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An Epistemological Analysis of Einsteinian Special Relativity: Do Physicists in Reality Use Lorentzian Ether Theory?

Qing-Ping Ma

Department of Finance, Accounting and Economics, Nottingham University Business School China, University of Nottingham Ningbo China

The present study examines the physical foundation of special relativity concepts and the derivations of time dilation and length contraction in special relativity. We find that the logical results of special relativity are time contraction and length expansion of the observed frame (moving frame). To obtain the same results as the Lorentz ether theory, special relativity calls the "relative time dilation" of the observing frame (rest frame) due to the time contraction of the observed frame the "time dilation". Similarly, special relativity calls the "relative length contraction" of the observing frame (rest frame) due to the length expansion of the observed frame the "length contraction". The Einsteinian "time dilation" and "length contraction" are the opposites of the Lorentzian time dilation and length contraction. We also find that the proper time and length of a reference frame are different from those of this frame's time and length observed by another frame, while the proper time and length of the two frames are equal. Since physical processes are governed by a frame's proper time and length, if acceleration does not impact a person's age, the twins in the twin paradox should be the same age when the traveling one returns. In replicating Lorentzian results rather than using its logical consequence, special relativity makes the Minkowski coordinates incapable of providing time intervals. Since special relativity effects are based on the relative velocity between two reference frames, terms such as "rest frame" and "moving frame" are inappropriate and ambiguous; they should be replaced by "observing frame" and "observed frame" in describing special relativity effects. At least regarding time dilation and length contraction, physicists are using the Lorentz ether theory rather than Einsteinian special relativity.

1. Introduction

The Lorentz transformation has been used in various scenarios in physics. It is generally believed that none of the experiments conducted so far to verify special relativity can distinguish between the two interpretations of the Lorentz transformation because Lorentzian ether theory and Einstein's special relativity have the same measurable predictions[1][2]. This is unusual given that Lorentzian ether theory leads to no paradoxes, while Einstein's special relativity produces many paradoxes. Mainstream physicists adopted Einstein's special relativity more on assumed philosophical grounds than on experimental evidence. Since the two theories differ substantially regarding the medium of light, variables in the apparently identical transformation might mean

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different measurements. What the variables in the Lorentz transformation equations stand for has not been clearly defined or scrutinized in special relativity literature[3][4].

The commonly expressed forms of the Lorentz transformation from an observing frame *K* to a frame *K'* that is moving along the positive direction of the observing frame's x-axis are

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}, t' = \frac{t - vx/c^2}{\sqrt{1 - \frac{v^2}{c^2}}}. \qquad (1)$$

The inverse transformation from the aforementioned observed frame *K'* to the observing frame *K* (now their roles are swapped) is

$$x = \frac{x' + vt'}{\sqrt{1 - \frac{v^2}{c^2}}}, t = \frac{t' + vx'/c^2}{\sqrt{1 - \frac{v^2}{c^2}}}. \qquad (2)$$

In a recent study, Ma[5] argues that the Lorentz transformation and the Poincaré transformation are transformations of coordinate differences rather than coordinates per se. The Lorentz transformation gives people the impression of a coordinate transformation because the initial values of variables in the Poincaré transformation all take a 0 value. Since they are transformations of coordinate differences, they need a reference point to provide the initial values. Therefore, the correct forms of the Lorentz transformation and the Poincaré transformation should be

$$dx' = \frac{dx - vdt}{\sqrt{1 - \frac{v^2}{c^2}}}, dt' = \frac{dt - vdx/c^2}{\sqrt{1 - \frac{v^2}{c^2}}}. dx = \frac{dx' + vdt'}{\sqrt{1 - \frac{v^2}{c^2}}}, dt = \frac{dt' + vdx'/c^2}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

Using the Lorentz transformation, Einstein derived the length contraction and time dilation[6], which Lorentz had hypothesized to explain the Michelson-Morley experiment and used to devise the Lorentz transformation[7][8][9][10][11]. In Lorentz's theory, the velocity *v* in the above equation is the one between a moving frame and the ether frame, which is somehow "absolute" in terms of the privileged ether frame. Lorentz's theory does not emphasize the synchronization of clocks at different locations in a reference frame, so we may consider them ideally synchronized in terms of the privileged ether frame. In Einstein's theory, *v* is the relative velocity between two frames without ether. Clock synchronization has a prominent role in special relativity, which largely underlies the relativistic effects through the relativity of simultaneity. How and why the different interpretations of *v* yield the same measurable predictions have not been well explored.

It is generally agreed that Lorentzian time dilation and length contraction are physical changes and Einsteinian ones are measurement effects due to the relativity of simultaneity[9][12]. It seems unusual that two different underlying mechanisms produce the same results or predictions. The present study analyzes the Einsteinian results from an epistemological perspective and investigates how special relativity obtains the same results as those predicted by the Lorentzian ether theory. We find that Einstein's special relativity, based on the relative velocity between two frames without ether as the medium for light, cannot produce the Lorentzian results logically; hence, the two theories do not give the same predictions. To replicate the Lorentzian results, Einsteinian researchers have mis-specified or misinterpreted the Einsteinian derivation of time and space effects of relative velocity between two reference frames. The rest of this paper is organized as follows: Section 2 presents a thought experiment that raises a question of time measurement by two reference frames; Section 3 explains how Lorentz devised the Lorentz transformation from length contraction and time dilation; Section 4 examines how Einsteinian time dilation and length contraction emerge from measurement with the relativity of simultaneity; Section 5 investigates how Einsteinian time dilation explains the twin paradox; Section 6 discusses the present findings; Section 7 concludes this study.

2. Time measured in two reference frames in relative motion

To illustrate issues in Einsteinian special relativity, we first present a thought experiment (as illustrated by Fig.1):

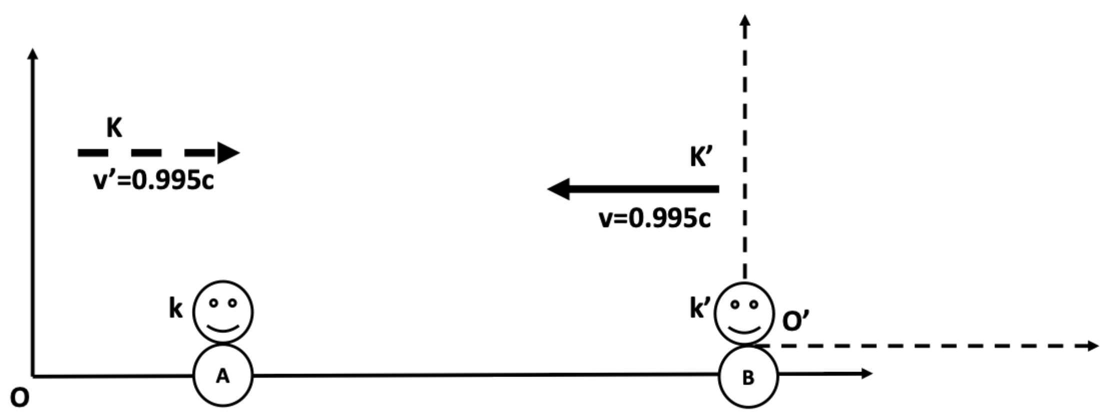

Figure 1. *The same time interval is measured by two reference frames K and K' with a relative velocity of 0.995 c. Observer k and observer k' are stationary at location A of frame K and the origin O' of frame K', respectively.*

"There are two fixed locations *A* and *B* on the *x*-axis in frame *K*. Observer *k* is stationary at location *A*, and another observer *k'* moves from location *B* to *A* with a velocity of 0.995*c*. Observer *k'* is stationary at the origin of frame *K'*, which uses standard measuring rods and clocks identical to those used in frame *K*. Thus, observer *k'* also finds that observer *k* moves from location "*A*" (we use "*A*" to indicate the location in frame K' that corresponds to A when the origin *O'* of frame *K'* coincides with B) to the origin *O'* of frame *K'* with a velocity of 0.995*c*. Our question is if the time used by observer *k'* to travel from *B* to *A*, as measured by frame *K*, is 6.4 μs, how long will it take for observer *k* (to travel from *A* to *O'*) to meet observer *k'* as measured in frame *K'*?"

Some relativists' answers are "about 0.64 μs," resulting from the Lorentzian time dilation formula $\Delta t' = \Delta t\sqrt{1 - v^2/c^2}$. If the time measured by the observer in frame *K'* is 0.64 μs, then is the follow-up question:

"There are two fixed locations *A* and *B* on the *x*-axis in frame *K*. Observer *k* is stationary at location *A*, and another observer *k'* moves from location *B* to *A* with a velocity of 0.995*c*. Observer *k'* is stationary at the origin of frame *K'*, which uses standard measuring rods and clocks identical to those used in frame *K*. Thus, observer *k'* also finds that observer *k* moves from location "*A"* to the origin *O'* of frame *K'* with a velocity of 0.995*c*. Our question is if the time used by observer *k* (to travel from "*A*" to *O'*) to meet observer *k'* as measured in frame *K'* is 0.64 μs, how long will it take for observer *k'* to travel from *B* to *A* (i.e., to meet observer *k*) as measured by frame *K*?"

Some of those relativists who have answered 0.64 μs answer 0.064 μs. However, the follow-up question is the same as the initial question, and the only difference is that the follow-up question provides time measured in frame *K'* and asks for time measured in frame *K*. Obviously, the answer 0.064 μs contradicts the initial value of 6.4 μs. Some researchers contend that only the first question can be asked; the follow-up question is not allowed in special relativity. This seems to be a very inadequate treatment of the conflicting answers to the two questions and shows discrepancies in people's understanding of special relativity. In the above thought experiment, if we allow the second question, the logically consistent result should be equal time intervals measured in the two reference frames. However, if the time interval measured by frame *K'* should also be 6.4 μs, what is the time dilation value 0.64 μs? This result suggests that the Lorentz time dilation formula cannot be used unscrupulously in Einsteinian special relativity. We need to understand what the variables in the time dilation formula represent and, more generally, what the variables in the Lorentz transformation represent.

3. From length contraction and time dilation to Lorentz transformation

Fitzgerald[13] first proposed length contraction to explain the null result of the Michelson-Morley experiment that measured the earth's velocity relative to ether in space[14][15]. Voigt[16] and Larmor[17][18] also proposed space and time transformations to explain the null result. Lorentz independently used length contraction and time dilation to explain the Michelson-Morley experiment[7][8][9]. Length contraction alone can explain the null result of the Michelson-Morley experiment, which uses interferometry with equal arms, but not those with unequal arms, such as the Kennedy-Thorndike experiment[19]. Lorentz's objective was to explain the Michelson-Morley experiment and find a transformation that ensures the invariance of Maxwell electromagnetic equations across reference frames.

