

Physico-Mathematical Errors in Einstein's 1905 Derivation of the Lorentz Transformation

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Abstract

The Lorentz transformation is obtained in the same form both in Lorentz's ether-based framework and in Einstein's ether-free framework. Starting from this paradox, we rigorously distinguish two paradigms of spacetime measurement: the mechanical rest frame, constructed from rigid rods, atomic clocks, and light, and the optical moving system, constructed from atomic clocks and light alone. A rest frame is defined as an inertial frame in which the round-trip light time is the same at every position and in every direction. We further distinguish measured coordinates, read directly at stationary points, from borrowed coordinates, which a moving point takes over from the stationary points it passes. Within this framework the invariance of the speed of light is asymmetric: the rest frame exhibits round-trip invariance, whereas the moving system exhibits only borrowed-speed invariance. On this basis we reconstruct the Lorentz transformation and its inverse, using the absolute time dilation of moving atomic clocks and the dilation of the longitudinal coordinate measured with a light ruler. The reconstruction shows that the time of the moving system is the sum of the atomic-clock dilation effect and a time-correction effect required to keep the borrowed speed of light constant. We then reconstruct, step by step, the derivation in Secs. 1–3 of Einstein's 1905 paper and identify six key errors: (i) an operational asymmetry that treats rigid rods as equivalent to light rulers; (ii) a domain collapse in which the Galilean auxiliary variable is combined with a light-ray condition, reducing the domain of analysis to a one-dimensional ray; (iii) an unjustified extension of relations valid only on that ray to all of spacetime; (iv) an event mismatch in which two distinct events are combined in the construction of the transverse coordinates; (v) a circular parameter fixing in which the invariance of rigid rods is presupposed when the undetermined coefficient is fixed; and (vi) a category mistake in which the ellipsoidal contraction of a rigid sphere is interpreted as a physical deformation. These results indicate that relativistic spacetime relativism originates from a confusion of measuring instruments and from optical illusion. The Lorentz transformation is valid not because spacetime itself is distorted, but because it encodes inter-point relativity and the geometry of borrowed coordinates referred to an absolute rest frame. We therefore propose an interpretation of spacetime founded on an absolute rest frame and on a measurement mechanics that keeps rigid rods and light rulers distinct.

Keywords: Special Relativity, Lorentz Transformation, Einstein 1905, Operational Definition, Clock Synchronization, Category Mistake, Absolute Rest Frame

1. Introduction

Classical mechanics adopted the Galilean transformation, which presupposes absolute space and absolute time, as the standard rule for transforming coordinates between inertial frames. With the rapid development of electromagnetism, however, this rule was brought to the point of abandonment by the Michelson–Morley interferometer experiment of 1887 [1], which was designed to detect an absolutely stationary ether [1]. The null result—the absence of any ether wind—exposed a fundamental contradiction between the Galilean transformation and the form of the wave equation of Maxwell's electromagnetism [2]. The physics community accordingly began to seek a new coordinate transformation under which the electromagnetic wave equation is covariant.

In this process a decisive historical divergence arose in how the ether hypothesis and the physical reality of the coordinate transformation were viewed. H. A. Lorentz retained the stationary-ether hypothesis, introduced correction factors into the Galilean transformation, and, adopting FitzGerald's idea, proposed the contraction hypothesis for rigid bodies to second order in v/c [3,4]. He then introduced the concept of "local time" to account for the Doppler effect and the Fizeau experiment [5], among others, but fell short of achieving full covariance for the transformation of charge density and velocity [6,7]. H. Poincaré, by contrast, held that a state of absolute rest is physically meaningless because it can in principle never be detected. He therefore proclaimed the principle of relativity as a universal law of nature [8] and rigorously proved the mathematical covariance of the Lorentz transformation [9]. Finally, Albert Einstein, discarding the ether hypothesis entirely, derived the Lorentz transformation in an original manner from two postulates—the principle of relativity and the principle of the constancy of the speed of light—by means of a clock-synchronization procedure [10-12]. This resolved the long-standing conflict between electromagnetism and mechanics, and the modern relativistic paradigm attained a firmly established status.

Here, however, a fundamental question arises that cannot be overlooked. Why do Einstein's ether-free framework and Lorentz's ether-based framework yield the Lorentz transformation in identical form, despite their diametrically opposed positions on the existence of an absolute rest frame? From the epistemological standpoint that the "absolutism" inherent in the classical and quantum-mechanical domains coexists with the "relativity" manifested in electromagnetic phenomena, the present paper points out that the algebraic derivation in Einstein's original paper contains critical logical leaps and structural defects.

