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NEW THEORY OF RELATIVITY THAT USES GALILEAN TRANSFORMATION AS BASIS OF TRANSFORMATION BETWEEN INERTIA COORDINATE SYSTEMS

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After the experiments of Michelson and Morley (1887), Fitzgerald and Lorentz, based on their belief in the existence of the ether, showed that there could be a transformation, now called the Lorentz transformation, in the propagation of light to explain the experimental results. Einstein (1905) derived the Lorentz transformation under the principles of relativity and light speed invariance. It was given in a modified form of the Galilean transformation, a known coordinate transformation. As a result, the relativistic time and length are applied in physics. However, since Einstein's theory of relativity led to the Lorentz transformation for coordinate systems, its consequences were attributed to the theories of Fitzgerald and Lorentz, which assumed the existence of the ether. Einstein's theory of relativity thus leads to various paradoxes. Here, the author presents a new theory of relativity that does not lead to any paradoxes. This theory, which is the exact opposite of Einstein's theory of relativity, asserts the absoluteness of time and length and uses the Galilean transformation as a coordinate transformation law. Based on the coordinate transformations, Lorentz transformations are constructed as the transformation laws of electromagnetic theory. Dynamics and electromagnetics using electromagnetic waves such as light for observation are defined as relativistic dynamics and relativistic electromagnetics. Newton's laws of motion are modified under Galilean transformations as the laws of motion for a stationary object until it acquires an infinitesimal velocity. The new theory of relativity correctly explains all previous results of physics experiments. This paper integrates the contents of Refs. 3), 4), and 5) and is presented here in English. Further details are given in Ref. 5) in Japanese.

Key Words : *Galilean transformation, Lorentz transformation, light speed, twin paradox, relativistic time and length, absolute time and length, Newton's laws of motion*

1. INTRODUCTION

In his theory of relativity,[1)] published in 1905, Einstein derived the Lorentz transformation by modifying the Galilean transformation under the principles of relativity and the invariance of the speed of light, and used it as the foundation of relativity. This replaced the concepts of invariant time and length in physics, believed since Newton, with relativistic concepts of time and length.

In his paper, Einstein gives the following explanation.[2)]

"Consider a clock that, when fixed in a stationary system, exhibits time t, and when fixed in a moving system, gives time τ. Suppose a clock with these characteristics is fixed at the origin of the coordinates of the *k*-system (moving system) and is adjusted to indicate time τ. Now, when we *view* this clock from the stationary system, at what tempo does it *appear* to tick?"

"If we assume that the above conclusion, which holds for any movement along an arbitrary polyline, holds for any movement along an arbitrary continuous curve, then the following theorem follows. Suppose there are two clocks at point A that show the same time. Suppose that one of the clocks is moved at a constant speed v for t seconds along an arbitrary closed curve passing through A, and then moved back to A again. When this clock arrives at A, the time it shows is delayed by $t \cdot (v/c)^2/2$ seconds relative to the other clock that stayed at A."

These explanations illustrate the time delay for a clock in a moving system, which leads to time paradoxes. The general perception in the modern physics community of the various paradoxes related to Einstein's theory of relativity is that they are not actual paradoxes. Recall Einstein's statement, "Now, when we *view* this clock from the stationary system, at what tempo does it *appear* to tick?" The expressions "view" and "appear" are ambiguous from the standpoint of the definition of measurements in physics. Although many commentary books on relativity use expressions such as the above, we must be explicit about the definition of measurements in physics.

In order to clarify the problems with such an explanation, the present author proposed a physical method for photometric measurement of the time and length for a moving system.[3] A Lorentz transformation whose physical meaning is almost the exact opposite of Einstein's theory of relativity was constructed using this method. Based on this Lorentz transformation, a new theory of relativity was constructed. The features of this new theory can be summarized as follows:[3), 4), 5)].

