Demonstration of the existence of a velocity vector missing from the special theory of relativity

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Abstract: The special theory of relativity (STR) does not describe physical laws pertaining to objective reality. It is a theory that predicts and explains the values of physical quantities measured using two synchronized clocks. When developing the STR, Einstein asserted that there is no need to introduce concepts such as the ether or velocity vectors, and he later denied their existence. However, through a discussion from the standpoint of real existence, this paper points out that there are cases where there is a velocity vector attached to an inertial system, and it presents an equation determining that vector's size. © *2015 Physics Essays Publication.*
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Résumé: La théorie de la relativité restreinte n'est pas celle qui décrit les lois physiques en rapport avec la réalité objective: elle estime et explique la valeur de la quantité physique mesurée grâce à deux horloges synchronisées. Lorsqu'Einstein élabore cette théorie, il affirme qu'il n'est pas nécessaire d'introduire les concepts d'éther ou de vecteur-vitesse, et réfute par la suite leur existence. Cependant, notre but principal est ici de montrer qu'en réalité, un système d'inertie peut être accompagné d'un vecteur-vitesse, et de présenter une formule en définissant la grandeur.

Key words: Special Theory of Relativity; Velocity Addition Law; Relativistic Synchronization of Clocks; Relativistically Stationary System; Velocity Vector.

I. INTRODUCTION

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

Michelson and Morley attempted to detect Earth's motion relative to this luminiferous ether, i.e., the absolute velocity. However, they failed to detect the expected effect.[1]

To explain this experimental result, Michelson and Lorentz developed the following interpretations:

(1) Michelson's interpretation: The reason why the expected result was not detected in the experiment is that the ether is stationary relative to the moving earth (i.e., the ether is moving together with the earth).
(2) Lorentz's interpretation: The reason why the ether could not be detected even though it exists is because the length of the earth contracts by $\sqrt{1-(v/c)^2}$ times in the direction of motion.[2]

However, in his special theory of relativity (STR) published in 1905, Einstein insisted that physics does not require an "absolutely stationary system" provided with special properties, and that there be no such things as "specially favored" coordinate systems to permit the introduction of the ether idea.[3]

Einstein's aim at the time was not to explain, like Lorentz and Poincaré, the reason why the expected results were not observed in the Michelson–Morley experiment, but to instead derive a transformation between coordinate systems in order to resolve the asymmetry apparent in electromagnetism. However, for physicists at that time, the ether was a reality, not a concept or hypothesis.

When Einstein developed the STR, he assumed the "principle of relativity" and the "principle of the constancy of the speed of light." The latter includes the following two principles.

"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."[4]

"Let a ray of light start at the 'A time' t_A from A toward B, let it at the 'B time' t_B be reflected at B in the direction of A, and arrive again at A at the A time t'_A.

In agreement with experience, we further assume the quantity

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

to be a universal constant—The velocity of light in empty space."[5]

In this paper, we distinguish between the former principle as the "principle of the constancy of the speed of light I" and the latter principle as the "principle of the constancy of the speed of light II." The principle of the constancy of the speed of light I asserts that the speed of light in vacuum does not depend on the speed of the light source. The principle of the constancy of the speed of light II asserts that the speed of light calculated from the round-trip travel time is constant.

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Therefore, if the principle of the constancy of the speed of light I is taken into account, it is impossible to say with certainty based on the principle of the constancy of the speed of light II that the round-trip (one way) speed of light is c.

Next, let us check these ideas of Michelson and Lorentz regarding the speed of light.

"Principle of the constancy of the speed of light M" (*a priori* isotropic propagation M): Propagation of light predicted by Michelson ("M" stands for Michelson). According to the principle of the constancy of the speed of light M, light propagates isotropically in an *a priori* sense. Therefore, an observer in a stationary system determines that the times when light emitted from a light source at the origin of the x-axis arrives at clocks positioned at the points $x = \pm L$ are absolutely the same times. Also, in this stationary system, the speed of light on both the outward and return paths is c. This paper defines a "Michelson's stationary system" to mean a coordinate system where the principle of the constancy of the speed of light M is valid.

