\left(t' + \frac{vx'}{c^2}\right). \tag{5}$$

The following relation is derived in the textbook by French.[7]

$$t_2' - t_1' = \gamma(t_2 - t_1). \tag{6}$$

Equation (4) is the transformation used to derive Eq. (6), but this paper addresses the opposite perspective. That is, the observer in frame S' is the one who derived Eq. (6), but the observer in system S is the one who derives Eq. (10) in this paper. Therefore, the transformation used in this paper must be Eq. (5).

Keeping this in mind, we proceed with the following discussion, borrowing the reasoning in the textbook by French as is.

Let us imagine that a single clock is at rest at the point $x' = x_0'$ in frame S'. Consider two events corresponding to two different readings of the clock: Event 1: (x_0', t_A'); Event 2: $(x_0', t_{A'}')$.

Let us now calculate the time coordinates of these events as measured in the frame S that has a velocity $\boldsymbol{v}$ with respect to S'.

Using the Lorentz transformations, we have

$$t_A = \gamma\left(t_A' + \frac{vx_0'}{c^2}\right) \quad \text{with} \quad \gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}. \tag{7}$$

$$t_{A'} = \gamma\left(t_{A'}' + \frac{vx_0'}{c^2}\right). \tag{8}$$

Therefore,

$$t_{A'} - t_A = \gamma(t_{A'}' - t_A'). \tag{9}$$

Rewriting this equation, we derive the following equation:

$$t_{A'}' - t_A' = (t_{A'} - t_A)\sqrt{1-(v/c)^2}. \tag{10}$$

Here, the left side of Eq. (10) can be written as

$$t_{A'}' - t_A' = (t_B' - t_A') + (t_{A'}' - t_B'). \tag{11}$$

On the other hand, the right side of Eq. (10) can be written as

$$(t_{A'} - t_A)\sqrt{1-(v/c)^2} = \{(t_B - t_A) + (t_{A'} - t_B)\}\sqrt{1-(v/c)^2}. \tag{12}$$

Combining the right sides of Eqs. (11) and (12), we derive the following relationship:

$$(t_B' - t_A') + (t_{A'}' - t_B') = \{(t_B - t_A) + (t_{A'} - t_B)\}\sqrt{1-(v/c)^2}. \tag{13}$$

Incidentally, the times in the stationary system t_A, t_B, and $t_{A'}$ correspond to the times t_A', t_B', and $t_{A'}'$, which elapse at one point in the moving system.

Therefore, Eq. (13) can be separated into the following two equations:

$$t_B' - t_A' = (t_B - t_A)\sqrt{1-(v/c)^2}. \tag{14a}$$

$$t_{A'}' - t_B' = (t_{A'} - t_B)\sqrt{1-(v/c)^2}. \tag{14b}$$

In order to clarify this discussion, we represent the time t_A' (clock A), $t_{A'}'$ (clock A) of clock A at time t_A', $t_{A'}'$, and the time t_B' of clock B at time as t_B' (clock B). Also, t_B' (clock A) refers to the time of clock A when light emitted from point A (clock A) reaches point B (clock B). Based on the above, Eq. (14a) can be expressed as follows:

$$t_B'(\text{clock A}) - t_A'(\text{clock A}) = (t_B - t_A)\sqrt{1-(v/c)^2}. \tag{15}$$

Incidentally, this paper does not simply synchronize the times of clocks at both ends of the rod moving at constant velocity using Einstein's method. It also addresses the actual time for adjustment as a problem.

Therefore, it was necessary for the times of clocks, at both ends of a rod whose times were originally synchronized while stationary in frame S, to match completely for an observer in the stationary system.

When this rod begins to move at a constant velocity, the passage of time of the clocks at both ends of the rod slows down, but the tempo with which these two clocks count off time is the same. Therefore, in this situation, when the time in frame S is t_A, the times of clocks A and B in frame S' are both t_A'. When the time in frame S is t_B, the times of clocks A and B in frame S' are both t_B'.

If it is assumed that light departing from point A at time t'_A arrives at clock B at time t'_B, then that time difference is $(t'_B - t'_A)$.

This time difference matches the time, which elapses on clock A, while light propagates from point A to point B.

