Correlation between $\mu_0\varepsilon_0$ and Time Course

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Abstract: In nature, matter and its motion take precedence. Time serves merely as a conceptual tool and a method utilized by people to gauge the rate of motion of matter. $\mu_0\varepsilon_0$ constitutes an intriguing pair of physical quantities. When directly measured, they remain constant. However, they can vary when indirectly measured. Research has revealed that $\mu_0\varepsilon_0$ influences the motion rate of all matter within a local area. Correlated with the passage of time, $\mu_0\varepsilon_0$ affects and reflects the motion rate of matter. Time, like other physical concepts, has a specific scope of applicability and is not universally valid across all physical phenomena under study.

Keywords: time ; space ; speed of light ; $\mu_0\varepsilon_0$

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Introduction: The concept of time is profoundly intricate and multidimensional in physics, encompassing all aspects from classical physics to modern theories. In Newtonian mechanics, time is regarded as an absolute quantity independent of the observer, implying that time progresses steadily irrespective of the observer's state (whether at rest or in motion). This concept forms the basis of Newtonian mechanics, assuming the independent existence of time and space.

Einstein's theory of relativity revolutionized people's understanding of time. In relativity, time ceases to be an absolute quantity. Rather, it is a physical quantity closely linked to space. Time and space merge into a single entity within a four-dimensional space-time continuum. This implies that time elapses differently depending on the relative velocity of the observer, a phenomenon famously known as time dilation[1-4]. In essence, time passes more slowly for an object moving at a high speed compared to a stationary object or one moving at a slower speed. Furthermore, gravity, as described in general relativity[5-7], also influences time. Time passes more slowly in proximity to a strong gravitational field, such as that of a black hole[8-9], than it does in regions distant from gravitational sources.

The concept of time is more intricate in the realm of quantum mechanics[10-13]. Within the framework of standard quantum theory, time is typically treated as a fixed parameter, akin to its treatment in Newtonian mechanics, unaffected by quantum states. However, in quantum gravity theories, such as string theory and loop quantum gravity theory, attempts have been made to combine the uncertainty principles of quantum mechanics with the space-time concept of general relativity. As a result, hypotheses suggesting that time may possess a quantum nature have been proposed.

Time travel remains a popular theme in science fiction, with a certain theoretical foundation in physics. In some theoretical solutions, such as Kerr black holes and wormholes[14], time travel is permitted. However, its practical verification or realization has yet to be achieved. Time travel has numerous paradoxes, such as the “grandfather paradox,” sparking in-depth discussions in both physics and philosophy.

In the realm of physics, time is a fundamental yet complex concept. It is intricately linked to various theories and experimental research. Many mysteries surrounding time persist to this day, awaiting further exploration and understanding.

In general relativity, it is understood that the passage of time can be influenced by variations in the distribution of matter mass within space. This implies that the passage of time may differ across various local regions within the universe. Subsequent experiments have validated this prediction of general relativity. For instance, physical phenomena such as the slower time course on the sun compared to that on Earth demonstrate the internal physical relationship between the passage of time and the motion and distribution of matter in space. In the following discussion, we will delve into the physical causes underlying this intrinsic connection.

1. The speed of light is both constant and variable

As is well known, the principle of the constant speed of light stems[15-21] from the findings of the Michelson-Morley Experiment[22-23]. It is also one of Einstein's relativity theories. This principle asserts that, in any reference frame, the travel speed of light in a vacuum remains constant and does not change with the motion state of the light source. However, the experiment also revealed that the speed of light appears to vary when measured indirectly. For instance, in the radar echo test of the sun[24-26], it was discovered that the echo was delayed, indicating that delays in the echo showed a reduction in the travel speed of electromagnetic waves near the sun. Additionally, in astronomical observations, it was observed that light would deflect towards the sun[27-32], as illustrated in Figure 1. According to the principle of light refraction, the closer light is to the sun, the slower its speed becomes, leading to the phenomenon of light refraction. These two experiments indicate that the speed of light near the sun is indeed slower. Thus, we conclude that while the speed of light is generally constant, it can appear relatively variable under certain conditions.

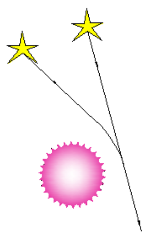

Figure 1 The sun leads to light deflection

2. The physical causes of the variable and constant light speed

The computational formula for light speed (c):

$$c = \frac{\Delta s}{\Delta t} \tag{2-1}$$

Where, c is the light speed, Δs is the light travel distance, and Δt is the light travel time.

The computational formula for speed may seem simple, but it is intricately linked to two fundamental physical quantities: space and time.

If both the numerator and denominator in the above equation are multiplied by the same proportion coefficient k, the speed of light can still remain the same.

$$c = \frac{\Delta s}{\Delta t} = \frac{k\Delta s}{k\Delta t} \tag{2-2}$$

This demonstrates that the speed of light within any local area remains consistent as long as space and time expand or contract in tandem[33]. Alternatively, space and time within any given locality must expand or contract proportionally based on the principle of the constant speed of light. This ensures that the speed of light remains unchanged across all localities. The relative variation in the speed of light is attributed to differing rates of time passage in two distinct local areas. Therefore, the expansion and contraction of space and time in proportional harmony serve as the sole physical cause of the absolutely constant yet relatively variable speed of light.