The Fitzgerald-Lorentz length contraction formula is

$$l = l_0 \sqrt{1 - \frac{v^2}{c^2}}. \qquad (3)$$

In Eq. (3), l is the length of an object moving at v relative to the ether, and l_0 is its length at rest with the ether. The observers traveling with the object cannot observe this length contraction because they and their measuring rod would also contract proportionally. Only observers at rest in the ether frame can find the length contraction at the proportion of $\sqrt{1 - v^2/c^2}$. Length contraction can lead to the null result of the Michelson-Morley experiment but not to the constancy of the speed of light. It also implies that the same spatial distance measured by the moving frame will be larger in its numerical value,

$$x_r = \frac{x}{\sqrt{1 - \frac{v^2}{c^2}}}. \qquad (4)$$

In Eq. (4), x_r is the coordinate on the x-axis in the ether frame measured with a contracted measuring rod, and x is the same spatial distance measured with a measuring rod of the original length, that is, the length of the measuring rod when it is at rest in the ether frame.

The two-way apparent speed of light c_r for observers in the moving frame with a solid object of length l_0 and a velocity of v in the context of ether theory without length contraction should be

$$c_r = \frac{2l_0}{t} = \frac{c^2 - v^2}{c} = c - \frac{v^2}{c} = c\left(1 - \frac{v^2}{c^2}\right). \qquad (4)$$

With length contraction, the two-way apparent speed of light in the moving frame becomes

$$c_r = \frac{2l_0}{t\sqrt{1 - v^2/c^2}} = \frac{(c^2 - v^2)}{c\sqrt{1 - v^2/c^2}} = c\sqrt{1 - \frac{v^2}{c^2}}. \qquad (5)$$

Eq. (5) arises because the observers in the moving frame would still obtain the same value l_0 as the length at rest in the ether, and the apparent velocity of light in the ether frame measured with the contracted rod will be increased[4]. Thus, the light speed will still differ across reference frames, even with the Fitzgerald-Lorentz contraction.

To make the speed of light invariant across reference frames, Lorentz introduced the concept of "local time" and proposed that clocks in the moving frame will be slower, with each time unit representing a longer time interval, the so-called time dilation or, more precisely, time unit dilation. The formula for time dilation in the moving frame is

$$t_r = t\sqrt{1 - \frac{v^2}{c^2}}. \qquad (6)$$

Replacing t in Eq. (5) with t_r will return the value of c_r to c.

$$c_r = \frac{2l_0}{t_r\sqrt{1-v^2/c^2}} = \frac{(c^2-v^2)}{c\sqrt{1-v^2/c^2}\sqrt{1-v^2/c^2}} = c. \qquad (7)$$

How do length contraction and time dilation affect space and time transformation between the ether frame and the moving frame? Lorentz[9] proposed the following transformation between the moving frame *K'* and the ether frame *K*,

$$x' = \frac{x}{\sqrt{1-v^2/c^2}}, y' = y, z' = z. \qquad (8)$$

$$t' = t\sqrt{1-v^2/c^2} - \frac{vx/c^2}{\sqrt{1-v^2/c^2}}. \qquad (9)$$

In the above equations, x is the corresponding coordinate interval of x' in frame *K*, excluding the distance vt. Replacing x in Eq. (8) with x-vt will give us Eq. (1).

Eq. (8) can be obtained directly by applying contracted measuring rods to a spatial distance that does not change in the Lorentz ether theory. We might reconstruct how Lorentz obtained Eq. (9) by dividing the overall time used in frame *K* into the time for traveling the distance x-vt (corresponding to x' in the moving frame) and the time for traveling the distance vt. The first term on the right-hand side of Eq. (9) represents the total time for a beam of light to travel x, including vt, the second term is the time for the light beam to travel the distance vt (which is $vt' = \frac{vt}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{v(x-vt)/c}{\sqrt{1-\frac{v^2}{c^2}}}$ to observers in frame *K'*), both of which are measured by clocks moving relative to the ether frame at velocity v. On the left-hand side, t' is the time used for traveling x' in frame *K'* (corresponding to the distance x-vt in frame *K*). Notice that x-vt in this paragraph is the x in Eqs (8) and (9).

From the above analysis, we can see that in Lorentz ether theory, x and t in Eq. (1) are the same x and t in Eq. (2), and x' and t' in Eq. (1) are the same x' and t' in Eq. (2). Whether this is still the case in Einsteinian special relativity is debatable[3][4]. Most relativity researchers hold that this is still true in Einsteinian special relativity. However, the answers to the thought experiment questions in Section 2 suggest a contradiction caused by assuming that x and t in Eq. (1) are the same x and t in Eq. (2), or x' and t' in Eq. (1) are the same x' and t' in Eq. (2). A detailed analysis of how Einsteinian special relativity deals with time dilation and length contraction seems necessary.

4. Einsteinian time dilation and length contraction

While Lorentzian time dilation and length contraction involve physical changes in the clocks and the measuring rods that move relative to the ether frame, Einsteinian ones have no such physical changes. Einsteinian time dilation and length contraction arise purely due to the relativity of simultaneity following clock synchronization by light signals. Hardly any studies have investigated how the fundamentally different mechanisms in generating time dilation and length contraction fail to produce detectable differences in their predictions. To address this issue, we look into how time dilation and length contraction emerge from the relativity of simultaneity in Einsteinian special relativity.

4.1. Einsteinian time dilation

Let us first look into time dilation in two reference systems *K* and *K'* with a relative velocity of 0.995*c* (Fig.2). Since Einsteinian time dilation arises due to another frame moving relative to the observing frame, time dilation occurs in the observed frame. Here we avoid using the terms "rest frame" and "moving frame" because no privileged frame helps identify a rest frame in special relativity. It is meaningful in the Lorentz ether theory to talk about moving frames and rest frames because the ether frame is the rest frame and the one that moves relative to the ether frame is the moving frame. Einstein confusingly continued to use the terms moving frame and rest frame when special relativity effects depend on the relative velocity between two arbitrary inertial frames. He had denied the existence of ether or any privileged frame. The appropriate terms for describing special relativity effects should be the observing frame and the observed frame[3][4].

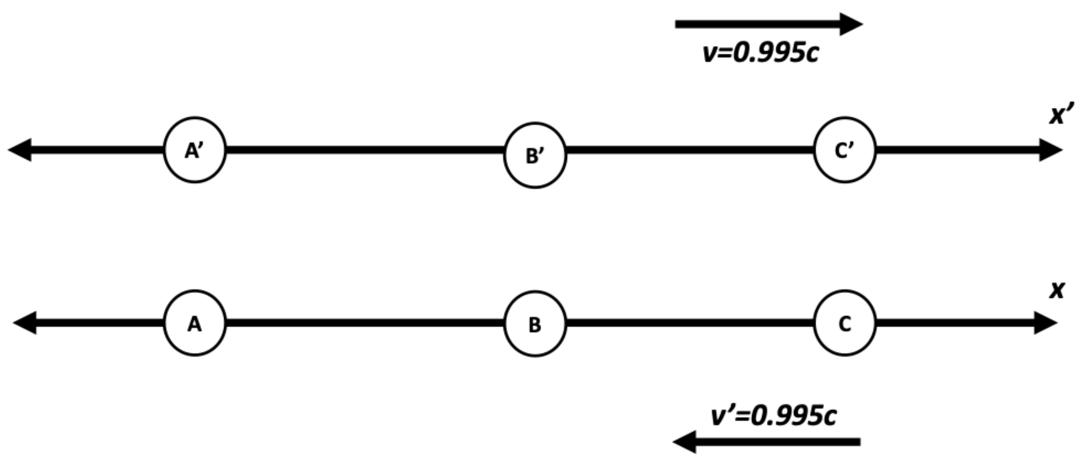

Figure 2. *Two reference frames with a relative velocity of 0.995c. A and A', B and B', and C and C' are coinciding spots at certain times, respectively. The two frames use identical clocks and measuring rods to measure time and distance.*

Unlike in the Lorentz ether theory, where length contraction and time dilation are the foundation of the Lorentz transformation, in special relativity, time dilation is derived from the Lorentz transformation by comparing time differences between two reference frames,

$$t'_2 - t'_1 = \frac{t_2 - \frac{vx_2}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{t_1 - \frac{vx_1}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{t_2 - t_1 - \frac{v(x_2 - x_1)}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}.$$

Two issues arise from the above equation: 1) Which frame should be on the left-hand side of the first equality and which frame should be on the right-hand side of the first equality? 2) Who reads the measurements of the variables on the left-hand side of the first equality and who reads the measurements of the variables on the right-hand side of the first equality? The following analysis may help us address these issues.

Since the time difference can be measured more reliably by clocks at the same location, i.e. $x_2 = x_1$, to reduce errors produced during synchronizing clocks and communicating measured values between two sites, the above equation becomes

$$t'_2 - t'_1 = \frac{t_2 - t_1}{\sqrt{1 - \frac{v^2}{c^2}}}. \qquad (10)$$

Eq. (10) implies the right-hand side time variables are measured or read by observers with local stationary clocks at one site (such as *A* in Fig. 2) in frame *K*. So, the time interval on the right-hand side is the proper time of frame *K*. The time variables on the left-hand side need to be measured by clocks at two sites (such as *A'* and *B'* in Fig. 2) in frame *K'*, so the time difference is a coordinate time. This coordinate time cannot be read by observers in frame *K'* because doing so cannot logically assign the observing (rest) or observed (moving) status to the two frames. If clocks at one site measure $t'_2 - t'_1$ on the left-hand side, it requires observers at the same site in frame *K'* or two sites in frame *K*. Observers at the same site measure the proper time of frame *K'*, which will lead to a contradiction like the one in the thought experiment in Section 2. Moreover, neither can it logically assign the observing (rest) or observed (moving) status to the two frames. Readings by two sites (such as *A* and *B* in Fig. 2) in frame *K* produce complications in communicating the values measured. Therefore, those time variables on the left-hand side shown by clocks in frame *K'* are read by the same observers at one site in frame *K*, who have measured the time variables on the right-hand side.

From the above analysis, the observers in frame *K* read their clocks to obtain their proper time and read clocks in frame *K'* to measure the coordinate time of frame *K'*, so frame *K* is the observing frame (rest frame). In Eq. (10), values of frame *K'* are read by observers in frame *K*, so frame *K'* is the observed frame (moving frame). According to our present interpretation, the logical result of Eq. (10) should be time contraction in the observed frame (moving frame). The usual interpretation of Eq. (10) from relativity researchers is that $\Delta t = t_2 - t_1$ is the proper time, which is the same as ours. However, mainstream special relativity researchers maintain that the moving frame measures the proper time and the rest frame measures the coordinate time $\Delta t' = t'_2 - t'_1$ in Eq. (10). Thus, moving clocks are slower than clocks at rest according to Eq. (10), which implies time dilation of the moving frame.

