On the Alternative Special Theory of Relativity Applicable to Physical Theorems of Rotation in the Uniform Rotating Frames

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Abstract: Albert Einstein formulated the Special Theory of Relativity in 1905 based on the principles of relativity and constancy of light velocity principles. The Lorentz transformation, applicable to inertial frames, ensures the form of physical laws remains the same when transformed between them. It should be noted that the viewpoints expressed in this paper are merely the personal insights of the authors and do not necessarily represent absolute correctness. This paper notes that physical rotation theorems have the same form in uniform rotating frames (**Alternative Principle of Relativity**). Relativity states no object can exceed light speed. Similarly, this paper postulates that the rotational angular speed of a "structural body" in nature has a maximum limit. Photons in vacuum are the "structural body" with the fastest rotational angular velocity ($\Omega_{max} = c/2\pi$, unit: *rad/s*), called the **principle of constancy of light angular velocity**. Using analogy, the paper obtains the **Alternative Lorentz Transformation** for rotational physics in uniform rotating frames and derives the **Alternative Special Theory of Relativity** within angular displacement space - time. Photons thus have dual properties: the fastest - moving "particles" and the "structural body" with the fastest rotational angular velocity.

This theory may offer new insights into rotational physical phenomena in uniform rotating frames and photon behavior. It could bridge the gap between the special theory of relativity for linear motion and the field of rotational motion. Future research should focus on experimentally validating predicted phenomena, like the maximum angular velocity limit and the effects of the **Alternative Lorentz Transformation**. Exploring its application in other physics areas, such as rotating celestial bodies in astrophysics, could also bring new understandings. Although this work is just a start with many uncertainties, the authors hope to contribute to scientific progress.

Key words: Inertial frames of reference, Uniform rotating frames, Maximum angular velocity, Alternative Lorentz Transformation, Alternative Special Theory of Relativity

1 Introduction

The Special Theory of Relativity, based on the principles of relativity and the principle of constancy of light velocity, has existed for more than a century. Theory of relativity has changed people's traditional concept of space-time [1], and the form of physical theorem has also changed from Galilean transformation to Lorentz transformation. Lorentz transformation is based on inertial frames, Feynman [2] & Landau [3] clearly point out that Lorentz transformation is not suitable for uniform rotation frames. Shu xinghai [4] argued that as long as the concept of space-time has not been completely changed, the rotational frames have no relativity. Moreover, the physical theorems of rotation, such as the differential equation of rotation of a rigid body about a fixed-axis, the theorem of angular momentum, and the theorem of angular momentum about the mass center of a particle system, all have the same form in the uniform rotating frames (Equation 5).

In addition, the theory of relativity explicitly states that the light velocity (c) is the maximum speed limit of the motion of any object in nature (that is, the maximum limit value of velocity is the light velocity (c)), and is independent of the motion of the light source. Landau had provided some explanation of why physical quantities in nature (such as light velocity) must have certain limit values [3]. However, is there a maximum limit value for angular velocity in nature as well? Does it not change with the motion of the "rotating source"? That is, is there also a principle of constancy of object angular velocity? If so, what is the value of the maximum limit angular velocity in the universe? (Note: In this paper, the angular velocity ($\boldsymbol{\omega}$) is the angular velocity of an object (such as a rigid disk) with a certain "structural shape", rather than the "rotational angular velocity" of a point (or particle) when it moves in a circle around another point in a pure mathematical (geometric) sense, as shown in Figure 2.) Furthermore, since the laws of rotational physics have the same form in the uniform rotating frames (Equation 5), does that indicate that there is also an "**Alternative Lorentz Transformation**" applicable to laws of rotational physics? However, all the above issues were seldom reported in the current publicly published literature.

This paper postulates that the rotational angular velocity of objects which have a certain "structural shape" (such as a rigid disk) in nature also has the maximum limit value. Photons in vacuum are the "structural body" with the fastest angular velocity ($\Omega_{\max}$) in nature, and its value is $c/2\pi$ ($\Omega_{\max} = c/2\pi$, unit: rad/s), where c is the light velocity, also independent of the motion of the light source, which is called the **Principle of Constancy of Light Angular Velocity** in this paper.

Based on the **Principles of Alternative Relativity** (another postulate in this paper, Equation 5) and the **Principle of Constancy of Light Angular Velocity**, using analogy method, we derived the expression of the **Alternative Special Theory of Relativity** within angular displacement space-time ($\boldsymbol{\varphi}(\tau)$). Therefore, photons in vacuum have dual properties: they are both the fastest moving "particles" and the "structure body" with the fastest rotating angular velocity at the same time in nature! When we begin to explore the **Alternative Special Theory of Relativity**, we are acutely aware that we are merely attempting to expand the boundaries of our understanding of rotational physics. This new theory might potentially integrate some concepts across different physical areas. For instance, in astrophysics, the rotation of celestial bodies is a key aspect, and in micro - scale physics, the rotational dynamics of nanoparticles and molecules are drawing increasing attention. We hope that this exploration could contribute to further research, both theoretical and experimental.

In theoretical research, we can try to clarify the postulates, examine the mathematical consistency of the derived equations, and gradually apply the theory to more complex situations. Experimentalists may explore new ways to test the predictions of the maximum angular velocity limit and the effects of the **Alternative Lorentz Transformation**. Overall, we sincerely hope that this work can slightly deepen our understanding of the fundamental laws of nature and encourage the next generation of physicists to engage in scientific exploration. We recognize that our efforts are just a small step in the vast journey of scientific discovery, and there is still a long way to go.

