The Implications of the Time Dilation Factor in Classical Theories

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Abstract

The time dilation factor in special relativity is an algebraic expression derived through mathematical deduction based on the principle of the constancy of the speed of light and the principle of special relativity. This expression quantitatively describes the functional relationship between the velocity of motion and the change in time. In this paper, Building upon classical physical theories and taking as a premise that the speed of information propagation equals the speed of light, through theoretical derivation, The algebraic expression of the time dilation factor in special relativity is also derived. And within the framework of classical physics, it clarifies the physical meaning of this time dilation factor, theoretically explains why it lacks a contraction function, and provides a new pathway for further research into the theory of temporal relativity.

1. Derivation of the Time Dilation Factor's Algebraic Expression

In classical physics theory, when two objects are in a state of relative rest, their relative positions do not change. However, when they are in relative motion, their relative positions changes continuously. This change in position leads to a variation in their relative distance, thereby altering the time it takes for an information wave to reach the particles.

Below, we will use classical physics theory to theoretically derive and calculate the time at which a particle receives an information wave when two particles are in a state of relative rest and relative motion respectively, and thus obtain the algebraic expression of the time dilation factor in special relativity. For the convenience of description, the time when a particle receives an information wave in a state of relative rest is referred to as the static time, denoted by T_0. The time when a particle receives an information wave in a state of relative motion is referred to as the dynamic time, denoted by T.

Refer to Figure1, there are two particles Z1 and Z2 in space, particle Z1 is located at the coordinate origin and particle Z2 at the coordinate M1. Both Z1 and Z2 are equipped with a clock, and the two clocks remain synchronized at all times. At the clock time t=0, a spherical information wave Q is emitted from particle Z1, with the wave propagating at a speed of C.

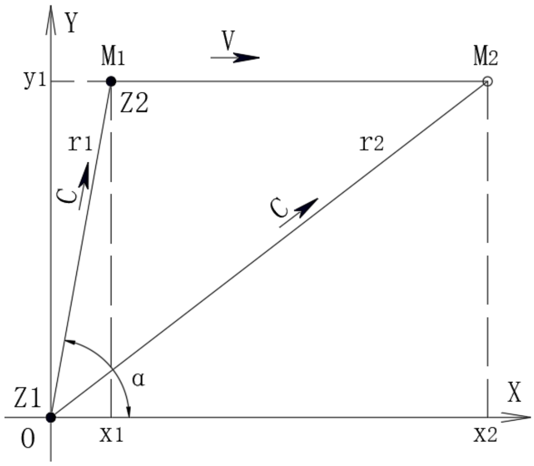

Figure1

a. Static Time T_0

When particle Z2 remains stationary at coordinate

M_1, the distance traveled by the information wave Q to reach particle Z2 is r_1. Then, the mathematical expression for the static time T_0 displayed by the clock on particle Z2 when the information wave Q emitted from particle Z1 arrives at particle Z2 is

$$T_0 = \frac{r_1}{C}. \qquad (1)$$

b. Dynamic Time T

When the clock time t=0, at the instant the information wave Q is emitted, particle Z2 departs from coordinate M_1 and moves in a uniform linear motion along the X-axis with velocity V, and collides with the information wave Q at coordinate M_2. The distance traveled by the information wave Q to reach particle Z2 is r_2. Then the mathematical expression for the dynamic time T displayed by the clock on particle Z2 when the information wave Q emitted from particle Z1 arrives at particle Z2 is

$$T = \frac{r_2}{C}. \qquad (2)$$

c. Functional Relationship between the Static Time T_0 and the Dynamic Time T

Refer to Figure1; in triangle OM_2x_2

$$x_2^2 + y_1^2 = r_2^2.$$

According to Figure 1, substituting $x_2 = x_1 + VT$, $x_1 = r_1\cos\alpha$ and $y_1 = r_1\sin\alpha$ into the above equation yields