Let us use Fig. 2 to examine the relativistic interpretation of Eq. (10) and assume *A* is the frame *K* observer on the right-hand side. So, we have

$$t'_{B',A} - t'_{A',A} = \frac{t_{A,2_{B'}} - t_{A,1_{A'}}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{t_{A,2_{B'}} - t_{A,1_{A'}}}{\sqrt{1-0.995^2}} \approx 10 \bullet \left(t_{A,2_{B'}} - t_{A,1_{A'}}\right).$$

In Eq. (10A), $t'_{B',A}$ denotes the time that observer *A* reads off the frame *K'* clocks stationary at *B'* and $t'_{A',A}$ denotes the time that observer *A* reads off the frame *K'* clocks stationary at *A'*. On the right-hand side, $t_{A,2_{B'}}$ denotes the time that observer *A* reads off her clocks on occasion 2 when *A* and *B'* coincide; and $t_{A,1_{A'}}$ denotes the time that observer *A* reads off her clocks on occasion 1 when *A* and *A'* coincide. The clock of observer *A* shows a time interval $t_{A,2_{B'}} - t_{A,1_{A'}}$ which observer *B'* takes to arrive at *A*, but the two clocks at *A'* and *B'* in frame *K'* will show a time interval $t'_{B',A} - t'_{A',A} \approx 10 \bullet \left(t_{A,2_{B'}} - t_{A,1_{A'}}\right)$ to observer *A*. Observer *A* might conclude that time flows 10-fold faster in frame *K'* than the proper time observer A measured with clocks at rest in frame *K*. Both results are observed by *A* in frame *K*; should we consider frame *K* the moving frame or the rest frame? In our view, frame *K* is the observing frame (rest frame) and time contracts in the observed frame (moving frame). As noted earlier, mainstream special relativity researchers denote frame *K* as the moving frame in this scenario, which we think is incorrect.

Coming back to our Section 2 thought experiment, when the clock of observer *A* shows that it takes 6.4 µs for observer *B'* to arrive, i.e., $t_{A,2_{B'}} - t_{A,1_{A'}} = 6.4\ \mu s$, how long does the clock of observer *B'* show for observer *A* to arrive, i.e., $t'_{B',2_A} - t'_{B',1_B} =$? The Lorentz transformation in special relativity does not answer such questions. It deals with questions represented by Eq. (10A). Since there is no privileged frame in special relativity and the two frames use identical clocks and measuring rods, the most reasonable answer should be $t_{A,2_{B'}} - t_{A,1_{A'}} = t'_{B',2_A} - t'_{B',1_B} = 6.4 \mu s$. Using Fig.2, we can see that there are four times registered regarding the same event of observer *A* meeting observer *B'*: 1) the time interval measured by observer *A* with clocks at rest at site *A* in frame *K*, $t_{A,2_{B'}} - t_{A,1_{A'}}$; 2) the time interval calculated by observer *A* via reading clocks at rest at sites *A'* and *B'* in frame *K'*, $t'_{B',A} - t'_{A',A}$; 3) the time interval measured by observer *B'* with clocks at rest at site *B'* in frame *K'*, $t'_{B',2_A} - t'_{B',1_B}$; 4) the time interval calculated by observer *B'* via reading clocks at rest at sites *A* and *B* in frame *K*, $t_{A,B'} - t_{B,B'}$. We may add two more time intervals relevant to the event: 5) the time interval calculated by observers *A* and *B* reading their clocks stationary in frame *K* respectively when they coincide with *B'*, $t_{A,2_{B'}} - t_{B,1_{B'}}$; 6) the time interval calculated by observers *A'* and *B'* reading their clocks stationary in frame *K'* respectively when they coincide with *A*, $t'_{B',2_A} - t'_{A',1_A}$.

In the above analysis, time 1 is the proper time of frame *K*, which corresponds to *dt* in the right-hand side of Eq. (1A). Time 2 is the coordinate time of frame *K'* obtained by frame *K* observers at one site reading clocks of frame *K'*, which corresponds to *dt'* in the left-hand side of Eq. (1A). Time 3 is the proper time of frame *K'*, which corresponds to *dt'* in the right-hand side of Eq. (2A). Time 4 is the coordinate time of frame *K* obtained by frame *K'* observers at one site reading clocks of frame *K*, which corresponds to *dt* in the left-hand side of Eq. (2A). Time 5 is the coordinate time of frame *K* obtained by frame *K* observers at two sites reading clocks stationary in frame *K* and communicating their measurements, which should equal time 1 according to Einstein's clock synchronization method. Time 6 is the coordinate time of frame *K'* obtained by frame *K'* observers at two sites reading clocks stationary in frame *K'* and communicating their measurements, which should equal time 3 according to Einstein's clock synchronization method.

It is obvious from the above analysis that time 2 is different from time 3 so that *t'* on the left-hand side of Eqs. (1) and (1A) is not *t'* on the right-hand side of Eqs. (2) and (2A) in special relativity. Time 4 is different from time 3 so that *t* on the left-hand side of Eqs. (2) and (2A) is not *t* on the right-hand side of Eqs. (1) and (1A) in special relativity. However, most special relativity researchers are not aware of these differences, and they unwittingly identify *t* in Eqs. (1) and (2) as the same and *t'* in Eqs. (1) and (2) as the same. We will show later that the mix-up of a frame's proper time and its coordinate time observed by another frame is the cause of the relativistic paradox.

With the above analysis, we are now prepared to find the nature of the Einsteinian time dilation derivation. By designating frame *K* as the moving frame, time 1 (the proper time of frame *K*) as the moving frame time, and frame *K'* as the rest frame in Eq. (10), special relativity has to use time 6 on the left-hand side of Eq. (10) and assert Eq. (10B), because none of the variables in Eq. (10A) are observed by frame *K'*.

$$t'_{B',2_A} - t'_{A',1_A} = \frac{t_{A,2_{B'}} - t_{A,1_{A'}}}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

In Eq. (10B), $t'_{B',2_A} - t'_{A',1_A}$ is the time difference between *A* coinciding with *A'* and with *B'* as registered by *A'* and *B'* reading their clocks stationary in frame *K'*. However, Eq. (10B) is incorrect. As pointed out earlier, $t'_{B',2} - t'_{A',1} = t'_{B',2} - t'_{B',1}$because the Einsteinian clock synchronization method defines this relation. We know from our Section 2 thought experiment $t'_{B',2_B} - t'_{B',1_A} = t_{A,2_{B'}} - t_{A,1_{A'}}$, so Eq. (10B) implies

$$t'_{B',2_B} - t'_{B',1_A} = \frac{t_{A,2_{B'}} - t_{A,1_{A'}}}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

It is easy to see that Eq. (10C) is incorrect. Moreover, there is no clear mechanism to relate the proper time of frame *K* with the proper time of frame *K'* except assuming they are equal.

Because Eq. (10B) is incorrect, special relativity uses $t'_{B',A} - t'_{A',A}$ to replace $t'_{B',2_B} - t'_{B',1_A}$ and pretend the former is the latter, i.e., the observation of frame *K* by frame *K'* in Eq. (10). This replacement by special relativity is logically invalid. Firstly, moving (observed) or at rest (observing) is determined by an object's relation with an observer, so it is more appropriate to consider frame *K* with observer *A* as the rest frame (observing frame) because $t'_{B',A} - t'_{A',A}$ is observed by observer *A* in frame *K*. Secondly, the two frame *K'* clocks move relative to and are read by observer *A* in frame *K*, hence frame *K'* should be the moving frame, even though their time interval increases faster than the proper time interval in frame *K* as calculated by the time dilation formula. If we correctly assign the observing (rest) status, special relativity should predict time contraction in the observed frame (moving frame). Clocks in the observed frame (moving frame) run faster than clocks in the observing frame (rest frame). This result conflicts directly with the time dilation of the Lorentz ether theory.

Even if we accept special relativity's mishandling of rest (observing) or moving (observed) status, special relativity's derivation of time dilation still produces results that conflict with the Lorentz ether theory. In the Lorentz ether theory, clocks stationary in the ether frame (rest frame) are the fastest, and moving clocks are the slowest. In the special relativity interpretation of time dilation, local stationary clocks with proper time (corresponding to the rest clocks in the ether frame), which should not dilate or contract according to special relativity, are the slowest. This special relativity interpretation indicates that a "moving frame" will cause time contraction in its observing frame ("rest frame") whose clocks run faster than the proper time with a factor of $1/\sqrt{1 - v^2/c^2}$. Since there can be an infinite number of "moving frames" with an infinite number of velocities for one Einsteinian "rest frame," the special relativity interpretation seems absurd because the "rest frame" would have difficulty deciding to contract according to whose velocity. Therefore, Einsteinian special relativity should logically predict time contraction but deliberately assigns the observing frame (the rest frame) the role of the moving frame (the observed frame) to obtain time dilation. However, assigning the observing frame the role of the moving frame makes the proper time the slowest in special relativity. In contrast, the proper time (measured by clocks at rest in the ether frame) is the fastest in Lorentz's ether theory.

The Lorentz ether theory does not have the above dual-time or triple-time issue because Lorentzian effects depend on the "absolute" velocity relative to the ether frame rather than velocity relative to each other. The clocks in the ether frame are the fastest-running ones in the Lorentz ether theory, so all clocks moving relative to the ether frame run slower than those at rest in the ether frame. For the same scenario in Fig.2, when frame *K* is the ether frame and $x_2 = x_1$, Eq. (9) will give the Lorentzian time dilation result:

$$\begin{aligned} t'_{B',A} - t'_{A',A} &= t_{A,2_{B'}}\sqrt{1 - \frac{v^2}{c^2}} - \frac{\frac{vx_2}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} - t_{A,1_{A'}}\sqrt{1 - \frac{v^2}{c^2}} + \frac{\frac{vx_1}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} \\ &= \left(t_{A,2_{B'}} - t_{A,1_{A'}}\right)\sqrt{1 - \frac{v^2}{c^2}}. \end{aligned} \qquad (11)$$

When v=0.995c, the time interval in frame K', $t'_{B',A} - t'_{A',A}$, is only 1/10 of $t_{A,2_{B'}} - t_{A,1_{A'}}$, the time interval for B' to arrive at A measured by observer A with clocks stationary in frame K. When v approaches c, $t'_{B',A} - t'_{A',A}$ approaches 0, i.e., clocks run infinitely slow. The special relativity's interpretation is the opposite of Lorentzian time dilation. The proper time becomes the time interval measured by the "moving frame", which would not change with the relative velocity between the two frames. Then, the larger the relative velocity, the larger the time interval measured by the "rest clocks" compared with that measured by the "moving clocks". When v approaches c, the "rest clocks" run infinitely fast. This is better called time contraction than time dilation. Therefore, special relativity predicts time contraction rather than time dilation, in contrast with the Lorentz ether theory[3][4].