Accordingly, this study rigorously distinguishes the essential difference, established in previous work, between the mechanical rest frame (absolute rest frame), in which rigid rods, atomic clocks, and light are combined, and the optical moving system, which consists of atomic clocks and light alone. That is, we point out the category mistake [13] by which mainstream physics has conflated mechanical and optical measuring instruments, and we critically reassess Secs. 1–3 of the English translation of Einstein's 1905 paper [10] from a new measurement-mechanical perspective. Rather than merely refuting the validity of the existing theory, this paper reconstructs, on the new measurement-mechanical paradigm, the genuine process by which the Lorentz transformation and its inverse are obtained. Furthermore, we identify in detail six key physico-mathematical errors that Einstein committed in carrying through his own postulates: operational asymmetry, domain collapse, unjustified extension, event mismatch, circular parameter fixing, and category mistake. We thereby demonstrate that the spacetime relativism of special relativity in fact originates from a confusion of measuring instruments and from optical illusion.

2. Two Paradigms of Measuring Instruments: The Mechanical Rest Frame and the Optical Moving System

Methods of surveying spacetime coordinates divide into a mechanical and an optical paradigm of measuring instruments, according to the nature of the physical medium used in the measurement. By overlooking the fundamental difference between these two kinds of instruments, or by indiscriminately identifying them, mainstream physics has concealed a critical logical leap in the derivation of special relativity. In this section we rigorously distinguish and establish the mathematical and physical reality of the mechanical rest frame (rigid rods, atomic clocks, and light) and of the optical moving system (atomic clocks and light).

A. Mechanical Rest Frame

Einstein asserts that a rest frame and a uniformly moving frame cannot be distinguished among inertial frames [10]. This is a claim of classical mechanics, which could distinguish only inertial from noninertial frames, and it was adopted in electromagnetism without verification. A rest frame and a moving frame can in fact be distinguished by a round-trip light experiment, because the round-trip light times coincide in a rest frame, where isotropy and homogeneity hold, but do not coincide in a moving frame, where relativity and linearity hold. In this paper, an inertial frame in which the round-trip light time is the same regardless of position and direction is called a rest frame, and any other inertial frame is called a moving frame. That is, the speed of light can be measured by a round-trip light experiment only in the rest frame K . If the round-trip light time is T and the length of the rigid rod is L , the speed of light c is measured as

$$c = \frac{2L}{T}. \quad (1)$$

Determining the rest frame by the round-trip light experiment alone means that a rest frame can be constructed with rigid rods, atomic clocks, and light. We call this the mechanical rest frame.

A rigid rod (or rigid ruler) is an instrument that measures physical spatial intervals (lengths) on the basis of the interatomic binding forces and stresses within it, and it serves as the standard defining length [14,15]. A rigid rod maintains its intrinsic spatial invariance irrespective of the state of motion of the inertial frame, and rigid rods in relative motion are assigned the same length when their ends coincide. A length measured with a light ruler, however, agrees with this length only when the times at the two ends of the rigid rod are simultaneous.

An atomic clock is an instrument that measures time on the basis of the periodic oscillation frequency of local particles, and it serves as the standard defining time [15]. It accumulates time as a local entity at each point, without relying on arbitrary round trips of light signals across spacetime. The periods of atomic clocks at rest relative to one another coincide, but the period of an atomic clock in a moving frame is longer than that of an atomic clock in the rest frame [16,17].

In the rest frame, a stationary point is measured directly with rods and clocks, whereas a moving point is described by borrowing the coordinates of the stationary points it passes. We call the former measured coordinates and the latter borrowed coordinates. For a moving point to use borrowed coordinates, the times of the stationary points are made to agree by means of rigid rods and light. When light emitted from the stationary origin O at $t = t_0$ reaches a stationary point $P(x, y, z, t)$ a distance r away, the atomic clock at P is synchronized as

$$t = t_0 + \frac{r}{c}, \quad r = \sqrt{x^2 + y^2 + z^2}. \quad (2)$$

We call this a one-way light clock [18,19]. When the clocks of the rest frame are synchronized with light clocks, the entire rest frame becomes simultaneous. Once the clocks of the rest frame are synchronized, distances can be measured with atomic clocks synchronized by light. We call this a light ruler:

$$R = c(t - t_0). \quad (3)$$

B. Optical Moving System

To construct a moving frame that travels with velocity v , (>0) along the x axis of the rest frame, it is equipped with light and atomic clocks. Unlike the rest frame, the moving frame cannot determine the speed of light by a round-trip experiment, and the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$ uses light and atomic clocks to match himself to the rest-frame observer $P(x, y, z, t)$; we therefore call it an optical moving system. Light emitted simultaneously from the light source $O(0,0,0,0)$ of the rest frame and the light source $O'_0(0,0,0,0)$ of the moving frame propagates rectilinearly in discrete fashion and arrives together at the rest-frame observer $P(x, y, z, t)$ and the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$. The moving-frame observer P' therefore assigns the speed c to light, following the rest-frame observer P . This is because, by coordinate borrowing, the moving-frame observer regards the two light rays as having left the same source and arrived at the same observer.

However, the relation

$$x^2 + y^2 + z^2 = c^2 t^2; \Rightarrow \xi^2 + \eta^2 + \zeta^2 = c^2 \tau^2 \quad (4)$$

is mathematically an equivalence, but its physical content differs on the two sides? The left-hand equation uses the measured speed of light obtained from a round-trip experiment, whereas the right-hand equation uses a borrowed speed of light transcribed according to the borrowed coordinates. That is,

The law of the constancy of the speed of light holds in inertial frames, but it is asymmetric: in the rest frame it is round-trip invariance of the speed of light, whereas in the moving frame it is invariance of the borrowed speed.

Because linearity holds for inertial frames, the following equations hold between the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$ and the rest-frame observer $P(x, y, z, t)$:

$$\xi = k(x - vt), \quad (5)$$

$$\tau = at + bx, \quad (6)$$

$$\eta = my, \quad (7)$$

$$\zeta = mz. \quad (8)$$

We first determine the transverse coordinates. The points at which the planes passing through the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$ and the rest-frame observer $P(x, y, z, t)$, respectively, and perpendicular to the longitudinal axis meet that axis are called the moving-frame simultaneity point $Q'(\xi, 0, 0, \tau)$ and the rest-frame simultaneity point $Q(x, 0, 0, t)$. Since the ends of the moving-frame rigid rod $Q'P'$ and of the rest-frame rigid rod QP coincide, the lengths of the two rods agree:

$$\sqrt{\eta^2 + \zeta^2} = \sqrt{y^2 + z^2}. \quad (9)$$

From Eqs. (7), (8), and (9),

$$(my)^2 + (mz)^2 = y^2 + z^2. \quad (10)$$

Since m is a function of v ,

$$m = 1, \quad \eta = y, \quad \zeta = z. \quad (11)$$

Next, the atomic clocks of the moving frame are matched to those of the rest frame by means of the light of the moving frame and the light of the rest frame. Light emitted together from the moving-frame origin O_0' and the rest-frame origin O arrives at the moving-frame observer M' on the transverse η axis and at the rest-frame observer M passing nearby. The light of the moving frame satisfies $\xi = 0, \eta = c\tau, \zeta = 0$, and the light of the rest frame satisfies $x = vt, y = \sqrt{c^2 - v^2}t, z = 0$:

$$\xi = 0, \quad \eta = c\tau, \quad \zeta = 0; \quad x = vt, \quad y = \sqrt{c^2 - v^2}t, \quad z = 0. \quad (12)$$

From Eqs. (11) and (12),

$$\eta = c\tau = \sqrt{c^2 - v^2}t = y. \quad (13)$$

That is,

$$\tau = \frac{t}{\beta}, \quad \beta = \frac{1}{\sqrt{1 - (v/c)^2}}. \quad (14)$$

Equation (14) shows that the atomic clock of the moving frame exhibits a time dilation by a factor $1/\beta$ relative to the atomic clock of the rest frame.

The time dilation of the moving frame relative to the rest frame is not relative but absolute [20].

We now determine the longitudinal coordinate.