The Michelson's stationary system does not necessarily have to be an "absolute stationary system." This paper does not regard it as a problem even if two inertial systems with a relative speed together form the Michelson's stationary system. This is because there is no theory which prohibits that.

"Principle of the constancy of the speed of light L" (anisotropic propagation of light L): Propagation of light predicted by Lorentz ("L" stands for Lorentz). An observer in a stationary system applies the principle of the constancy of the speed of light I to a system moving at constant velocity relative to the stationary system. However, an observer in a moving system recognizes that the principle of the constancy of the speed of light II is valid, even in his own system, but he determines that the propagation of light is anisotropic. In other words, the average speed calculated from the round-trip travel time of light is c, but the speed of light is not c on either the outward or return path. This paper defines a "Lorentz's moving system" to mean a coordinate system where the principle of the constancy of the speed of light L is valid.

The reason why the speed of light is not c is the velocity vector attached to the inertial system.

II. RELATIVISTIC SYNCHRONIZATION OF TWO CLOCKS IN A COORDINATE SYSTEM MOVING AT CONSTANT VELOCITY

Let there be a given stationary rigid rod of length L_0 as measured by a ruler which is stationary, and assume that the rod is placed along the positive direction of the stationary system x-axis.

Assume that clocks A and B of the same type are set up at points A and B on the rear and front 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 $t_{A'}$ 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]

$$t_B - t_A = t_{A'} - t_B, \tag{1}$$

$$\frac{1}{2}(t_A + t_{A'}) = t_B. \tag{2}$$

In this paper, let us adjust the time of C_B and synchronize the times of C_A and C_B when the rod is stationary.

Also let us indicate C_B, whose time was adjusted while stationary at the beginning, as C_{B1}. (The 1 in B1 signifies that time was adjusted once. C_A is not adjusted, so its indication is not changed.)

Here, the times are synchronized when the two clocks are stationary because the author wishes to carry the discussion up to the time adjustment when performing synchronization later.

Next, assume that the stationary rod has been accelerated and has attained the constant velocity v (see Fig. 1). Note that the velocities of the rod discussed in this paper will be assumed to be high velocities to which the STR must be applied.

When this rod begins to move, the times of the two clocks remain absolutely synchronized, but it can no longer be said that they are relativistically synchronized. The reason for this is because, when the rod begins moving at a constant velocity, the relation in Eq. (3) no longer holds between the times of C_A and C_{B1}. (This is clear on account of the principle of the constancy of the speed of light I.)

Suppose a ray of light is emitted in the direction of B from A at the 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 $t'_{A'}$ of C_A. (The $'$ mark on t' signifies a moving system.)

If the following relation holds between the times of the two clocks at this time, then the times of the two clocks are the same by definition

$$t'_B - t'_A = t'_{A'} - t'_B, \tag{3}$$

$$\frac{1}{2}(t'_A + t'_{A'}) = t'_B. \tag{4}$$

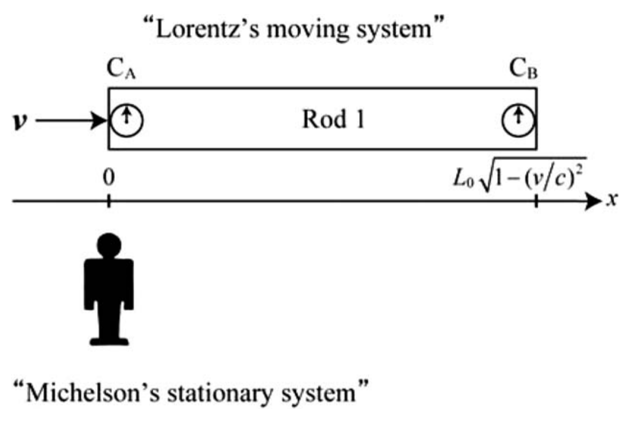

FIG. 1. A rod is moving at a constant velocity v relative to stationary system. Clocks A and B are set up at A and B at each end of this rod, and the times of each of these clocks are synchronized while the system is stationary.

