ISSN 0027-1349, Moscow University Physics Bulletin, 2018, Vol. 73, No. 4, pp. 413–421. © Allerton Press, Inc., 2018.
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ASTRONOMY, ASTROPHYSICS, AND COSMOLOGY

Kinematics in the Special Theory of Ether

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Received October 6, 2017; in final form, February 1, 2018

Abstract—The aim of this paper is to show that the Michelson–Morley and Kennedy–Thorndike experiments are not sufficient for justification of the theory of special relativity because these experiments can be explained using another theory in which a universal reference frame exists. In this paper, we derive a novel theory of body kinematics with a universal reference frame. We call this theory the special theory of ether (STE). The reason that the universal reference frame could not be found using the Michelson–Morley and Kennedy–Thorndike experiments is also explained. As well, based on a geometric analysis of the Michelson–Morley and Kennedy–Thorndike experiments, we derive another coordinate and time transformation that differs from the Lorentz transformation. In addition, the transformation law of speed, the formula for the addition of velocities for the absolute velocity, as well as length-contraction and time-dilation formulas are derived. The paper contains only the investigations of the original authors.

Keywords: kinematics of bodies, universal frame of reference, coordinate and time transformation, one-way speed of light.

DOI: 10.3103/S0027134918040136

INTRODUCTION

The Michelson–Morley experiment is not the only experimental or observational result on which the theory of special relativity is constructed; here, however, we do not consider other results that are now considered as foundations of the theory of special relativity.

This paper presents an explanation for the results of the Michelson–Morley [1] and Kennedy–Thorndike experiments [2] provided that an inertial frame of reference (the universal frame of reference (UFR), the ether) exists in which the speed of light is constant. In inertial frames of reference moving relative to the UFR, the one-way speed of light can be different. This paper presents the derivation of transformations from an inertial system to the UFR and from the UFR to an inertial system using the geometric method.

The one-way speed of light has never been measured accurately. In all accurate laboratory experiments, as in the Michelson–Morley experiment, only the mean speed of light passing along a closed trajectory was measured. In these experiments, the light always returns to the starting point. Therefore, the assumption of the constancy of the speed of light (instantaneous speed), which is made in the special theory of relativity (STR), has no convincing experimental justification. In this paper, the derivation of transformations is based on an assumption that follows from these experiments, i.e., that the mean speed of light in passing along a path and returning is constant for any observer.

The “UFR–inertial system” transformation (27), (28) obtained in this paper by the geometric method was found earlier by another method in [3, 4]. In [3], the author obtained this transformation from the Lorentz transformation due to synchronization of watches in inertial systems using an external method. The transformation obtained in [3] is the Lorentz transformation written in another way after changing the method for measuring time in an inertial frame of reference; for this reason, the property of the theory of special relativity was assigned to this transformation. Transformation (27), (28) has another physical meaning different from that of the Lorentz transformation because, according to the theory presented in this paper, the speed can be determined relative to the universal frame of reference using a local measurement. Thus, the universal frame of reference is real and this is not a freely chosen inertial system.

1. ASSUMPTIONS

In the presented analysis of the Michelson–Morley and Kennedy–Thorndike experiments, we make the following assumptions:

(I) There exists a frame of reference relative to which the speed of light in a vacuum is the same in all

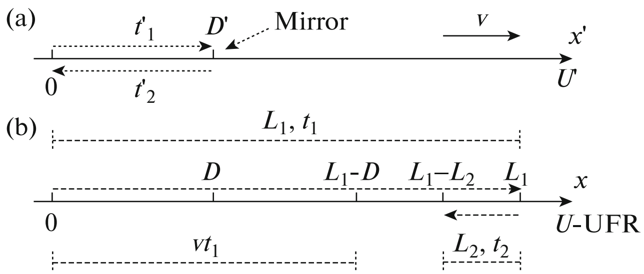

Fig. 1. The time and path of the passage of light to a mirror and back: light path observed (a) from an inertial system U' and (b) from the UFR.

directions. We call this universal frame of reference the ether.

(II) For each observer, the mean speed of light on its path and back again does not depend on the direction of light propagation. This follows from the Michelson–Morley experiment.

(III) The mean speed of light on its path and back again does not depend on the speed of the observer relative to the universal frame of reference (the ether). This follows from the Kennedy–Thorndike experiment.

(IV) The body is neither contracted nor elongated in the direction perpendicular to the direction of the speed of the body moving relative to the ether.

(V) The ether–system transformation is linear.

The way in which the transformation is derived in this paper differs from the derivation of the Lorentz transformation as the base of the STR according to the geometric method. In the STR, the Lorentz transformation is derived under the assumption that the inverse transformation has the same form as the primary transformation. This assumption is based on the belief that all inertial systems are equivalent. For the derivation presented in this paper we do not specify the form of the inverse transformation.