02 Classical space-time review

The classical space-time relation in the inertial frames can be expressed by the space-time coordinate $\boldsymbol{r}$ ($\boldsymbol{r} = \boldsymbol{r}(t)$), $\boldsymbol{r}$ is the displacement (linear displacement, Unit: meter) , t is the time (Unit: seconds) in the linear displacement space-time. In the study of space-time relations, an event can be expressed as $P\ (\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}, t)$ in the space-time Cartesian coordinate system. Besides the representation of an event, for multiple physical quantities in these systems, we can derive them based on linear displacement $\boldsymbol{r}$ and time t, some physical quantities can be directly derived, for example, linear velocity $\boldsymbol{v}$ ($\boldsymbol{v} = \dot{\boldsymbol{r}}$, dot is the derivative with respect to time) is the first derivative of displacement $\boldsymbol{r}$ with respect to time (t), Acceleration $\boldsymbol{a}$ ($\boldsymbol{a} = \dot{\boldsymbol{v}} = \ddot{\boldsymbol{r}}$) is the first derivative of velocity with respect to time, which is also the second derivative of displacement $\boldsymbol{r}$ with respect to time. Of course, there are other indirect physical quantities such as the linear momentum ($m\boldsymbol{v}$) of a particle, where m is the mass (unit: kg) of an object (such as a particle). In addition, there are some typical physical theorems such as Newton's second law of motion ($\boldsymbol{F} = m\ddot{\boldsymbol{r}} = m\dot{\boldsymbol{v}} = m\boldsymbol{a}$). At present, the concept of space-time has developed from Newton's absolute view of space-time to the current Einstein's relativistic view of space-time [1].

The **alternative space-time** relationship in the rotating frames can be expressed as $\boldsymbol{\varphi}(\tau)$, where $\boldsymbol{\varphi}$ is the angular displacement (Unit: rad), and τ is the time (Unit: seconds) in the angular displacement space-time. An event also can be expressed as $P\ (\boldsymbol{\varphi}, \tau)$ in the **alternative space-time**. Based on the angular displacement $\boldsymbol{\varphi}$ and time τ, some physical quantities can also be directly derived, for example, angular velocity $\boldsymbol{\omega}$ ($\boldsymbol{\omega} = \dot{\boldsymbol{\varphi}}$) is the first derivative of angular displacement $\boldsymbol{\varphi}$ over time τ, and angular acceleration $\boldsymbol{\beta}$ ($\boldsymbol{\beta} = \dot{\boldsymbol{\omega}} = \ddot{\boldsymbol{\varphi}}$) is the first derivative of angular velocity $\boldsymbol{\omega}$ over time, that is, the second derivative of angular displacement $\boldsymbol{\varphi}$ over time τ. Similar, there are other indirect physical quantities such as the angular momentum ($J_c\boldsymbol{\omega}$) of an object, where J_c is the mass moment of inertia of the object (unit: $Kg \cdot m^2$). In addition, there are also some typical physical theorems of rotation, such as the differential equation of rotation of a rigid body about a fixed-axis ($M_c(\boldsymbol{F}) = J_c\ddot{\boldsymbol{\varphi}} = J_c\dot{\boldsymbol{\omega}} = J_c\boldsymbol{\beta}$, where $M_c(\boldsymbol{F})$ is moment (torque) on the shaft c).

Note: Regarding time, in this paper, for the convenience of distinguishing, the time in the linear displacement space-time ($\boldsymbol{r}(t)$) is denoted as t, and in the angular displacement space-time ($\boldsymbol{\varphi}(\tau)$) is denoted as τ. Here we define a new variable named "Time" which is related to the previous defined t and τ as:

$$Time = t + \boldsymbol{i}\tau \qquad (*)$$

In other words, in formula (∗), the real part t represents time in the linear displacement space-time ($\boldsymbol{r}(t)$), while the imaginary part τ represents time in the angular displacement space-time ($\boldsymbol{\varphi}(\tau)$), this paper called τ is the **Alternative time**.

03 About angular velocity

The angular velocity $\boldsymbol{\omega}$ in this paper, refers to the rotational angular velocity of an object with a certain "structural shape". Figure 1 shows a uniform circular motion of geometric point A (or particle A) around point O, with a radius of r and a velocity magnitude value of $\boldsymbol{v}_A$; the " point rotational angular velocity" of point A is $\boldsymbol{\omega}_A$ ($\boldsymbol{\omega}_A = \boldsymbol{v}_A/r$). However, this type of "**point** angular velocity" ($\boldsymbol{\omega}_A = \boldsymbol{v}_A/r$) is not within the scope of this paper. In this paper, the angular velocity $\boldsymbol{\omega}$ ($\boldsymbol{\omega} = \dot{\boldsymbol{\varphi}}$) refers to that of an object (like a rigid disk) with a certain "structural shape" in alternative space-time ($\boldsymbol{\varphi}(\tau)$, Figure 2), rather than that of a point (or particle) moving in a circle around another point in a pure mathematical (geometric) sense (as shown in Figure 1.) As shown in Figure 3, when the Ferris wheel rotates at a constant speed of $\boldsymbol{\omega}$, however, the rotational angular velocity of the tourist in the Ferris wheel is equal to 0 (not $\boldsymbol{\omega}$) [5]. Similarly, in fluid mechanics, as shown in Figure 4, the characteristic of free vortices is that the velocity of fluid particles is inversely proportional to the radius of rotation, at this time, the rotational angular velocity of fluid particles (except for the vortex center) is equal to 0 [6-8].

