Chapter 9
Print ISBN: 978-93-90206-53-7, eBook ISBN: 978-93-90206-54-4

Violation of the Special Theory of Relativity and Elucidation of the Twin Paradox

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DOI: 10.9734/bpi/nips/v4

ABSTRACT

Einstein assumed the “principle of relativity” when constructing the special theory of relativity (STR). He claimed that all inertial frames are equivalent, and that it is impossible to discriminate between inertial frames.
However, among the coordinate systems regarded by Einstein as inertial frames, there are some in which light propagates isotropically, and some in which light propagates anisotropically. A method has been found which discriminates between these.
The author has already pointed out that there are problems with the STR, but this paper first examines the "principle of constancy of light speed" assumed by Einstein in order to determine the cause of violation of the STR.
Next, this paper discusses the “triplet thought experiment” in which accelerated motion is eliminated from the famous *twin paradox* thought experiment of the STR. Here the inertial frames regarded as equivalent by the STR are identified as “classically stationary frames S_{cl} ” and “classically moving frames S'_{cl}. ” First, an observer M in frame S_{cl} performs the triplet thought experiment, and it is confirmed that the delay in time which elapses in the moving frame agrees with the predictions of the STR. Next, an observer in rocket A $\left(S'_{\mathrm{cl}}\right)$ performs the triplet thought experiment, and observes the same time delay.
This paper elucidates a system whereby symmetrical experiment results can be obtained, even if the two coordinate systems are not equivalent. The traditional interpretation of the *twin paradox* must be revised.

Keywords: *Special theory of relativity; Twin Paradox; triplet thought experiment; classically stationary frame; relativistically stationary frame; classically moving frame; Lorentz-Einstein transformations; Minkowski Diagram; velocity vector.*

1. INTRODUCTION

As a physical theory representing the 20th century, Einstein’s special theory of relativity (STR) has held sway in the world of physics for more than a century. During this time, the STR has fended off challenges and counterarguments from many physicists [1].

The STR is not just a single theoretical system. It is composed of two theories of different types. The first is a theory derived from Lorentz-Einstein transformations which has full symmetry, and the second is Einstein's energy-momentum relationship which holds in free space.

Of these two theories, it is the former that is treated as a problem in this paper.

Now, consider a situation where two rods, which have the same length when stationary, are moving at constant velocity along the *x*-axis. Clocks of the same type are placed on the two rods, rod I and rod II.

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Here, the coordinate system of rod I is taken to be frame S, and the coordinate system of rod II to be frame S'. The relative velocity of frame S and frame S' is taken to be *v*.

According to the STR, when an observer in frame S measures the time which elapses on the clock in frame S', the time which elapses in frame S' is delayed compared to the time which elapses in frame S. Next, the observer in frame S' measures the length of rod I placed on the *x*-axis in frame S by using a clock that is advancing slowly in frame S'. The observer in frame S' measures the time *t* required for both ends of rod I to pass in front of himself, and finds the rod length *vt*.At this time, rod I is shorter than rod II. Next, when the situation is reversed, and the observer in frame S' makes observations, the time which elapses on the clock in frame S is delayed. Next, when the observer in frame S measures the length of rod II in frame S' using a clock which is slowly advancing in frame S, the rod is contracted in the direction of motion. According to the "principle of relativity," the two inertial frames are equivalent, and thus the observers in frame S and frame S' measure the same value as a matter of course.

However, there are problems with the STR. Whereas the delay in time predicted by the STR is a physical delay, the contraction of the rod is not thought to be physical contraction. This is a problem from the standpoint of symmetry. Also, whereas the observer in frame S who observes the delay of time in frame S' is an observer in a stationary frame, the clock in frame S where contraction of the rod in frame S' is observed is a clock in a slowly advancing moving frame, and this too is a problem.

Normally, a clock measuring the length of rod II in frame S' must be a clock in frame S (the stationary frame). However, if contraction of the rod II is observed in measurement using a clock in a stationary frame, then that contraction will be physical contraction. However, in that case, the causes of the two contractions are different, and an asymmetry arises between the two inertial frames. That is a problem for the STR, which has an absolute commitment to the principle of relativity.

In this paper, section 2 rechecks the "principle of constancy of light speed" which Einstein assumed when developing the STR. Section 3 elucidates the mechanism of the *Twin Paradox*, which has been heatedly discussed from the time the STR was originally established to today.

2. PROBLEMS WITH THE "PRINCIPLE OF CONSTANCY OF LIGHT SPEED E" ESTABLISHED BY EINSTEIN

According to the "principle of relativity" that was assumed when developing the STR, all inertial frames are equivalent. Therefore, the STR denies the existence of inertial frames to which velocity vectors are attached. Einstein developed the STR by asserting that there is no need for the theory to incorporate velocity vectors or the ether [2].

Einstein assumed the "principle of relativity" and the "principle of constancy of light speed."[3].

2.1 Principle of Relativity

"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 co-ordinates in uniform translatorymotion".

2.1.1 Principle of constancy of light speed I(principle I)

"Light is always propagated in empty space with a definite velocity *c* which is independent of the state of motion of the emitting body."

2.1.2 Principle of constancy of light speed II (principle II)

1) "Let a ray of light start at the "A time" t_{A} from A towards 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."

2) "Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity *c*, whether the ray be emitted by a stationary or by a moving body. Hence

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

where time interval is to be taken in the sence of the definition in § 1." (Formula (1) of this paper).

The "principle I" asserts that the light speed in vacuum does not depend on the speed of the light source. The "principle II" asserts that the light speed calculated from the round-trip travel time is constant.

Let there be a given stationary rigid rod of length *L* as measured by a ruler which is stationary, and assume that the rod is placed along the stationary frame's *x*-axis.

Assume that clocks A and B of the same type are set up at points A and B on the rear (negative direction) and front (positive direction) end of this rod. Here clock A will be abbreviated as C_A, and clock B as C_B.