Let us imagine the coordinate system in which clocks at both ends of a rod are originally synchronized as the "coordinate system M." The times of clock A and clock B on each end of a rod, which has begun moving at constant velocity, are in sync in absolute terms. Therefore, at the stage when constant velocity begins in relation to the "coordinate system M," the following relationship is true between clock A and clock B, which have not yet been recalibrated to show the same time in the moving system as observed by an observer in the "coordinate system M."

$$t'_B(\text{clock A}) - t'_A(\text{clock A}) = t'_B(\text{clock B}) - t'_A(\text{clock A}). \tag{16}$$

Meanwhile, when the first time synchronization is performed in the "coordinate system L," the times of clock A and clock B cannot be said to be the same as observed by an observer in the "coordinate system M." Therefore,

$$t'_B(\text{clock A}) - t'_A(\text{clock A}) \neq t'_B(\text{clock B}) - t'_A(\text{clock A}). \tag{17}$$

Incidentally, Michelson predicted that light emitted from a light source on the x-axis of "coordinate system M" would reach points $x = \pm L$ at "absolutely the same time." If we follow Michelson's supposition in this paper without any changes, then it might appear to readers that the author is inferring the existence of a stationary ether system. Some readers may be thinking that this paper is completely ignoring STR. However, rather than providing an explanation here using the concept of "absolutely the same time," the author will instead provide this explanation at the time when it is possible to convince readers in the conclusion outlined in Sec. IV.

Now, based on Eqs. (15) and (16), the following relationship is true:

$$t'_B(\text{clock B}) - t'_A(\text{clock A}) = (t_B - t_A)\sqrt{1-(v/c)^2}. \tag{18}$$

As indicated above, if the coordinate system where the times of clocks on both ends of the rod were first synchronized was a coordinate system M, then we can conclude that Eq. (18) holds true if Eq. (15) holds true.

On the other hand, if the coordinate system where the times of clocks on both ends of the rod were first synchronized was a coordinate system L, then Eq. (18) does not hold true, even if Eq. (15) holds true. Namely,

$$t'_B(\text{clock B}) - t'_A(\text{clock A}) \neq (t_B - t_A)\sqrt{1-(v/c)^2}. \tag{19}$$

Incidentally, from Eqs. (3) and (18), the following formula can be derived in the coordinate system M.

$$t'_B - t'_A = \frac{L(\sqrt{1-(v/c)^2})^2}{c^2} \tag{20a}$$

$$= \frac{L(c+v)}{c^2} \quad (\text{s}). \tag{20b}$$

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 coordinate system M.

$$t'_{A'} - t'_B = \frac{L(c-v)}{c^2} \quad (\text{s}). \tag{21}$$

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

$$\tfrac{1}{2}t'_{A'} = \tfrac{1}{2}[(t'_B - t'_A) + (t'_{A'} - t'_B)] \tag{22a}$$

$$= \frac{1}{2}\left[\frac{L(c+v)}{c^2} + \frac{L(c-v)}{c^2}\right] \tag{22b}$$

$$= \frac{L}{c} \quad (\text{s}). \tag{22c}$$

While the observer in the coordinate system M 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, it should be possible to take the difference between the two as this time. Namely,

$$\Delta t = (t'_B - t'_A) - \tfrac{1}{2}t'_{A'} \tag{23a}$$

$$= \frac{L(c+v)}{c^2} - \frac{L}{c} \tag{23b}$$

$$= \frac{Lv}{c^2} \quad (\text{s}). \tag{23c}$$

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.

Therefore, when adjusting time in this way, we must either set clock A ahead by Δt or set clock B behind by Δt.

In the normal time synchronization method as proposed by Einstein, clocks only need to be synchronized in order to confirm the veracity of Eqs. (1) and (2) hold true—there is no need to determine how large of an adjustment is required.

By calibrating time in this way, the relationship between Eqs. (1) and (2) is upheld in this moving system as well.

III. DISCUSSION

In Sec. II, it was proven that it is possible to differentiate between "Michelson's coordinate system" and "Lorentz's coordinate system" from the amount of calibration time of clocks moving at constant velocity, but why is the calibration time for clocks on a rod moving at constant velocity in relation to the coordinate system L different from Lv/c^2 (s)?

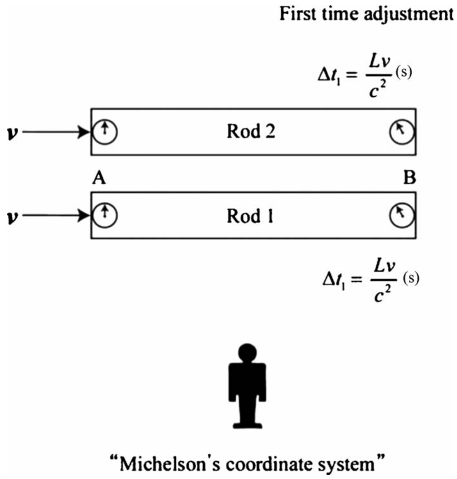

FIG. 3. Time adjustment Δt_1 of clock B of rod 1 and first time adjustment Δt_1 of clock B of rod 2, as predicted by an observer in the Michelson's coordinate system.