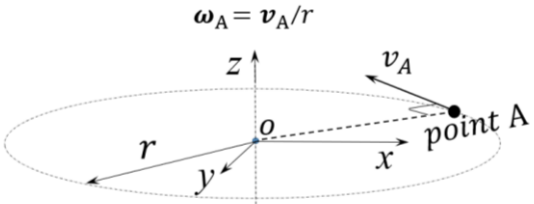

Fig. 1. A uniform circular motion of geometric point A

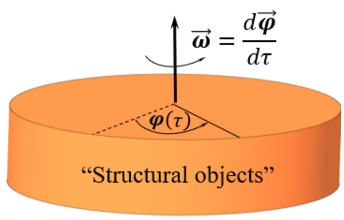

Fig. 2. Rotational angular velocity of a "structural object"

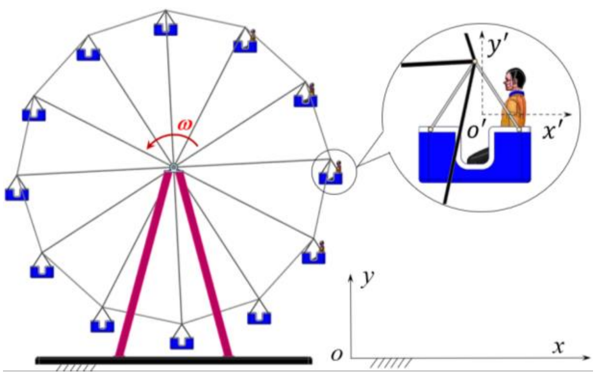

Fig. 3. Angular velocity of the tourist in the Ferris wheel

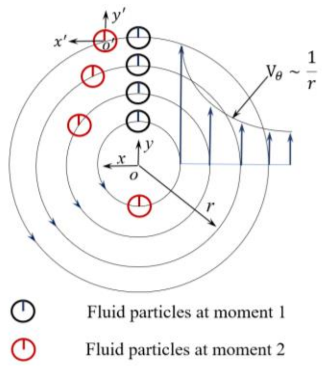

Fig. 4. The velocity distribution of free vortices in fluid mechanics

04 Relativity in Classical Mechanics

First, as shown in Figure 5, set an inertial coordinate system *S*, the displacement vector of the particle *m* is $\boldsymbol{r}(x,y,z,t\ )$, then the velocity and acceleration of the particle m are $\boldsymbol{v_a}$ $(\boldsymbol{v_a}=d\boldsymbol{r}/dt)$, $\boldsymbol{a_a}$ $(\boldsymbol{a_a}=d^2\boldsymbol{r}/dt^2)$,respectively. If S' is the second inertial frame, which is moving in direction along the X-axis at a constant velocity, $\boldsymbol{v_e}$ relative to *S*, the displacement vector of the particle *m* in S' is $\boldsymbol{r}'(x',y',z',t')$, then the velocity and acceleration of the particle *m* are $\boldsymbol{v_r}$ $(\boldsymbol{v_r}=\boldsymbol{v}'=d\boldsymbol{r}'/dt')$, $\boldsymbol{a_r}$ $(\boldsymbol{a_r}=\boldsymbol{a}'=d^2\boldsymbol{r}'/dt'^2)$, respectively.

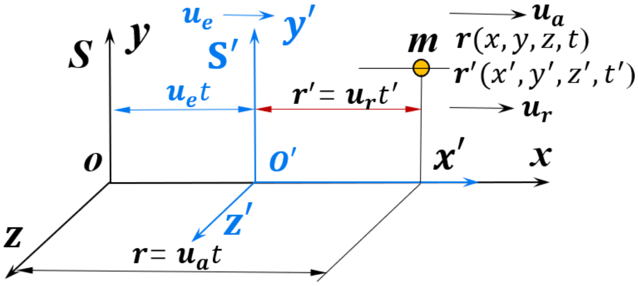

Fig. 5. Two coordinate systems in uniform relative motion along their x-axes.

The relationship of the coordinates in the two systems is clear from the diagram. After time t origin of S' has moved a distance $\boldsymbol{v_e}t$, and if the two systems originally coincided. For the sake of convenience, the mathematical expression of Galilean transformation's mechanical relativity principle for the movement in the horizontal axis direction were given [5]:

$$\left.\begin{aligned} &\boldsymbol{x}'=\boldsymbol{x}-\boldsymbol{v_e}t \\ &t'=t \\ &\boldsymbol{v_r}=\boldsymbol{v}'=\frac{d\boldsymbol{x}'}{dt'}=\frac{d(\boldsymbol{x}-\boldsymbol{v_e}t)}{dt}=\frac{d\boldsymbol{x}}{dt}-\boldsymbol{v_e}=\boldsymbol{v_a}-\boldsymbol{v_e} \end{aligned}\right\} \quad (1)$$

In other words, the velocities are taken to add linearly (which is in agreement with "common sense"). Note, $t'=t$, which asserts that time is not affected by relation motion. We substitute this transformation of coordinates into Newton's second laws:

$$\boldsymbol{F}'=m\boldsymbol{a_r}=m\frac{d\boldsymbol{v_r}}{dt'}=m\frac{d^2\boldsymbol{x}'}{dt'^2}=m\frac{d^2\boldsymbol{x}}{dt^2}=m\frac{d\boldsymbol{v_a}}{dt}=m\boldsymbol{a_a}=\boldsymbol{F} \quad (2)$$

It shows that in the inertial system, mechanical phenomena such as Newton's second law all have the same mechanical law.