The assumptions in this paper on the speed of light are also weaker than those in the STR. In the STR, it is assumed that the speed of light is absolutely constant. In this paper, the assumption following from experiments was made, namely, that the mean speed of light is constant on the path to the mirror and back (assumptions II and III). In the presented reasoning, it is postulated that the speed of light is constant only in a specified frame of reference, namely, in the UFR (assumption I).

Assumptions IV and V are valid in the STE, as well as in the STR.

The transformations introduced in [5] and [6] are identical to those in this paper but with an additional assumption. In those works, the passage of only one light flow was analyzed.

2. THE TIME AND PATH OF THE PASSAGE OF LIGHT IN THE ETHER

Let us consider a system U' that moves relative to the system U associated with the ether with a speed v (Fig. 1). In system U', there is a mirror at a distance D' from the coordinate origin. The light moves in the ether with a constant speed c. A light ray was sent from the system U' from point $x' = 0$ at time $t = 0$ towards the mirror. Upon reaching the mirror the light is reflected and moves in the ether in the opposite direction with a speed $-c$.

We take the following notation for the observer in the ether: t_1 is the time of passage of light to the mirror and t_2 is the time of light return to the starting point. L_1 and L_2 are the distances traveled by light in the ether on its path and back.

When the light moves towards the mirror, the mirror moves away from it with a speed v. When the light returns to point $x' = 0$ after the reflection from the mirror, this point approaches it with a speed v. The observer in system U sees the distance D' as D. We obtain

$$L_1 = D + vt_1, \quad L_2 = D - vt_2, \tag{1}$$

$$t_1 = \frac{L_1}{c} = \frac{D + vt_1}{c}, \quad t_2 = \frac{L_2}{c} = \frac{D - vt_2}{c}. \tag{2}$$

Equations (2) should be solved for t_1 and t_2. We obtain the time and distance of the passage of light in the ether:

$$t_1 = \frac{D}{c - v}, \quad t_2 = \frac{D}{c + v}, \tag{3}$$

$$L_1 = ct_1 = D\frac{c}{c - v}, \quad L_2 = ct_2 = D\frac{c}{c + v}. \tag{4}$$

3. A GEOMETRICAL DERIVATION OF THE TRANSFORMATION

The results of the experiment with light were analyzed as shown in Fig. 2. The inertial system U' moves with a speed v relative to the inertial system U associated with the UFR, parallel to the x axis. The x and x' axes lie on the same straight line.

At the instant when the system origins coincide, the clocks in both systems are synchronized. The clock in the system U related to the ether is synchronized by an internal method [3]. The clock in the system U' is synchronized by an external method in such a manner that if the clock of the system U indicates time $t = 0$, the clock of the system U' next to it is also reset, that is $t' = 0$.

In the system U', an experiment was carried out on measuring the speed of light in a vacuum perpendicularly and parallel to the motion direction of the system U' relative to the ether. In each of the directions the light passes to the mirror and back. Figure 2a shows the paths the passage of light seen by the observer in the system U'; Fig. 2b gives those seen by the observer in the system U.

In the U system, the speed of light is always constant (assumption I). The reasoning concerns the passage of light in a vacuum.

According to conclusions that follow from the Michelson–Morley experiment, it was assumed that the mean speed of light c_p on its path to the mirror and back in the system U' was the same in every direction, in particular, in the direction parallel to the y' axis (assumption II). Besides, it was assumed that the mean speed of light c_p on its path to the mirror and back does not depend on the speed of the observer relative to the UFR (assumption III).

It follows from assumptions II and III that the mean speed of light c_p in the inertial frame of reference U' is the same as the speed of light c in the system U. If we assume that the mean speed of light c_p in the system U' is a function of the speed of light c in the system U depending on the speed v, then

$$c_p = f(v)c. \tag{5}$$

It follows from assumption III that the mean speed of light c_p is the same for different speeds of the Earth relative to the ether (assumption III); therefore, $f(v_1) = f(v_2)$. Since $f(0) = 1$, $f(v) = 1$ for every speed v. It follows that $c = c_p$.

The mirrors are associated with the system U' and are placed at a distance D' from the coordinate origin. One of the mirrors is on the x' axis; the second one is on the y' axis. It is assumed that the distance D' perpendicular to the velocity v is the same for observers from both systems (assumption IV). For this reason, the length D' in Figs. 2a and 2b is the same.

The time of the passage of light in the system U along the x axis to the mirror is denoted as t_1; the return time is t_2. The time of the light passage in the system U' along the x' axis to the mirror is denoted as t_1'; the return time, as t_2'. The total time is consequently denoted as t and t' ($t = t_1 + t_2$ and $t' = t_1' + t_2'$).

From the viewpoint of the system U, a light ray moving parallel to the y' axis moves along lateral sides of an isosceles triangle with the length L. The triangle is isosceles in connection with assumption I. Since the speed of light in the system U is constant, the time of the passage along each side is similar and equals $t/2$.

In the system U, a light ray moving parallel to the x axis towards the mirror moves the distance L_1 during time t_1. On its path back, it moves the distance L_2 during time t_2. These distances are different because the mirror and the point from which the light ray was sent move in the ether.