Here, let us consider a case in which rod 2, identical to rod 1 from Sec. II, is moving at constant velocity $\boldsymbol{w}$ (where $\boldsymbol{w} \gg \boldsymbol{v}$). (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. II where Δt_2 is the time adjustment to be performed for clock B of rod 2,

$$\Delta t_2 = \frac{Lw}{c^2} \quad (\mathrm{s}). \tag{24}$$

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

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

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

$$w = \frac{v + v'}{1 + \frac{vv'}{c^2}}. \tag{25}$$

Here, if the second time adjustment of clock B of rod 2 when rod 2 reaches velocity $\boldsymbol{w}$ is Δt_3, then an observer in the coordinate system M can determine that the following relationship exists between these three time adjustments.

$$\Delta t_2 = \Delta t_1 + \Delta t_3. \tag{26}$$

From the above, an observer in the coordinate system M can predict Δt_3 as follows (see Fig. 4):

$$\Delta t_3 = \Delta t_2 - \Delta t_1 \tag{27a}$$

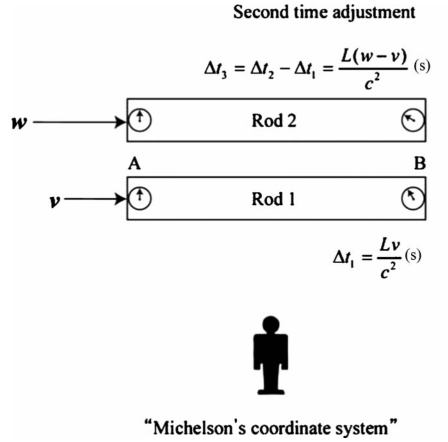

FIG. 4. Second time adjustment Δt_3 of clock B of rod 2, as predicted by an observer in the Michelson's coordinate system.

$$= \frac{L(w - v)}{c^2} \quad (\mathrm{s}). \tag{27b}$$

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 $\boldsymbol{v}'$. 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):

$$\Delta t_4 = \frac{Lv'}{c^2} \quad (\mathrm{s}). \tag{28}$$

Ultimately, the times predicted by the observer in Michelson's coordinate system and the observer on rod 1 (Lorentz's coordinate system) are different (see Appendix B).

Based on calibration time for the "second time synchronization" of the clocks from the moving system, it is possible to determine whether the coordinate system in which the clocks were originally synchronized while they were at "rest" is, in fact, the coordinate system M or the coordinate system L.

In this case, the time adjustment to calibrate the clocks at both ends of these rods is dependent on the unknown veloc-

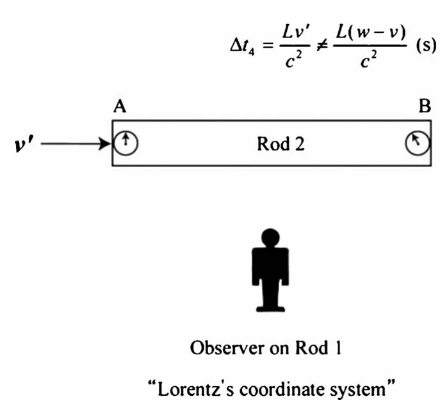

FIG. 5. Time adjustment Δt_4 of clock B of rod 2, as predicted by observer on rod 1 who believes his coordinate system is stationary.

TABLE I. Physical principles and observed experimental results in two types of stationary systems.

Stationary system where clocks of rod are initially synchronized	"Michelson's coordinate system"	"Lorentz's coordinate system"
Relationship of Eq. (16)	Upheld	Not upheld
Time Δt for calibrating clocks on rod that has begun moving at constant velocity $\boldsymbol{v}$	$\Delta t = Lv/c^2$	$\Delta t \neq Lv/c^2$ unable to predict

ity $\boldsymbol{v}$ which is related to that stationary system. Therefore, depending on the size of $\boldsymbol{v}$, there will be differences in the time adjusted by observers in the coordinate systems of the rods, even if all rods are moving at equal velocities.

IV. CONCLUSION

Let us summarize the process of the thought experiment outlined in this paper. First, times of clocks A and B on each end of a rod of length L placed in a stationary space were synchronized by using light signals. This time synchronization was performed using the method proposed by Einstein.

This rod next began moving, and when the rod reaches constant velocity $\boldsymbol{v}$ with relation to the coordinate system in which it was initially at rest, observers on the rod then synchronized the clocks a second time. This operation was performed to ensure that both clocks showed the same time within the coordinate system of the rod.