A rigid rod of length $x' = x - vt$ is placed on the ξ axis of the moving frame, with one end at the origin O_0' and the other at P_0' . Light rays leaving the two origins O_0' and O are reflected by the mirrors P_1' and P_1 , respectively, and return to the original origin O_0' and to the rest-frame observer O_0 . From the standpoint of the rest frame, light traveling parallel to the direction of motion takes

$$t_1 = \frac{x'}{c - v} \quad (15)$$

to reach the mirror P_1' , and

$$t_2 = \frac{x'}{c + v} \quad (16)$$

to return to the origin. The total time for light to make the round trip along the rigid rod of length x' is

$$t_3 = \frac{2\beta^2 x'}{c}. \quad (17)$$

From the standpoint of the moving frame, by Eq. (5), the time for light to reach the mirror P_1 is $\tau_1 = kx'/c$, and the time to return to the origin O_0' is $\tau_2 = kx'/c$, so that the total round-trip time is $\tau_3 = 2kx'/c$:

$$\tau_1 = \frac{kx'}{c}, \quad \tau_2 = \frac{kx'}{c}, \quad \tau_3 = \frac{2kx'}{c}. \quad (18)$$

From Eqs. (14), (17), and (18), since the atomic clock of the moving frame is dilated relative to that of the rest frame, $k = \beta$; then from Eq. (5),

$$k = \beta, \quad \xi = \beta(x - vt). \quad (19)$$

When the longitudinal length is measured with a light ruler in the moving frame, it comes out larger by a factor β than when measured with a rigid rod. This means that, in order for the light of the moving frame to maintain the borrowed speed c , the atomic clock undergoes time dilation (t / β) and the coordinate ξ along the axis of motion is dilated by a factor β . Lorentz, conversely, taking the light ruler as the standard, claimed that a moving body contracts by a factor $1/\beta$ in the direction of motion [6], and Einstein interpreted this as a deformation of physical spacetime [10].

Finally, we determine the time coordinate.

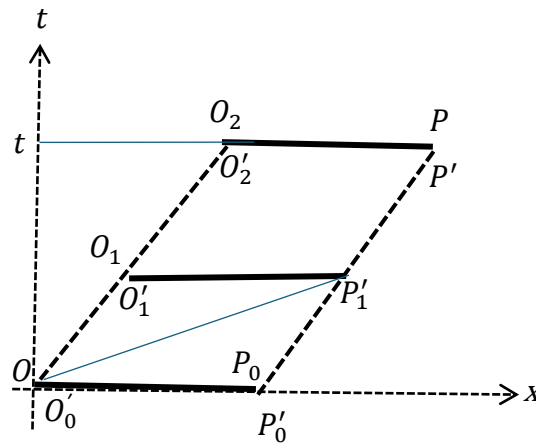


Figure 1: Schematic representation, in the $x-t$ plane, of the synchronization process when a rigid rod of length x' moves with velocity v along the axis of motion (x). At $t = 0$ the rigid rod $O'_0 P'_0$ passes the two points O and P_0 ; at $t = x'/(c - v)$ the rigid rod $O'_1 P'_1$ passes the two points O_1 and P_1 ; and at time t the rigid rod $O'_2 P'_2$ passes the two points O_2 and P .

The figure depicts, in the $x-t$ plane, a rigid rod fixed in the moving frame that moves along the x axis with velocity v while maintaining its length $x' = x - vt$. A light source and an observer of the moving frame are fixed at the two ends of the rod. By Eq. (18), the separation between the source and the observer measured with the light ruler is constant:

$$\xi = \beta(x - vt) = \beta x'. \quad (20)$$

When the rest-frame clock reads $t = 0$, by Eqs. (6) and (20) the ends $O'_0 (0,0,0,0)$ and $P'_0 (\beta x', 0, 0, \beta x'/c)$ of the rigid rod pass $O(0,0,0,0)$ and $P_0 (x', 0, 0, 0)$, respectively. At $t_1 = x'/(c - v)$, by Eqs. (14), (15), and (20) the ends $O'_1 (0,0,0, x'/[\beta(c - v)])$ and $P'_1 (\beta x', 0, 0, \beta x'/c)$ pass the rest-frame observers $O_1 (vx'/(c - v), 0, 0, x'/(c - v))$ and $P_1 (cx'/(c - v), 0, 0, x'/(c - v))$, respectively. At time t , by Eqs. (14) and (20) the ends $O'_2 (0,0,0, t/\beta)$ and $P' (\beta x', 0, 0, \tau)$ pass the rest-frame observers $O_2 (vt, 0, 0, t)$ and $P(x, 0, 0, t)$, respectively.