Both light rays return to the starting point at the same time, both in the system U and in the system U'. This follows from assumption II and from the fact that the mirrors are situated at the same distance from the point of light emission.

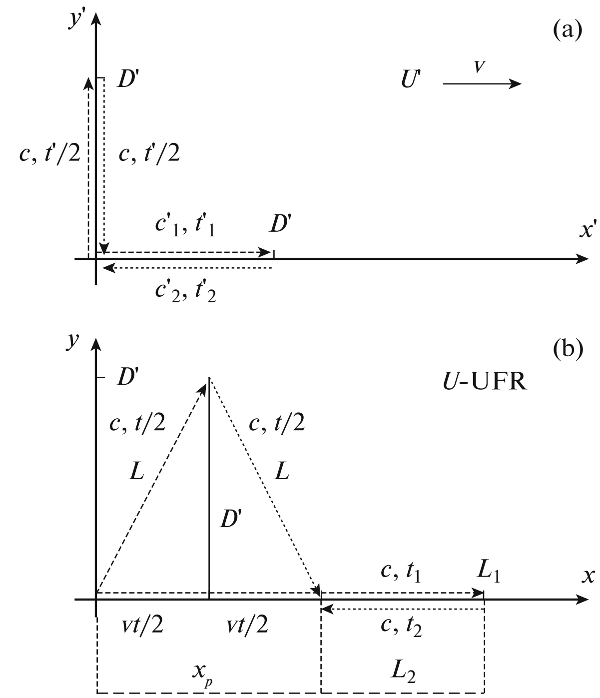

Fig. 2. The paths of two light rays: those observed by the observer (a) from the system U' and (b) from the system U (the ether).

Both for the observer from the inertial system U' and for the observer from the system U', the speed of light can be written as

$$\frac{2D'}{t_1' + t_2'} = \frac{2D'}{t'} = c = \frac{2L}{t} = \frac{L_1 + L_2}{t_1 + t_2}. \tag{6}$$

From Eq. (6), one can determine paths L and D' which depend on the speed of light c and times of the passage of light t_1 and t' in the systems U and U', respectively:

$$L = \frac{ct}{2}; \quad D' = \frac{ct'}{2}. \tag{7}$$

The speed of the system U' relative to the absolute frame of reference U is denoted as v. Since x_p is its path that is passed during time t of the passage of light,

$$v = \frac{x_p}{t}; \quad x_p = vt. \tag{8}$$

Using the geometry presented in Fig. 2, one can express its path L as

$$L = \sqrt{(x_p/2)^2 + D'^2} = \sqrt{(vt/2)^2 + D'^2}. \tag{9}$$

Equation (9), after squaring and with allowance for Eq. (7), takes the following form:

$$(ct/2)^2 = (vt/2)^2 + (ct'/2)^2. \tag{10}$$

Simplifying, we obtain

$$t^2(c^2 - v^2) = (ct')^2, \tag{11}$$

$$t = t'\frac{1}{\sqrt{1-(v/c)^2}} \quad \text{for} \quad x' = 0. \tag{12}$$

The equation presented above contains only times t and t', which refer to the entire path of the light ray, that is, towards the mirror and back. It should be noted that these times are measured at the point $x' = 0$. Since the length D' can be chosen for an arbitrary time of the passage of light, Eq. (12) is valid for any time t' and time t corresponding to it.

From the viewpoint of the system U, the length D' associated with the system U' and parallel to the x axis is observed as D. If the light moves towards the mirror in the absolute frame of reference U, it pursues the mirror, which is at the distance D from it. After reflection, the light returns to the starting point, which moves towards it. Using Eqs. (4), we obtain an equation for its path of the passage of light in the system U in both directions along the x' axis:

$$L_1 = ct_1 = D\frac{c}{c-v}; \quad L_2 = ct_2 = D\frac{c}{c+v}. \tag{13}$$

From Eqs. (13), one can determine the sum and difference of paths L_1 and L_2 passed by the light in the system U:

$$\begin{aligned} L_1 + L_2 &= D\frac{c}{c-v} + D\frac{c}{c+v} = 2D\frac{1}{1-(v/c)^2}, \\ L_1 - L_2 &= D\frac{c}{c-v} - D\frac{c}{c+v} = 2D\frac{v}{c}\frac{1}{1-(v/c)^2}. \end{aligned} \tag{14}$$

From the second equation, one can determine the path passed by the system U' during half of the time of the passage of light $t/2$. i.e.,

$$\frac{x_p}{2} = \frac{vt}{2} = \frac{L_1 - L_2}{2} = D\frac{v}{c}\frac{1}{1-(v/c)^2}. \tag{15}$$

Since it is assumed that the speed of light c is constant in system U associated with the ether, both paths traveled by the light, $2L$ and $L_1 + L_2$, are similar:

$$2L = L_1 + L_2. \tag{16}$$

Substituting (9) and the first of Eqs. (14), we obtain

$$2\sqrt{(vt/2)^2 + D'^2} = 2D\frac{1}{1-(v/c)^2}. \tag{17}$$

Dividing both sides of the equation by 2, squaring, and taking (15) into account we obtain

$$\left(D\frac{v}{c}\frac{1}{1-(v/c)^2}\right)^2 + D'^2 = D^2\left(\frac{1}{1-(v/c)^2}\right)^2. \tag{18}$$