Suppose a ray of light is emitted in the direction of B from A at time t_{A} of C_A, reaches and is reflected at B at time t_{B} of C_B, and then returns to A at time $t_{\mathrm{A'}}$ of C_A. Einstein determined that if the following relationships hold between these two times, then the two clocks represent the same time by definition [4].

$$t_{\mathrm{B}}-t_{\mathrm{A}}=t_{\mathrm{A'}}-t_{\mathrm{B}}. \tag{1}$$

$$\frac{1}{2}\left(t_{\mathrm{A}}+t_{\mathrm{A'}}\right)=t_{\mathrm{B}}. \tag{2}$$

If the relationship in Formula (1) does not hold for the times of C_A and C_B, then it is necessary to adjust the time of C_B so that the relationship in Formula (1) holds. (Actually, either clock can be adjusted).

Formulas (1) and (2) can also be applied to an inertial frame S' (coordinate system of the rod) in which a rod is moving at constant velocity relative to a stationary frame $S.$ (in this case, t_{A} and t_{B} become times in frame $S'.$).

Now, the rod which was stationary begins to move at constant velocity along the *x*-axis of frame $S.$ At an arbitrary time, a light signal is emitted from point A on the rear side of the rod toward point B on the front side.

If the principle I is applied, then propagation of light in frame S' seen from an observer in frame S is anisotropic. Therefore, from the classical perspective, an observer in frame S' determines the propagation of light in frame S' to be anisotropic in the same way. Also, it is concluded that the light speed on the outward path and return path is not *c*.

However, the principle II also holds in frame S', and thus the light speed calculated by the observer in frame S' from the round-trip time of the light becomes *c*. The STR denies part of this judgment by the observer in S'. However, according to the STR, the two inertial frames are equivalent, and thus the light speed measured by the observer in frame S' must be *c* for both the outward and return path.

Considered classically, an inertial frame in which light propagates isotropically is a “classically stationary frame S_{cl},” and an inertial frame in which light propagates anisotropically is a “classically moving frame S'_{cl}.”

However, if two clocks in an inertial frame are synchronized using the method of Einstein, then even in frame S'_{cl}, the light speed is measured as *c* on both the outward and return path, just as in a frame S_{cl}.

As a result, both frame S_{cl} and frame S'_{cl} fall under the heading of a “relativistically stationary frame S_{re},” and it is impossible to experimentally identify the two. (Here, the subscript "re" of S_{re} indicates relativistically).

Also, all inertial frames become stationary frames in the sense of the principle of relativity.

In this paper, the "principle of constancy of light speed" introduced by Einstein is called the "principle of constancy of light speed E." (where "E" stands for Einstein. This may sometimes be abbreviated below as "principle E." That is,

Principle of constancy of light speed E: In all inertial frames, light speed of the outward path and return path is constant (*c*).

However, the expression "principle of constancy of light speed E" does not appear in Einstein's paper. That expression was coined by the author.

The principle II asserts that the light speed calculated from the round-trip travel time is constant.

However, principle II does not assert that light speed is *c* on both the outward and return paths. Taking principle I into account, it is clear that no such assertion can be made.

However, Einstein proposed synchronization of clocks at both ends of a rod moving at constant velocity by using Einstein's method (Formula (1)). If the times on the clocks are adjusted so the relation in Formula (1) holds, then it is possible to set the light speed on both the outward and return paths to *c* ("principle E"). Here, this paper uses the term "relativistically stationary frame S_{re}" for a coordinate system where principle E holds. Due to adjustment of the clock in frame S'_{cl}, light propagates isotropically in this coordinate system too (relativistic isotropic propagation), and it is incorporated into a relativistic stationary frame in the sense of the theory of relativity.

Einstein's thought process, up to the establishment of the STR, can be inferred as follows.

Inertial frame prior to STR   Result of clock synchronization   Application of principle of relativity

$$\begin{bmatrix} \text{1. Classically stationary frame } S_{\text{cl}} \\ (\textit{A priori} \text{ isotropic propagation}) \\ \text{Light speed} = c \\ \text{2.Classically moving frame } S'_{\text{cl}} \\ (\text{Anisotropic propagation}) \\ \text{Light speed} \neq c \end{bmatrix} \rightarrow \begin{bmatrix} \text{1.} S_{\text{cl}} (\textit{A priori} \text{ isotropic propagation}) \\ \text{Light speed} = c \\ \text{2.} S'_{\text{cl}} (\text{Relativistic isotropic propagation}^{*1}) \\ \text{Light speed} = c_{\text{mp}} \end{bmatrix} \rightarrow \begin{bmatrix} \text{Relativistically stationary frame } S_{\text{re}} \\ \text{Principle of constancy of light speed E} \\ (\textit{A priori} \text{ isotropic propagation}) \\ \text{Light speed} = c \end{bmatrix}$$

Classical physics $\rightarrow$ STR

$$\begin{bmatrix} \text{Principle of constancy of light speed I} \\ \text{Principle of constancy of light speed II} \\ \text{Principle of relativity} \end{bmatrix} \rightarrow \begin{bmatrix} \text{Principle of constancy of light speed E} \\ \text{Principle of relativity} \end{bmatrix}$$

Propagation of light in frame S'_{cl} should, by nature, be anisotropic. However, at the beginning of the 20th century, there was still no thought experiment for ascertaining this fact. Thus, Einstein did not distinguish between frames S_{cl} and S'_{cl}.

The term "relativistic isotropic propagation" indicated by *1 refers to propagation of light in a coordinate system where clock times have been adjusted so that the relation in Formula (1) holds between the times of the 2 clocks. Here, c_{mp} is the light speed when a light speed that originally was not *c* is forced to be *c* by adjusting clocks. (Here, the subscript "mp" of c_{mp} indicates a light speed realized by manipulating clock times).