From the perspective of the (Lorentzian) moving frame, we obtain from Eq. (9) the transformation from frame K' to frame K,

$$t = \frac{t' + vx'/c^2}{\sqrt{1 - v^2/c^2}} \qquad (12)$$

The time interval measured by observer B' with her clocks for A to arrive at B' is $t'_{B',2_A} - t'_{B',1_B}$ in the moving frame K'. Observer B' will also find that the time interval shown by clocks at B and A in frame K, $t_{B,B'} - t_{A,B'}$ is

$$t_{B,B'} - t_{A,B'} = \frac{t'_{B',2_A} - t'_{B',1_B}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{t'_{B',2_A} - t'_{B',1_B}}{\sqrt{1-0.995^2}} \approx 10 \bullet \left(t'_{B',2_A} - t'_{B',1_B}\right).$$

It is about 10-fold as large as the time interval measured by observer B' with her clocks. Eqs. (11) and (12) show that Lorentzian time dilation is not reciprocal. One frame is time dilation, another will be relative time contraction.

The above derivation of time dilation from the Lorentz transformation is not necessary in Lorentz ether theory because time dilation and length contraction are primary (physical) changes that lead to the Lorentz transformation, rather than the Lorentz transformation producing time dilation and length contraction. In modern physics, physicists use the Lorentzian time dilation formula Eq. (11), rather than the Einsteinian "time dilation" formula Eq. (10) or (10A), which results in faster-running clocks in the observed frame.

4.2. Einsteinian length contraction

We add a rod to Fig.2 to illustrate the Einsteinian "length contraction" by assuming a rod with its two ends stationary at locations A and B in frame K (Fig.3). In fact, for special relativity, it seems better not to use a rod and simply to consider a distance between two locations A and B in frame K to avoid the interference of thinking about a solid object (in the Lorentz ether theory, velocity relative to ether affects the length of a solid rod and the length between two points in space differently). Obviously, its length is l_{AB} in frame *K*, but how long is it in frame *K'*? Applying the Lorentz space transformation as $t_B = t_A$, we obtain

$$l'_{AB} = x'_{B'} - x'_{A'} = \frac{x_B - vt_B}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{x_A - vt_A}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{x_B - x_A}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{l_{AB}}{\sqrt{1-\frac{v^2}{c^2}}}. \qquad (13)$$

In Eq. (13), the subscripts of *x'* and *l'* use *A* and *B* instead of *A'* and *B'* because it is not certain that they coincide during length measurements. The length measured in frame *K' l'*$_{AB}$ is obtained by observers at *B* and *A* in frame *K* reading the coincident coordinates x'_B and x'_A in frame *K'*. This result is consistent with that of Lorentz ether theory, i.e., the rest rods in the ether frame appear longer to the observers in the moving frame because their rods have contracted. The above length expansion result is not accepted in special relativity because simultaneity in frame *K* is not simultaneity in frame *K'*. Instead, special relativity assumes that coordinates x_B and x_A are what observers in frame *K'* find in frame *K*, hence

$$x_B - x_A = \frac{x'_{B'} + vt'_{B'}}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{x'_{A'} + vt'_{A'}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{x'_{B'} - x'_{A'}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{l'_{A'B'}}{\sqrt{1-\frac{v^2}{c^2}}}. \; l'_{A'B'} = x'_{B'} - x'_{A'}$$

$$= (x_B - x_A)\sqrt{1-\frac{v^2}{c^2}} = l_{AB}\sqrt{1-\frac{v^2}{c^2}}. \qquad (14)$$

Eq. (14) indicates that the length of a moving rod shortens in the direction of its velocity.

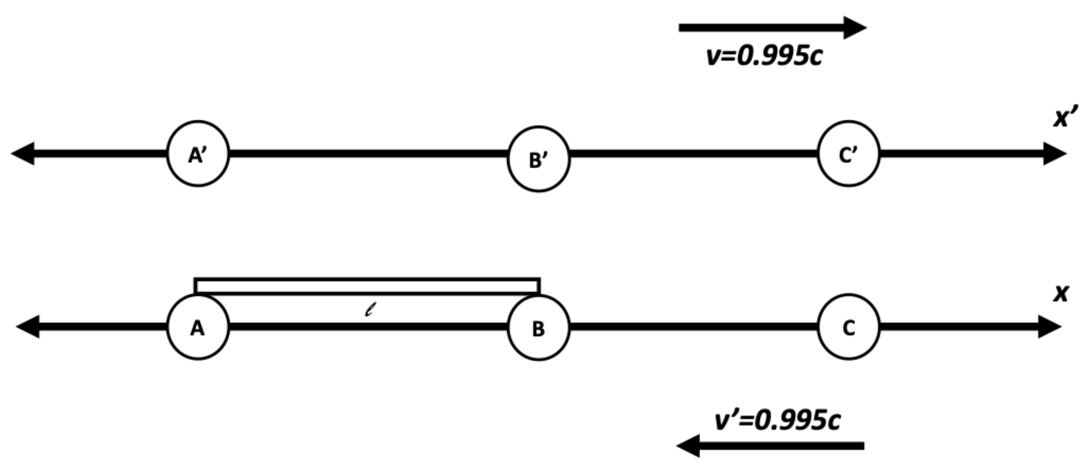

Figure 3. *One rod is stationary in frame K with two ends at A and B respectively. Two reference frames with a relative velocity of 0.995c. A and A', B and B', and C and C' are coinciding spots at certain times, respectively.*

As pointed out earlier, the coordinates of events should be more detailed with information on location, time, and frame; otherwise, incorrect results may arise from ambiguously assigned roles. Thus, Eq. (13) should be

$$l'_{AB} = x'_{B,t_B} - x'_{A,t_A} = \frac{x_{B,t_B} - vt_B}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{x_{A,t_A} - vt_A}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{x_{B,t_A} - x_{A,t_A}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{l_{AB}}{\sqrt{1-\frac{v^2}{c^2}}}.$$

In Eq. (13B), x'_{A,t_A} denotes the *x'* ordinate in frame *K'* corresponding to location *A* at time t_A in frame *K* (observed in frame *K*);x'_{B,t_B} denotes the *x'* ordinate in frame *K'* corresponding to location *B* at time t_B in frame *K* (observed in frame *K*); x_{A,t_A} denotes the *x* ordinate of location *A* at time t_A in frame *K* (observed in frame *K*); x_{B,t_B} denotes the *x* ordinate of location *B* at time t_B in frame *K* (observed in frame *K*). The third equality has used the condition $t_B = t_A$. Eq. (13A) should be

$$x_{B',t'_{B'}} - x_{A',t'_{A'}} = \frac{x'_{B',t'_{B'}} + vt'_B}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{x'_{A',t'_{A'}} + vt'_A}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{x'_{B',t'_{A'}} - x'_{A',t'_{A'}}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{l'_{A'B'}}{\sqrt{1-\frac{v^2}{c^2}}}.$$

In Eq. (13C), $x_{A',t'_{A'}}$ denotes the *x* ordinate in frame *K* corresponding to location *A'* at time $t'_{A'}$ in frame *K'* (observed in frame *K'*);$x_{B',t'_{B'}}$ denotes the *x* ordinate in frame *K* corresponding to location *B'* at time $t'_{B'}$ in frame *K'* (observed in frame *K'*); $x'_{A',t'_{A'}}$ denotes the *x'* ordinate of location *A'* (the corresponding location of *A* in frame *K'*) at time $t'_{A'}$ in frame *K'* (observed in frame *K'*); $x'_{B',t'_{B'}}$ denotes the *x'* ordinate of location *B'* (the corresponding location of *B* in frame *K'*) at time $t'_{B'}$ in frame *K'* (observed in frame *K'*). The second equality has used the condition $t'_{B'} = t'_{A'}$.

From a comparison between Eq. (13A) and Eq. (13C), if we require simultaneously measuring coordinates $x'_{B'}$ and $x'_{A'}$ in frame *K'*, the moving length measured according to special relativity, $x'_{B',t'_{A'}} - x'_{A',t'_{A'}}$, does not correspond to the original length in frame *K*, $x_{B,t_A} - x_{A,t_A}$. It corresponds to $x_{B',t'_{B'}} - x_{A',t'_{A'}}$ and the coordinates of the two locations are not simultaneously measured in frame *K*. Therefore, with the relativity of simultaneity in special relativity, it is impossible to have two coordinates of a length that are measured simultaneously in both frames. Using Eq. (13B), we obtain two lengths measured simultaneously in frame *K* using coordinates in frames *K* and *K'*, but the length for frame *K'* is not simultaneously measured in frame *K'*. Using Eq. (13C), we obtain two lengths measured simultaneously in frame *K'* using coordinates in frames *K* and *K'*, but the length for frame *K* is not simultaneously measured in frame *K*. Which one should we choose to represent the relationship between the observing and the observed frames? In our view, Eq. (13B) or (13) should be used, because it relates the original length in frame *K* with the coordinates of the length in frame *K'* measured (observed) simultaneously by observers in frame *K*. Therefore, the logical result of the special relativity space effect is length expansion in the observed frame (moving frame) instead of length contraction. Although Eq. (13C) or (13) provides the simultaneous measurement of the coordinates of the length in frame *K'* by observers in frame *K'*, the length does not correspond to the original length in frame *K* due to the relativity of simultaneity.

The length contraction derivation of special relativity further raises the issue of where proper length and proper time should be placed in the Lorentz transformation. In the time dilation derivation, proper time is placed on the right-hand side of the equality in Eq. (10), whereas in the length contraction derivation, proper length is placed on the left-hand side of the equality in Eq. (13A). The use of the terms "moving frame" and "rest frame" in special relativity makes the arbitrary assignments of these labels and arbitrary inputs into the Lorentz transformation possible. It has been suggested that the two terms are meaningful only in Lorentz ether theory and they should be replaced by "observed frame" and "observing frame" in special relativity[3][4]. The arbitrariness of placing proper time or length on which sides of the Lorentz transformation casts doubts on the validity of their derivations in special relativity. In our view, the proper time and proper length or the coordinates of the observing frame should be on the right-hand side of the Lorentz transformation equations; the coordinates of the observed frame should be on the left-hand side.