Therefore, if a rod which was stationary begins moving at a constant velocity, then the time C_{B1} must be adjusted again so that the relationship in Eq. (3) holds between the times C_A and C_B. Due to this operation, the speed of light on the outward and return paths measured in the moving system of the rod is measured as c on both paths. (At this time, the indication of clock B is changed from C_{B1} to C_{B2}.)

When the above point is taken into account, the principle of the constancy of the speed of light, as conceived by Einstein, becomes as follows.

"Principle of the constancy of the speed of light E" (relativistically isotropic propagation E): Even if "anisotropic propagation of light L" holds in a coordinate system, if the times of two clocks are synchronized within that coordinate system, then the propagation of light in the coordinate system will be isotropic in the relativistic sense. Also, the round-trip (one way) speed of light will be measured as c. As a result, all inertial systems will be equivalent, and the debate regarding identification of "*a priori* isotropic propagation M" and anisotropic propagation of light L will come to an end. Einstein conceived of a new principle, the principle of the constancy of the speed of light E, which integrates these two types of propagation, and introduced that principle to physics. In this paper, a "relativistically stationary system" is defined as a coordinate system in which light propagates isotropically in the relativistic sense.

This principle of the constancy of the speed of light E is a principle unique to the STR. Let us assume that the velocity of the coordinate system of a rod moving at constant velocity has changed and shifted to a different motion at constant velocity. Then the times C_A and C_{B1}, which were synchronized beforehand, are no longer the same time from the standpoint of relativity theory. Thus, in order to synchronize the two clocks again, it is necessary to adjust the time of clock B. (After the time adjustment, clock B becomes C_{B2}.) If the coordinate system is shifted once again to a different motion at constant velocity, adjustment of the clock's time must be repeated. (After the time adjustment, clock B becomes C_{B3}.) If this adjustment is not performed, the speed of light will not be c on the outward and return paths. Ultimately, the principle of the constancy of the speed of light E is an artificial principle which cannot continue to exist without human assistance.[6]

However, if two clocks in an inertial system are synchronized using the method of Einstein, then even in the Lorentz's moving system the speed of light is measured as c on both the outward and return path, just as in the Michelson's stationary system.

As a result, both the Michelson's stationary system and the Lorentz's moving system fall under the heading of a relativistically stationary system, and it is impossible to experimentally identify the two.

However, manipulation of the clock based on Einstein's method does not result in disappearance of the velocity vector which was initially attached to the Lorentz's moving system. Einstein completed the STR without touching on the whether the velocity vector exists as a real entity.

III. TIME THAT IS ACTUALLY ADJUSTED IN SYNCHRONIZATION OF THE TWO CLOCKS

Consider the case where the rod, placed in a stationary system in Section II, begins to move at a constant velocity v with respect to this stationary system. However, in this case, assume that the stationary system is the Michelson's stationary system.

In Section II, we defined t'_A, t'_B, and $t'_{A'}$ in S'. Let us assume that t_A, t_B, and $t_{A'}$ in S correspond to these times.

Incidentally, when the time needed for light emitted from A in S' to travel from A to B is measured with the clock in S, the result is $(t_B - t_A)$ s.

According to the STR, when viewed from S, the rod contracts by $\sqrt{1-(v/c)^2}$ times in the direction of motion. In addition, when the velocity of light emitted from S' is seen from S, it is always constant regardless of the velocity of the light source, and thus $(t_B - t_A)$ is given by the following equation:

$$t_B - t_A = \frac{L_0\sqrt{1-(v/c)^2}}{c-v}(\mathrm{s}). \tag{5}$$

If the time needed for light to return from B to A is measured with the clock in S and is taken to be $(t_{A'} - t_B)$ s, then

$$t_{A'} - t_B = \frac{L_0\sqrt{1-(v/c)^2}}{c+v}(\mathrm{s}). \tag{6}$$

However, the denominator on the right hand side of Eqs. (5) and (6) does not mean that the speed of light varies depend on the velocity of the light source.[7]