Even though Einstein created c_{mp}, it seems that before long he forgot about it. Here, the distinction between *c* and c_{mp} was also lost due to application of the principle of relativity to 2 types of coordinate systems. As a result, the principle E arose, asserting that light speed is *c* on both the outward and returns paths. At the same time, S_{cl} and S'_{cl} were included in S_{re}, and it became meaningless to discriminate between the two.

The principle E is not a universal principle, but a personal principle introduced by Einstein (However, Einstein was probably unaware of this fact.)

To maintain this principle, the observer in a moving frame must adjust the time on a clock each time the velocity of a moving frame changes. If the observer neglects this task, the principle E is no longer a principle.

When deriving the Lorentz-Einstein transformation, Einstein made the following assumption [5,6].

$$x = ct, \quad x' = ct'. \tag{3}$$

Here, light emitted from the two inertial frames propagates isotropically in an *a priori* sense. (Before the advent of the STR, there was no need to call attention to ideas such as *a priori*.) However, Formula (3) obtained as a result of using principle E placed too much emphasis on the principle of relativity. Therefore, principle I, which should rightfully stand on an equal footing, was eclipsed. (Or, this can be interpreted as excluding principle I.)

However, the formula which should rightfully be assumed is not Formula (3). It must be the following formula.

$$x = ct, \quad x' = c_{\text{mp}}t'. \tag{4}$$

It is no surprise there is paradox in the STR, which was developed from the starting point of a mistaken assumption (Formula (3)) which rightfully shouldn't be there. Even if the mathematics are perfect, if there are problems with the starting assumptions, it will be impossible to develop a correct theory. The next section presents the *Twin Paradox* problem of the STR from a paper by the author.

3. THREE KINDS OF"TRIPLET THOUGHT EXPERIMENT"

Among the hypothetical paradoxes generated by the STR, the *twin paradox* (or clock paradox) is the most famous.

Suppose two clocks have been synchronized to the current time, and mark time at the same rhythm. Assume that one clock (the first clock) remains stationary in a certain inertial frame, and the other clock (the second clock) is carried away along an arbitrary path, eventually returning to the departure point. The STR predicts that, at this time, the second clock will be delayed compared to the first clock [7,8].

To use a modern example, if the older of two twin astronauts returns from a trip through space, he will find that he is younger than his younger brother who remained on earth. This problem has been vigorously debated in the past, and today the issue is thought to be settled [9].

The tradition view put forward to avoid the paradox is as follows.

"The coordinate system of the second clock moving with respect to the inertial frame undergoes accelerated motion, and thus an asymmetry exists between the two coordinate systems. The side which has moved is clearly the second clock, and thus it is natural for the second clock to be delayed."

A coordinate system which has attained movement at constant velocity through accelerated motion cannot be regarded physically as a stationary frame.

However, in order to avoid discussion of the accelerated motion treated in the *twin paradox* thought experiment, here the author considers the "triplet thought experiment."

The “triplet thought experiment” is performed by introducing an inertial frame experimentally confirmed to be frame S_{cl}.

3.1 Triplet Thought Experiment 1 Performed by Observer M

Rocket A is moving at constant velocity 0.6*c* in the *x*-axis direction of the coordinate system M (S_{M}). (Fig.1a)

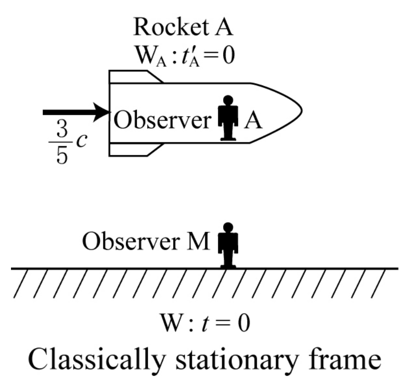

Fig. 1a. When the observer on rocket A passes in front of observer M, the two observers start their own stopwatches

In preparation for the thought experiment to be conducted, it is assumed that it has been confirmed through an experiment beforehand that frame S_{M} is a classically stationary frame S_{cl}. (The coordinate system of rocket A, classically moving frame S'_{cl} is described as frame S'_{A}. A method for discriminating between these coordinate systems has already been presented in other papers [10,11,12,13]).

There is an observer M at the origin O of the *x*-axis of frame S_{cl}, and M has a stop watch W. In addition, there is an observer A at the origin O'_{A} of the x'_{A} -axis of frame S'_{A}, and A has a stopwatch W_{A}.

Now, when rocket A passes in front of observer M, observer M starts W, and observer A starts W_A. Then, when 1(s) has elapsed on W, rocket A passes by rocket B that has approached from the forward direction. (Fig. 1b)

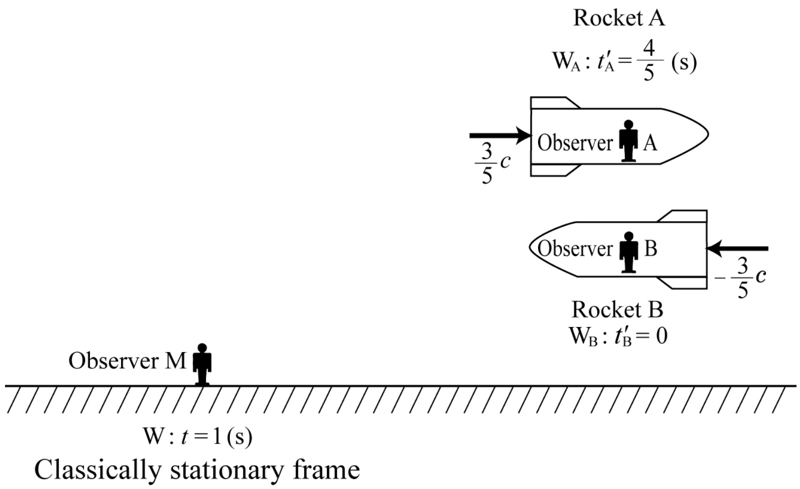

Fig. 1b. Instant when rocket A and rocket B pass by each other. At this time, observer A stops W_A, and observer B on rocket B starts stopwatch W_B

At this time, observer A stops W_A, and observer B on rocket B starts stopwatch W_B. (However, it is assumed that the velocity of rocket B measured by an observer in frame S_{cl} is –0.6*c*.)