1) The Galilean transformation is the only coordinate transformation that connects inertial systems.
2) Therefore, Einstein's relativistic time and length are replaced by absolute time and length.
3) With the Galilean transformation as the basis of coordinate transformation, the relativistic transformation law for light (i.e., electromagnetic theory) is defined as the Lorentz transformation.
4) Relativistic dynamics and relativistic electromagnetic theory are constructed by applying Lorentz transformations to the dynamics and electromagnetic theory for stationary systems, with the Galilean transformations used as the basis of coordinate transformations.
5) The general theory of relativity explains the effect of gravity (acceleration) on relativistic dynamics and relativistic electromagnetic theory.
6) An important discovery in general relativity is that the action of gravity propagates at the speed of light and is subject to the action of red shift in the same way as the action of electromagnetism.
7) The conventional concept of space-time distortion in relativity must be modified to refer to the distortion of time and space measured on the basis of photometry using the Galilean transformation as a foundation and placing the Cartesian linear coordinate system in actual time and space.
8) Since photometry (measurement using electromagnetic waves) is used for physical measurements, the speed of light is defined as the limit of measurement speed.
9) Therefore, relativity does not place a limit on the relative velocity of objects.

Next, the construction of the new theory of relativity is shown in detail.

2. CONSTRUCTION OF NEW THEORY OF RELATIVITY

1) Coordinate transformation between inertial systems and photometric measurement of length of stationary bar

The following explanation is generally given for Einstein's theory of relativity. Galilean transformations covariantly transform Newton's equation of motion, but do not covariantly transform Maxwell's electromagnetic equations. On the other hand, the Lorentz transformation does not covariantly transform Newton's equation of motion, but it does covariantly transform Maxwell's electromagnetic theory. In terms of accuracy, Maxwell's electromagnetic theory and the Lorentz transformation are more reliable than Newton's equation of motion and the Galilean transformation. Therefore, the Lorentz transformation is the correct coordinate transformation law between inertial systems and the Galilean transformation, and Newton's equation of motion needs to be modified.

Under the principles of relativity and light speed invariance, Einstein showed that when clocks placed at two distant points in a moving system are *viewed from a stationary system*, they do not indicate the same time. He derived the Lorentz transformation by modifying these times to make them simultaneous.

However, the following questions appear:

a) What unit of time is used for the two clocks in the moving system as viewed from the stationary system and what time do these clocks indicate?
b) What unit of length is used for the distance between two points in the moving system and what is the length?

If the time and length in these questions are not fixed in advance, the statement "If we *view* the time and length in a moving system from a stationary system ..." does not make sense.

In conventional relativity, proper time and proper length are defined. Based on this and the principle of relativity, an intrinsic time or length must be established in a stationary or moving system. This implies that the Galilean transformation must be strictly established between inertial systems.

In the new theory of relativity[3), 4), 5)], the Galilean transformation is used as a coordinate transformation law for connecting inertial systems. As a result, the relativity of time and length defined by Einstein are removed from the physics and replaced by absolute time and length. Thus, the Galilean transformation forms the basis of the new theory of relativity.

With the time and space coordinates of the stationary system denoted by (t, x, y, z) and those of the moving system denoted by (t', x', y', z'), the Galilean transformation is generally defined as follows.

$$t' = t \tag{1}$$

$$x' = x - vt \tag{2}$$

$$y' = t \tag{3}$$

$$z' = t \tag{4}$$

where v is the relative velocity of the moving system with respect to the stationary system. In this case, the motion of the moving system is in the positive direction along the x-axis.

Based on the principle of relativity and the Galilean transformation, when the length of a bar of length l_0, which is stationary in front of the observer in the stationary system and the observer in the moving system, respectively, is measured using photometry by each observer (with the bar axis along the x-axis direction), the time required for the measurement for observers is given as follows.

$$t_0 = \frac{l_0}{c} \tag{5}$$

where c is the speed of light.

Although the speed of light does not appear in the Galilean transformation equations (1)-(4), it does appear in the photometric results shown in equation (5).

2) Photometric measurement of length of moving bar

At first glance, the following discussion appears to be the setting of the time of the clocks placed at two points in a moving system, as done in the commentaries on Einstein's theory of relativity. However, it is quite different from the case of Einstein's theory of relativity.

Let us consider the case where the length of a bar (bar axis is along the x-axis direction) moving away from the stationary system in the positive direction along the x-axis at constant velocity v is being photometry measured remotely from the stationary system by an observer in the stationary system.

For an optical survey from the stationary system in the direction in which the light follows the bar, the measurement time is given as follows.

$$t_1 = \frac{l_0}{c - v} = \frac{1}{1 - v/c}\frac{l_0}{c} \tag{6}$$

Conversely, for an optical survey by the observer in the stationary system with light propagating in the direction facing the bar, the measurement time is given as follows.

$$t_2 = \frac{l_0}{c + v} = \frac{1}{1 + v/c}\frac{l_0}{c} \tag{7}$$

The measurement times shown in equations (6) and (7) are different. Therefore, the distance between the two points in the moving system is not measured correctly.