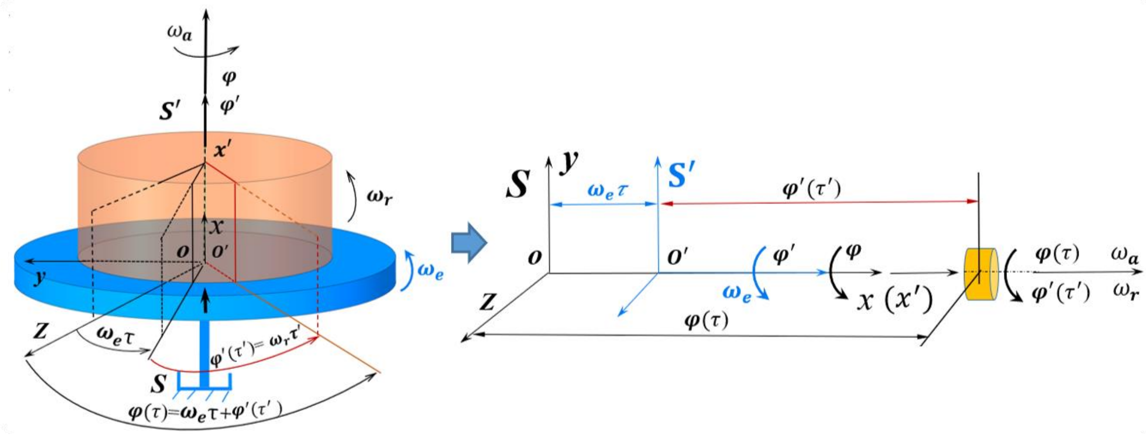

Fig. 6. Two uniform rotating frames *S* and S' with parallel axes rotate relative to each other at the angular velocity $\boldsymbol{\omega_e}$

Similarly, given a uniform rotating frames *S*, as shown in Figure 6, the angular displacement vector of a smaller orange rigid disk is $\boldsymbol{\varphi}(\tau)$ within *S*, then the angular velocity and angular acceleration of the orange rigid disk are

$\boldsymbol{\omega}_a$ ($\boldsymbol{\omega}_a = d\boldsymbol{\varphi}/d\tau$), $\boldsymbol{\beta}_a$ ($\boldsymbol{\beta}_a = d^2\boldsymbol{\varphi}/d\tau^2$),respectively. If S' is the second uniform rotating frames, referred to fixed the bigger blue rigid disk ,which is rotating at a constant angular velocity, $\boldsymbol{\omega}_e$ relative to S, the angular displacement vector of the smaller orange rigid disk in S' is $\boldsymbol{\varphi}'(\tau')$, then the angular velocity and angular acceleration are $\boldsymbol{\omega}_r$ ($\boldsymbol{\omega}_r = d\boldsymbol{\varphi}'/d\tau$), $\boldsymbol{\beta}_r$ ($\boldsymbol{\beta}_r = d^2\boldsymbol{\varphi}'/d\tau'^2$) in S', respectively. The relationship of the coordinates in the two rotating frames is clear from the diagram. After time τ origin of S' has moved a distance $\boldsymbol{\omega}_e\tau$, and if the two systems originally coincided. Also, for the sake of convenience, the rotation directions of $\boldsymbol{\omega}_a$, $\boldsymbol{\omega}_e$, $\boldsymbol{\omega}_r$, all rotate along the X direction (whose direction satisfies the right-hand thread rule), and the mathematical expression transformation's mechanical relativity principle were given [5]:

$$\boldsymbol{\varphi}' = \boldsymbol{\varphi} - \boldsymbol{\omega}_e\tau$$
$$\tau' = \tau \tag{3}$$
$$\boldsymbol{\omega}_r = \boldsymbol{\omega}' = \frac{d\boldsymbol{\varphi}'}{d\tau'} = \frac{d(\boldsymbol{\varphi} - \boldsymbol{\omega}_e\tau)}{d\tau} = \frac{d\boldsymbol{\varphi}}{d\tau} - \boldsymbol{\omega}_e = \boldsymbol{\omega}_a - \boldsymbol{\omega}_e$$

Equation (3) is called the **Alternative Galileo Transformation** in this paper. In addition, the differential equation of rotation of a rigid body about a fixed-axis is [5]:

$$M_c(\boldsymbol{F}) = J_c\ddot{\boldsymbol{\varphi}} = J_c\dot{\boldsymbol{\omega}} = J_c\boldsymbol{\beta} \tag{4}$$

In Equation (4), where $M_c(\boldsymbol{F})$ is torque on the shaft c, J_c is the mass moment of inertia of the object. We substitute the transformation of coordinates (Equation (3)) into Equation (4):

$$M_{x'}(\vec{F}') = J_{x'}\boldsymbol{\beta}_r = J\frac{d^2\boldsymbol{\varphi}\prime}{d\tau'^2} = J_x\frac{d^2\boldsymbol{\varphi}}{d\tau^2} = J\frac{d\boldsymbol{\omega}_a}{d\tau} = J\boldsymbol{\beta}_a = M_x(\vec{F}) = M(\boldsymbol{F}) \tag{5}$$

Where $J_{x'}$ is the mass moment of inertia of the object (orange rigid body disk) about axis x', J_x is the mass moment of inertia about axis x, Obviously, $J_{x'} = J_x = J$. While $M_{x'}(\vec{F}')$ is the moment of the force (torque) on axis x' , $M_x(\vec{F})$ is the moment of the force (torque) on axis x. Obviously, $M_{x'}(\vec{F}') = M_x(\vec{F}) = M(\vec{F})$.

Equation (5) shows that the differential equation of rotation of a rigid body about a fixed-axis has the same form in the uniform rotating frames. Similar to physical theorems, such as the theorem of angular momentum about plane motion of a rigid body relative to its mass center C [5]:

$$J_C\boldsymbol{\beta}_r = J_C\frac{d^2\boldsymbol{\varphi}\prime}{d\tau'^2} = J_x\frac{d^2\boldsymbol{\varphi}}{d\tau^2} = J\frac{d\boldsymbol{\omega}_a}{d\tau} = J\boldsymbol{\beta}_a = M_C(\vec{F}^{(e)}) = M(\boldsymbol{F}) \tag{5.1}$$

In Equation 5.1, J_C is the moment of inertia of the rigid body relative to its mass center C, and $M_C(\vec{F}^{(e)})$ is the moment of external force to the mass center C. In fact, various the laws of rotational physics, such as the theorem of angular momentum about the mass center of a particle system, the theorem of angular momentum, the conservation theorem of angular momentum, etc., all also have the same form in the uniform rotating frames [2] [5]. We postulate that all rotational physics theorems about a fixed point or center of mass have the same form in the uniform rotating frames. This paper calls this property the **Alternative Principle of Relativity** which is applicable to the laws of rotational physics. Note that the corresponding physical quantities in uniform rotating frames should be: angular displacement ($\boldsymbol{\varphi}$), angular velocity ($\boldsymbol{\omega}$), angular acceleration ($\boldsymbol{\beta}$), moment of inertia (J), moment of momentum ($\boldsymbol{L}$) (angular momentum ($J\boldsymbol{\omega}$)), moment of the force (or couple), etc.