According to the STR, the relationship between $(t'_B - t'_A)$ and $(t_B - t_A)$ is

$$t'_B - t'_A = (t_B - t_A)\sqrt{1-(v/c)^2}. \tag{7}$$

If the right hand side of Eq. (5) is substituted for $(t_B - t_A)$ in Eq. (7),

$$t'_B - t'_A = \frac{L_0\left(\sqrt{1-(v/c)^2}\right)^2}{c-v}, \tag{8a}$$

$$= \frac{L_0(c+v)}{c^2}(\mathrm{s}). \tag{8b}$$

If, in the same way, the time elapsed on a clock in S' while light returns from B to A $(t'_{A'} - t'_B)$ is measured by an observer in S

$$t'_{A'} - t'_B = \frac{L_0(c-v)}{c^2}(\mathrm{s}). \tag{9}$$

If we set $t'_A = 0$ to simplify the equation, then the following value is obtained from Eqs. (8b) and (9):

$$\frac{1}{2}t'_{A'} = \frac{1}{2}\left[\left(t'_B - t'_A\right) + \left(t'_{A'} - t'_B\right)\right], \tag{10a}$$

$$= \frac{1}{2}\left[\frac{L_0(c+v)}{c^2} + \frac{L_0(c-v)}{c^2}\right], \tag{10b}$$

$$= \frac{L_0}{c}\,(\mathrm{s}). \tag{10c}$$

When light travels from A to B in S', an observer in S determines that $L_0(c+v)/c^2$ s have passed on the clock in S'. However, when this light which left A at $t'_{\mathrm{A}} = 0$ reaches B, by definition, the time shown on clock B must be L_0/c s.

However, since $L_0(c+v)/c^2 > L_0/c$, the time on clock B must be later than the time on clock A to resolve this discrepancy. Thus, if the time adjustment to actually make the time on clock B later is $\Delta t'_{\mathrm{B}}$, it should be possible to take the difference between the two as this time. Namely,

$$\Delta t'_{\mathrm{B}} = \left(t'_{\mathrm{B}} - t'_{\mathrm{A}}\right) - \frac{1}{2}t'_{\mathrm{A}'}, \tag{11a}$$

$$= \frac{L_0(c+v)}{c^2} - \frac{L_0}{c}, \tag{11b}$$

$$= \frac{L_0 v}{c^2}\,(\mathrm{s}). \tag{11c}$$

If an observer in S' delays the time on clock B by $L_0 v/c^2$ s, then the relationship in Eq. (3) will hold in this coordinate system.

This inertial system that is moving at a constant velocity becomes a stationary system in the sense of the theory of relativity.

IV. METHOD OF IDENTIFYING THE MICHELSON'S STATIONARY SYSTEM OR THE LORENTZ'S MOVING SYSTEM

The velocity addition law in STR is given by the following equation:

$$u = \frac{v+w}{1+\dfrac{vw}{c^2}}. \tag{12}$$

Here, v is the velocity of the moving system S' measured from the stationary system S, and w is the velocity of another moving system S'' measured from S'. Also, u is taken to be the velocity of S'' measured by an observer in S. (The movement directions of S' and S'' are taken to be the positive direction of the x-axis of the stationary system. In this paper, the stationary system S is abbreviated S, the moving system S' is abbreviated S', and the moving system S'' is abbreviated S''.)

Now, consider the case where two rods are placed in the Michelson's stationary system (the two rods will be distinguished as rod 1 and rod 2) (see Fig. 2).

On rod 1, clock A will be indicated as C_{1A} and clock B will be indicated as C_{1B}. (In C_{1A}, 1 indicates rod 1, and A indicates clock A. The same holds for C_{1B}.) The clocks at both ends of rod 2 will be indicated as C_{2A} and C_{2B}.

It is assumed that the times of C_{1A} and C_{1B}, as well as C_{2A} and C_{2B} are synchronized when the clocks are at rest. (Once their times have been adjusted, C_{1B} will be indicated as C_{1B1}, and C_{2B} will be indicated as C_{2B1}.)