According to the STR, an observer in frame S_{cl} finds the following relationship between the time *t* which elapses on W and the time t'_A which elapses on W_A.

$$t'_A = \frac{t}{\gamma} = t\left(1 - \frac{v^2}{c^2}\right)^{1/2}. \tag{5}$$

Here, when 1(s) is substituted for *t*,

$$t'_A = \frac{4}{5} \text{ (s)}. \tag{6}$$

Next, when the observer in rocket B, who continues to move at constant velocity, passes in front of observer M, the two observers stop their stopwatches. (Fig. 1c)

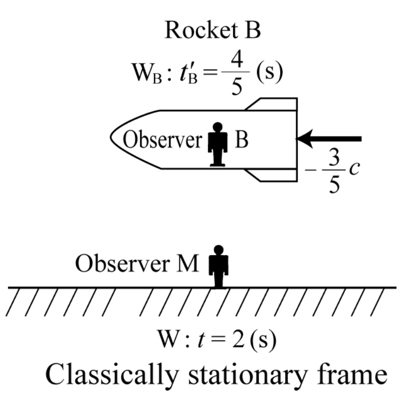

Fig. 1c. When the observer on rocket B passes in front of observer M, the two observers stop their stopwatches

If the time elapsed on W_B at this time is taken to be t'_B, then since t'_B is equal to Formula(6). That is,

$$t'_B = \frac{4}{5} \text{ (s)}. \tag{7}$$

On the other hand, the time elapsed on W in frame S_{cl} is 2(s). According to the STR, during the interval where 1 (s) elapses on W, both the time t'_A which elapses on W_A and the time t'_B which elapses on W_B are both 0.8 (s). Therefore, an observer in frame S_{cl} derives the following relationship from *t*, t'_A and t'_B.

$$t = 2 \text{ (s)},\ t'_A = \frac{4}{5} \text{ (s)},\ t'_B = \frac{4}{5} \text{ (s)}. \tag{8}$$

$$t : (t'_A + t'_B) = 1 : \frac{4}{5}. \tag{9}$$

The time $(t'_A + t'_B)$ which passes on rockets A and B moving at constant velocity is delayed compared to the time *t* which elapses in frame S_{cl}. Thought experiment 1 is an experiment in which accelerated movement has been removed from the famous *twin paradox*, and is called the "triplet thought experiment." (In this case, the triplets correspond to W,W_A and W_B).

Here, this thought experiment is explained using Minkowski diagram 1 [14]. (Fig.2).

The following explanation in this section is an excerpt from another paper [15,16].

Point O indicates both origins: $x = 0,\ t = 0$ and $x'_A = 0,\ t'_A = 0.$ The point event M_0 of stop watch W of frame S_{cl} and the point event A_0 of stop watch W_A are at the origin O. (Here, the subscripts "$_0$" of the point events M_0 and A_0 mean, respectively, $t = 0$ and $t'_A = 0.$)

The *x*-axis indicates the *x*-axis of the inertial frame S_{cl} when $t = 0.$ In addition, the x'_A-axis indicates the x'_A-axis of the inertial frame S'_A when $t'_A = 0.$ (However, the x'_B-axis is omitted for brevity.)

The*ct*-axis is the path for $x = 0.$ Put another way, it is the world line of stop watch W. The ct'_A-axis is the world line of stop watch W_A.

In addition, the straight line extending at a 45° angle from the origin O indicates the light signal emitted from the two light sources at the instant that O and O'_A pass by each other.

OE is the distance over which the light signal emitted from O propagates in the *x*-axis direction while 1(s) elapses on the stop watch W in frame S_{cl}.

OE′ is the distance over which the light signal emitted from O'_A propagates in the x'_A-axis direction while 1(s) elapses on the stop watch W_A in frame S'_A.

Oe is the value when an observer in frame S_{cl} measures the distance OE′, and Oe′ is the value when the distance OE is measured by an observer in frame S'_A. However, Ee′ is parallel to the *ct*-axis, and eE′ is parallel to the ct'_A-axis. Therefore, the relationship between OE, OE′, Oe and Oe′ is as follows.

$$\frac{\text{Oe}}{\text{OE}} = \frac{\text{Oe}'}{\text{OE}'} = \frac{1}{\gamma}. \tag{10}$$

If a point is plotted on the *ct*-axis at a distance equal to OE from O, that is the point event M_1 of W when $t = 1$ (s). Also, if a point is plotted on the ct'_A-axis at a distance equal to OE′ from O, that is the point event A_1 of W_A when $t'_A = 1$ (s).