Note: In angular displacement space ($\varphi(\tau)$), **forces** (Unit: N) including centrifugal force and Coriolis force **are no longer** physical quantities**,** but **moments or couples** (Unit: $N \cdot m$) **are "forces"** in angular displacement space.

05 The Lorentz Transformation

The Lorentz transformation is a set of equations that describe how measurements of space-time between two inertial reference frames are related when they are moving relative to each other at constant velocities. As shown in

Figure 2, the Lorentz transformation equations are as follows:

$$\left.\begin{aligned} \boldsymbol{x}' &= \frac{\boldsymbol{x} - \boldsymbol{v}_e t}{\sqrt{1-({}^{v_e}/_{c})^2}} \\ \boldsymbol{y}' &= \boldsymbol{y} \\ \boldsymbol{z}' &= \boldsymbol{z} \\ t' &= \frac{(t - \frac{\boldsymbol{v}_e x}{c^2})}{\sqrt{1-({}^{v_e}/_{c})^2}} \end{aligned}\right\} \quad (6)$$

where c is the speed of light and its inverse transformation is:

$$\left.\begin{aligned} \boldsymbol{x} &= \frac{\boldsymbol{x}' + \boldsymbol{v}_e t'}{\sqrt{1-({}^{v_e}/_{c})^2}} \\ \boldsymbol{y} &= \boldsymbol{y}' \\ \boldsymbol{z} &= \boldsymbol{z}' \\ t &= \frac{(t' + \frac{\boldsymbol{v}_e \boldsymbol{x}'}{c^2})}{\sqrt{1-({}^{v_e}/_{c})^2}} \end{aligned}\right\} \quad (7)$$

Equation (6)-(7) detailed proof process could be found in many publicly published publications [2-4]. The Lorentz transformation equations account for the time dilation and length contraction effects that arise from the relativistic nature of space-time.

06 The Alternative Lorentz Transformation

Firstly, this paper postulates that the rotational angular velocity of an object with a certain "structural shape" in nature also has a maximum limit value. Photons in vacuum are the "structures body" with the fastest rotational angular velocity ($\Omega_{\max}$) in nature, and its value is $c/2\pi$ ($\Omega_{\max} = c/2\pi$, unit: rad/s), where c is the light velocity, also independent of the motion of the light source, which is called the **Principle of Constancy of Light Angular Velocity** in this paper. In addition, the laws of rotational physics, have the same form in the uniform rotating frames. In this paper, it is referred to as the **Alternative Principle of Relativity** which is applicable to the laws of rotational physics.

As shown in Figure 6, there are two uniform rotating frames S and S'. The S' system moves at a uniform angular velocity of $\boldsymbol{\omega_e}$ relative to the S system. The two systems originally coincided, that is $\tau' = \tau = 0$, The angular displacement coordinates of the orange rigid disk in the S is $(\boldsymbol{\varphi}, \tau)$, while in the $\boldsymbol{S}'$, is $(\boldsymbol{\varphi}', \tau')$. The transformation of $(\boldsymbol{\varphi}, \tau)$ and $(\boldsymbol{\varphi}', \tau')$ is based on the following two points:

1，The space-time $(\boldsymbol{\varphi}, \tau)$ transformation in uniform rotating frames is “linear”.

2，At low angular velocity, The transformation$(\boldsymbol{\varphi}, \tau)$ should be degenerated into **Alternative Galileo transformation** (Equation (3)).

The transformation from S' to S is $(S' \to S)$:

$$\boldsymbol{\varphi} = k(\boldsymbol{\varphi}' + \boldsymbol{\omega}_e \tau') \quad (8)$$

Where k is the proportional coefficient, it is called **alternative Lorentz factor** in this paper. According to the **Alternative Principle of Relativity**, the transformation from S to S' is $(S \to S')$ is:

$$\boldsymbol{\varphi}' = k(\boldsymbol{\varphi} - \boldsymbol{\omega}_e \tau) \quad (9)$$

When the origin of S' and S system coincide, a beam of light is emitted from the origin with the angular velocity

$\Omega_{\max}$ ($\Omega_{\max} = c/2\pi$ rad/s), and its angular displacement in uniform rotating frames S is:

$$\boldsymbol{\varphi} = \Omega_{\max}\tau \qquad (10)$$

Similarly, according to the **principle of constancy of light angular velocity**, the angular displacement in in uniform rotating frames S' is:

$$\boldsymbol{\varphi}' = \Omega_{\max}\tau' \qquad (11)$$

From Equation (8), Equation (10) and Equation (11), we get:

$$\Omega_{\max}\tau = k(\boldsymbol{\varphi}' + \boldsymbol{\omega_e}\tau') = k(\Omega_{\max}\tau' + \boldsymbol{\omega_e}\tau') = k\tau'(\Omega_{\max} + \boldsymbol{\omega_e}) \qquad (12)$$