Another frequently mentioned derivation of length contraction in special relativity is to use the relative velocity and the time spent for the two ends to pass the same point. As in Fig.3, if end *B* of the rod passes $x'_{B,t'_{1,B'}}$ at time $t'_{1,B'}$ and end *A* passes $x'_{B,t'_{1,B'}}$ at time $t'_{1,B'} + \Delta t'$, end *B* will be at $x'_{B,t'_{2,B'}} = x'_{B,t'_{1,B'}} + v\Delta t'$ when end *A* passes $x'_{B,t'_{1,B'}}$. Here $x'_{B,t'_{1,B'}}$ denotes the corresponding position of *B* in frame *K'* when the time at *B'* is t'_1; $x'_{B,t'_{2,B'}}$ denotes the corresponding position of *B* in frame *K'* when the time at *B'* is t'_2. Then, the rod's length in frame *K'* will be

$$l'_{AB} = x'_{B,t'_{2,B'}} - x'_{B,t'_{1,B'}} = v\Delta t'. \qquad (15)$$

The time difference in frame *K* between the two ends passing $x'_{B,t'_{1,B'}}$ is $\Delta t = l_{AB}/v$. Since Δt is a coordinate time with two events occurring at different places, its relationship with the proper time $\Delta t'$ is

$$\Delta t' = \Delta t \sqrt{1 - \frac{v^2}{c^2}} = \frac{l_{AB}}{v} \sqrt{1 - \frac{v^2}{c^2}}. \qquad (16)$$

Substituting Eq. (16) in (15), we obtain

$$l'_{AB} = l_{AB} \sqrt{1 - \frac{v^2}{c^2}}. \qquad (17)$$

The above approach transforms length measurements into time measurements. However, we must determine who reads the clocks in frame *K* to obtain Δ*t*. If observers at $x'_{B,t'_{1,B'}}$ read them, Eq. (10A) is used for time transformation, and the length measured equals that of Eq. (13C), which is not the original length in frame K due to the relativity of simultaneity. If observers at locations *A* and *B* in frame *K* read the clocks, Eq. (10B) is used for time transformation, and we have shown it is incorrect. Moreover, in this special relativity derivation, we have the proper length in frame *K* but the proper time in frame *K'*, which seems logically inconsistent. The derivation can be viewed as applying Eq. (13A) or (13C) with $x'_{B,t'_{1,B'}} = x'_{A,t'_{2,B'}}$, $l_{AB} = x_B - x_A$, and $l'_{AB} = v(t'_{2,B'} - t'_{1,B'})$. We have

$$l_{AB} = x_B - x_A = \frac{x'_{B,t'_{2,B'}} + vt'_{2,B'}}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{x'_{B,t'_{1,B'}} + vt'_{1,B'}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{v(t'_{2,B'} - t'_{1,B'})}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$= \frac{l'_{AB}}{\sqrt{1-\frac{v^2}{c^2}}}, \qquad (18)\, l'_{AB} = l_{AB}\sqrt{1-\frac{v^2}{c^2}}.$$

If observers in the same frame can communicate and collaborate in measuring length, which must be true to make any measurement of length possible, we will have six lengths measured: 1) length in frame *K* measured by collaboration of observers at *A* and *B* in frame *K*, $l_{AB,AB} = x_{B,B} - x_{A,A}$; 2) length in frame *K'* measured by collaboration of observers at *A* and *B* in frame *K*, $l'_{A'B',AB} = x'_{B',B} - x'_{A',A}$; 3) length measured through time difference by observers at *B'* in frame *K'*, $l'_{AB,B'} = v(t'_{2,B'} - t'_{1,B'})$; 4) length measured through time difference by observers at *A* in frame *K*, $l_{A'B',A} = v(t_{2,A} - t_{1,A})$; 5) length in frame *K'* measured by collaboration of observers at *A'* and *B'* in frame *K'*, $l'_{A'B',A'B'} = x'_{B',B'} - x'_{A',A'}$; 6) length in frame *K* measured by collaboration of observers at *A'* and *B'* in frame *K'*, $l_{AB,A'B'} = x_{B,B'} - x_{A,A'}$. Here, we use $x_{A,A}$ to denote the coordinate of *A* in frame *K* observed by observers at *A*; $x_{B,B}$ to denote the coordinate of *B* in frame *K* observed by observers at *B*; $x'_{A',A}$ to denote the coordinate of *A* in frame *K'* observed by observers at *A* stationary in frame *K*; $x'_{B',B}$ to denote the coordinate of *B* in frame *K'* observed by observers at *B* stationary in frame *K*; $x'_{A',A'}$ to denote the coordinate of *A'* (the coordinate of *A*) in frame *K'* observed by observers at *A'*; $x'_{B',B'}$ to denote the coordinate of *B'* (the coordinate of *B*) in frame *K'* observed by observers at *B'*; $x_{A,A'}$ to denote the coordinate of *A* in frame *K* observed by observers at *A'* stationary in frame *K'*; $x_{B,B'}$ to denote the coordinate of *B* in frame *K* observed by observers at *B'* stationary in frame *K'*. Some people may doubt whether observer *A* can measure the time used for *B'* to reach A (corresponding to *A'*) in frame *K*. This is possible because observers at *B* can inform those at *A* that *B'* in frame *K'* corresponds to *B*, so *A* can measure the time interval between *A'* passing *A* and *B'* passing *A*.

In the above six lengths, lengths 1 and 5 are proper lengths measured by observers in the same frame. Lengths 2 and 6 are the ones in one frame measured by observers in another frame. Lengths 3 and 4 are measured by another frame using time differences. In terms of lengths 3 and 4, Einsteinian length contraction is due to time contraction in the observed frame (the "rest frame" in the special relativity interpretation). The derivations using Eq. (13A) or (18) treat the rod stationary in frame *K* as the moving object. Using the same logic of deriving Eq. (17), we can derive the length in frame *K'* as measured by observers stationary at *A* in frame *K*, i.e., length 4 in the preceding paragraph. As in Fig.3, the coordinate of end A_0 of the rod in frame *K'* is $x'_{A_0,t_{1,A}}$ at time $t_{1,A}$ as observed by observers stationary at *A* in frame *K*, and the coordinate of end B_0 of the rod in frame *K'* is $x'_{B0,t_{1,B}}$ at time $t_{1,B}$ as observed by observers stationary at *B* in frame *K*. The observers at *B* can inform those at *A* of $x'_{B_0,t_{1,B}}$. When $x'_{B0,t_{1,B}}$ passes *A* in frame *K* at time $t_{1,A} + \Delta t$, $x'_{A_0,t_{1,A}}$ will be at $x_{A_0,t2} = x_{A_0,t_{1,A}} + v\Delta t$. Then, the rod's length measured through time differences by observers at *A* in frame *K* will be

$$l_{A_0'B_0',A} = x_{A_0,t_2} - x_{A_0,t_{1,A}} = v\Delta t. \qquad (19)$$

The time difference in frame *K'* between $x'_{A_0,t_{1,A}}$ passing A and $x'_{B_0,t_{1,B}}$ passing *A* is $\Delta t' = l'_{A_0'B_0'}/v$. Since $\Delta t'$ is a coordinate time with two events occurring at different places, its relationship with the proper time Δt is

$$\Delta t = \Delta t' \sqrt{1 - \frac{v^2}{c^2}} = \frac{l'_{A_0'B_0'}}{v} \sqrt{1 - \frac{v^2}{c^2}}. \qquad (20)$$

Substituting Eq. (20) in (19), we obtain

$$l_{A_0'B_0',A} = l'_{A_0'B_0'} \sqrt{1 - \frac{v^2}{c^2}}. \qquad (21)$$

The above derivation corresponds to Eq. (13B), where the length is measured simultaneously in frame *K* but not in frame *K'*. Therefore, the length in the observed frame (moving frame) expands rather than contracts. Since we have argued that the Einsteinian rest frame should be called the observing frame and the Einsteinian moving frame should be called the observed frame, length expands in the observed frame (moving frame). Special relativity obtains length contraction by wrongly designating the observing frame as moving. In this section, we have used a detailed subscript system in our notation to indicate the location, frame, observer, and time measured for specific variables to avoid ambiguity in derivation, which Ma[4] has advocated.

5. Einsteinian time dilation and the twin paradox

The Lorentzian time dilation and length contraction are the primary changes due to "absolute" velocity relative to the ether frame, and they are the foundation of the Lorentz transformation.

Thus, Lorentzian time dilation and length contraction formulae need not be derived from the Lorentz transformation. Applying the Lorentzian time dilation formula to the one traveling twin and one staying twin saga causes no paradox. The traveling twin becomes younger than the staying twin because the traveling twin's clock and local time become slower. The Einsteinian time dilation leads to many paradoxes, among which the twin paradox is the most famous[20]. Many explanations have been proposed to show no contradiction in the twin paradox, and they can be roughly classified into two schools: the acceleration school and the frame jumping school. The former thinks that the acceleration experienced by the traveling twin causes the age difference[20][21]. The latter considers that frame jumping triggered by acceleration, rather than acceleration per se, causes the differential aging of the twins[22][23][24].

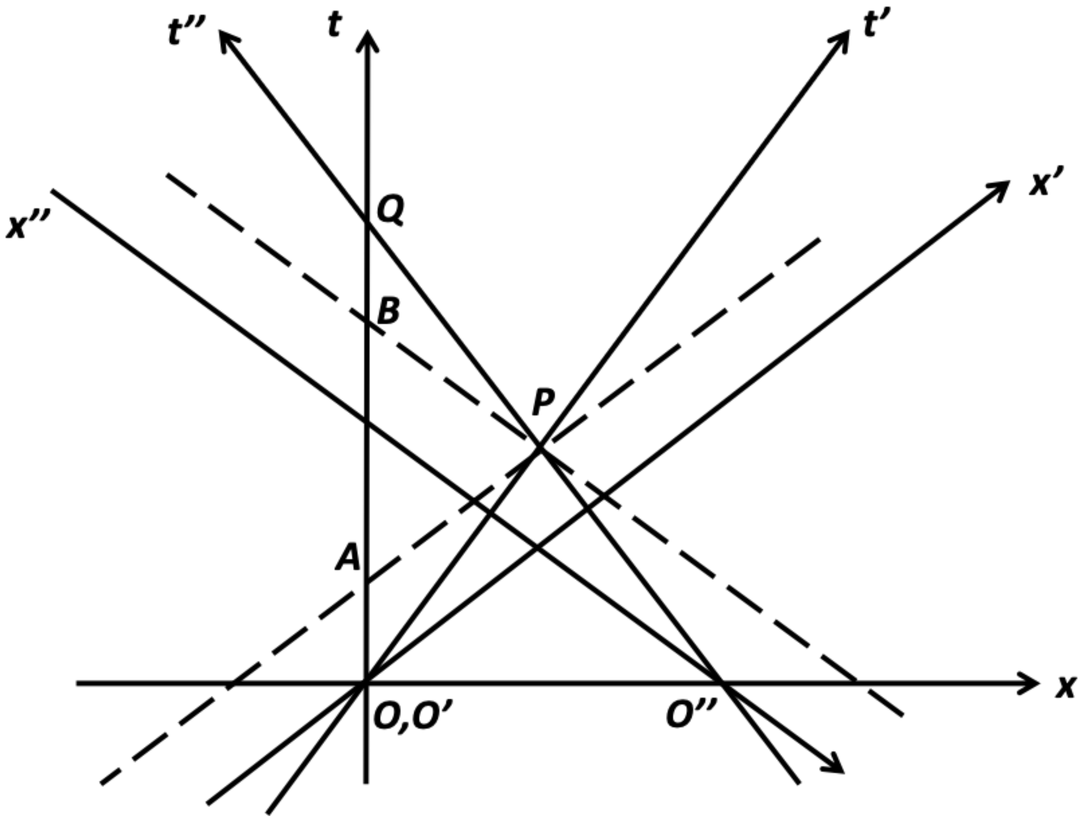

Figure 4. *The Minkowski diagram with Alice, the twin sister on the earth, as the "stationary" observer. The traveler Betty departs at O (O'), turns back at P, and returns to the earth at Q. At P, Betty jumps from frame O' to frame O''.*