From Eq. (18), one can determine the equation of length contraction:

$$D'^2 = D^2\left(\frac{1}{1-(v/c)^2}\right)^2(1-(v/c)^2), \tag{19}$$

$$\begin{aligned} D' &= D\left(\frac{1}{1-(v/c)^2}\right)\sqrt{1-(v/c)^2} = D\frac{1}{1-(v/c)^2}, \\ D &= D'\sqrt{1-(v/c)^2}. \end{aligned} \tag{20}$$

The equation presented above contains two lengths D and D', which are the distances between the mirrors and point of light emission. Since the length D' can be chosen arbitrarily, Eq. (20) is valid for any values of D'.

Substituting (12) into (8), we obtain

$$x_p = vt'\frac{1}{1-(v/c)^2} \quad \text{for} \quad x' = 0. \tag{21}$$

We assume that the transformation from the inertial system U' to the ether U is linear (assumption V). If the transformation of time and coordinates of position (12), (21) is complemented by a linear expression that depends on x', we obtain a transformation with unknown coefficients a and b:

$$\begin{aligned} t &= t'\frac{1}{1-(v/c)^2} + ax', \\ x &= vt'\frac{1}{1-(v/c)^2} + bx'. \end{aligned} \tag{22}$$

Transformation (22) must be valid for any time and coordinates of the position. In particular, it is valid at the instant of clock synchronization, i.e., when the time $t = t' = 0$ for a point with coordinates D' in the system U'. In connection with this, we substitute $t = t' = 0$, $x' = D'$, and $x = D$ into transformation (22). Taking (20) into account we obtain

$$\begin{aligned} 0 &= aD', \\ \sqrt{1-(v/c)^2}D' &= bD'. \end{aligned} \tag{23}$$

From here, we obtain the coefficients a and b:

$$\begin{aligned} a &= 0, \\ b &= \sqrt{1-(v/c)^2}. \end{aligned} \tag{24}$$

Finally, the transformation from any inertial system U' to the system U associated with the ether takes the form

$$t = \frac{1}{\sqrt{1-(v/c)^2}}t', \tag{25}$$

$$x = \frac{1}{\sqrt{1-(v/c)^2}}vt' + \sqrt{1-(v/c)^2}x'. \tag{26}$$

After the transformation, we obtain the inverse transformation, namely, the transformation from

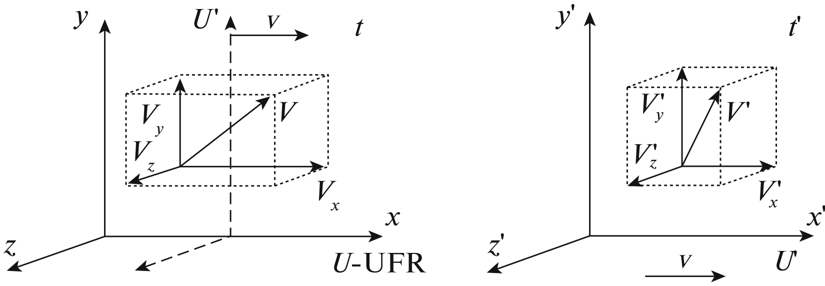

Fig. 3. Motion observed from the ether and an inertial system.

the system U associated with the ether to an inertial system U':

$$t' = \sqrt{1-(v/c)^2}\,t, \tag{27}$$

$$x' = \frac{1}{\sqrt{1-(v/c)^2}}(-vt + x). \tag{28}$$

In view of assumption IV, we have

$$y' = y \quad \text{and} \quad z' = z. \tag{29}$$

The speed v is the speed of the inertial system relative to the universal frame of reference.

4. TRANSFORMATION OF THE VELOCITY

The axes of the inertial system U' and system U associated with the ether are defined so that they are parallel to each other (Fig. 3). The inertial system moves with a speed v parallel to the x and x' axes.

Differentiating transformation (27)–(29), we obtain

$$\begin{cases} dt' = \sqrt{1-(v/c)^2}\,dt, \\ dx' = \dfrac{1}{\sqrt{1-(v/c)^2}}(-vdt + dx), \\ dy' = dy, \\ dz' = dz. \end{cases} \tag{30}$$

A moving body is observed from the ether U and inertial frame of reference U'. The velocity of the body in the ether is equal to V; in the inertial system, it is V'. The components of these velocities are shown in Fig. 3.