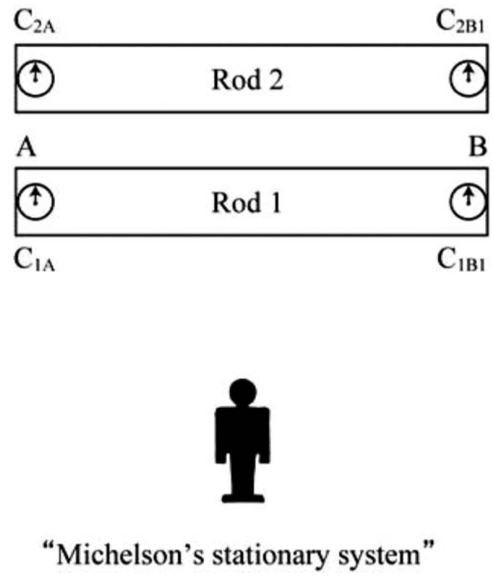

FIG. 2. Two rods with length L_0 are placed parallel to the x-axis of the Michelson's stationary system. At this time, the clocks at both ends of the two rods are synchronized.

Also, if the stationary system is the Michelson's stationary system, then C_{1A} and C_{1B1}, and C_{2A} and C_{2B1}, match in an absolute sense by definition.

Next, consider the case when rod 1 and rod 2 begin to move at the constant velocity, in the positive direction of the x-axis of the stationary system (velocity of rod 1 is assumed to be v, and velocity of rod 2 to be u). It is assumed here that $v < u$ (see Fig. 3).

As has already been pointed out, the times of clock A and clock B, which were synchronized while at rest, lose their relativistic synchronization when the rod begins moving at constant velocity. Thus, it is necessary to adjust the

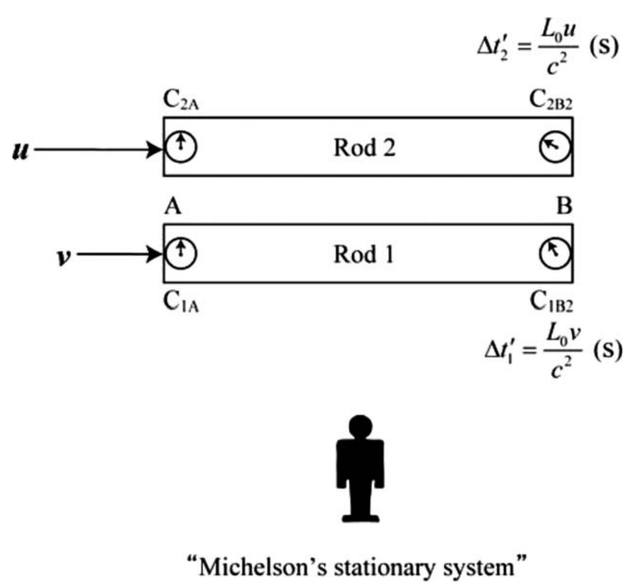

FIG. 3. Time adjustment $\Delta t'_1$ of C_{1B1} moving at a constant velocity v relative to the Michelson's stationary system and time adjustment $\Delta t'_2$ of C_{2B1} moving in the same way at a constant velocity u. By making this time adjustment, the coordinate systems of rod 1 and rod 2 can maintain their status as relativistically stationary systems.

times on the B clocks of the two rods so that the times are synchronized in the coordinate system of the rod which has begun to move. Here, when clock B on rod 1 is adjusted, the indication C_{1B1} is changed to C_{1B2}. Also, when clock B on rod 2 is adjusted, the indication C_{2B1} is changed to C_{2B2}. If the respective time adjustments are taken to be $\Delta t_1'$ and $\Delta t_2'$ then $\Delta t_1'$ and $\Delta t_2'$ are given as follows:

$$\Delta t_1' = \Delta t'_{1B1\to 1B2} = \frac{L_0 v}{c^2}(\mathrm{s}), \tag{13}$$

$$\Delta t_2' = \Delta t'_{2B1\to 2B2} = \frac{L_0 u}{c^2}(\mathrm{s}). \tag{14}$$

Next, assume that rod 2 does not move from the beginning at the constant velocity u, and instead that it originally moves at the same constant velocity v as rod 1 (see Fig. 4).

In this case, the time adjustments for C_{2B1} of rod 2 and C_{1B1} of rod 1 both become $L_0 v/c^2$ s.