The acceleration explanation can generally be discredited because there is no mechanism to relate the effect of a certain acceleration to arbitrary lengths of time the traveling twin spends in uniform motion[3][4]. The frame-jumping explanation using Einsteinian time dilation also appears incorrect in light of our analysis of the six types of time intervals. We assume a case of twin sisters Alice and Betty; Alice stays on the earth for 10 years while Betty travels outwards at 0.995c, and then another 10 years for Betty's return journey to the earth. In a typical frame-jumping explanation using a Minkowski diagram (Fig. 4), as Betty travels out along line *OP*, Alice is aging more slowly than her because Alice's event *A* is simultaneous with event *P* in Betty's frame. When Betty changes the direction of her spaceship to return, she jumps into a new frame of reference with *P* simultaneous with Alice's event *B*. This frame jumping corresponds to Alice aging incredibly fast during this instant. Although Betty still finds Alice aging more slowly than her, it is insufficient to cancel out the age added to Alice during the turning around moment. Betty appears to have written off a large part of her age (the part on the *t*-axis between points *A* and *B*) and become younger than Alice. In Alice's frame, Betty, traveling at 0.995c, ages more slowly according to the Lorentz time dilation formula

$$t'_{Betty} = t_{Alice}\sqrt{1 - v^2/c^2}. \qquad (22)$$

In Eq. (22), t'_{Betty} is Betty's time interval observed by Alice, and t_{Alice} is Alice's time interval measured by Alice herself. The frame jumping by Betty is the mechanism that makes the outcomes observed by Alice and Betty compatible[22][23][24].

Several points may be raised against the above frame-jumping explanation using the Minkowski diagram in special relativity:

First, which time among the six types in our early analysis of special relativity does this explanation use? If we use the Einsteinian interpretation of Eq. (10), Alice with her proper time is the moving frame, Betty's frame is the rest frame, and the clocks in her frame are much faster than Alice's. Thus, Betty should be much older than Alice when she returns.

Second, Alice and Betty should compare their local stationary clocks, which indicate times 1 and 3 respectively. Since there is no physical change in clocks in special relativity, if acceleration has no direct effects on clocks, Alice's and Betty's clocks should indicate the same time and they have the same age, as illustrated by the Section 2 thought experiment. If acceleration affects clocks directly, Betty's age should be Alice's plus the effect of acceleration. So far, there is no theory or experimental evidence on whether or how acceleration affects clocks in terms of their running rate. For example, if it does affect clocks' running, does the effect depend on the overall change in velocity or acceleration? If the effect depends on an overall change in velocity, a low acceleration over a long time will achieve the same effect as a high acceleration over a short time. If the effect depends on acceleration, a low acceleration will not achieve the same effect as a high acceleration regardless of the overall change in velocity.

Third, Eq. (22) is the Lorentzian time dilation formula where proper time (ether frame time) is the fastest and moving clocks are slower. In Einsteinian time dilation, the proper time measured with stationary clocks in the same frame is the slowest and the clocks in the observing (or rest) frame are faster. However, the observing (or rest) frame in special relativity is assigned to the left-hand side of the Lorentz transformation equations. In our view, the observing frame should be on the right-hand side and have the proper time indicated by its stationary clocks. Either way, special relativity or the Einsteinian time dilation should predict Betty becoming older than Alice (according to the Einsteinian interpretation of Eq. (10)).

Fourth, what is the use of coordinates in a Minkowski diagram? If they are coordinates, shouldn't they indicate time and space? If Alice has spent OQ time by staying on the earth, shouldn't Betty have spent OQ time as well after she started from O and arrived at Q at the same spot as Alice? In a coordinate system, the distance between two points can be calculated by their coordinates. Why can't the coordinates of O and Q provide information on Betty's time interval between O and Q? In our view, the time intervals spent by Alice and Betty should all be OQ.

Fifth, special relativity researchers often overlook what happens at the turning point when the spacecraft slows to zero velocity and Betty jumps back to Alice's frame. As shown in Fig.5A, the line of simultaneity at P in Betty's frame before her deceleration to zero velocity is DP, while the line of simultaneity of E (halfway between O and Q) in Betty's frame is EF. Therefore, Alice finds that Betty ages more slowly and that Betty is much younger than her at P before Betty's deceleration. When Betty decelerates to zero velocity at P, Betty and Alice are in the same reference frame in which E and P are on the same line of simultaneity; therefore, they have the same age at the end of Betty's outward journey. In Fig.5, PG represents Betty's world line if she keeps $v = 0$ after arriving at P. When the return journey starts and Betty accelerates from $v = 0$ to $0.995c$ instantly at point P, she jumps from frame O into frame O'' at point P. Alice moves along the t axis of her own frame from E to Q, and Betty travels from P to Q (Fig.5B). In Betty's frame, the line of simultaneity at P is KP, which is above HE, so at the moment of Betty's acceleration, Alice finds that Betty ages incredibly fast and becomes much older than her. After Betty's acceleration, Alice finds that Betty ages more slowly than her, so their age difference decreases as they approach Q. At Q, when Betty decelerates to $v = 0$, they should have the same age because they are both at rest at Q in the earth frame (Fig.5B).

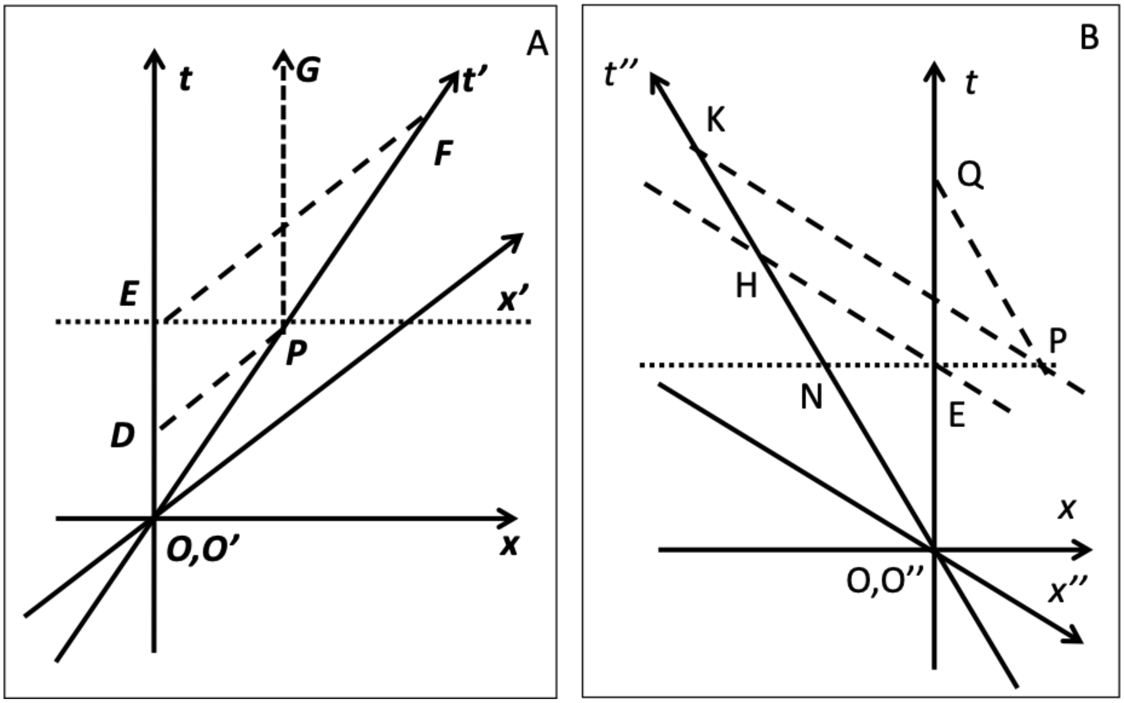

Figure 5. *A. Minkowski diagrams for Betty's outward journey. Alice's frame is the observing frame. Betty travels along the t' axis of her own frame and reaches turning back point P, which is on the same line of simultaneity as D. B. The Minkowski diagrams for Betty's return journey, including the time of the outward journey. Alice's frame is the observing frame. Betty travels along PQ, which is parallel to the t'' axis of her own frame. Alice travels along the t axis of her own frame and meets Betty at Q.*

Using our understanding of notations in Einstein's Lorentz transformation, we will not find any relativistic paradox. For example, the twin paradox will be purely due to the extrapolation of the twin sister on the earth (as well as the sister on the spacecraft) to reconcile the observed inconstant velocity of light in another frame and the postulated constancy of light velocity. The reality is that there is no change in their clocks or age differences, and they will meet at the same age bar acceleration-induced changes (because of asymmetric acceleration between them) or some effects of velocity relative to the ether frame if such a medium exists. Similarly, length contraction-related paradoxes will also disappear due to the extrapolation nature of the Lorentz transformation in Einstein's special theory of relativity. The fat man and grate paradox and the ladder paradox (or barn and pole paradox)[25][26] will disappear because what matters is the proper length of the pole (as well as the proper width of the barn).

6. Discussion

In the present study, we have examined how special relativity derives the Einsteinian time dilation and length contraction and compared them with those in the Lorentz ether theory. Despite the claims by many relativity researchers that special relativity and the Lorentz ether theory give identical predictions, our present results show that they are very different. Special relativity continues to use the Lorentzian terms "rest frame" and "moving frame" when they should be called the observing frame and the observed frame respectively[3][4]. Special relativity effects depend on the relative velocity between two inertial frames, which makes resting or moving effectively meaningless. The continued use of these terms contributes to blurring the differences between the Lorentz ether theory and Einsteinian special relativity.

6.1. Time dilation in Lorentz theory and special relativity

Time dilation and length contraction are the primary changes in Lorentz's theory due to objects moving relative to the medium of light, ether, which is the privileged frame of reference. Therefore, there is no need to derive them from the Lorentz transformation. On the contrary, the Lorentz transformation results from time dilation and length contraction. Since measuring rods in the moving frame contract according to the formula $l = l_0\sqrt{1-\frac{v^2}{c^2}}$, we have the Lorentz transformation space equation

$$x' = \frac{x - vt}{\sqrt{1-\frac{v^2}{c^2}}}.$$

In the above equation, $x - vt$ is the part of x that corresponds to x'. Time dilation with the formula $\Delta t' = \Delta t/\sqrt{1-v^2/c^2}$ results in the Lorentz transformation time equation

$$t' = t\sqrt{1-v^2/c^2} - \frac{v(x-vt)/c^2}{\sqrt{1-v^2/c^2}}.$$

As explained earlier, the first term on the right-hand side is the time interval measured by the moving clock for light to travel across x, and the second term is the time measured by the moving clock for light to travel across vt. If we want to calculate how a moving clock slows compared with an ether frame clock, we use the Lorentzian time dilation formula. If we want to calculate how a rod contracts when moving relative to the ether, we just use the Lorentzian length contraction formula.