The velocity of the body in the system of the ether U can be written in the form

$$V_x = \frac{dx}{dt}, \quad V_y = \frac{dy}{dt}, \quad V_z = \frac{dz}{dt}. \tag{31}$$

The velocity of the body in the inertial system U' can be written in the form

$$V'_x = \frac{dx'}{dt'}, \quad V'_y = \frac{dy'}{dt'}, \quad V'_z = \frac{dz'}{dt'}. \tag{32}$$

We substitute the differentials (30) into Eqs. (32). Then, we obtain

$$\begin{cases} V'_x = \dfrac{\dfrac{1}{\sqrt{1-(v/c)^2}}(-vdt + dx)}{\sqrt{1-(v/c)^2}dt}, \\ V'_y = \dfrac{dy}{\sqrt{1-(v/c)^2}dt}, \\ V'_z = \dfrac{dz}{\sqrt{1-(v/c)^2}dt}; \end{cases} \tag{33}$$

i.e.,

$$\begin{cases} V'_x = \dfrac{-v}{1-(v/c)^2} + \dfrac{1}{1-(v/c)^2}\dfrac{dx}{dt}, \\ V'_y = \dfrac{1}{\sqrt{1-(v/c)^2}}\dfrac{dy}{dt}, \\ V'_z = \dfrac{1}{\sqrt{1-(v/c)^2}}\dfrac{dz}{dt}. \end{cases} \tag{34}$$

Based on (31), we obtain the sought transformation of the velocity

$$\begin{cases} V'_x = \dfrac{V_x - v}{1-(v/c)^2}, \\ V'_y = \dfrac{V_y}{\sqrt{1-(v/c)^2}}, \\ V'_z = \dfrac{V_z}{\sqrt{1-(v/c)^2}}. \end{cases} \tag{35}$$

Transformation (35) expresses the relative velocity V' in terms of absolute velocities V and v. Based on the first equation of this transformation, one can define the formula of velocity addition in the form (for $V_y = V'_y = 0$ and $V_z = V'_z = 0$)

$$V_x = v + V'_x(1-(v/c)^2). \tag{36}$$

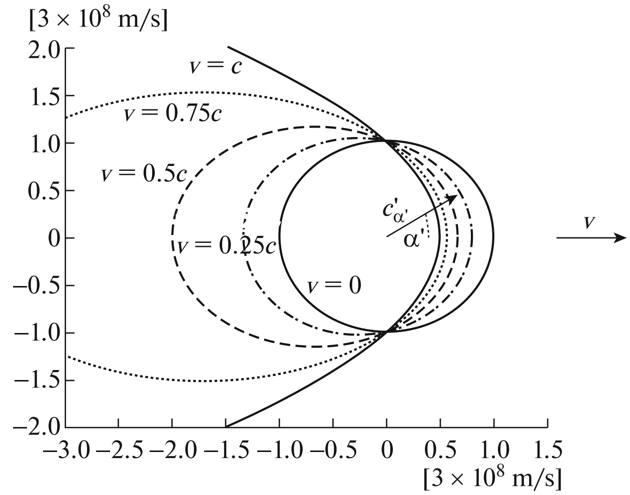

Fig. 4. The one-way speed of light $c'_{\alpha'}$ in an inertial system for $v = 0$, $0.25c$, $0.5c$, $0.75c$, and c.

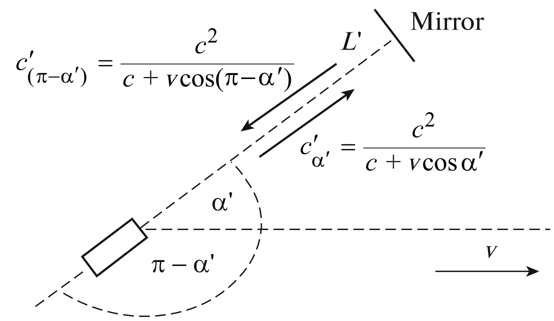

Fig. 5. The speeds of light in the Michelson–Morley experiment.

5. THE SPEED OF LIGHT IN A VACUUM FOR A MOVING OBSERVER

In [7, 8], based on representation (25), (26), the general formula for the speed of light as it propagates in any direction was derived. For light propagation in a vacuum, it has the following form (Fig. 4):

$$c'_{\alpha'} = \frac{c^2}{c + v\cos\alpha'}. \tag{37}$$

For light propagating in a material medium that is immobile relative to the observer [7], the formula is as follows:

$$c'_{s\alpha'} = \frac{c^2 c_s}{c^2 + c_s v\cos\alpha'}. \tag{38}$$

In these two formulas, the angle α' measured by the observer is the angle between the vector of his velocity relative to the UFR and the light velocity vector. The speed c_s is the speed of light in a material medium that is immobile relative to the UFR seen by the observer who is also immobile relative to the UFR.