Since the photogrammetry is conducted by an observer of a stationary system, the light propagation is with respect to the stationary system, and the measurement times shown in equations (6) and (7) show the classical Doppler effect, namely $1/(1 \pm v/c)$. In other words, the apparent velocity of light propagation relative to the motion of the moving system changes and is measured. In this case, the apparent light speed is $c' = (1 \pm v/c)c$. The average of these apparent light speeds gives $c'^{-} = c$.

Taking the average of the measurement times shown in equations (6) and (7) yields

$$\begin{aligned}\bar{t} = (t_1 + t_2)/2 &= \left(\frac{1}{1 - v/c} \cdot \frac{1}{1 + v/c}\right)\frac{l_0}{c} \\ &= \frac{1}{1 - v^2/c^2}\frac{l_0}{c}\end{aligned} \tag{8}$$

where $\bar{t}$ is the average measurement time.

In equation (8), the Doppler effect is in the form of the effects on the light going and returning propagations.

The average measurement length corresponding to the average measurement time is given by

$$\bar{l} = c\bar{t} = \frac{1}{1 - v^2/c^2} l_0 \tag{9}$$

where $\bar{l}$ is the average measured length.

Since the discussion up to this point is based on the observations of an observer in a stationary system, the speed of light propagation in the stationary system is c.

The conventional explanation of relativity does not include asking the observer of a moving system about the observation, as explained in the next section. In other words, the theory of relativity is constructed only from the standpoint of observers of stationary systems.

3) Asking observer of moving system

In this section, we discuss how light emitted by an observer of a stationary system in a photogrammetric survey becomes that which is observed by an observer with the bar in a moving system.

It is assumed that Einstein introduced the principle of light velocity invariance based on discussions concerning the results of experiments conducted by Michelson and Morley[6] in 1887. However, here, the experimental fact that light emitted from a light source with relative velocity is measured with a shift in its frequency is applied.

According to experiments, the propagation of light emitted by a stationary system, as measured by an observer in a moving system, has a classical Doppler shift and a second-order shift (red shift) in its frequency. Therefore, the measurement time for the observer with the bar in the moving system is as follows.

The measurement time t_1 for the stationary system is

$$\begin{aligned}\tau_1 &= t_1 \frac{1}{1+v/c}\sqrt{1-v^2/c^2} \\ &= \sqrt{1-v^2/c^2}\,\overline{t} \qquad (10)\end{aligned}$$

The measurement time t_2 for the stationary system is

$$\begin{aligned}\tau_2 &= t_2 \frac{1}{1-v/c}\sqrt{1-v^2/c^2} \\ &= \sqrt{1-v^2/c^2}\,\overline{t} \qquad (11)\end{aligned}$$

where τ_1 and τ_2 are the propagation times when the observer with the bar in the moving system directly measures the propagation of the optical survey light emitted by the observer in the stationary system through the moving system. $1/(1 \pm v/c)$ is the classical Doppler shift of the frequency and $\sqrt{1-v^2/c^2}$ is the second-order shift.

Based on the above, the following important relationship is established between the time of measurement by an observer in a stationary system and the time of measurement by an observer in a moving system:

$$\tau = \sqrt{1-v^2/c^2}\,\overline{t} \qquad (12)$$

where τ is the time measured by the observer in the moving system. τ_1 and τ_2 indicate simultaneity, so they are represented by τ.

From equation (11), the propagation distance of the light emitted by the photometry conducted by the observer in the stationary system through the moving system is given by

$$\xi = c\tau = \sqrt{1-v^2/c^2}\,\overline{l} \qquad (13)$$

where ξ is the propagation distance when light emitted by the optical survey of the observer in the stationary system is observed by the observer in the moving system as the light propagating in the moving system.

To obtain equation (13), the propagation velocity of light that reaches the moving system from the stationary system is preempted by the fact that the velocity in the moving system is equal to that in the stationary system, but this does not mean that the principle of light velocity invariance is introduced. This is explained in physical terms later.