$$(r_1\cos\alpha + VT)^2 + (r_1\sin\alpha)^2 = r_2^2.$$

$$r_1^2 + 2VTr_1\cos\alpha + V^2T^2 = r_2^2.$$

According to Equations (1) and (2), substituting $r_1 = CT_0$ and $r_2 = CT$ into the above equation yields

$$C^2T_0^2 + 2VTCT_0\cos\alpha + V^2T^2 = C^2T^2.$$

$$(C^2 - V^2)T^2 - 2VCT_0\cos\alpha T - C^2T_0^2 = 0. \qquad (3)$$

Solving Equation (3) for T yields

$$T = \frac{2VCT_0\cos\alpha \pm \sqrt{(-2VCT_0\cos\alpha)^2 + 4(C^2 - V_x^2)C^2T_0^2}}{2(C^2 - V^2)}.$$

$$= \frac{2VCT_0\cos\alpha \pm \sqrt{4C^2V^2T_0^2\cos^2\alpha + 4(C^2 - V^2)C^2T_0^2}}{2(C^2 - V^2)}.$$

$$= \frac{2VCT_0\cos\alpha \pm 2CT_0\sqrt{V^2\cos^2\alpha + C^2 - V^2}}{2(C^2 - V^2)}.$$

$$= \frac{V\cos\alpha \pm \sqrt{C^2 - V^2\sin^2\alpha}}{C^2 - V^2}CT_0.$$

Since the moving velocity V of the particle is always less than the speed of light C, i.e., V<C,

the inequality $\mathrm{Vcos}\alpha < \sqrt{\mathrm{C}^2 - \mathrm{V}^2\mathrm{sin}^2\alpha}$ holds true. Therefore, when the negative sign is taken before the square root in the above equation, the dynamic time T takes a negative value; when the positive sign is taken before the square root, the dynamic time T takes a positive value. As a negative time has no physical meaning, the physically meaningful solution to the above equation is

$$\mathrm{T} = \frac{\mathrm{Vcos}\alpha + \sqrt{\mathrm{C}^2 - \mathrm{V}^2\mathrm{sin}^2\alpha}}{\mathrm{C}^2 - \mathrm{V}^2}\mathrm{CT}_0. \quad (4)$$

Where:

T: The dynamic time between the two particles (s);

T_0: The static time between the two particles (s);

V: The velocity of particle Z2 moving along the X-axis (m/s).

C: The speed of light (m/s);

α: The included angle between the line connecting the two particles and the positive X-axis at t=0 (°).

d. Algebraic Expression for the Time Dilation Factor

It can be seen from Equation (4) that when the static time T_0 takes a definite value, the magnitude of the dynamic time T varies with the relative motion velocity V between the particles and the change of the included angle α between the line connecting the two particles and the positive X-axis. Substituting α=90° into Equation (4) yields

$$\mathrm{T} = \frac{\mathrm{Vcos}\alpha + \sqrt{\mathrm{C}^2 - \mathrm{V}^2\mathrm{sin}^2\alpha}}{\mathrm{C}^2 - \mathrm{V}^2}\mathrm{CT}_0.$$

$$= \frac{\sqrt{\mathrm{C}^2 - \mathrm{V}^2}}{\mathrm{C}^2 - \mathrm{V}^2}\mathrm{CT}_0.$$

$$\mathrm{T} = \frac{1}{\sqrt{1 - \frac{\mathrm{V}^2}{\mathrm{C}^2}}}\mathrm{T}_0. \quad (5)$$

It is easy to see that the algebraic expression $\frac{1}{\sqrt{1-\frac{\mathrm{V}^2}{\mathrm{C}^2}}}$ in Equation (5) is the algebraic form of the time dilation factor γ in special relativity.