By Equation (9), Equation (10) and Equation (11), we have:

$$\Omega_{\max}\tau' = k(\boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau) = k(\Omega_{\max}\tau - \boldsymbol{\omega_e}\tau) = k\tau(\Omega_{\max} - \boldsymbol{\omega_e}) \qquad (13)$$

multiply Equation (12) with Equation (13)， we have:

$$\Omega_{\max}^2\tau\tau' = k^2(\boldsymbol{\varphi}' + \boldsymbol{\omega_e}\tau')(\boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau) = k^2\tau\tau'(\Omega_{\max} + \boldsymbol{\omega_e})(\Omega_{\max} - \boldsymbol{\omega_e}) \qquad (14)$$

Then the **alternative Lorentz factor** (k) obtained from equation (14) is:

$$k = \frac{1}{\sqrt{1-({}^{\omega_e}/_{\Omega_{\max}})^2}} \qquad (15)$$

Substitute the **alternative Lorentz factor** (k) into the above equations, and finally we could get **the Alternative Lorentz Transformation**:

$$\left.\begin{aligned} \boldsymbol{\varphi} &= \frac{\boldsymbol{\varphi}' + \boldsymbol{\omega_e}\tau'}{\sqrt{1-({}^{\omega_e}/_{\Omega_{\max}})^2}} = \frac{\boldsymbol{\varphi}' + \boldsymbol{\omega_e}\tau'}{\sqrt{1-4\pi^2({}^{\omega_e}/_{c})^2}} \\ \tau &= \frac{\tau' + \frac{\boldsymbol{\omega_e}}{\Omega_{\max}^2}\varphi'}{\sqrt{1-({}^{\boldsymbol{\omega_e}}/_{\Omega_{\max}})^2}} = \frac{\tau' + \frac{4\pi^2\boldsymbol{\omega_e}}{c^2}\varphi'}{\sqrt{1-4\pi^2({}^{\boldsymbol{\omega_e}}/_{c})^2}} \end{aligned}\right\} \qquad (16)$$

and

$$\left.\begin{aligned} \boldsymbol{\varphi}' &= \frac{\boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau}{\sqrt{1-({}^{\omega_e}/_{\Omega_{\max}})^2}} = \frac{\boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau}{\sqrt{1-4\pi^2({}^{\omega_e}/_{c})^2}} \\ \tau' &= \frac{\tau - \frac{\omega_e}{\Omega_{\max}^2}\boldsymbol{\varphi}}{\sqrt{1-({}^{\omega_e}/_{\Omega_{\max}})^2}} = \frac{\tau - \frac{4\pi^2\omega_e}{c^2}\boldsymbol{\varphi}}{\sqrt{1-4\pi^2({}^{\omega_e}/_{c})^2}} \end{aligned}\right\} \qquad (17)$$

Equation (17) is called forward transformation (($\boldsymbol{\varphi}, \tau$) $\rightarrow$ ($\boldsymbol{\varphi}', \tau'$)), while equation (16) is inverse transformation (($\boldsymbol{\varphi}', \tau'$) $\rightarrow$ ($\boldsymbol{\varphi}, \tau$)).

From formulas (16) and (17), it is not difficult to know that:

1, Observers in different in the uniform rotating frames have different concepts of space-time.

2, When the angular velocity $\boldsymbol{\omega_e}$ is much less than $\Omega_{\max}$ ($\Omega_{\max} = c/2\pi\, rad/s$)， in other words, $\omega_e \ll \Omega_{\max}$ ($({}^{\omega_e}/_{\Omega_{\max}})^2 \rightarrow 0$), then $\boldsymbol{\varphi}' = \frac{\boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau}{\sqrt{1-({}^{\omega_e}/_{\Omega_{\max}})^2}} = \frac{\boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau}{\sqrt{1-4\pi^2({}^{\omega_e}/_{c})^2}} \rightarrow \boldsymbol{\varphi} - \boldsymbol{\omega_e}\tau$ and $\tau' = \frac{\tau - \frac{\omega_e}{\Omega_{\max}^2}\varphi}{\sqrt{1-({}^{\omega_e}/_{\Omega_{\max}})^2}} \rightarrow \tau$

That is, Equation (17) reduces to Equation (3).

3， Photons in vacuum are the "structures body" with the fastest rotational angular velocity ($\Omega_{\max}$) in nature, and its value is $c/2\pi$ ($\Omega_{\max} = c/2\pi$, unit: rad/s)

07 Alternative Relativistic Angular Velocity Transformation

From the **Alternative Lorentz Transformation** (Equation (16) and Equation (17)), we could derive the **Alternative Relativistic Angular Velocity Transformation**

$$\boldsymbol{\omega} = \boldsymbol{\omega_a} = \frac{d\boldsymbol{\varphi}}{d\tau} = \frac{d\boldsymbol{\varphi}}{d\tau'} \cdot \frac{d\tau'}{d\tau} = \frac{d\left[\frac{\boldsymbol{\varphi}' + \boldsymbol{\omega_e}\tau'}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}}\right]}{d\tau'} \cdot \frac{d\left[\frac{\tau - \frac{\omega_e}{\Omega_{\max}^2}\boldsymbol{\varphi}}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}}\right]}{d\tau}$$

$$= \frac{1}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}}\left(\frac{d\boldsymbol{\varphi}'}{d\tau'} + \boldsymbol{\omega_e}\right) \cdot \frac{1}{\sqrt{1-\left(\boldsymbol{\omega_e}/\Omega_{\max}\right)^2}}\left(1 - \frac{\boldsymbol{\omega_e}}{\Omega_{\max}^2}\frac{d\boldsymbol{\varphi}}{d\tau}\right)$$

$$= \frac{1}{1-\left(\omega_e/\Omega_{\max}\right)^2}(\boldsymbol{\omega_r} + \boldsymbol{\omega_e}) \cdot \left(1 - \frac{\boldsymbol{\omega_r\omega_e}}{\Omega_{\max}^2}\right) = \frac{\boldsymbol{\omega_r} + \boldsymbol{\omega_e}}{1 + \frac{\boldsymbol{\omega_r\omega_e}}{\Omega_{\max}^2}}$$