Now, we determine the mean speed of light, which in any inertial system passes a path with a length L', reflects from a mirror, and returns by the same path to the starting point (Fig. 5). If t'_1 is the time during which the light passes its path L' in one direction and t'_2 is the time during which the light passes the same path in the backward direction, the mean speed of light on its path and back, based on (37), is

$$c'_{sr} = \frac{2L'}{t'_1 + t'_2} = \frac{2L'}{\dfrac{L'}{\dfrac{c^2}{c + v\cos\alpha'}} + \dfrac{L'}{\dfrac{c^2}{c + v\cos(\pi - \alpha')}}}, \tag{39}$$

$$c'_{sr} = \frac{2}{\dfrac{c + v\cos\alpha'}{c^2} + \dfrac{c - v\cos\alpha'}{c^2}} = \frac{2}{\dfrac{2c}{c^2}} = c. \tag{40}$$

It follows that the mean speed of light is constant and is equal to the one-way speed of light c observed from the ether. This mean speed depends neither on the angle α' nor on the velocity v. For this reason, rotation of the interferometer in the Michelson–Morley and Kennedy–Thorndike experiments has no effect on interference fringes. That is the reason that those experiments could not find the ether.

6. TRANSFORMATION BETWEEN TWO INERTIAL SYSTEMS

The transformation from the inertial system U_2 to the system U associated with the ether can be written based on transformation (25), (26). The transformation from the system U associated with the ether to the inertial system U_1 can be written based on transformation (27), (28). The velocity v_1 is the velocity of system U_1 in the system U; the velocity v_2 is the velocity of system U_2 in the system U. Hence, we obtain

$$\begin{cases} t = \dfrac{1}{\sqrt{1 - (v/c)^2}} t_2, \\ x = \dfrac{1}{\sqrt{1 - (v/c)^2}} v_2 t_2 + \sqrt{1 - (v/c)^2} x_2, \\ y = y_2, \\ z = z_2, \end{cases} \tag{41}$$

as well as

$$\begin{cases} t_1 = \sqrt{1 - (v/c)^2} t, \\ x_1 = \dfrac{1}{\sqrt{1 - (v/c)^2}} (-v_1 t + x), \\ y_1 = y, \\ z_1 = z. \end{cases} \tag{42}$$

We consider only the simplest case in which the velocities v_1 and v_2 are parallel to each other. We substitute Eqs. (41) into Eqs. (42). Proceeding from this, after some calculations, we obtain the transformation from inertial system U_2 to the inertial system U_1 in the form

$$\begin{cases} t_1 = \dfrac{\sqrt{1-(v_1/c)^2}}{\sqrt{1-(v_2/c)^2}} t_2, \\ x_1 = \dfrac{v_2 - v_1}{\sqrt{1-(v_1/c)^2}\sqrt{1-(v_2/c)^2}} t_2 + \dfrac{\sqrt{1-(v_2/c)^2}}{\sqrt{1-(v_1/c)^2}} x_2, \\ y_1 = y_2, \\ z_1 = z_2. \end{cases} \quad (43)$$

7. CONTRACTION AND DILATION IN THE STE

7.1. Length Contraction

Let us consider two systems U_1 and U_2 that move in the ether in the same direction with velocities v_1 and v_2, respectively. In these systems, two immobile similar rulers with a length $L_{1/1} = L_{2/2}$ were placed parallel to the direction of motion. Let $L_{i/j}$ denote the length of an immobile ruler measured in system U_i by the observer from system U_j. The ends of the ruler, which is immobile in system U_2 are at the positions x_2^A and x_2^B. Based on (43), the ends of this ruler have the following coordinates in system U_1 at every time t_2:

$$x_{2/1}^A = \frac{v_2 - v_1}{\sqrt{1-(v_1/c)^2}\sqrt{1-(v_2/c)^2}} t_2 + \frac{\sqrt{1-(v_2/c)^2}}{\sqrt{1-(v_1/c)^2}} x_2^A, \quad (44)$$

$$x_{2/1}^B = \frac{v_2 - v_1}{\sqrt{1-(v_1/c)^2}\sqrt{1-(v_2/c)^2}} t_2 + \frac{\sqrt{1-(v_2/c)^2}}{\sqrt{1-(v_1/c)^2}} x_2^B. \quad (45)$$

Subtracting Eq. (44) from Eq. (45), we obtain $L_{2/1}$, i.e., the length of the ruler situated in system U_2 and observed from system U_1:

$$L_{2/1} = x_{2/1}^B - x_{2/1}^A = \frac{\sqrt{1-(v_2/c)^2}}{\sqrt{1-(v_1/c)^2}} (x_2^B - x_2^A). \quad (46)$$

Since

$$L_{2/2} = x_2^B - x_2^A, \quad (47)$$

we obtain the following formula for the length contraction expressed in terms of the absolute speeds:

$$L_{2/1} = \frac{\sqrt{c^2 - v_2^2}}{\sqrt{c^2 - v_1^2}} L_{2/2}. \quad (48)$$

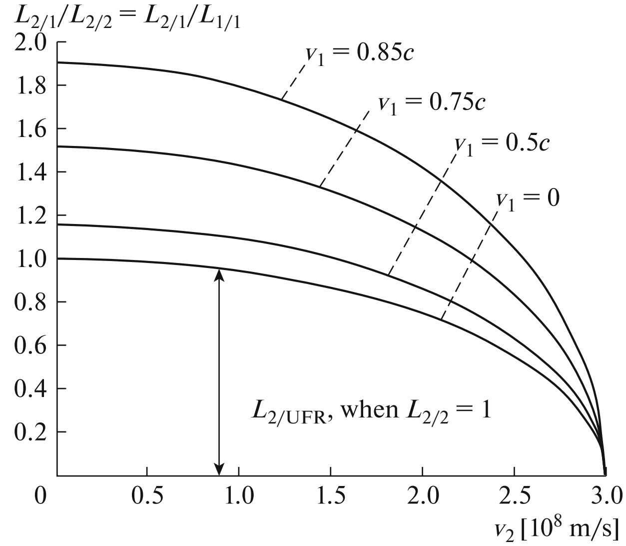

Fig. 6. The length contraction in U_2 observed from system U_1, where v_1 is a given constant speed of system U_1.

Figure 6 presents the length contraction (48) as a function of the speed v_2 when system U_1 has a constant speed v_1.

When system U_1 is immobile relative to the UFR (i.e., $v_1 = 0$), the formula of length contraction (48) takes the same form as the Lorentz contraction formula from the special theory of relativity:

$$L_{2/\mathrm{UFR}} = \sqrt{1-(v_2/c)^2} L_{2/2}. \quad (49)$$

It follows that the body length in the STE is contracted in the same manner as in the STR but only for a observer immobile relative to the UFR.

7.2. Time Dilation

Let us consider two systems U_1 and U_2 moving in the ether in the same direction with speeds v_1 and v_2, respectively. In system U_2, two events occur at the instants t_2^A and t_2^B. In system U_1, according to (43), these events occur at the instants

$$t_1^A = \frac{\sqrt{1-(v_1/c)^2}}{\sqrt{1-(v_2/c)^2}} t_2^A, \quad (50)$$

$$t_1^B = \frac{\sqrt{1-(v_1/c)^2}}{\sqrt{1-(v_2/c)^2}} t_2^B. \quad (51)$$

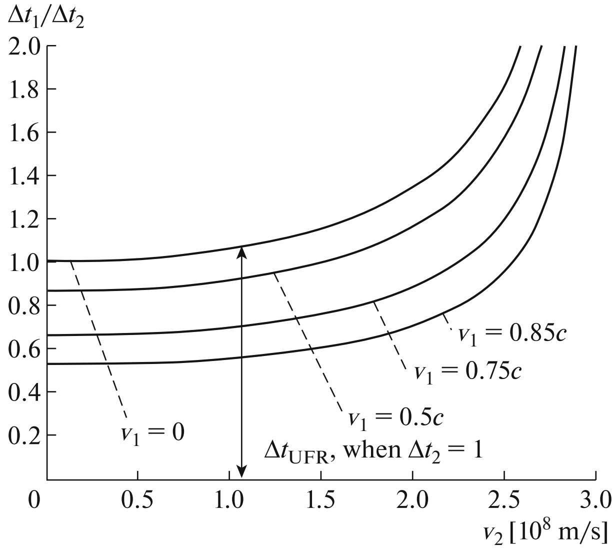

Fig. 7. Time dilation in U_2 observed from system U_1, where v_1 is a given constant speed of system U_1.

Subtracting Eq. (50) from Eq. (51), we obtain Δt_1, i.e., the interval observed between the events from system U_1:

$$\Delta t_1 = t_1^B - t_1^A = \frac{\sqrt{1-(v_1/c)^2}}{\sqrt{1-(v_2/c)^2}}(t_2^B - t_2^A). \tag{52}$$

Since

$$\Delta t_2 = t_2^B - t_2^A, \tag{53}$$

we obtain the time-dilation formula expressed in terms of absolute speeds in the form

$$\Delta t_1 = \frac{\sqrt{c^2 - v_1^2}}{\sqrt{c^2 - v_2^2}}\Delta t_2. \tag{54}$$

Figure 7 shows the time dilation (54) as a function of the speed v_2 when system U_1 has a constant speed v_1.

When system U_1 is immobile relative to the UFR (i.e., $v_1 = 0$), the time dilation formula (54) takes the same form as the time dilation formula from the special theory of relativity:

$$\Delta t_{\rm UFR} = \frac{1}{\sqrt{1-(v_2/c)^2}}\Delta t_2. \tag{55}$$

It follows that the time dilation in the STE occurs in the same manner as the time dilation in the STR but only for the observer who is immobile relative to the UFR.

As follows from formula (54), the synchronization of events in the STE is absolute due to the fact that

$$\Delta t_2 = 0 \Rightarrow \Delta t_1 = 0. \tag{56}$$

8. SIMILARITIES AND DIFFERENCES BETWEEN THE STR AND STE

The predictions of the special theory of relativity and the special theory of the ether are very similar. In the STE, if the observer is immobile relative to the ether, then STE predictions are identical for any observer in the STR. This fact follows, e.g., from formulas (37), (49), and (55) (Fig. 8).