Special relativity asserts that time dilation and length contraction depend on the relative velocity between two reference frames, but they are measurement effects rather than physical changes like those in the Lorentz ether theory. Since Einstein and special relativity researchers give the constancy of the speed of light and the principle of relativity primary status, they derive the Einsteinian Lorentz transformation first. Then, they derive time dilation and length contraction from the Lorentz transformation. As Ma[5], has shown, it is impossible to derive the Lorentz transformation from Einstein's two postulates because they are not sufficient conditions. Using relative velocity, it is tricky to assign the status of the rest frame or the moving frame, and it is also confusing about which side of the equation the "rest frame" or the "moving frame" variables should be placed on. As shown in this study, if the observing frame (rest frame) should be on the right-hand side, we obtain time contraction in the observed frame (moving frame). However, special relativity assigns the rest status to the left-hand side (the observed frame in our terminology) such that the "rest frame" clocks become faster than the "moving frame" (the observing frame in our terminology) clocks that show the proper time. This operation enables special relativity to seemingly obtain the time dilation of the Lorentz ether theory.

On closer examination, it is easy to find that there is no time dilation in the Einsteinian "time dilation" because the proper time is the slowest in special relativity while the ether or rest frame's clocks are the fastest in Lorentz's theory. The so-called time dilation in the Einsteinian "moving frame" (the observing frame whose variables are on the right-hand side of the Lorentz transformation) is time contraction in the Einsteinian "rest frame," which creates a "relative time dilation" in the Einsteinian "moving frame," in the same way that the Lorentzian moving frame finds relative time contraction in the ether frame because Lorentzian moving-frame clocks per se become slower. Since we think that the frame on the right-hand side of the Lorentz transformation should be the observing frame, hence the "rest frame" in special relativity, what special relativity should obtain logically is time contraction or clocks running faster in the "moving frame," i.e., time contraction in the observed frame. The purpose of mis-assigning the rest or moving status by relativity researchers is to avoid a result that conflicts with the Lorentz ether theory and the experimental findings.

6.2. Proper time, observed time, and coordinate time

In the Lorentz ether theory, there is no difference between the proper time and the observed coordinate time indicated by clocks in the moving frame because the moving clocks slow physically, and the rest frame is always the ether frame. Special relativity asserts no physical changes in the clocks of either the observed frame or the observing frame, which is correct when there is no ether background. Therefore, Einsteinian relativistic effects can only be measurement effects or observation effects due to the constancy of the speed of light. If this is true, we have the following issues regarding the relationships between different measurements of time in the two reference frames with relative motion: 1) the relationship between $\Delta t_{B,B}$ and $\Delta t'_{B',B'}$, the proper times of the two frames; 2) the relationship between $\Delta t'_{B',B'}$ (the observed frame proper time) and $\Delta t'_{A'B',B}$ (the coordinate time of the observed frame measured by the observing frame); 3) the relationship between the proper time $\Delta t'_{B',B'}$ (or $\Delta t_{B,B}$) and the coordinate time $\Delta t'_{A'B',A'B'}$ (or $\Delta t_{AB,AB}$) in a frame; 4) the relationship between $\Delta t'_{A'B',A'B'}$ (or $\Delta t_{AB,AB}$) (the observed frame's coordinate time, i.e., the time for *B* in frame *K* to travel from *A'* to *B'* measured by *A'* and *B'* in frame *K'*) and $\Delta t'_{A'B',B}$ (or $\Delta t_{AB,B'}$) (the coordinate time of the observed frame measured by the observing frame). Here we use frame *K'* as the observed frame in 2), and in other scenarios, the roles can be swapped.

Many special relativity researchers dodge questions about the relationship between the proper times of the two frames and assert that they cannot be compared directly. Some may admit that the proper times of the two frames are equal; otherwise, contradictions arise in special relativity, as revealed by the Section 2 thought experiment. Concerning the relationship between the observed frame's proper time and the coordinate time of the observed frame measured by the observing frame, special relativity researchers generally assert they are equal. If they are equal, the second part of the Section 2 thought experiment would be a valid question, and special relativity would be self-contradictory between $\Delta t = 6.4$ and $\Delta t = 0.064$ while $\Delta t' = 0.64$. Thus, although most relativity researchers assert that the observed frame's proper time and the time of the observed frame measured by the observing frame are the same, it must be wrong because it leads to a real contradiction in special relativity.

If the observed frame's proper time and the time of the observed frame measured by the observing frame are not the same, the time of the observed frame measured by the observing frame does not reflect what is going on in the observed frame. What matters is the proper time in the observed frame, which cannot be measured by the observing frame directly. In our view, the proper times of the two frames are equal, i.e. $\Delta t_{B,B} = \Delta t'_{B\prime,B\prime}$, because they use identical clocks and no other factors influence their clocks. If they are equal, the Einsteinian Lorentz transformation results become pure observational effects, which are only meaningful to the observers. According to Einstein's clock synchronization using light signals, the proper time $\Delta t'_{B\prime,B\prime}$ (or $\Delta t_{B,B}$) and the coordinate time $\Delta t'_{A\prime B\prime,A\prime B\prime}$ (or $\Delta t_{AB,AB}$) should be equal because they are measured in the same frame. Then, $\Delta t'_{A\prime B\prime,A\prime B\prime}$ (the observed frame's coordinate time) and $\Delta t'_{A\prime B\prime,B}$ (the time of the observed frame measured by the observing frame) should be different because observers are not in the same reference frame. The differences between $\Delta t'_{B\prime,B\prime}$ (or $\Delta t_{B,B}$)/$\Delta t'_{A\prime B\prime,A\prime B\prime}$ (or $\Delta t_{AB,AB}$) and $\Delta t'_{A\prime B\prime,B}$ (or $\Delta t_{AB,B\prime}$) underlie the special relativity effects.

6.3. Analysis of the twin paradox and the increased lifetime of high-speed particles

The Lorentz ether theory has an unambiguous answer to the thought experiment of the twin traveller or the increased lifetime of high-speed particles. Betty will be younger when she returns because the moving clock slows absolutely. In terms of the increased lifetime of high-speed particles, the Lorentz ether theory thinks that the particles' time (or clock) becomes slower because of their velocity relative to the ether frame. Special relativity tries to replicate the Lorentzian result by comparing Alice's proper time with the coordinate time of Betty's frames. In the derivation of Einsteinian time dilation, the frame with the proper time is designated as the "moving frame" and the frame with the coordinate time is designated as the "rest frame" whose clocks run faster than the "moving frame". When explaining the twin paradox, special relativity researchers assign the traveler's frame with the coordinate time as the "moving frame" and apply the Lorentzian time dilation formula to obtain a result of the traveler's clocks running slower than the proper time. In doing this, special relativity does not follow its time dilation logic in explaining the twin paradox. Following Einsteinian logic of deriving time dilation, the traveler (the observed frame) should age faster.

Special relativity says little about comparing the proper times of two frames with relative motion. Since the twins separate and meet again, their proper times should be compared rather than one proper time measured by self and one coordinate time measured by another twin. When Betty departs, her clock should be synchronized or compared with Alice's. When Betty returns, comparing their clocks on the spot will tell who is younger. If acceleration does not influence Betty's clock, as special relativity asserts no physical changes in observed-frame clocks, they should have the same age. If acceleration influences Betty's clock, their age difference is the acceleration effect. Therefore, the correct explanation of the twin paradox in special relativity is no age difference between Alice and Betty if acceleration does not influence Betty's clock/time. If acceleration affects Betty's clock/time, their age difference is the acceleration effect, which does not follow the Lorentzian time dilation formula.

Time dilation has been key experimental evidence for special relativity. The often-cited examples are the increased lifetime of high-speed particles[27][28][29][30][31][32][33] and the Hafele-Keating experiment[34]. However, as mentioned earlier, the logical consequence of Einsteinian "time dilation" is clocks running faster in the observed frame than the proper time in the observing frame. In the case of high-speed particles, it seems obvious that the particles are in the observed frame, so they should decay faster than the "rest" particles in the observing frame. Therefore, special relativity researchers have not followed the logic they used in deriving Einsteinian time dilation. Even if we accept this illogical assignment of the moving or rest status, there is still the issue of which time should be compared, proper time or coordinate time. Hafele and Keating made their predictions based on the different distances and velocities of the ground clocks and the flying clocks relative to the center of the Earth rather than the velocity between the ground clocks and the flying clocks[35][36], which is more Lorentzian than Einsteinian and can be explained by the Lorentzian time dilation[4]. The time dilation observed in the Hafele-Keating experiment is not an Einsteinian special relativity measurement effect without physical change.

The Section 2 thought experiment is an illustration of high-speed particles such as muons generated in the high-altitude atmosphere. The observers *k* on the ground found that muons reached them, indicating that the lifetime of high-speed particles *k'* had increased substantially compared with low-speed ones. If *k* and *k'* use their stationary clocks respectively, what time do they obtain and how do their times measured differ? Combining information from Fig.1 and Fig.2, in our opinion, they should measure their proper times, which should be equal, i.e., they both obtain a value of 6.4 μs. In measuring or estimating the lifetime of high-speed particles, the observers in the laboratory or on Earth could not observe clocks in the particle frame to obtain their coordinate time. The lifetime of the particles is calculated by dividing the distance traveled by the particles' velocity, which is roughly equivalent to observer *k* measuring the time elapsed before meeting observer *k'* in the Section 2 thought experiment. Therefore, they are proper time, $\Delta t_{A,A} = \Delta t'_{B\prime,B\prime}$.

Obviously, the particles are the observed frame, and observers on the ground are the observing frame, but observers in the Earth frame could not read clocks in the particle frame. We may also view this as observer k and co-observer k_1 in the Earth frame reading their clocks when they coincide with B' in the particle frame respectively. However, this is simply $t_{B',k} - t_{B',k_1} = t_{A,2_{B'}} - t_{A,1_{A'}}$, which does not give us any readings of clocks in the particle frame. All times are readings from the clocks of the Earth frame. According to the Einsteinian interpretation of time dilation, the observers on the ground should find the clocks of the high-speed particles running much faster than their clocks, as suggested by the following equation

$$t'_{B',A} - t'_{A',A} = \frac{t_{A,2_{B'}} - t_{A,1_{A'}}}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

Hence high-speed particles should decay much earlier than low-speed particles. Therefore, following Einsteinian logic, special relativity should have faster-decaying high-speed particles rather than slower-decaying ones. The slower-decaying result is consistent with the Lorentzian time dilation. Some special relativity researchers may argue that the times shown by the clocks on the ground should be on the left-hand side of the Lorentz transformation equation, and the high-speed particle's clocks should be on the right-hand side. This will imply that an observer's own clock's reading will be influenced by other frames with relative velocity to the observer. This is absurd because there are so many objects with various velocities to the observer. The relativistic velocity effect should only occur to variables in the observed frame measured by the observing frame.