After that, rod 2 accelerates until it reaches the constant velocity u, but as is also evident from Eq. (12), this velocity u is the velocity at which the relative velocity of the coordinates systems of rod 1 and rod 2 becomes w (see Figs. 5 and 6).

Figure 5 shows observation of the motion of rod 2 from the Michelson's stationary system, and Fig. 6 shows observation from the coordinate system of rod 1.

Here, let us predict, from the Michelson's stationary system, the time adjustment of clock B on rod 2 which has reached the constant velocity u. If the time adjustment of clock B is assumed to be $\Delta t_3'$, then the following relation holds:

$$\Delta t_1' + \Delta t_3' = \Delta t_2'. \tag{15}$$

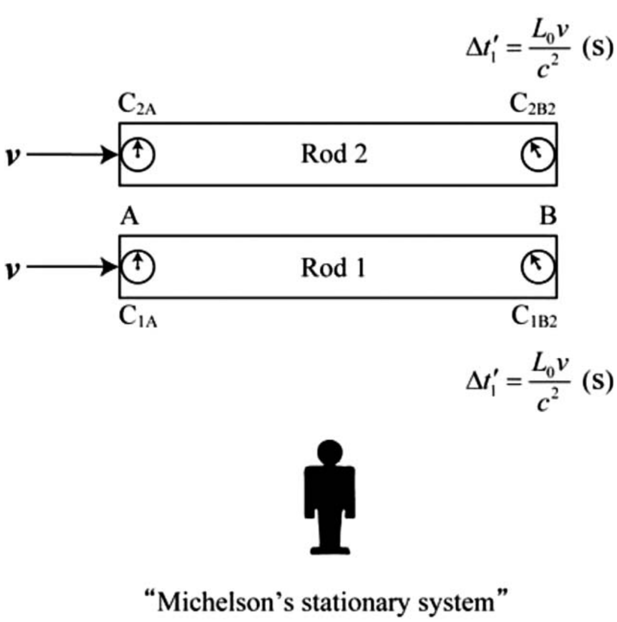

FIG. 4. In this case, at the stage before rod 2 attains the constant velocity u, it moves at the constant velocity v. The time of clock B on rod 2 is adjusted at that time. This is the second time adjustment of clock B, so the indication changes from C_{2B1} to C_{2B2}. Note that in the thought experiment performed later, rod 1 is regarded as a stationary system and thus the time adjustment performed here is the first adjustment.

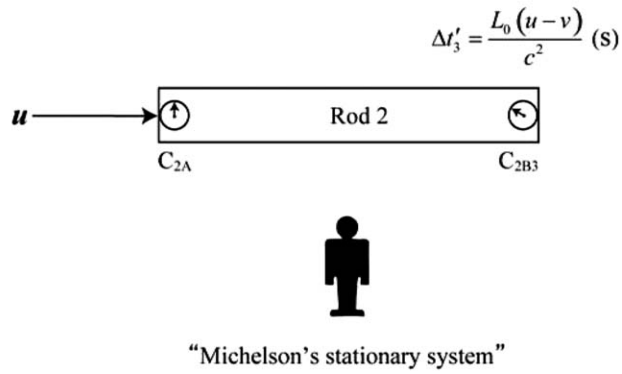

FIG. 5. Rod 2 is moving at the constant velocity u relative to the Michelson's stationary system. In this case, if the time adjustment $\Delta t_3'$ performed with clock B of rod 2 is predicted by an observer in the stationary system, it will be $L_0(u-w)/c^2$ s.

From this, $\Delta t_3'$ becomes

$$\Delta t_3' = \Delta t_2' - \Delta t_1' = \Delta t'_{2B2\to 2B3} = \frac{L_0(u-v)}{c^2}(\mathrm{s}). \tag{16}$$

This time adjustment becomes the third adjustment of clock B (indication of the clock changes from C_{2B2} to C_{2B3}).