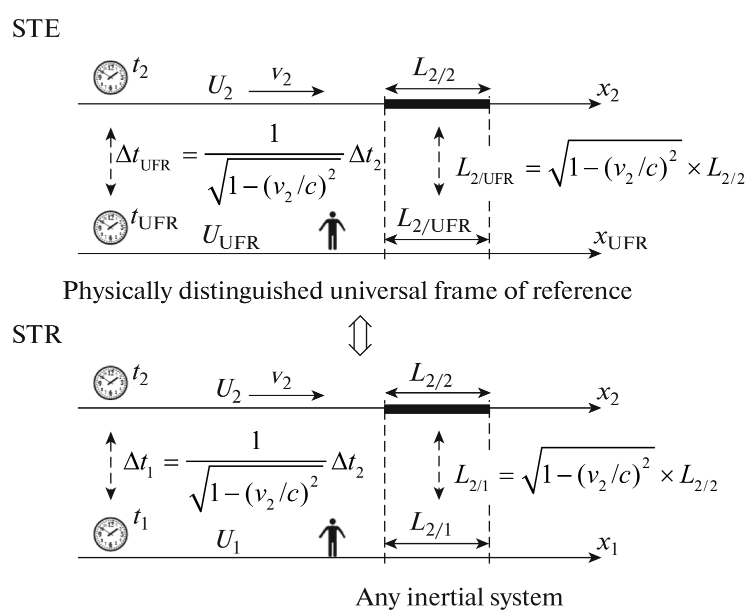

Fig. 8. The similarity between the STR and STE.

Differences between the theories appear when the observer in the STE moves relative to the ether. Therefore, the possibility of experimental falsification of the STE in the future exists. In the STR, all inertial systems are equivalent, i.e., the universal frame of reference does not exist. For this reason, according to the STR, the absolute speed cannot be measured using a local measurement. This means that space is completely isotropic (has similar properties in each direction) for each observer. At the same time, according to the STE, the observer can determine the direction of his motion relative to the ether by a local measurement (i.e., when he is completely isolated from the ambient medium). This means that space is not isotropic (has different properties in different directions) for observers moving relative to the ether. This is the most important difference between the special theory of relativity and the special theory of ether.

The experimental falsification of the STE is very difficult due to the low velocity of the Solar System relative to the ether. In [8], this speed was estimated as 369.3 km/s = $0.0012c$. For such a low speed, the effects of the absence of the isotropy of space, as predicted by the STE, are insignificant. Therefore, falsification of this theory requires specially developed experiments and their performance with a sufficiently high accuracy.

CONCLUSIONS

The presented analysis shows that results of the Michelson–Morley experiment can be explained based on a universal frame of reference. The statement that the Michelson–Morley experiment proved that the speed of light is absolutely constant is false. The statement that the Michelson–Morley experiment proved that there is no universal frame of reference in which light propagates and moves with a constant speed is also false. It follows from the obtained transformations (25), (26) and (27), (28) that measurements of the speed of light in a vacuum by methods used until now will always yield the mean value c. This occurs in spite of the fact that the speed of light has different values in different directions for a moving observer. The mean speed of light is always constant and does not depend on the speed of the inertial frame of reference. Due to this property of the speed of light, the Michelson–Morley and Kennedy–Thorndike experiments could not find the universal frame of reference.

Acceptance of the fact that the speed of light can depend on the direction of its emission does not distinguish any direction in space. We are concerned with the light speed measured by a moving observer. The speed with which the observer moves relative to the universal frame of reference distinguishes a characteristic direction in space, but only for this observer. For an observer who is immobile relative to the universal frame of reference, the speed of light is always constant and does not depend on the direction of its emission. If the observer moves relative to the universal frame of reference, space is not symmetric for him. This case is similar to the case of an observer who is sailing through water and measures the wave speed on the water. In spite of the fact that the wave propagates over the water with a constant speed in each direction, the speed of the wave will be different in different directions for a sailing observer.

In [7], based on the transformation defined here, a new physical theory of kinematics and dynamics of bodies was derived. The authors called it the special ether theory. In [8], it was shown that assumption IV can be weakened and a more general form of the transformation (25)–(29) can be derived. In this way, many forms of kinematics compatible with the Michelson–Morley and Kennedy–Thorndike experiments can be obtained. In [7], it was shown that one can obtain infinitely many forms of dynamics within each form of kinematics. To obtain the dynamics, it is necessary to accept an additional assumption that allows one to introduce the concepts of mass, kinetic energy, and momentum into the theory.

Based on the presented kinematics, one can explain the anisotropy of the microwave background radiation in a natural way. The anisotropy was discussed in more detail in [9]. This allows one to determine the speed with which the Solar System moves relative to the universal frame of reference, i.e., 369.3 km/s. It was shown in [6] and [8].

The Michelson–Morley and Kennedy–Thorndike experiments were repeatedly carried out by different research teams. Each of the experiments corroborated only the fact that the mean speed of light is constant. Therefore, the assumptions that serve as a basis for the presented derivation have been experimentally justified.

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Translated by A. Nikol'skii