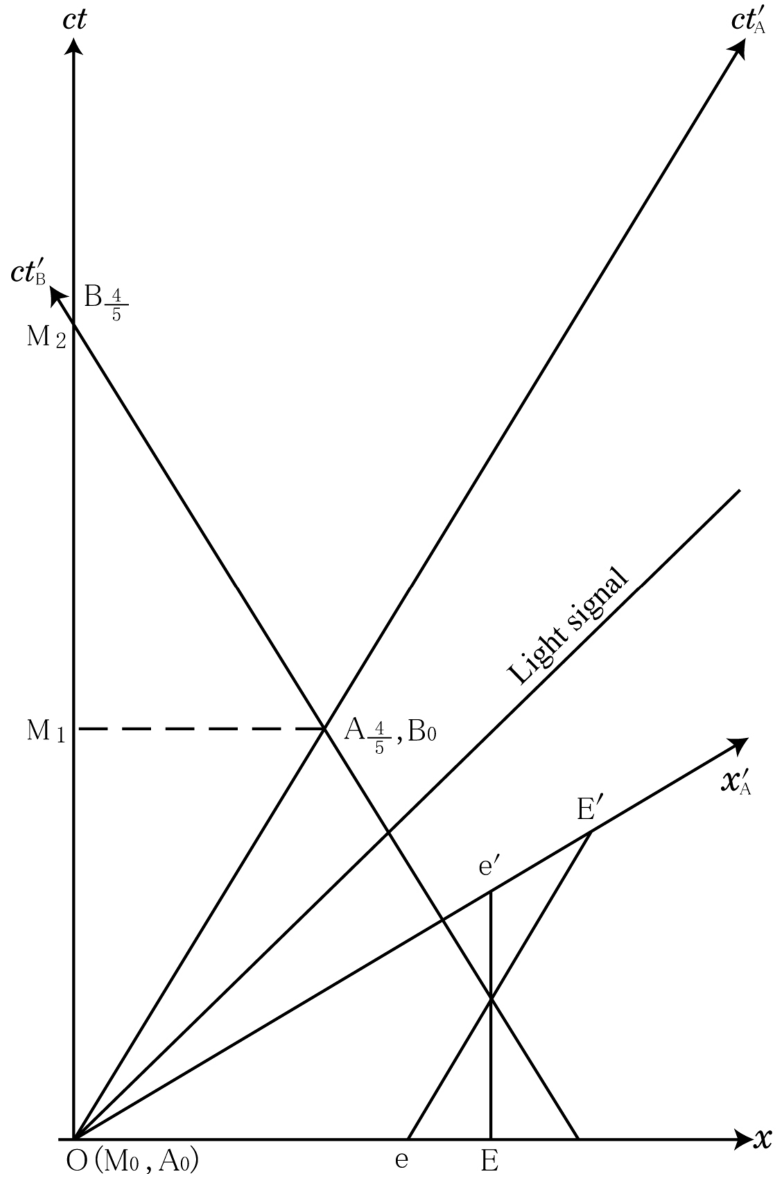

Fig. 2. Minkowski diagram 1: This diagram corresponds to thought experiment 1. World lines of stop watches $W_A(A_0A_{4/5})$, $W_B(B_0B_{4/5})$ and $W(M_0M_1M_2)$

Now, how should we find the relationship between the times which elapse in the stationary frame and in the coordinate system of rocket A?

To find that, it is enough to compare the times when the straight line parallel to the *x*-axis intersects with the *ct*-axis and ct'_A-axis.

For example, among the lines which pass through M_1, the straight line parallel with the *x*-axis intersects the ct'_A-axis at point $A_{4/5}$, and this is the point event of W_A when $t = 1$ (s). Therefore t'_A matches with Formula(6).

The point events $A_{4/5}$ and B_0 are the point events of the two at the instant when W_A and W_B pass by each other. (Here, the point events $A_{4/5}$ and B_0 mean $t'_A = 0.8$ (s) and $t'_B = 0.$).

Also, the point events M_2 and $B_{4/5}$ are the point events of the two at the instant when W_B passes in front of W of frame S_{cl}. (Here, the point events M_2 and $B_{4/5}$ mean $t = 2$ (s) and $t'_B = 0.8$ (s).) .

3.2 Triplet Thought Experiment 2 Performed by Observer M

In this case, rocket C is taken to be the subject of consideration instead of rocket B. In the first stage, just as in thought experiment 1, observers M and A start their own stop watches W and W_A when observer A passes in front of observer M. (Fig. 1a)

After that, when 0.8 (s) has elapsed on W, rocket C passes in front of observer M at constant velocity ***u***. When observer C on rocket C passes in front of observer M, observer M stops W, and observer C starts stop watch W_C. (Fig. 3a)

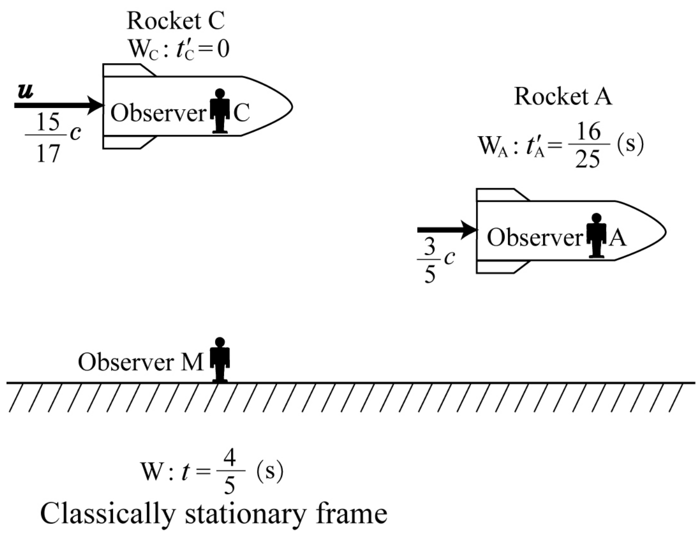

Fig. 3a. Instant when 0.8 (s) has elapsed on W in the stationary frame, and W_C of rocket C passes in front of observer M

Here, the velocity ***u***is the velocity at which rocket C approaches rocket A at a speed of 0.6*c*.