6.4. Length contraction in Lorentz theory and special relativity

There is no experimental evidence for length contraction, which is postulated to explain the null result of the Michelson-Morley experiment[13][7][8]. An object's length contracts with the Lorentzian length contraction formula in the direction of its velocity relative to the ether frame. In special relativity, length contraction is usually illustrated by a two-way beam of light vertical to the observed frame's velocity relative to the observing frame[37]. In the observed frame, the two-way path of the light beam is vertical and overlapping. To observers in the observing frame, the two ways and the distance traveled by the light source form an isosceles triangle, with each waist corresponding to each way of the vertical light path. Since the vertical path and the isosceles triangular path are the same event observed from two frames, the constancy of the speed of light requires the latter to contract according to the formula $l = l_0\sqrt{1 - v^2/c^2}$. The time difference produced during the synchronization of clocks by light signals by the observed frame's velocity as measured by the observing frame is

$$\Delta t' = \frac{l}{c - v} + \frac{l}{c + v} = \frac{2cl}{c^2 - v^2} = \frac{2l_0\sqrt{1 - v^2/c^2}}{c\left(1 - \frac{v^2}{c^2}\right)} = \frac{\Delta t}{\sqrt{1 - v^2/c^2}}.$$

The key issues in the Einsteinian length contraction derivation are still: 1) Which frame is the observing frame and which frame is the observed frame? 2) On which side of the Lorentz transformation equation should the observing frame be? Using "rest frame" and "moving frame" in special relativity when they are relative terms enables researchers to arbitrarily assign these labels to obtain the desired results. In our view, the frame with the proper time and the proper length is the observing frame, whose variables should be on the right-hand side of the Lorentz transformation equation; the frame observed by the one with the proper time and the proper length is the observed frame, whose variables should be on the left-hand side of the Lorentz transformation equation. Proper time is measured by the observers reading their clocks in the same frame. Proper length is a length in the observers' frame measured by the observers using standard rods or coordinates in the same frame. The observed time is the time indicated by clocks in the observed frame, which are read by observers in the observing frame at the corresponding location and time. The observed length is the length indicated by the corresponding coordinates in the observed frame, which are read by observers in the observing frame at the corresponding locations and times. The Lorentz transformation should transform a frame's own measured variable values to obtain the corresponding variable values in another frame rather than transform another frame's measured variable values to obtain one's own frame's corresponding variable values.

With the above view, we view Eq. (13A) as placing the observing frame (*K'*) on the right-hand side and the observed frame on the left-hand side. Its result implies length expansion in the observed frame, the same as Eq. (13), which uses frame *K* as the observing frame and obtains the length expansion in frame *K'*. Mainstream special relativity researchers think of frame *K*, with the proper length, as the moving frame (observed frame) because the observing frame should choose simultaneous readings of the coordinates in the frame concerned (here, frame *K'*), but frame *K* cannot. However, as special relativity argues that simultaneity in frame *K'* implies no simultaneity in frame *K*, the length measured by frame *K'* with its simultaneity might not correspond to the proper length in frame *K* because the two ends of the length are not measured simultaneously in frame *K*. The length measured via reading the corresponding frame *K'* coordinates simultaneously by the frame *K'* observers might not correspond to the proper length in frame *K* due to the relativity of simultaneity. In contrast, frame *K*, as the observing frame, can compare its proper length with the corresponding frame *K'* coordinates read simultaneously by the frame *K* observers to obtain the corresponding length in the observed frame. This seems more logically consistent with the idea that a frame is at rest with itself, such that the proper length is the rest length. Mainstream special relativity researchers place the proper length on the left-hand side of the Lorentz transformation equation since they try to replicate Lorentz's length contraction result and avoid a length expansion result that conflicts with the Lorentz ether theory.

The length contraction derivation using Eqs. (15)-(18) relies on the time contraction we pointed out earlier. Since the proper time $\Delta t'$ should not decrease and hence the corresponding length $v\Delta t'$ in frame *K'*, the increase in the value of Δt in frame *K* should correspond to a length expansion $v\Delta t$. Following this logic, observers in frame *K'* should find a proper length, which is $\sqrt{1 - v^2/c^2}$ of the corresponding expanded length in the "moving frame" (frame *K*) caused by its velocity relative to frame *K'*. In special relativity, it is impossible to derive a consistent corresponding length in another frame. For example, mainstream special relativity researchers dismiss the length expansion result of Eq. (13) on the ground that the coordinates in the observed frame are not simultaneously read. However, although Eq. (13A) lets the coordinates in the counterparty frame be simultaneously read, the original coordinates in the first frame would not be simultaneously read, so the corresponding coordinates and length for the length obtained from Eq. (13A) are no longer the original length and coordinates. For this reason, Ma[4] advocates detailed information on the time, locations, and observers for values measured for any particular variable. The result from Eq. (13) is $l'_{AB,AB,t_A=t_B}$, which means the length in frame *K'* corresponding to the length *AB* in frame *K*, measured by observers at locations *A* and *B* at time t_1 in frame *K*. The result from Eq. (13A) is $l'_{AB,A'B',t'_{A'}=t'_{B'}}$, which means the length in frame *K'* corresponding to the length *AB* in frame *K*, measured by observers at location *A'* and *B'* at time t'_1 in frame *K'*. Since the original length is $l_{AB,AB,t_A=t_B}$, when obtaining $l'_{AB,AB,t_A=t_B}$, we have $t'_{A'} \neq t'_{B'}$, observers in frame *K'* may disagree on $l'_{AB,AB,t_A=t_B}$being the length in frame *K'*. When obtaining $l'_{AB,A'B',t'_{A'}=t'_{B'}}$, we have $t_A \neq t_B$, i.e., its corresponding length in frame *K* is no longer the original length there. Therefore, according to special relativity, it is impossible to obtain length measurements in two frames with relative motion, both of which are measured simultaneously at two locations.

6.5. The Minkowski space-time and the Lorentz transformation

The Einsteinian Lorentz transformation can be represented geometrically as the Minkowski four-dimensional space-time. However, the Minkowski coordinate system seems unusual compared with other coordinate systems. In a Cartesian space-time coordinate system, the time interval between two space-time points can be calculated directly from their time ordinates, and so can their spatial distance. As we have seen in Section 5, in the interpretation of the twin paradox by mainstream special relativity researchers, the Minkowski coordinates seem unable to supply time interval information. The time interval experienced by an observer seems path-dependent rather than coordinates-determined. If the Minkowski space-time coordinates cannot determine the time interval between two space-time points, can it still be called a coordinate system? Or is the special relativity interpretation incorrect?

Some previous studies have emphasized the necessity of distinguishing variables under different circumstances, such as variables measured by observers in the same frame and variables in one frame measured by observers in another[3][4]. What determines observers' temporal state is the proper time in special relativity. Therefore, if acceleration does not impact the traveler's proper time, the twins should be the same age when the traveler returns. The correct interpretation of the Minkowski coordinates should be that when the twins have a constant velocity between them, the Minkowski coordinates are the superimposition of two coordinate systems, one for each. On each overlapping point, the observing frame (rest frame) indicates different time and space coordinates from those indicated by the observed frame (moving frame). The Einsteinian Lorentz transformation reflects the relationship between the observed frame's variables measured by the observing frame and the observed frame per se. When their relative velocity disappears, the special relativity effects disappear. Then, the Minkowski coordinates can have the same role as other coordinate systems in providing time and space information.

Special relativity does not draw its conclusion from its internal logic, which will lead to no age difference between the traveling and staying twins, time contraction, and length expansion. Instead, it tries to replicate the results of the Lorentz ether theory, which can only be achieved by twisting the relationship between the observing and observed frames. Some researchers use Minkowski diagrams to derive time dilation and length contraction[38], but Ma has shown that time contraction can be derived with the same logic used by Schutz to derive length contraction[3][4].

7. Conclusion

From the analysis and discussion in the present paper, we can draw the following conclusions:

First, length contraction and time dilation are primary changes that result from the Lorentz transformation, leading to the constancy of the speed of light in the Lorentz ether theory. Einstein tried to replicate Lorentz's results by postulating the constancy of the speed of light and the principle of relativity, first deriving the Lorentz transformation and then deriving time dilation and length contraction from the Lorentz transformation. None of the two attempts are achieved in a logically valid manner.

Second, there are two distinct values for a variable measured by identical clocks and standard rods in special relativity due to the relativity of simultaneity: the value obtained by observers in the same frame and the value acquired by observers in another with relative motion. In contrast, the differences between values measured by the rest and moving frames in the Lorentz ether theory arise because moving clocks become slower (time dilation) and moving rods contract (length contraction).

Third, the proper time (measured with identical clocks by stationary observers in the same frame) and the proper length (measured with identical measuring rods by stationary observers in the same frame) should be the same in different reference frames in special relativity.

Fourth, the value measured by observers in the same frame, e.g., the proper time and length in special relativity, governs physical processes in a reference frame. Therefore, if acceleration does not impact a clock's running rate, the traveling and staying twins should be the same age in special relativity. So, the twin paradox is a consequence of mixing up the proper time of a frame and its corresponding coordinate time measured by another frame. Relativity researchers' explanations of the twin paradox are their attempts to replicate the results of the Lorentz ether theory.

Fifth, the terms "rest frame" and "moving frame" are meaningful and appropriate in the Lorentz ether theory because they are based on a frame's velocity relative to the ether frame. The terms become confusing in special relativity because the relativistic effects are based on the relative velocity between two reference frames. The correct names for the two terms should be "observing frame" and "observed frame."

Sixth, variable values from the observing frame should be placed on the right-hand side of the Lorentz transformation equations. Variable values for the observed frames are those on the left-hand side of the Lorentz transformation equations.

Seventh, time dilation in the moving frame is the result of the Lorentz ether theory; there is "relative time contraction" in the ether frame as observed by the moving frame because of its "absolute time dilation." The logical result of special relativity should be time contraction in the observed frame, which results in a "relative time dilation" in the observing frame.

Eighth, length contraction in the moving frame is the result of the Lorentz ether theory; there is "relative length expansion" in the ether frame as observed by the moving frame because of its "absolute length contraction." The logical result of special relativity should be length expansion in the observed frame, which results in a "relative length contraction" in the observing frame.

Ninth, simultaneity in the observed frame implied no simultaneity in the observing frame in special relativity. The length contraction commonly derived for the moving frame (observed frame) in special relativity does not correspond to the original length in the observing frame; therefore, length expansion in the observed frame is a more logical result for special relativity.

Tenth, (values of) variables should be designated with their frames and their observers' locations, times, and frames in special relativity to avoid mistakes arising from incorrect assignments of frames, locations, times, and observers.

Eleventh, modern physics uses Lorentzian time dilation and length contraction rather than Einsteinian "time dilation" and "length contraction," i.e., time contraction and length expansion.

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