The above equations provide the relation for light propagation between the stationary system and the moving system. Note that according to equations (12) and (13), the time measured by the observer of the stationary system with respect to light propagation is not directly shortened in the moving system, but the average measurement time of the stationary system is shortened.

As mentioned, the meaning of "see," "observe", "view", etc. in the conventional explanation of relativity is ambiguous. Equations (12) and (13) give the relationship when the propagation of light emitted from a stationary system is observed by an observer in a moving system. Therefore, when an observer of the stationary system observes the light emitted from the moving system, the time shown on the two sides of equations (12) and (13) are interchanged. In addition, the observer of the stationary system will observe the propagation of light emitted by the moving system over the average measurement time in a time-shortened form.

4) Conversion of measurement time for observer of stationary system to average measurement time

From equation (12), since the measurement time for the observer in the stationary system with respect to light propagation is not directly shortened for the observer in the moving system, but the averaged measurement time is shortened. Our task here is to find a conversion law that corrects the measurement time for the stationary system to the average measurement time.

Assume the following relationship between the measurement time and average measurement time for stationary systems.

$$\overline{t} = t + \Delta t \qquad (14)$$

where t is the measurement time for the stationary system and Δt is the time correction.

Substituting the measured values shown in equation (6) into equation (14), we obtain from equation

(8) the following relation

$$\frac{1}{1-v^2/c^2}\frac{l_0}{c}=\frac{1}{1-v/c}\frac{l_0}{c}+\Delta t \qquad (15)$$

From this, the time correction Δt is given by

$$\begin{aligned}\Delta t &= \frac{1}{1-v^2/c^2}\frac{l_0}{c}-\frac{1}{1-v/c}\frac{l_0}{c}\\ &= -\frac{v/c}{1-v^2/c^2}\frac{l_0}{c} \qquad (16)\end{aligned}$$

Thus, the relational expression for converting the measurement time for a stationary system to the average measurement time is given by

$$\bar{t}=t-\frac{v/c}{1-v^2/c^2}\frac{l_0}{c} \qquad (17)$$

5) Derivation of new Lorentz transformation

The Lorentz transformation defined by Einstein's theory of relativity is a modified form of the Galilean transformation, which maps the coordinate system (t, x, y, z) of a stationary system to the coordinate system (t', x', y', z') of a moving system. Thus, Einstein's theory of relativity gives the relative time and length, where the actual time and length for the moving system depend on the relative velocity. This leads to time and length paradoxes.

Here, a new Lorentz transformation that does not lead to any paradoxes is proposed.

First, from the coordinate transformation via the Galilean transformation, the following equation is obtained.

$$l_0=x-vt \qquad (18)$$

Thus, from equations (12), (17), and (18), we have

$$\begin{aligned}\tau &= \sqrt{1-v^2/c^2}\left(t-\frac{v/c}{1-v^2/c^2}\frac{l_0}{c}\right)\\ &= \frac{1}{\sqrt{1-v^2/c^2}}(t-vx/c^2) \qquad (19)\end{aligned}$$

The form of equation (19) obtained here agrees with that of the Lorentz transformation for time in Einstein's theory of relativity. Its physical meaning, however, is quite different from the Lorentz transformation in Einstein's theory. Equation (19) does not represent a transformation of a coordinate system. As is clear from the process of its deduction, it gives the relationship between the average propagation time for light emitted by a stationary system when observed by an observer of the stationary system and the propagation time when it is observed by an observer of the moving system. In other words, it is a conversion equation for the phase of the propagating wave of light.

Furthermore, from equations (9), (13), and (18), the following equation is obtained.

$$\begin{aligned}\xi &= \sqrt{1-v^2/c^2}\frac{1}{1-v^2/c^2}l_0\\ &= \frac{1}{\sqrt{1-v^2/c^2}}(x-vt) \qquad (20)\end{aligned}$$

As is clear from the above process of deduction, this relation gives the relationship between the average propagation distance of light emitted by a stationary system when observed by an observer of the stationary system and the propagation distance when it is observed by an observer of the moving system. In other words, it is a conversion equation for the phase of the propagating wave of light.