2. Causes for the Deficiency of the Contraction Function of the Time Dilation Factor in Special Relativity

We derived the algebraic expression for the time dilation factor in special relativity by setting α=90° in Equation (4). As can be seen from Figure 2, in this state, the starting point of particle Z2 lies on the Y-axis, and the line connecting the two particles is perpendicular to the direction of motion of particle Z2. Therefore, r_2 is always greater than r_1 regardless of whether particle Z2 moves along the positive or negative X-axis. Hence, with the propagation speed of the information wave being a constant C, the dynamic time T is always greater than the static time T_0. This is the reason for the deficiency of the contraction function of the time dilation factor in special relativity, as deduced from theoretical analysis based on classical theory.

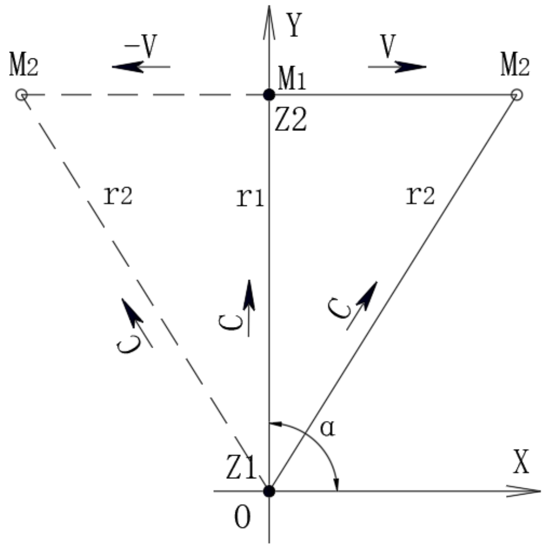

Figure2（α=90°）

3. Analysis of the Physical Meaning of the Time Dilation Factor within the Framework of Classical Theory

It can be concluded from the foregoing derivation that the static time T_0 and dynamic time T in Equation (5) represent the time for one particle to receive the information wave emitted from the other particle when the two particles are in a state of relative rest and relative motion, respectively. Equation (5) is merely an expression for the functional relationship between these two times under the specific condition of α=90°, and it does not reflect the variation law of the time interval in these two states of relative motion. It can thus be simply considered that, within the framework of classical theory, the time dilation factor in special relativity is a conversion factor between the static time T_0 and the dynamic time T under a specific state, rather than a conversion factor between the static time interval and the dynamic time interval.

Then, what is the conversion factor between the static time interval and the dynamic time interval? Based on classical theory, a brief discussion on this question is presented below.

Referring to Figure 3, there are two particles Z1 and Z2 in space, where particle Z1 is located at the coordinate origin and particle Z2 at the coordinate M_1. Each of particles Z1 and Z2 is equipped with a clock, and the times of the two clocks remain synchronized at all times. At clock time t=0, two spherical information waves Q1 and Q2 are emitted successively from particle Z1 at a time interval of τ, with the propagation speed of the information waves being C.

When particle Z2 remains stationary at the coordinate M_1, calculations show that the time interval ΔT_0 (static time interval) at which the

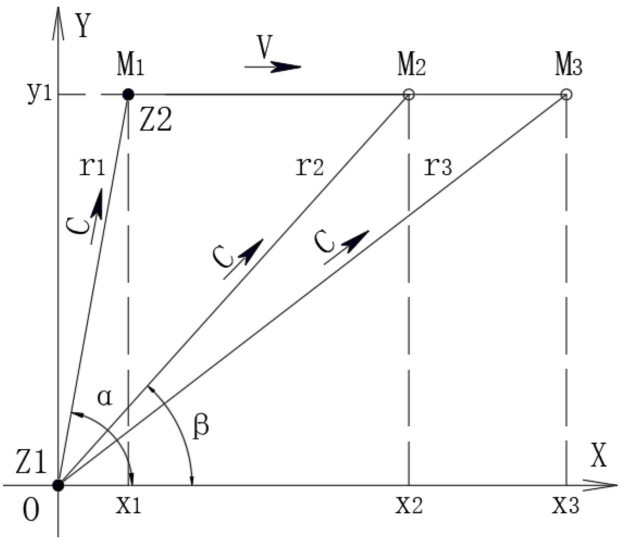

Figure3

clock on particle Z2 displays the reception of information waves Q1 and Q2 is equal to the emission time interval τ of information waves Q1 and Q2, i.e.,