Next, if the u in Eq. (16) is eliminated by using Eq. (12), then $\Delta t_3'$ is as follows:

$$\Delta t_3' = \frac{L_0 w\left(1 - \frac{v^2}{c^2}\right)}{c^2 + vw}(\mathrm{s}). \tag{17}$$

However, according to the STR, if there are inertial systems in motion relative to each other, then the only important velocity is the relative velocity between the coordinate systems. Therefore, the observer of rod 1 believes that his own coordinate system is a stationary system, he will regard the

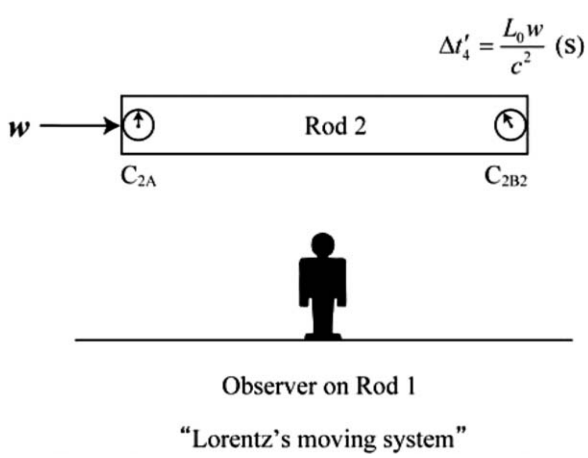

FIG. 6. The case when rod 2 in Fig. 5 is viewed by the observer of rod 1. In this case, the observer of rod 1 believes that his own coordinate system is a stationary system, and thus he believes that the time adjustment for clock B of rod 2 is $L_0 w/c^2$ s. In the case of rod 2 in Fig. 5, the first time adjustment for clock B is performed while it is at rest in the Michelson's stationary system. In the case of Fig. 6, in contrast, the first time adjustment of clock B is performed while moving parallel with rod 1. (However, in this case, the time adjustment cannot be predicted.)

coordinate system of rod 2 as moving at the constant velocity w. Also, the observer of rod 1 will predict the following time as the time adjustment $\Delta t'_4$ performed by clock B of rod 2

$$\Delta t'_4 = \frac{L_0 w}{c^2}\,(\mathrm{s}). \tag{18}$$

In the end, the time adjustment $\Delta t'_3$ of clock B predicted by an observer in the Michelson's stationary system does not match with the time adjustment $\Delta t'_4$ predicted by an observer in the Lorentz's moving system.

Now, let us find the size of the component in the x-axis direction of the unknown velocity vector which causes this mismatch of $\Delta t'_3$ and $\Delta t'_4$. Assume here that $\Delta t'_3/\Delta t'_4$ is a. That is,

$$\frac{\Delta t'_3}{\Delta t'_4} = \frac{c^2 - v_x^2}{c^2 + v_x w} = \mathrm{a}, \quad 0 < \mathrm{a} < 1. \tag{19}$$

From this, it is possible to derive a quadratic equation like the following for v_x:

$$v_x^2 + \mathrm{a} w v_x - (1+\mathrm{a})c^2. \tag{20}$$

If this equation is solved while taking into account that the size of v_x is positive, then v_x is as follows:

$$v_x = \frac{-\mathrm{a}w + \sqrt{\mathrm{a}^2 w^2 + 4(1+\mathrm{a})c^2}}{2}. \tag{21}$$

In the clock synchronization proposed by Einstein, it is enough if the relation in Eq. (3) holds between two clocks, and the analysis does not go as far as the actual clock time adjustments. However, this paper has examined the times for actual adjustment as an issue. As a result, it was found that times for clock adjustment differ depending on whether an experiment is carried out in the Michelson's stationary system or the Lorentz's moving system.

The reason why the time adjustment of the clock in the Lorentz's moving system differs from the prediction is the unknown velocity vector attached to the Lorentz's moving system. The STR does not describe physical laws pertaining to an objective reality which exists independently of our own existence. It is a theory which predicts and explains the values of physical quantities, such as distance and velocity, measured using two synchronized clocks.

Through a discussion from the standpoint of real existence, this paper has pointed out that there are cases where there is a velocity vector attached to an inertial system.

V. PHYSICAL MEANING OF THE UNKNOWN VELOCITY VECTOR

This section clarifies the meaning of the unknown velocity vector.