Although the details of the deduction process are not shown here, the following relations are given for the y- and z-axis directions based on the same considerations as above.

$$\eta=y \qquad (21)$$

$$\zeta=z \qquad (22)$$

The Lorentz transformation with a new physical meaning (i.e., the new Lorentz transformation) was derived from equations (19)-(22). The Galilean transformation is used as a transformation law for coordinate systems. The theory of relativity based on this new Lorentz transformation is called the new theory of relativity. In this new theory, the Galilean transformation and the Lorentz transformation coexist harmoniously.

As is clear from the previous discussion, since the Galilean transformation is a transformation of the coordinate system and the Lorentz transformation is a transformation applied in electromagnetic theory, their physics are completely independent.

Thus, for example, even if $v^2/c^2 \ll 1$, the Lorentz transformation cannot physically give a Galilean transformation. Even if both transformations are viewed only mathematically, the vx/c^2 term on the right-hand side of equation (19) cannot be ignored under the condition $v^2/c^2 \ll 1$. Furthermore, even when $c \to \infty$ is given in addition to the condition $v^2/c^2 \ll 1$, the term vx/c^2 on the right-hand side of equation (19) cannot be ignored. This is because we can set $x \to \infty$. Physically, since c represents the speed of light, the condition $c \to \infty$ cannot be given.[7), 8), 9), 10)]

6) Propagation time and distance for light in moving system

From the relationship in equation (12), it can be seen that the average measurement time for the stationary system is shortened by $\sqrt{1-v^2/c^2}$ in the moving system. Similarly, from equation (13), the propagation distance for light is also measured with a reduction of $\sqrt{1-v^2/c^2}$ in the moving system.

On the other hand, substituting $x = vt$ into equation (19) yields the following relation.

$$\begin{aligned}\tau &= \frac{1}{\sqrt{1-v^2/c^2}}(t - v^2 t/c^2) \\ &= \sqrt{1-v^2/c^2}\,t \end{aligned} \tag{23}$$

In addition, from equation (20), we obtain the following relationship.

$$\xi = \frac{1}{\sqrt{1-v^2/c^2}} l_0 \tag{24}$$

Equations (23) and (24) represent relational expressions commonly seen in Einstein's theory of relativity, but their physical meaning is quite different from that in Einstein's theory.

In Einstein's theory of relativity, these relations are the relativistic definitions of the actual time and actual length for the moving system, respectively. This leads to time and length paradoxes. However, this is not the physical meaning of equations (23) and (24). As is clear from the process of deduction so far, they represent the relationship between the propagation time and distance for light in a stationary system and a moving system, respectively. Therefore, the new theory of relativity does not lead to time and length paradoxes.

7) Invariance of phase of propagating light waves and speed of light

In this section, we consider the case where the moving system moves away from the stationary system at a constant speed in the x-axis direction.

Considering the phenomenon in one spatial dimension, let $\phi(x,t) = \phi(kx - \sigma t)$ be the profile of the light wave emitted from the stationary system when it is observed by an observer of the stationary system, and let $\phi'(\xi,\tau) = \phi'(k'\xi - \sigma'\tau)$ be the wave profile when the light emitted from the stationary system propagates in the moving system and is observed by an observer of the moving system. Since the observers of the stationary system and the moving system observe the same light wave, the following relation must hold for the observers.

$$kx - \sigma t = k'\xi - \sigma'\tau \tag{25}$$

where k and σ are the wavenumber and angular frequency of the light wave observed in the stationary system, respectively, and k' and σ' are the wavenumber and angular frequency of the light wave observed in the moving system, respectively.

From equation (25), the following relationship is obtained.

$$k(x - ct) = k'(\xi - c'\tau) \tag{26}$$

That is,

$$x - ct = \frac{k'}{k}(\xi - c'\tau) \tag{27}$$

where c' is the speed of light as measured in the moving system. Substituting the relations in equations (19) and (20) into the right-hand side of equation (27) yields the following equations.

$$\begin{gathered}\frac{k'}{k}(\xi - c'\tau) = \\ \frac{k'}{k}\frac{1}{\sqrt{1-v^2/c^2}}\left(x - vt - c'(t - vx/c^2)\right)\end{gathered} \tag{28}$$

$$\begin{aligned}&\frac{k'}{k}(\xi - c'\tau) \\ &= \frac{k'}{k}\frac{1}{\sqrt{1-v^2/c^2}}(1 + c'v/c^2) \\ &\quad \left[x - \frac{(1+v/c')}{(1+c'v/c^2)}c't\right]\end{aligned} \tag{29}$$