Since the rigid rod $O'_1 P'_1$ moves to the rigid rod $O'_0 P'_0$, the time taken to move from O'_1 to O'_0 equals the time taken to move from P'_1 to P'_0 :

$$\frac{t}{\beta} - \frac{x'}{\beta(c - v)} = \tau - \frac{\beta x'}{c}. \quad (21)$$

Hence

$$\tau = \frac{t}{\beta} - \frac{v\beta x'}{c^2} = \frac{t}{\beta} - \frac{v\xi}{c^2}. \quad (22)$$

Rearranging Eq. (22) yields the time equation of the Lorentz transformation,

$$\tau = \beta \left(t - \frac{vx}{c^2} \right). \quad (23)$$

From Eqs. (11), (20), and (23), the Lorentz transformation of the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$ with respect to the rest-frame observer $P(x, y, z, t)$ is

$$\tau = \beta \left(t - \frac{vx}{c^2} \right), \quad \xi = \beta(x - vt), \quad \eta = y, \quad \zeta = z. \quad (24)$$

Accordingly, the inverse Lorentz transformation of the rest-frame observer $P(x, y, z, t)$ with respect to the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$ is

$$t = \beta \left(\tau + \frac{v\xi}{c^2} \right), \quad x = \beta(\xi + v\tau), \quad y = \eta, \quad z = \zeta. \quad (25)$$

Equations (24) and (25) exhibit inter-point relativity, or observer relativity. However, from Eqs. (11), (20), and (22),

$$\tau = \frac{t}{\beta} - \frac{v\beta x'}{c^2} = \frac{t}{\beta} - \frac{v\xi}{c^2}, \quad \xi = \beta(x - vt), \quad \eta = y, \quad \zeta = z. \quad (26)$$

Equations (14) and (26) show that the time τ of the moving-frame observer $P'(\xi, \eta, \zeta, \tau)$ consists of the sum of the time-dilation term of the moving-frame atomic clock (t/β) and the time-correction term of the moving frame ($-v\xi/c^2$) required to maintain the borrowed speed c of light. Here the light ruler of the moving frame and that of the rest frame are relative to each other, but a comparison of the atomic clocks of the two frames shows that the moving frame is clearly distinguishable from the rest frame.

The inverse Lorentz transformation can then be rewritten as

$$x = \beta\xi + v\beta\tau, \quad t = \beta\tau + \frac{v\beta\xi}{c^2}, \quad y = \eta, \quad z = \zeta. \quad (27)$$

This shows that Eq. (27) is an equation that restores the dilation term of the atomic clock (t/β) and the light-travel-time correction term ($-v\xi/c^2$) introduced to maintain the borrowed speed of light (c) in the moving frame.

In short, the mechanical rest frame provides an absolute standard that measures space and time directly by means of rigid rods, light, and atomic clocks, whereas the optical moving system must rely on round-trip light times and borrowed coordinates. Overlooking this essential difference between the two measurement systems and indiscriminately identifying optical coordinates with mechanical reality is the decisive cause of the critical physico-mathematical errors in Einstein's derivation discussed in the following section.

3. Reconstruction and Critical Analysis of Einstein's 1905 Derivation

A. Step-by-Step Analysis of Einstein's Derivation (Reconstruction of Equations and Premises)

Before criticizing the physico-mathematical errors that Einstein committed in deriving the Lorentz transformation and its inverse, we reconstruct, in order, the derivation given in Sec. 3 of Ref. [10].

1. Synchronization and the Partial Differential Equation for τ

Section 1 of Ref. [10] defines the synchronization of clocks at two points A and B through the round-trip time of a light signal:

$$t_B - t_A = t'_A - t_B, \quad \frac{t_A + t'_A}{2} = t_B. \quad (28)$$

In terms of the time of the moving system, this is equivalent to

$$\frac{\tau_0 + \tau_2}{2} = \tau_1. \quad (29)$$

In Sec. 3, Eq. (4) of Ref. [10] is applied to a light signal emitted from the origin of the coordinate system k in the ξ direction, reflected at a mirror located at $x' = x - vt$, and returned. Since the outbound and return time intervals observed in the rest frame K are $x'/(c - v)$ and $x'/(c + v)$, respectively,

$$\frac{1}{2} \left[\tau(0,0,0,t) + \tau \left(0,0,0, t + \frac{x'}{c-v} + \frac{x'}{c+v} \right) \right] = \tau \left(x', 0,0, t + \frac{x'}{c-v} \right). \quad (30)$$