After the above equation was sorted out, it is obtained:

$$\left.\begin{aligned} \boldsymbol{\omega} = \boldsymbol{\omega_a} &= \frac{\boldsymbol{\omega_r} + \boldsymbol{\omega_e}}{1+\frac{\boldsymbol{\omega_r\omega_e}}{\Omega_{\max}^2}} = \frac{\boldsymbol{\omega_r} + \boldsymbol{\omega_e}}{1+\frac{4\pi^2(\boldsymbol{\omega_r\omega_e})}{c^2}} \\ \boldsymbol{\omega_r} &= \frac{\boldsymbol{\omega_a} - \boldsymbol{\omega_e}}{1-\frac{\boldsymbol{\omega_a\omega_e}}{\Omega_{\max}^2}} = \frac{\boldsymbol{\omega_a} - \boldsymbol{\omega_e}}{1+\frac{4\pi^2(\boldsymbol{\omega_a\omega_e})}{c^2}} \end{aligned}\right\} \quad (18)$$

It can be known from equation (18) that:

1, When the angular velocity $\boldsymbol{\omega_e}$ is much less than $\Omega_{\max}$ ($\omega_e \ll \Omega_{\max}$) , in other words, $\omega_e \ll \Omega_{\max}$ ($(\omega_e/\Omega_{\max})^2 \to 0$), $\boldsymbol{\omega_a} = \frac{\boldsymbol{\omega_r}+\boldsymbol{\omega_e}}{1+\frac{\boldsymbol{\omega_r\omega_e}}{\Omega_{\max}^2}} \to \boldsymbol{\omega_r} + \boldsymbol{\omega_e}$. That is, under the given condition, the **Alternative Relativistic Angular Velocity Transformation** (Equation (18)) reduces to the **Alternative Galileo Transformation** (Equation (3)) in terms of the mathematical relationship and physical meaning.

2, if $\boldsymbol{\omega_r}=\Omega_{\max}$, we have $\boldsymbol{\omega_a} = \frac{\Omega_{\max}+\boldsymbol{\omega_e}}{1+\frac{\Omega_{\max}\boldsymbol{\omega_e}}{\Omega_{\max}^2}} = \Omega_{\max} = c/2\pi\ (rad/s)$, so that we verify that angular velocity of photons in vacuum is the same in the new uniform rotating frame as it was in the old one.

08 Alternative Relativity of Simultaneity, Time dilation and Length contraction

First, there are two arbitrary events, which are expressed as event 1 $(\boldsymbol{\varphi}_1, \tau_1)$ and event 2 $(\boldsymbol{\varphi}_2, \tau_2)$ in uniform rotating frames S, respectively, and event 1 $(\boldsymbol{\varphi}'_1, \tau'_1)$ and event 2 $(\boldsymbol{\varphi}'_2, \tau'_2)$ in rotating frames S'. Making up the difference $\tau'_2 - \tau'_1$ and $\boldsymbol{\varphi}'_2 - \boldsymbol{\varphi}'_1$, i.e. subtracting the lower equations from the upper ones, and designating $\Delta\boldsymbol{\varphi} = \boldsymbol{\varphi}_2 - \boldsymbol{\varphi}_1$, $\Delta\boldsymbol{\varphi}' = \boldsymbol{\varphi}'_2 - \boldsymbol{\varphi}'_1$, $\Delta\tau = \tau_2 - \tau_1$, $\Delta\tau' = \tau'_2 - \tau'_1$, we obtain the equations:

$$\Delta\tau' = \tau'_2 - \tau'_1 = \frac{\tau_2 - \frac{\omega_e}{\Omega_{\max}^2}\boldsymbol{\varphi}_1}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} - \frac{\tau_1 - \frac{\omega_e}{\Omega_{\max}^2}\boldsymbol{\varphi}_2}{\sqrt{1-(\omega_e/\Omega_{\max})^2}} = \frac{(\tau_2-\tau_1) - \frac{\omega_e}{\Omega_{\max}^2}(\boldsymbol{\varphi}_2 - \boldsymbol{\varphi}_1)}{\sqrt{1-(\omega_e/\Omega_{\max})^2}} = \frac{\Delta\tau - \frac{\omega_e}{\Omega_{\max}^2}\Delta\boldsymbol{\varphi}}{\sqrt{1-(\omega_e/\Omega_{\max})^2}} \quad (19)$$

Similarly, the inverse transition equations are also written out:

$$\Delta\tau = \tau_2 - \tau_1 = \frac{\Delta\tau' + \frac{\omega_e}{\Omega_{\max}^2}\Delta\boldsymbol{\varphi}'}{\sqrt{1-(\omega_e/\Omega_{\max})^2}} \quad (20)$$

Equation 19 illustrates that those two simultaneous events in one rotating frame S are not necessarily simultaneous in another rotating frame S', which is called the **Alternative Relativity of Simultaneity** in this paper. According to this concept, two events that are simultaneous for one observer may not be simultaneous for another observer in relative rotational motion. This means that the perception of simultaneous events can differ depending on an observer's rotating frame of reference.