For equation (29) to form the left-hand side of equation (27), the following relationship must hold.

$$\frac{(1+v/c')}{(1+c'v/c^2)}c' = c \tag{30}$$

$$\frac{k'}{k}\frac{1}{\sqrt{1-v^2/c^2}}(1 + c'v/c^2) = 1 \tag{31}$$

Therefore,

$$c' = c \tag{32}$$

$$\frac{k'}{k} = \frac{1}{(1+v/c)}\sqrt{1-v^2/c^2} \tag{33}$$

The right-hand side of equation (33) represents the classical Doppler shift and the second-order shift in the frequency of light, as introduced in equation (10). In other words, it can be shown that the propagation of light undergoes the same shift in wavenumber as well as in frequency. It is also clear that, due to this physical mechanism, the speed of light in a moving system is exactly the same as that in a stationary system, as shown in equation (32).

8) Null propagation of light and line elements

Similar to equation (25), if we consider the phenomenon in one spatial dimension and consider the propagation of light in the positive and negative directions along the x-axis, the following relation is given:

$$kx - \sigma t = k'\xi - \sigma'\tau \tag{34}$$

$$kx + \sigma t = k''\xi + \sigma''\tau \tag{35}$$

where k'' and σ'' are the wavenumber and angular frequency of light propagating in the negative direction along the x-axis, respectively.

Multiplying the respective sides of equations (34) and (35) yields

$$k^2x^2 - \sigma^2t^2 = k'k''\xi^2 - \sigma'\sigma''\tau^2 \tag{36}$$

Therefore,

$$x^2 - c^2t^2 = k'k''/k^2(\xi^2 - c^2\tau^2) \tag{37}$$

From equations (11) and (34), $k'k''/k^2 = 1$, and equation (37) gives

$$x^2 - c^2t^2 = \xi^2 - c^2\tau^2 \tag{38}$$

This relation represents null propagation with respect to the propagation of light and expresses the relationship between the phase of light measured in a stationary system and the phase of light measured in a moving system.

Next, the following relationship holds for the distances between the particle position x and the front of the light when a particle moving with a constant speed is observed in photogrammetry conducted by observers in a stationary system and moving system.

$$s^2 = c^2t^2 - x^2 = c^2\tau^2 - \xi^2 \tag{39}$$

where s is called the line element.

9) Effect of gravity on propagation of light

When observing physical phenomena using light (i.e., electromagnetic waves) under the action of gravity, gravity affects the propagation of the light. The degree of this effect is given by solving Einstein's equations. A spherically symmetric simple stationary solution of Einstein's equations is the Schwarzschild solution. It is given using polar coordinates as follows.

$$(cd\tau)^2 = (1 - 2M/r)(cdt)^2 - (1 - 2M/r)^{-1}dr^2 - r^2d\theta^2 \tag{40}$$

where $d\tau$ is the short propagation time for light measured by an observer at rest in a gravitational field, dt is the propagation time for light measured by an observer at rest in a field where gravity does not act, c is the speed of light measured in a field without (or beyond) the action of gravity, M is the converted mass with length dimension, r is the Schwarzschild radial coordinate, and θ is the angle.

The distance equivalent mass M is given by

$$M = \frac{G}{c^2}M_{kg} \tag{41}$$

where G is the universal gravitational constant, c is the speed of light, and M_{kg} is the mass of the gravitational source.

In equation (40), setting $M \to 0$ or $r \to \infty$ gives equations (39) and (40) the same physical meaning. In Einstein's theory of relativity, equation (40) is called the Schwarzschild line element and represents the actual distortion of space-time due to the action of gravity.

However, in the new theory of relativity, as is clear from the previous discussion, it represents a small linear element taken tangentially to the trajectory of light as it propagates in a short propagation time measured in a gravitational field. In other words, in the new theory of relativity, the units of time and length in any field are invariant and absolute based on Galilean transformations. In such a coordinate system, the small elements in the direction tangential to the light propagation trajectory measured under the action of gravity are represented by equation (40).

From the Schwarzschild line element shown in equation (40), the time based on the frequency of light observed by a stationary observer in a gravitational field and the time measured in a field not subject to the action of gravity is given as follows.

$$(cd\tau)^2 = (1 - 2M/r)(cdt)^2 \tag{42}$$

That is,

$$d\tau = \sqrt{1 - 2M/r}dt \tag{43}$$

The relation shown in equation (43) is called the gravitational red shift of the frequency of light.