$$\Delta T_0 = \left(\tau + \frac{r_1}{C}\right) - \frac{r_1}{C} = \tau.$$

At clock time t=0, the first information wave Q1 is emitted, and at the same time, particle Z2 moves in a uniform linear motion from coordinate M_1 along the positive X-axis at a velocity V. It collides with the information wave Q1 at coordinate M_2 and with the information wave Q2 at coordinate M_3, respectively. The mathematical expression for the time interval ΔT (dynamic time interval) at which the clock on particle Z2 registers the reception of information waves Q1 and Q2 is given by

$$\Delta T = \left(\tau + \frac{r_3}{C}\right) - \frac{r_2}{C} = \tau + \frac{r_3 - r_2}{C}.$$

Based on the mathematical relationships among the various parameters in Figure 3, the functional relation between the static time interval (ΔT_0) and the dynamic time interval (ΔT) can be expressed as [1]

$$\Delta T = \frac{C}{C - V\cos\beta}\Delta T_0. \tag{6}$$

Equation (6) is the expression for the functional relationship between the static time interval and the dynamic time interval within the framework of classical theory, and the term $\frac{C}{C - V\cos\beta}$ in the equation is the conversion factor between the static time interval and the dynamic time interval. It can be seen from the algebraic expression of the conversion factor that the magnitude of this conversion factor is related not only to the relative motion velocity V between the particles, but also to the direction of the particle motion velocity and the included angle β between the line connecting the particles and the X-axis. Therefore, within the framework of classical theory, the relative motion between particles can not only cause time dilation, but also time contraction. If the information wave is a light wave, the relative motion between particles can cause not only the redshift of the light wave frequency, but also the blueshift of the light wave frequency.

Equation (6) is currently at the theoretical derivation stage and has not yet been verified by experiments. The simplest method to experimentally verify Equation (6) is to convert it into a functional relationship between the static frequency f_0 (emission frequency) and the dynamic frequency f (reception frequency) based on the relation $T = \frac{1}{f}$ between frequency f and period T, i.e.,

$$f = \frac{C - V\cos\beta}{C} f_0. \tag{7}$$

It is worthwhile to make this attempt when experimental conditions permit. If the experimental results are consistent with Equation (7), we are bound to accept this fact. In this way, it will not only greatly expand the scope of application of classical theory, but also open up a new path for the research on the relativity of time.

4. Conclusion

The laws of classical physics all derive from experiments without exception, serving as a summary and generalization of experimental results. Restricted by the experimental conditions of their time, the scientists of that era erroneously believed that information transmission is instantaneous with an infinite propagation speed. Precisely this misconception causes the calculation deviations of the laws of classical physics to increase as the motion velocity of objects rises, thereby confining the scope of application of classical physics theories.

Based on classical theory and incorporating the objective law of nature that the speed of information propagation is finite, this paper derives the algebraic expression for the law of time variation within the framework of classical theory through theoretical deduction, and clarifies from the perspective of classical theory that the relativity of time is an irresistible natural law. While classical theory and special relativity have reached a consensus on the proposition that time is relative, their time conversion factors are not identical, and there also exist non-negligible differences in the physical implications of time variation.

Since the birth of special relativity, the Lorentz transformation has long served as the sole tool for time conversion. While it has achieved certain successes in specific fields, it remains unsatisfactory in many aspects and is plagued by numerous unsolvable problems. This indicates that special relativity, as a theoretical system, still requires further refinement and improvement. At present, the time conversion formula within the framework of classical theory has been successfully derived through theoretical deduction. Its derivation process is entirely based on classical theory and grounded in facts, making it a relatively rational tool for time conversion. With the in-depth study of this theory, it is bound to play a positive and facilitating role in the further refinement and improvement of the theoretical system of special relativity.

References

[1] A New Functional Relationship Applicable to High-Speed Moving Objects,2-4.
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