Incidentally, the velocity addition law in the STR is given by the following formula.

$$u = \frac{v + w}{1 + \frac{vw}{c^2}}. \tag{11}$$

To obtain the velocity of rocket C as seen from frame S_{cl}, it is enough to substitute 0.6*c* for *v* and *w* in formula (11), and thus *u* is:

$$u = \frac{15}{17}c. \tag{12}$$

Rocket C continues its motion at constant velocity, and when it has caught up with rocket A, observer A stops W_A and observer C stops W_C. (Fig.3b)

The situation of the thought experiment thus far can be explained with the following Minkowski diagram 2. (Fig. 4)

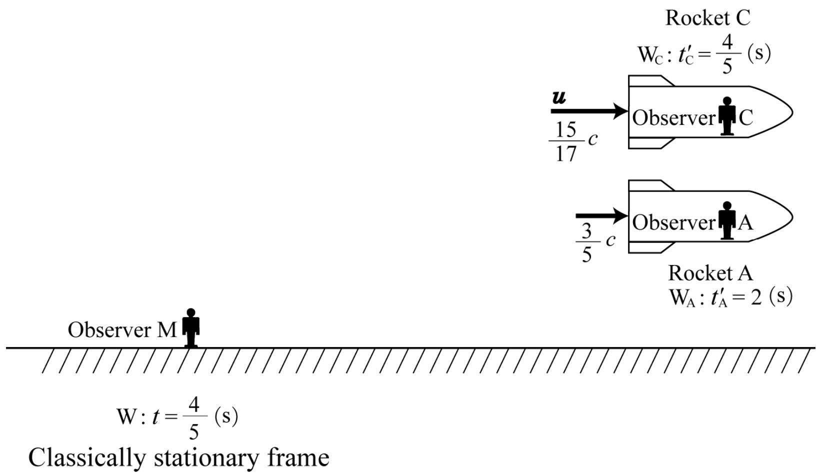

Fig. 3b. When rocket C has caught up with rocket A, observers A and C stop W_A and W_C.

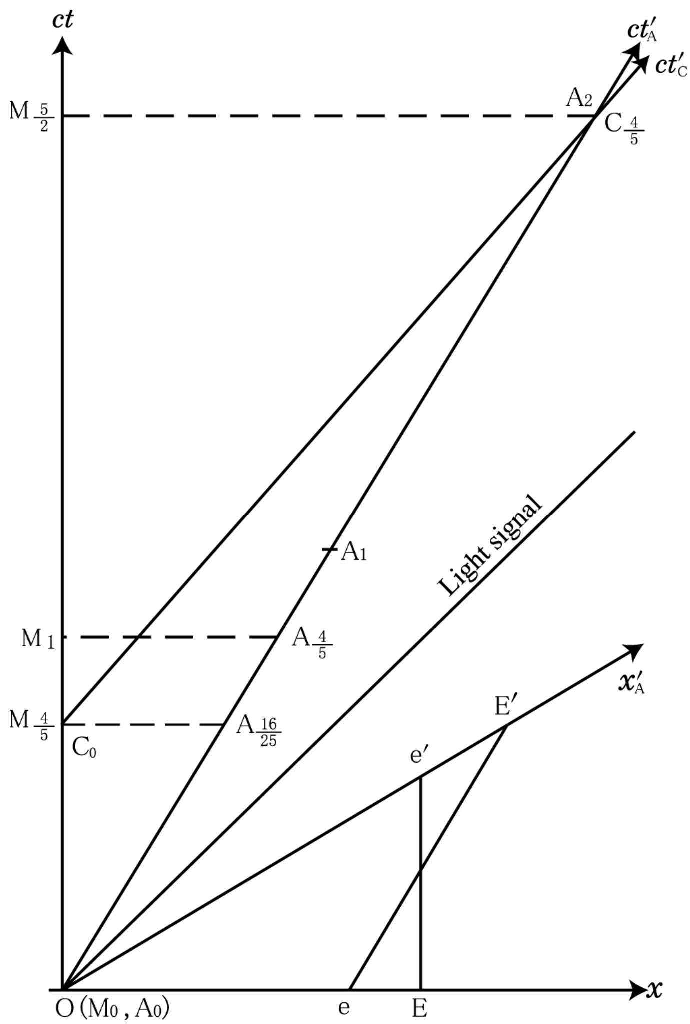

Fig. 4. Minkowski diagram 2: This diagram corresponds to thought experiment 2.World lines of stop watches $W_A(A_0A_2)$, $W_C(C_0C_{4/5})$ and $W(M_0M_{4/5})$

The ct'_c-axis of diagram 2 corresponds to the world line of stop watch W_C. In addition, the point events at the instant that W and W_C pass by each other are $M_{4/5}$ and C_0. (Here, the point events $M_{4/5}$ and C_0mean $t = 0.8$ (s) and $t'_C = 0.$)

Furthermore, the point events A_2 and $C_{4/5}$ are the point events of the two at the instant when W_C has caught up with W_A.(Here, the point events A_2 and $C_{4/5}$mean $t'_A = 2$ (s) and $t'_C = 0.8$ (s).)

Also, in thought experiment 2, the observer in frame S_{cl} compares the time t'_A elapsed on W_A with the value $(t + t'_C)$ obtained by totaling the time t elapsed on W with the time t'_C elapsed on W_C. Prior to that, the observer in frame S_{cl} compares t with t'_A and t'_C.

In order to find t'_A and t'_C, we first find t_A and t_C. When t_A elapses on W, t'_A elapses on W_A, and when t_C elapses on W, t'_C elapses on W_C. At this time, the following two equations hold.

$$t_A = \frac{4}{5} + t_C. \tag{13}$$

$$vt_A = ut_C. \tag{14}$$

The following t_A and t_C are obtained when Formulas (13) and (14) are solved.

$$t_A = 2.5 \text{ (s)}. \tag{15}$$

$$t_C = 1.7 \text{ (s)}. \tag{16}$$

Here, t_C is the time elapsed on W during the interval when W_C was operating.