Taking x' to be infinitesimal and expanding to first order gives

$$\frac{\partial \tau}{\partial x'} + \frac{v}{c^2 - v^2} \frac{\partial \tau}{\partial t} = 0. \quad (31)$$

For the transverse directions, $\partial \tau / \partial y = 0$ and $\partial \tau / \partial z = 0$ are imposed, and using linearity together with $\tau(0,0,0) = 0$ one obtains

$$\tau = a(v) \left(t - \frac{v}{c^2 - v^2} x' \right). \quad (32)$$

To distinguish the symbol k , denoting the moving reference frame, from the Lorentz factor, we retain the β of the original paper. The undetermined function $a(v)$ of this intermediate step is related to the $\phi(v)$ of Ref. [10] by $a(v) = \phi(v) / \beta$.

2. Longitudinal Coordinate ξ

For a ray of light emitted at $\tau = 0$ from the origin of the moving system along the positive ξ axis, the light postulate in that system assigns $\xi = c\tau$ along the ray. In the stationary frame, the ray recedes from the moving origin with speed $c - v$, so that

$$t = \frac{x'}{c - v}. \quad (33)$$

Substituting Eq. (33) into Eq. (32) and using $\xi = c\tau$, Ref. [10] obtains

$$\xi = a(v) \frac{c^2}{c^2 - v^2} x' = a(v) \frac{c^2}{c^2 - v^2} (x - vt). \quad (34)$$

3. Transverse Coordinates η , ζ and $\phi(v)$

For transverse light, $\eta = c\tau$ is imposed, and, using the transverse component $\sqrt{c^2 - v^2}$ in the stationary frame, $t = y/\sqrt{c^2 - v^2}$ and $x' = 0$ are substituted. The result is

$$\eta = a(v) \frac{c}{\sqrt{c^2 - v^2}} y, \quad \zeta = a(v) \frac{c}{\sqrt{c^2 - v^2}} z. \quad (35)$$

Section 3 of Ref. [10] (pp. 47–48) first composes the transformations for velocities v and $-v$ to obtain $\phi(v)\phi(-v) = 1$. It then uses the symmetry, under velocity reversal, of a moving rod lying in the transverse direction to obtain $\phi(v) = \phi(-v)$. Applying the usual positive scale factor together with the identity limit gives $\phi(v) = a(v)\beta = 1$. Equations (32), (34), and (35) then become the standard Lorentz transformation:

$$\tau = \beta \left(t - \frac{vx}{c^2} \right), \quad \xi = \beta(x - vt), \quad \eta = y, \quad \zeta = z. \quad (36)$$

B. Detailed Critique of Six Key Physico-Mathematical Errors in the Derivation of the Lorentz Transformation

Six structural and critical physico-mathematical errors, which mainstream physics has overlooked, are closely intertwined in the derivation reconstructed above.

- **Error I:** Operational asymmetry Reference [10] declares that the theory is founded on the kinematics of the rigid body and on measurement with mechanical rods [10]. From the standpoint of operational definition [21], however, the operational procedure by which spacetime coordinates are actually partitioned and formulated depends entirely on the round-trip time of light signals, that is, on the optical condition $\xi = c\tau$. The measuring scale introduced in the coordinate system k is therefore operationally a “light ruler.” In the rest frame K the physical length of a rigid rod and the round-trip distance of light assign the same spatial interval, but in an inertial frame k in relative motion the physical realities of the two measuring operations separate completely. The rigid rod, applied directly to an object independently of any synchronization convention, yields the geometric coordinate of the Galilean transformation, $x' = x - vt$, whereas the light ruler, dependent on the round-trip propagation time, yields $\xi = \beta(x - vt)$. Einstein committed the error of operational asymmetry by presupposing a priori, without proof or verification, that these two different measuring operations agree without contradiction in every inertial frame.