On the other hand, the following relation is given for the small distance measured in the radial direction by photogrammetry conducted by an observer who is stationary in a gravitational field.

$$dr' = dr/\sqrt{1 - 2M/r} \tag{44}$$

where dr is the small radial distance measured in a field where gravity does not act and dr' is the small radial distance measured in a field where gravity does act.

As shown above, in the new theory of relativity, actual time and space are represented as invariant time and space given by Galilean transformations. On the other hand, the measurements of propagation time and propagation distance that appear when observing the propagation of light under the action of gravity constitute a relativistically distorted space-time.

When using the Schwarzschild solution shown in equation (40), it is clear that the perihelion shift of comets can be explained by the action of gravity, i.e., gravitational waves have the same propagation characteristics as electromagnetic waves, and their action itself is subject to gravitational red shift.[11)]

10) Relativistic dynamics

In both stationary and moving systems connected by Galilean transformations, Newton's laws of motion must be strictly established based on the principle of relativity. Even a particle moving at a constant speed from a stationary system becomes a stationary object to an observer who has undergone a Galilean transformation from the stationary system. Therefore, Newton's laws of motion for the stationary system must be established there.

On the other hand, observing the dynamics in a moving system from a stationary system as the laws of motion of particles in motion constitutes relativistic dynamics. Observing the dynamics in a moving system from a stationary system means measuring the dynamics in the moving system by photometry from the stationary system.

The time and length of the moving system measured by photometry in the stationary system are connected to the time and length measured in the stationary system by equations (23) and (24).

Therefore, the acceleration in the moving system will be observed from the stationary system by photogrammetry as follows.

$$\frac{d^2x'}{dt'^2} = \frac{d^2x/\sqrt{1-v^2/c^2}}{\left(\sqrt{1-v^2/c^2}dt\right)^2} = \frac{1}{\sqrt{1-v^2/c^2}^3} d^2x/dt^2 \tag{45}$$

Newton's equations of motion observed by an observer in a moving system are isomorphic to the equations of motion of a stationary system by the principle of relativity and are given by

$$m\frac{d^2x'}{dt'^2} = f \tag{46}$$

where m is the mass and f is the force.

Therefore, from equations (45) and (46), the equation of motion for the moving system observed by photogrammetry from a stationary system is given as follows.

$$\frac{m}{\sqrt{1-v^2/c^2}^3}\frac{d^2x}{dt^2} = f \tag{47}$$

That is,

$$\frac{d}{dt}\left(\frac{mv}{\sqrt{1-v^2/c^2}}\right) = f \tag{48}$$

In the conventional explanation given by Einstein's theory of relativity, equation (48) is a modification of the classical Newtonian equation of motion. However, Newton's equations of motion exist strictly within both systems, as shown in equation (46). Equation (48) is not a modification of Newton's equation of motion, but rather the equation of motion for the system of motion remotely observed by an observer in the stationary system through photometry (relativistic equation of motion).

11) Modification of Newton's laws of motion

Newton's laws of motion, as we generally learn them, do not distinguish between an object that is stationary with respect to an observer and an object that is moving at a constant speed. In general, Newton's laws of motion are explained as follows.

a) **Law of inertia:** An object at rest will remain at rest as long as no force acts on it, while an object in motion at a constant speed will maintain its state of motion.
b) **Equation of motion:** When a force acts on an object, the following relationship is established between the acceleration d^2x/dt^2, the mass m of the object, and the acting force f.

$$m\frac{d^2x}{dt^2} = f \tag{49}$$

c) **Law of action-reaction:** For every action (force), there is an equal and opposite reaction.

The conventional Newton's laws of motion, given above, treat objects at rest with respect to an observer as well as objects in motion at a constant speed in a unified manner. However, as explained in the previous section, the motion of an object moving at a constant speed with respect to an observer in a stationary system must be treated using relativistic dynamics. This is because we need photogrammetry (electromagnetic measurement) to observe the dynamics of a system in motion at a constant velocity.