On the other hand, the time t'_A elapsed in frame S'_A is,

$$t'_A = \frac{t_A}{\gamma} = 2 \text{ (s)}. \tag{17}$$

If t'_C is taken to be the time which elapses on W_C while t_C elapses on W,

$$t'_C = \frac{t_C}{\gamma'}, \quad \gamma' = \left(1 - \frac{u^2}{c^2}\right)^{-1/2}. \tag{18}$$

Here, when the value of Formula (12) is substituted for u in Formula (18),

$$\gamma' = \frac{17}{8}. \tag{19}$$

To find t'_C, it is sufficient to substitute the value of Formula (16) for t_C in Formula (18), and thus

$$t'_C = \frac{4}{5} \text{ (s)}. \tag{20}$$

This t'_C is the time over which W_C was operating. Due to the above considerations, the observer M in frame S_{cl} obtains the following values for the elapsed times of t'_A, t and t'_C.

$$t'_A = 2 \text{ (s)},\ t = \frac{4}{5} \text{ (s)},\ t'_C = \frac{4}{5} \text{ (s)}. \quad \text{(Fig. 3b)} \tag{21}$$

$$t'_{\mathrm{A}} : \left(t + t'_{\mathrm{C}}\right) = 1 : \frac{4}{5}. \tag{22}$$

The value $\left(t + t'_{\mathrm{C}}\right)$ obtained by totaling the times elapsed on W and W_C is delayed compared to the time t'_{A} which elapses in frame S'_{A} which is not originally the stationary frame.

3.3 Triplet Thought Experiment 3Performed by Observer A on Rocket A

According to Einstein's "principle of relativity," the two inertial frames are equivalent, and thus the same results are obtained no matter which inertial frame measurement is carried out from. The coordinate system of rocket A is not a classically stationary frame, but relativistically it is a stationary frame.

The observer in rocket A regards his own coordinate system as a stationary frame.Therefore, Formulas (21) and (22) are interpreted as follows. (note the change in the dash ´ indicating the moving frame due to the change in the stationary frame.)

$$t_{\mathrm{A}} = 2\ (\mathrm{s}),\ t' = \frac{4}{5}\ (\mathrm{s}),\ t'_{\mathrm{C}} = \frac{4}{5}\ (\mathrm{s}). \text{(Fig. 5)} \tag{23}$$

$$t_{\mathrm{A}} : \left(t' + t'_{\mathrm{C}}\right) = 1 : \frac{4}{5}. \tag{24}$$

Formula (24) can be interpreted as indicating that observer A has conducted the triplet thought experiment.(Fig. 5)

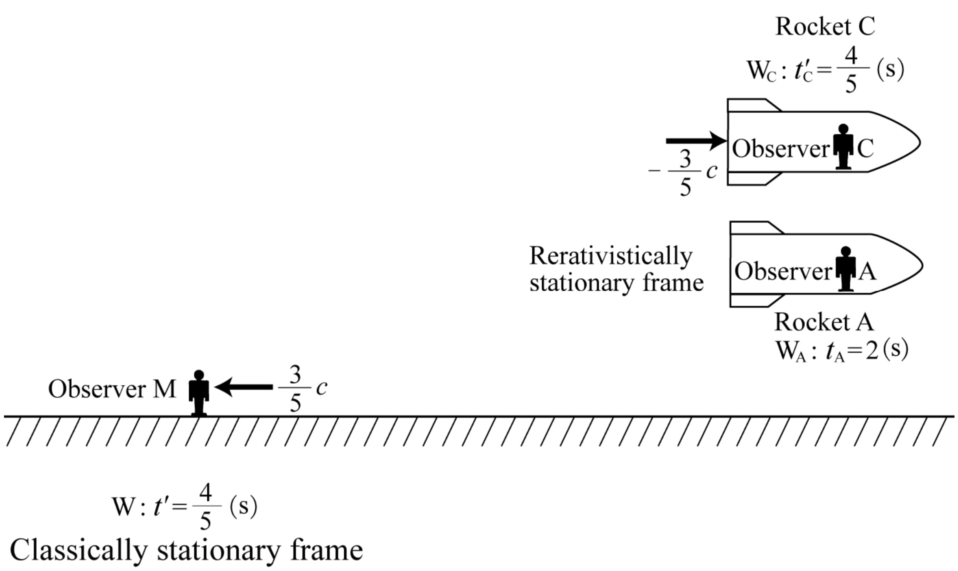

Fig. 5. Thought experiment 3 can be interpreted as indicating that observer A has carried out thought experiment 1, taking frame S'_{A} as the stationary frame

Formulas (9) and (24) are the experiment results predicted by the STR.

Let us consider, as far as possible, the *a priori* rhythm by which the stopwatches used in thought experiments mark off time. The problem of rhythm cannot be addressed in the STR, but this paper has introduced S_{cl} and thus it is possible to discuss the problem of rhythm.

Now, if the rhythms by which the three stopwatches mark time are expressed as rhythm (W), rhythm (W_A) and rhythm (W_B), then observer M can predict the following relationship from Formula (8).

$$\text{rhythm (W)} : \text{rhythm } (\mathrm{W_A}) : \text{rhythm } (\mathrm{W_B}) = 1 : \frac{4}{5} : \frac{4}{5}. \tag{25}$$

Also, in thought experiment 2, observer M can predict the following relationship if Formula (19) is taken into account.

$$\text{rhythm } (\mathrm{W_A}) : \text{rhythm (W)} : \text{rhythm } (\mathrm{W_C}) = \frac{4}{5} : 1 : \frac{8}{17}. \tag{26}$$

In contrast, the observer in rocket A regards his own coordinate system as a stationary frame, and interpreted the situation as in Formula(23). However, the problem of rhythm cannot be addressed with the STR, and thus the observer in rocket A cannot make the following prediction from Formula(23) [7,16,17,18]. That is,

$$\text{rhythm } (\mathrm{W_A}) : \text{rhythm (W)} : \text{rhythm } (\mathrm{W_C}) \neq 1 : \frac{4}{5} : \frac{4}{5}. \tag{27}$$

In the end, Formula (21) holds because Formula (26) holds. However, observer A carries out the thought experiment with the conviction that his own coordinate system is a stationary system, and thus a result (23) is obtained which agrees with the predictions of the STR.