This paper drew the following conclusions based on the amount of time adjustment performed by the observers on the rod at this time (see Table I).

However, at issue here is the usage of the expression "absolutely the same time" in this paper with reference to light propagation in coordinate system M. This expression is forbidden by the STR. The author is fully aware that it is not physically acceptable or possible to simply use this expression "absolutely the same time" without violating STR.

Thus, the thought process until now is abandoned for now when we have a relatively solid conclusion. Let us then instead attack this from the opposite direction and use the second time synchronization to define the coordinate system in which the rod was initially placed.

As the result of the thought experiment in this paper, time adjustment (23c) was required to uphold the relationship equation (16) between clocks A and B on each end of a rod moving at constant velocity.

However, if we turn this principle around, we conclude that when the second time adjustment is Eq. (23c), then Eq. (16) must hold true for the relationship between the times of clocks A and B. When this relationship is true, we define the coordinate system in which the clocks on each end of the rod were initially synchronized as Michelson's coordinate system. We can conclude that light propagates isotropically in Michelson's coordinate system.

Now, what is the case when the amount of second time adjustment is not Eq. (23c)? In this case, we define the coordinate system in which the clocks on each end of the rod were first synchronized as Lorentz's coordinate system. We can conclude that light propagates anisotropically in Lorentz's coordinate system. The above conclusions are summarized in Table II.

Because light does not propagate isotropically in coordinate system L, initially assumed to be the stationary system, Eq. (16) cannot be true for the relationship between the two clocks in the coordinate system of the rod that has begun moving at constant velocity (see Appendix C).

It is therefore possible for this paper to predict the existence of an unknown velocity related to coordinate system L based on the outcome of this experiment.

Furthermore, it is also possible to predict not only the existence of a velocity vector but also predict at the same time the existence of an unknown stationary system as the starting point of this velocity vector.

In this paper, the times of clocks at each end of a rod beginning motion at a constant velocity were synchronized a second time in order to be able to say that they show the same time in the coordinate system of the rod. The case in which the clock synchronization amount is Lv/c^2 (s) was defined as the coordinate system for the rod initially at rest as Michelson's coordinate system.

Based on analysis of various experiments conducted since the Michelson–Morley experiment, I believe that the current coordinate system of Earth is Michelson's coordinate system.[8–11]

However, this position is not intended to support the belief of early 20th century physicists in a virtual substance such as the ether that Michelson presumed to be surrounding Earth. In modern terms, it is natural to presume that light in the form of virtual particles acting as waves in a vacuum is the medium for propagation.

Let us assume that the coordinate system of Earth is indeed Michelson's coordinate system in which light propagates isotropically. Even in this case, even for Michelson's

TABLE II. Defining coordinate system when rod was initially at rest based on second time synchronization.

Time Δt for calibrating clocks on rod that has begun moving at constant velocity $\boldsymbol{v}$	$\Delta t = Lv/c^2$	$\Delta t \neq Lv/c^2$
Relationship of Eq. (16)	Upheld	Not upheld
Stationary system where clocks of rod are initially synchronized	"Michelson's coordinate system"	"Lorentz's coordinate system"
Unknown physical quantity related to stationary system	None	Unknown velocity vector is contributing
"Principle of relativity"	Upheld	Not upheld. However, upheld if considering the existence of unknown velocity vector

coordinate system, there should exist some coordinate system in space that is moving at relative velocity to Earth. At the very least, no physical law exists that would rule out the existence of such a coordinate system.

Based on the above, the assertion of this paper is that we should not seek a coordinate system distant from this one as a candidate for the stationary system, which is the starting point of a velocity vector that is associated with the Lorentz's coordinate system.

Presented below is the definition of the unknown velocity vector, which is newly predicted by this paper.

According to quantum electrodynamics, a vacuum, which transmits electrical force, is thought to be filled with opposing pairs of virtual particles and antiparticles.

Also, according to the "uncertainty principle," these virtual particles are constantly fluctuating and not at rest, even when in the lowest energy state.

Therefore, there are countless relative velocities between the coordinate system of a point within physical space and the coordinate system of virtual particles in a vacuum occupying the same coordinates as that point.

An unknown velocity vector can be defined as the mean value of relative velocities at a given moment between the coordinate system of a point in physical space and countless coordinate systems of virtual particles in the vacuum occupying the same coordinates as that point.

Incidentally, Einstein adopted the following "principle of relativity" as the axiom when deriving STR.[4]

> "The laws by which the states of physical systems undergo change are not affected, whether these changes of state be referred to the one or the other of two systems of coordinates in uniform translatory motion."