In quantum mechanics, the motion of the electron in the hydrogen atom cannot be conceived as a classical motion but is really a standing wave ψ, so that $|\psi * \psi|$ is symmetric and time independent all around the proton. Hence, the charge distribution is perfectly static (no classical motion).

This paper recognizes this point of view of quantum mechanics. However, in order to clarify the physical meaning of the velocity vector, the author believes a qualitative explanation using some kind of picture is needed, even if the region is one where quantum mechanics applies.

In quantum mechanics, light propagates as a wave and is observed as particles (photons). The principle of the constancy of the speed light I in the Introduction indicates that light propagates as a wave.

However, in order for light to propagate as a wave, some medium is necessary to transmit the wave. Also, if it is assumed that a velocity vector is attached to an inertial system, then there must also be a stationary system to be the starting point of that vector.

At the end of the 19th century, most physicists believed in a hypothetical substance called the ether. However, at present, it is not appropriate to assume such a substance as a medium.

Also, at that time it was thought that the ether is in a state of absolute rest, but this paper does not accept the existence of such a special coordinate system.

According to quantum electrodynamics, a vacuum which transmits electrical force is thought to be filled with opposing pairs of virtual particles and antiparticles. The vacuum can transmit light as a wave. Therefore, let us tentatively assume that these virtual particles are the modern day ether.

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

Here, it is assumed that a vacuum exists even at the deep layer of a single arbitrary point in the space of an inertial system. Next, vectors are used to indicate the velocities at a certain time of the countless virtual particles which exist at that point in the vacuum, and then those vectors are combined into a single vector. (If there is a problem here with the expression "which exists at the point," it can be changed to the more ambiguous expression "which exists in the neighborhood of that point.")

This combined vector is taken to be the velocity vector at that point.

Next, a vector is used to indicate the relative velocity between the combined vector and the inertial system.

If the relative velocity is zero, this inertial system is determined to be the Michelson's stationary system.

Conversely, if the relative velocity is not zero, this inertial system is determined to be the Lorentz's moving system. However, what determines the direction of this vector is convention.

In this paper, the author feels it is best treat this vector as having a starting point in the vacuum and an end point in the inertial system of physical space.

In this case, the point in the vacuum plays the role of a stationary system. Also, the v_x is the component in the x-axis direction of the velocity vector attached to the inertial system regarded as a problem here.

In contrast, if the direction of the vector is taken to be reversed, this can be interpreted as the blowing of an "ether drift" with a velocity $-v_x$ in the stationary inertial system.

VI. CONCLUSION

This paper has demonstrated that it is possible to identify the Michelson's stationary system and the Lorentz's moving system, even though this identification itself has been thought to have no significance due to the STR.

In the procedure, it is assumed that the relationship in Eq. (1) holds between the times of clocks at both ends of a rod when the rod is stationary at the beginning.

Next, this rod begins to move at a constant velocity w with respect to stationary system. At this time, the time of clock B is set later so that the times of the two clocks can be said to be synchronized in this coordinate system. If the coordinate system in which the rod was originally at rest is the Michelson's stationary system, then the time adjustment $\Delta t'_{\mathrm{B}}$ of clock B takes the following value:

$$\Delta t'_{\mathrm{B}} = \frac{L_0 w}{c^2}(\mathrm{s}). \tag{22}$$

In contrast, if the coordinate system in which the rod was originally at rest is the Lorentz's moving system, then the time adjustment of clock B does not match with Eq. (22). The time adjustment $\Delta t'_{\mathrm{B}}$ in the Lorentz's moving system has the following value:

$$\Delta t'_{\mathrm{B}} = \frac{L_0 w\left(1 - \frac{v_x^2}{c^2}\right)}{c^2 + v_x w}(\mathrm{s}). \tag{23}$$

In this way, it is possible to identify the Michelson's stationary system or the Lorentz's moving system based on the time adjustment of clock B.

The Lorentz's moving system has an attached unknown velocity vector. The size of the component of this velocity vector in the x-axis direction is given by the following equation.

$$v_x = \frac{-\mathrm{a}w + \sqrt{\mathrm{a}^2 w^2 + 4(1+\mathrm{a})c^2}}{2}, \quad 0 < \mathrm{a} < 1. \tag{24}$$

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