- **Error II:** Domain collapse the auxiliary variable $x' = x - vt$ is originally a Galilean variable that represents the position, in the rest frame, of an arbitrary spatial point fixed in the coordinate system k . Einstein, however, treats this variable as an independent variable of the partial differential equation while simultaneously substituting the light-propagation condition $t = x'/(c - v)$ to carry out the algebraic development. The moment this light-ray condition is combined directly with the variable of partial differentiation ($x' = x - vt$), the domain of analysis is artificially collapsed from the entire four-dimensional domain of spacetime events (x, y, z, t) to a one-dimensional set on the forward light ray $x = ct$. When a single symbol x' is assigned the three mutually contradictory roles of an independent variable of the partial differential equation, the world line of the origin of the moving system, and a light-ray constraint, the corresponding measurement-mechanical conditions must be stated explicitly.

- **Error III:** Unjustified extension of a restricted relation to general events The most serious mathematical leap in this derivation is the unwarranted extension of a special proportionality relation, valid only on a restricted light ray, to a general transformation of all of spacetime. The relations obtained under the condition $x = ct$ constitute, mathematically, an underdetermined system in which the number of unknowns exceeds the number of conditions. As can be seen in Fig. 1, the position of the rigid rod $O_1'P_1'$ at $t = x'/(c - v)$ differs from the position of the rigid rod O_2' at time t , and the physical conditions differ as well. Arbitrarily choosing coefficients for general events in the plane on the basis of a local relation valid only on the one-dimensional light ray $x = ct$, and fixing them as a transformation of all of spacetime, has no mathematical necessity or logical justification whatsoever.

- **Error IV:** Event mismatch in the transverse construction In deriving the transverse coordinate η , Einstein simultaneously substitutes two different conditions: $x' = 0$ (i.e., $x = vt$, the world line of the origin of the moving system) and $t = y/\sqrt{c^2 - v^2}$ (the time of the event at which light reaches a transverse mirror at height y). The partial differential equation (31) is an equation for determining ξ and τ , and the event at which light reaches a mirror on the transverse axis at $y > 0$ can never lie on the origin world line $x' = 0$ of the moving frame. Forcibly combining, algebraically, two independent events occurring at different spatial positions and times is an event-mismatch error that entirely lacks physical validity.

- **Error V:** Circular parameter fixing In determining and normalizing the undetermined coefficient as $\phi(v)=1$, Ref. [10] adopts a symmetry argument according to which the transverse rods of the two coordinate systems must have the same length regardless of the direction of motion. In the mechanical rest frame and the optical moving system, however, the lengths of rigid rods agree only when the rods lie perpendicular to the direction of motion at simultaneous instants. This amounts to reimposing a priori the physical invariance of the “rigid rod” on a moving frame constructed with light rulers. That is, it is a typical case of circular reasoning, in which the conclusion to be derived (the invariance of the measuring instruments and the validity of the postulates) is already laid down as a premise of the argument.

- **Error VI:** Category mistake concerning rulers in the interpretation of the rigid sphere Section 4 of Ref. [10] converts the equation $\xi^2 + \eta^2 + \zeta^2 = R^2$ of a “rigid sphere” centered at the origin of the moving system into rest-frame coordinates, interprets it as being deformed into an ellipsoid of revolution, and concludes that it represents a “material contraction of the rigid sphere due to motion.” This overlooks the fact that, in measuring distances, the coordinates (x, y, z) used in the mechanical rest frame are measured directly with rigid rods, whereas the coordinates (ξ, η, ζ) used in the optical moving system are measured with light rulers. The ellipsoidal interpretation is therefore not an actual physical deformation of the body; it is the result of a manifest category mistake concerning rulers, in which an observational illusion [22,23] arising from light-propagation delay and optical parallax is misread as a geometric contraction of rigid rods.

4. Discussion

The results of this study clearly reveal that Einstein’s 1905 derivation of special relativity is not a matter of a simple defect in a formula but

an aggregate of structural defects in which inconsistencies of measurement technique and mathematical leaps are intertwined. Proponents of relativity have claimed that the Lorentz transformation is the unique solution satisfying the covariance of electromagnetism and the symmetry of spacetime, but the six critical errors identified in this paper demonstrate that this claim is no more than a mathematical illusion lacking physical reality [24,25]. In this section we synthesize the main points of criticism and argue for the inevitability of a genuine physical interpretation based on an absolute rest frame.