Suppose that two events occurred at same point of the rotation frames S' at time moments τ'_1 and τ'_2 ($\Delta\boldsymbol{\varphi}' = \boldsymbol{\varphi}'_2 - \boldsymbol{\varphi}'_1 = 0$, $\Delta\tau' = \tau'_2 - \tau'_1 \neq 0$), according to Equation 20, The time intervals ($\Delta\tau$) between two events measured in rotating frames S is

$$\Delta\tau = \tau_2 - \tau_1 = \frac{\Delta\tau' + \frac{\omega_e}{\Omega_{\max}^2}\Delta\boldsymbol{\varphi}'}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} = \frac{\Delta\tau'}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} > \Delta\tau' \quad (21)$$

Which (Equation 21) is called **Alternative Time dilation** in this paper, it refers to the phenomenon where time appears to pass at different rates for observers rotating at different rotational angular speed. According to the theory, as an object's rotational angular speed approaches the speed of $\Omega_{\max}$, time for that object appears to slow down relative to a stationary observer. This effect becomes more pronounced as the object's rotational angular speed increases.

Similarly, suppose a "ruler" is at rest in the rotation frames S' and the coordinates of its ends are $\boldsymbol{\varphi}'_1$ and $\boldsymbol{\varphi}'_2$, the "length" (Unit: rad) of the ruler equal to $\boldsymbol{\varphi}'_2 - \boldsymbol{\varphi}'_1$. The proper "length" of the ruler is designated by $\boldsymbol{\varphi}_0$, i.e., $\boldsymbol{\varphi}_0 = \boldsymbol{\varphi}'_2 - \boldsymbol{\varphi}'_1$. Since the ruler is motionless in S', one may not worry about the simultaneity of measurements of the coordinates of its ends. While, at a certain moment in the uniform rotating frames S, the coordinates of the ruler's ends are measured as $\boldsymbol{\varphi}_1$ and $\boldsymbol{\varphi}_2$, the "length" of the ruler measured in S is $\boldsymbol{\varphi} = \boldsymbol{\varphi}_2 - \boldsymbol{\varphi}_1$, According to the **Alternative Lorentz Transformation**, we obtain

$$\boldsymbol{\varphi}_0 = \boldsymbol{\varphi}'_2 - \boldsymbol{\varphi}'_1 = \frac{\boldsymbol{\varphi}_2 - \boldsymbol{\omega}_e\tau}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} - \frac{\boldsymbol{\varphi}_1 - \boldsymbol{\omega}_e\tau}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} = \frac{\boldsymbol{\varphi}_2 - \boldsymbol{\varphi}_1}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} = \frac{\boldsymbol{\varphi}}{\sqrt{1-\left(\omega_e/\Omega_{\max}\right)^2}} \quad (22)$$

Which (Equation 22) is called **Alternative Length contraction** in this paper, it refers to the idea that an object in rotating motion will appear "shorter" in the direction of rotating motion (whose direction satisfies the right-hand thread rule) compared to the same object at rest. This effect is a consequence of the **Alternative Relativity of Simultaneity** and **Alternative Time dilation**.

09. CONCLUSIONS

In this paper, we proposed two key postulates. The first postulate asserts that the laws of rotational physics, such as the differential equation of rotation of a rigid body about a fixed-axis, are the same in the uniform rotating frames of reference. The fundamental rotational physics laws remain unchanged. This paper calls this property the **Alternative Principle of Relativity**. The second postulate states that the rotational angular speed of a "structural body" in nature also has a maximum limit value, Photons in vacuum are the "structures body" with the fastest angular velocity ($\Omega_{\max}$) in nature, and their value is c/2π ($\Omega_{\max} = c/2\pi$, unit: rad/s), where c is the light velocity, also independent of the motion of the light source, which is called the **Principle of Constancy of Light Angular Velocity** in this paper. Therefore, photons in vacuum have dual properties: they are both the fastest moving "particles" and the "structure body" with the fastest rotating angular velocity at the same time in nature!

Based on the above **two postulates**, we obtain the **Alternative Lorentz Transform** applicable to the laws of rotational physics, and then derive the expression of the **Alternative Special Theory of Relativity**. In fact, by using analogy, many similar concepts within Special Theory of Relativity in linear displacement space-time ($\boldsymbol{r}(t)$) could be extended to **Alternative Special Theory of Relativity** in angular displacement space-time ($\boldsymbol{\varphi}(\tau)$), However, these concepts are only applicable to the laws of rotational physics in the uniform rotating frames.

The newly developed **Alternative Special Theory of Relativity** might potentially open up some interesting directions for further exploration. From an experimental perspective, figuring out ways to test the proposed maximum rotational angular velocity limit and the predictions of the **Alternative Lorentz Transformation** is both a challenging task and a possible opportunity. For example, conducting high - precision measurements in ultra - fast rotating micro - mechanical systems or studying certain exotic materials with unique rotational properties could perhaps offer some clues about the validity of these concepts, although there are many difficulties to overcome.

Theoretically, attempting to integrate this theory with other branches of physics, like quantum mechanics in the context of rotating systems, might contribute to a more complete understanding of the fundamental nature of matter and energy. Also, applying this theory to astrophysical scenarios, such as rapidly rotating neutron stars or accretion disks around black holes, may provide some new ways of looking at their internal structures and dynamic behaviors. However, we are well aware that these are just preliminary speculations.

In conclusion, this paper simply tries to lay a basic foundation for a new approach to rotational physics in uniform rotating frames. There is still a long way to go to fully explore the implications, test the predictions, and incorporate it into the broader body of physical knowledge. We sincerely hope that this initial effort can inspire some follow - up research and make a small contribution to the progress of our understanding of the complex physical phenomena in the universe. It should be emphasized that the content and viewpoints presented in this paper are solely the personal insights of the authors. They are based on theoretical speculation and analogical reasoning, and have not been fully comprehensively verified by a large number of experiments and the academic community. Therefore, they do not necessarily represent absolute correctness. We sincerely hope that this paper can inspire more in - depth research and discussions in the field, and contribute to the exploration of the mysteries of the physical world in a positive way.

FUNDING

The authors did not receive support from any organization for the submitted work.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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