Thus, Newton's laws of motion need to be redefined for both stationary and moving systems, in the presence of Galilean transformations, as the dynamics of a stationary object until it acquires an infinitesimal velocity, as follows:

a) **Law of inertia:** An object at rest has an inertia that keeps it at rest as long as there is no force acting on it. The magnitude of its inertia is determined by its mass m.
b) **Equation of motion:** When a force acts on an object, the following equation is established between the infinitesimal velocity dv that the stationary object acquires in a minute time dt, the object's mass m, and the acting force f.

$$mdv = fdt \tag{50}$$

c) **Law of action-reaction:** An object remains stationary against the action of a force because it is subjected to a reaction of equal magnitude from that object.

The modified laws of motion described here place mass m as the new physical quantity that determines stationary inertia. In addition, the action-reaction law provides the conditions under which an object remains stationary.

Newton's equation of motion, given in equation (50), specifies the dynamics of an object at rest until it acquires an infinitesimal velocity for both stationary and moving systems. Thus, the equation undergoes a covariant transformation via the Galilean transformation. On the other hand, the equation of motion given in (48) specifies relativistic dynamics and is thus subject to covariant transformation by the new Lorentz transformation.

12) Why are atomic clocks delayed?

According to the new theory of relativity presented here, the units of time and length in a stationary system are exactly equal to those in a moving system via the Galilean transformation. Therefore, there is no room for time delay or length reduction between the two systems. Then, why is a time delay observed for atomic clocks in the experiment of Hafele and Keating[12), 13), 14)] and the atomic clocks on GPS satellites,[15)] and why are the lifetimes of cosmic ray muons[16)] determined by Rossi and Hall extended? These phenomena need to be explained.

According to the conventional explanation of relativity, the atomic clocks in the experiment of Hafele and Keating and the atomic clocks on GPS satellites[11)] appear to move at a constant speed in a direction tangential to their orbits when viewed over a short period of time. This is supposed to explain the time delay between inertial systems. Here, we show the fallacy of the conventional explanation.

Even if the motion of airplanes and GPS satellites, which appear to be moving at a constant speed from the ground, can be regarded as horizontal flight locally, it is actually circular motion and just like the circular/elliptical motion of the moon, these objects continue to fall at a constant speed relative to the center of the Earth. This continues to exert acceleration (centrifugal force) on airplanes and GPS satellites equipped with atomic clocks. The existence of a centrifugal force or gravity bends the propagation trajectory of light (i.e., electromagnetic waves) as seen by an observer. This curved propagation trajectory gives a longer propagation distance than that for a straight trajectory. The physical mechanism for the delay is thus a red shift of frequency caused by gravity and the centrifugal force acting on the atomic clocks.

Therefore, what has been conventionally explained as a time delay between inertial systems can be explained in terms of a delay in measurement time and a lengthening of measurement distance due to a red shift related to the acceleration or gravity. No experiments on the time delay as a purely inertial system have not been conducted.

3. CONCLUSIONS

In this study, the Galilean transformation was used as a transformation law for coordinate systems between inertial systems, and the Lorentz transformation was then constructed as a transformation law for electromagnetic theory. The conclusions of this study can be summarized as follows.

1) The Galilean transformation is the only coordinate transformation that connects inertial systems.
2) Therefore, Einstein's relativistic time and length are replaced by absolute time and length.
3) With the Galilean transformation as the basis of coordinate transformation, the relativistic transformation law for light (i.e., electromagnetic theory) is defined as the Lorentz transformation.
4) Relativistic dynamics and relativistic electromagnetic theory are constructed by applying Lorentz transformations to the dynamics and electromagnetic theory of stationary systems, with the Galilean transformation used as the basis of coordinate transformations.
5) The general theory of relativity explains the effect of gravity (acceleration) on relativistic dynamics and relativistic electromagnetic theory.
6) An important discovery in general relativity is that the action of gravity propagates at the speed of light and is subject to a red shift in the same way as the action of electromagnetism.
7) The conventional concept of space-time distor-

tion in relativity must be modified to refer to the distortion of time and space measured on the basis of photometry, using the Galilean transformation as a foundation and placing the Cartesian linear coordinate system in actual time and space.

8) Since photometry (measurement by electromagnetic waves) is used for physical measurements, the speed of light is defined as the limit of measurement speed.
9) Therefore, relativity does not place a limit on the relative velocity of objects.
10) Newton's laws of motion were modified as laws of motion for stationary objects in an inertia system.

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