Rocket A undergoes accelerated motion until it attains motion at constant velocity. The coordinate system of rocket A is clearly a moving frame. The two inertial frames M and A are by no means equivalent. Even so, the author was able to confirm the delay in time predicted by the STR even in the tripletthought experiment carried out by observer A. Aside from this, the author has also published a paper pointing out the contradictions of the STR [19,20].

Also, mathematical physicist Lanczos introduced the view of physicist Lowrentz on Einstein's theory as follows [21].

“He was always very appreciative of the work of others and had the greatest admiration for Einstein, but his own opinion was that the ingenious scheme of Einstein was essentially a clever mathematical trick which did not explain the real physical problem.”

4. CONCLUSION

1) Principle II, from before the advent of the STR, took into account principle I, and thus it was not asserted that the light speeds of the outward and return path are both *c* in all inertial frames.

Einstein originally recognized that there are two principles of constancy of light speed, principle I and principle II. However, when constructing the STR, Einstein placed higher priority on the principle of relativity than principle I. Also, he proposed that the time of clocks be adjusted so that the light speed is measured to be *c* on both the outward and return path. As a result, a new "principle of constancy of light speed E" was created. When the STR was constructed, the reason for being of the originally assumed principle I and principle II faded, and their status was usurped by principle E.

To maintain principle E, we must repeatedly adjust the times of clocks in a moving frame, each time the velocity of the moving frame changes. Principle E cannot be maintained if we do not cooperate with Einstein. This paper cannot accept principle E, which really cannot be regarded as a genuine principle. The STR, constructed based on this principle E, is a mistaken theory.

2)It is evident that the following relationships hold in the STR.

$$t = 2 \text{ (s)},\ t'_{\mathrm{A}} = \frac{4}{5} \text{ (s)},\ t'_{\mathrm{B}} = \frac{4}{5} \text{ (s)}. \tag{28}$$

$t_{\mathrm{A}} = 2\ (\mathrm{s}),\ t' = \frac{4}{5}\ (\mathrm{s}),\ t'_{\mathrm{C}} = \frac{4}{5}\ (\mathrm{s}).$ (Fig. 5) (29)

However, even if formulas (28) and (29) hold, it is not the case that the following relationships hold.

Rhythm predicted by observer M: $\mathrm{rhythm}\ (\mathrm{W}) : \mathrm{rhythm}\ (\mathrm{W_A}) = 1 : \frac{4}{5}.$ (30)

Rhythm predicted by observer A: $\mathrm{rhythm}\ (\mathrm{W_A}) : \mathrm{rhythm}\ (\mathrm{W}) = 1 : \frac{4}{5}.$ (31)

In the STR, the discussion never extends to the problem of rhythm. Rhythm is an *a priori* concept, and thus it is not possible for all observers to assert that there will be delay in the rhythm of a clock in an inertial frame moving at constant velocity relative to their own inertial frame.

In this paper, the following relationships were derived by incorporating frame S_{cl} into the thought experiment.

$$t = 2\ (\mathrm{s}),\ t'_{\mathrm{A}} = \frac{4}{5}\ (\mathrm{s}),\ t'_{\mathrm{B}} = \frac{4}{5}\ (\mathrm{s}). \tag{32}$$

$t = \frac{4}{5}\ (\mathrm{s}),\quad t'_{\mathrm{A}} = 2\ (\mathrm{s}),\quad t'_{\mathrm{C}} = \frac{4}{5}\ (\mathrm{s}).$ (Fig. 3b) (33)

The *a priori* rhythms with which the three clocks (stop watches) mark time are as follows.

$$\mathrm{rhythm}\ (\mathrm{W}) : \mathrm{rhythm}\ (\mathrm{W_A}) : \mathrm{rhythm}\ (\mathrm{W_B}) = 1 : \frac{4}{5} : \frac{4}{5}. \tag{34}$$

$$\mathrm{rhythm}\ (\mathrm{W}) : \mathrm{rhythm}\ (\mathrm{W_A}) : \mathrm{rhythm}\ (\mathrm{W_C}) = 1 : \frac{4}{5} : \frac{8}{17}. \tag{35}$$

However, in the STR all inertial frames are regarded as equivalent, and thus in thoughtexperiment 3, the coordinate system of rocket A becomes a stationary frame. Thus, the observer in rocket A interprets Formula (33) as Formula (29). (Here, t'_{A} has been changed to t_{A}, and t to t'.)

However, it is possible to conclude Formula (29) because Formula (33) holds, and Formula (33) holds because formula (35) holds.

This paper concludes that the traditional interpretation of the *twin paradox* must be revised.

ACKNOWLEDGEMENTS

I would like to express my thanks to the staff at ACN Translation Services for their translation assistance. Also, I wish to express my gratitude to Mr. H. Shimada for drawing figures.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Biography of author(s)

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He was born in Japan, in January 1955, and majored in chemistry at university. He began studying the special theory of relativity (STR) around the time he went to university. In the first 1 or 2 years, he worked hard to understand the STR, but gradually he began to have doubts.Time passed, and he wrote a number of papers in the 1990s. This paper is the result of correcting and improving an unpublished manuscript he wrote in 1996. Around 2000, there was a debate on the correctness of the STR in the Japanese physical science magazine Parity. He too joined this debate midway through, and pointed out the contradictions of the STR.That manuscript was published in the October 2001 issue of the magazine. His paper successfully refuting the STR was first published in a refereed journal in 2010. Also, in 2002, by taking Einstein's energy-momentum relationship as a hint, he derived an energy-momentum relationship applicable inside a hydrogen atom where there is potential energy. After that, he was able to present a candidate for dark matter based on that relationship. He was invited as a speaker to the Applied Physics and Mathematics Conference in 2018 held in Tokyo in October 2018, and presented a candidate for dark matter. To date, he has published 32 papers in 8 journals outside Japan. He is currently working as a representative officer of a Buddhist temple.

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This chapter is an extended version of the article published by the same author(s) in the following journal.
Journal of Physical Mathematics, 9(2), 2018.