First, the defense against the asymmetry of operational definitions and the category mistake concerning rulers is the weakest link of relativity. Einstein identified, without any verification, the coordinates derived by means of a “light ruler,” which depends on the round trip of light signals, with the coordinates of a static “rigid rod,” which possesses physical reality and is independent of the state of motion of the inertial frame (Errors I and VI). The interpretation commonly advanced by relativists—that “physical space itself contracts”—is a typical category mistake: an observational illusion arising from the dilation of atomic clocks and from optical parallax, rather than an actual deformation of bodies, is mistaken for the geometry of space itself. By establishing that rigid rods and light rulers are fundamentally different in physical character, this study clearly exposes the fictitious nature of the Lorentz–FitzGerald contraction [3,6] and of the relativistic length-contraction hypothesis.

Second, the artificial collapse of the domain and the unjustified generalization are defects that cannot be tolerated from the standpoint of mathematical rigor. In deriving the partial differential equation, Einstein simultaneously substituted the light-ray condition $x=ct$ into the Galilean auxiliary variable, thereby collapsing the domain of analysis from the general domain of spacetime events to a single one-dimensional forward light ray (Error II). He then unjustifiably extended this local, restricted particular solution, through an arbitrary choice of coefficients, to a general transformation of all spacetime events (Error III). Moreover, in deriving the transverse coordinates he algebraically conflated two different physical conditions, the world line of the origin and the arrival of light at a mirror on the transverse axis (Error IV). This is not a derivation by mathematical necessity but a deductive error in which the answer (the Lorentz transformation) was presupposed and then fitted.

Third, there is the circular reasoning and the falsity of the postulate of the constancy of the speed of light. Presupposing a priori the identity of the measuring instruments of the two coordinate systems in fixing the transverse scale factor $\phi(v)=1$ (Error V) is a typical circular argument that already takes as a premise the “postulates” at the core of relativity. In an inertial frame a rigid rod agrees with a light ruler only when the two ends of the rigid rod are simultaneous. Therefore, to measure a rigid rod on the transverse axis with light, the condition under which the rigid rod and the light ruler agree must be stated explicitly. Einstein, however, out of his devotion to the principle of relativity, erred in regarding the instruments of the two coordinate systems as identical a priori.

Consequently, Einstein’s 1905 procedure shows that the true Lorentz transformation and its inverse cannot be derived when the absolute rest frame is excluded. The physics community has blindly trusted the validity of special relativity because it has confused the inter-point relativity and the round-trip/borrowed light-speed invariance contained in the Lorentz transformation itself with the illusion of the relativity of spacetime. Genuine spacetime symmetry is completed without physical contradiction only when an absolute rest frame is presupposed.

5. Conclusion

This study has rigorously re-examined the derivation of the Lorentz transformation presented in Secs. 1–3 of Einstein’s original 1905 paper and has finally identified six critical physico-mathematical defects inherent in it. The principal conclusions are as follows.

Operational confusion and asymmetry (Errors I and VI). Identifying, without justification, “light-ruler” coordinates based on round-trip light signals with physical “rigid-rod” coordinates, and on this basis interpreting the ellipsoidal deformation of a sphere as a physical contraction, is a category mistake that confuses measurement technique with geometry.

Breakdown of the mathematical development (Errors II, III, and IV). The algebraic derivation—which substitutes a local light-ray condition into the independent variable of a partial differential equation, thereby collapsing the domain to a one-dimensional light ray, then unjustifiably extends the result to a transformation of all of spacetime, and arbitrarily mixes the transverse arrival event—has lost its mathematical validity.

Circular argument and collapse of the postulates (Error V). Because the identity of the instruments is presupposed a priori in normalizing the undetermined coefficient, the postulate of the constancy of the speed of light, which underlies the theory, is shown to rest on a circular assumption rather than on a rigorous empirical derivation.

This analysis clearly demonstrates that the principle of relativity and the postulate of the constancy of the speed of light, which Einstein

introduced in order to reject the ether and the absolute rest frame, are in fact the product of combining mathematical artifice with optical illusion while disregarding physical reality.

Therefore, Einstein's derivation of special relativity, which excludes the absolute rest frame, does not by itself fully warrant the Lorentz transformation and its inverse. The Lorentz transformation can nevertheless retain partial validity in electromagnetism and mechanics because it correctly reflects the "inter-point relativity" of physical laws referred to the absolute rest frame and the "geometry of borrowed coordinates," not because spacetime itself is relatively distorted. This study strongly proposes that physics should depart from Einstein-type spacetime relativism and return to an absolute relativity grounded in the absolute rest frame and in a clear measurement mechanics that separates rigid rods from light rulers.

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