However, this paper has shown frames of reference, which through Einstein's work have been presumed to all be the same, can actually be divided into two categories.

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

ACKNOWLEDGMENTS

I have quoted Einstein's original paper in Sec. II. I would like to express my thanks to Einstein. Also, I would like to express my thanks to the staff at ACN Translation Services for their translation assistance. Moreover, I wish to express my gratitude to Mr. H. Shimada for drawing figures. Finally, I have modified this manuscript based on the valuable comments of the Physics Essays reviewers. I would like to express my gratitude to the reviewers.

APPENDIX A

A rod that is initially at rest and then later reaches a constant velocity must undergo acceleration. However, STR does not address coordinate systems undergoing acceleration. Therefore, some readers may assert that STR is not applicable to this thought experiment.

From the perspective of an observer in the coordinate system in which the rod is initially at rest, the passage of time for clocks on each end of the rod once it has begun accelerating will appear slower than the passage of time for a clock in the observer's coordinate system.

However, this thought experiment does not take into consideration how far behind are the clocks on each end of the rod as it accelerates. Because the clocks at each end of the rod are ticking at the same tempo from the perspective of an observer in the stationary system, the times of the two clocks is always in sync. For this reason, no matter how late the two clocks become during rod acceleration, it has no effect on the outcome of the thought experiment of this paper.

When the rod begins moving, readers should also not imagine a stationary rod suddenly begins accelerating in the positive direction on the x-axis.

It is actually necessary to move the stationary rod in the negative direction on the x-axis ahead of time. Readers should imagine that the rod at this point begins acceleration in the positive direction of the x-axis and reaches constant velocity when passing the place where the rod is initially at rest. This situation is depicted in Fig. 1.

APPENDIX B

Even though we synchronized the clocks at each end of the rod when it was initially at rest, it is clearly a violation of the principle of relativity if we assume various values without confirming this time adjustment amount at second synchronization, after the rod has begun moving at constant velocity.

We cannot predict the clock synchronization amount even if we know the rod's speed. If the coordinate system in which the rod was initially at rest is Michelson's coordinate system, then the second time synchronization amount is Lv/c^2 (s). If the coordinate system in which the rod was initially at rest is a Lorentz's coordinate system; however, then the synchronization value is not Lv/c^2 (s); it is a value that cannot be predicted. This experimental outcome contradicts the principle of relativity. However, the objective of this paper is not to tear down the principle of relativity. Instead, the objective is to uphold the principle of relativity by enveloping this unknown velocity vector into the theory, as something which should be contributing essentially to Lorentz's coordinate systems.

APPENDIX C

Tables I and II present a paradox only evident in the Lorentz's coordinate system. They are not in Michelson's coordinate system. Therefore, STR proponents might disagree and feel that invalidity of my analysis of the Lorentz's coordinate system (light not propagating isotropically) does not affect STR. This paper thus explains about this problem.

According to the principle of relativity which Einstein required when building STR, the same physical laws apply to all frames of reference. Also, for this reason, all frames of reference are equivalent. Therefore, STR makes no differentiation for a stationary coordinate system.

Seeing the failure of the Michelson–Morley experiment to detect the expected motion of Earth relative to an ether, Einstein presumed that it would be physically meaningless to differentiate between Lorentz and Michelson coordinate systems.

Why, then, did scientists stop theorizing about differentiation between coordinate systems around the time of emergence of STR, differentiation being something that Michelson and Lorentz presumed absolutely must exist?

In building STR, Einstein asserted that times of clocks in different frames of reference should be synchronized in order to uphold the relationship between Eqs. (1) and (2).

Einstein's method requires this synchronization of clocks in these coordinate systems in order to be able to assert that light propagates isotropically in all frames of reference.

By making this time synchronization, light now propagates isotropically even in the coordinate systems of Lorentz, even though it should normally propagate anisotropically. This makes it difficult to differentiate between the two different of coordinate systems.

From Einstein's perspective, both the coordinate systems of Lorentz and Michelson were incorporated as a stationary system, and it was therefore unnecessary to further break down categories of stationary system.

Considering the above, it appears that Einstein mixed together frames of reference as a matter of course for the coordinate systems of Michelson and Lorentz, since he felt that all were equivalent.

Einstein did not disprove the existence of the two coordinate systems. Einstein's clever time calibration method rendered meaningless any differentiation between the Michelson and Lorentz coordinate systems.

Ultimately, because the frame of reference for STR embodies Lorentz's coordinate systems, any invalidation of the Lorentz coordinate system would result in a violation of the principle of relativity. In this case, STR would not survive because it depends fundamentally on the principle of relativity and would thus require modification of the theory.

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