3. The relationship between the speed of light, space, and time

Let's say that there are two vacuum spaces: Space A and Space B. Both of them are inertial spaces. Observers in both spaces measure the speed of light to be equal, but the speed of light in Space B is relatively lower than that in Space A.

Suppose that c_a is the light speed in Space A and c_b is the light speed in Space B as measured in Space A. In 1 second in Space A, the light travel distance is S_a, while the light travel distance in Space B, as measured in Space A, is S_b. The difference between these two distance values indicates the relative expansion and contraction of the two spaces. Thus, the proportion coefficient *k* of space expansion and contraction is calculated as follows:

$$k = \frac{S_b}{S_a} = \frac{c_b}{c_a} \tag{3-1}$$

$$\Delta S_b = k\Delta S_a \tag{3-2}$$

The expansion and contraction coefficients of space and time must be equal. Therefore, the relational expression between the speed of time courses in the two local areas is as follows:

$$\Delta t_b = k\Delta t_a \tag{3-3}$$

For instance, if the speed of light measured in Space A is 3.0×10^{8}m/s and the speed of light in Space B relative to Space A is 2.4×10^{8}m/s, it is evident that the relative speed of light in Space B is lower than that in Space A. The expansion and contraction coefficients of Space B relative to Space A can be determined based on this speed of light discrepancy as follows:

$$k = \frac{c_b}{c_a} = \frac{2.4\times10^8}{3.0\times10^8} = 0.8 \tag{3-4}$$

Substituting k=0.8 into Equations (3-2) and (3-3) above gives:

$$\Delta t_b = 0.8\Delta t_a \tag{3-5}$$

$$\Delta s_b = 0.8\Delta s_a \tag{3-6}$$

From Equations (3-5) above, we observe that the time course in Space B is 0.2 times slower than that in Space A. Even when calculated using the time course in Space B, the speed of light in Space B remains 3.0×108 m/s:

$$c = \frac{2.4 \times 10^8 (m)}{0.8(s)} = 3.0 \times 10^8 (m/s)$$

Through the preceding discussion, we derived the relational expression between the relative change in the speed of light and the expansion and contraction of space and time. Now, what physical factors influence the speed of light and the expansion and contraction of space and time?

4. The relationship between the physical properties of vacuum and the speed of light, space, and time

Vacuum has numerous physical properties, including curved space-time[34-36] and quantum fluctuations, rendering it non-empty and inherently physical. Light, being an electromagnetic wave, propagates within the physical context of vacuum. Consequently, Space A or Space B is not merely an abstract mathematical construct. Rather, they represent spaces within the physical background of vacuum.

In accordance with Maxwell's equations, we can derive the relational expression between the speed of light in a vacuum (c) and the permeability of the vacuum (μ_0) and dielectric constant (ε_0):

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \tag{4-1}$$

Where c is the speed of light in a vacuum, μ_0 is the permeability of the vacuum, and ε_0 is the dielectric constant in a vacuum.

From the above equation, we observe that the speed of light in a vacuum is solely determined by μ_0 and ε_0. Therefore, the speed of light in a vacuum can only be altered by modifying $\mu_0\varepsilon_0$. As previously mentioned, the speed of light on the sun's side is lower than that on Earth, suggesting that the value of $\mu_0\varepsilon_0$ on the sun's side is higher than that on Earth. Given the relative change in the speed of light, there are corresponding alterations in space and time expansion and contraction. Hence, we can establish the functional relationship between $\mu_0\varepsilon_0$ and space and time.

Suppose that $\mu_0\varepsilon_0$ is the permeability of the vacuum and dielectric constant in Space A and $\mu_{0b}\varepsilon_{0b}$ is the $\mu_0\varepsilon_0$ in Space B relative to Space A.

Using Equation (4-1), we derive:

$$c_b = \frac{1}{\sqrt{\mu_{0b}\varepsilon_{0b}}} \tag{4-2}$$

$$c_a = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \tag{4-3}$$

Substituting Equations (4-2) and (4-3) into Equation (3-1), we obtain the proportion coefficient k:

$$k = \frac{c_b}{c_a} = \frac{\frac{1}{\sqrt{\mu_{0b}\varepsilon_{0b}}}}{\frac{1}{\sqrt{\mu_0\varepsilon_0}}} = \frac{\sqrt{\mu_0\varepsilon_0}}{\sqrt{\mu_{0b}\varepsilon_{0b}}} \tag{4-4}$$

$$k = \sqrt{\frac{\mu_0\varepsilon_0}{\mu_{0b}\varepsilon_{0b}}} \tag{4-5}$$

Through Equation (4-4), we obtain the relational expression between $\mu_0\varepsilon_0$ and the proportion coefficient k, as shown in Equation (4-5). This enables us to calculate the relationship between the expansion and contraction of relative space and time in Space A and Space B:

$$\Delta s_b = \Delta s \sqrt{\frac{\mu_0\varepsilon_0}{\mu_{0b}\varepsilon_{0b}}} \tag{4-6}$$

$$\Delta t_b = \Delta t \sqrt{\frac{\mu_0\varepsilon_0}{\mu_{0b}\varepsilon_{0b}}} \tag{4-7}$$

Equations (4-6) and (4-7) demonstrate that $\mu_0\varepsilon_0$ and $\mu_{0b}\varepsilon_{0b}$ determine the spatial interval and time course in their respective spaces, while $\mu_0\varepsilon_0$ determines the speed at which time elapses. As

$\mu_0\varepsilon_0$ is always positive, time can only go by irreversibly in one direction. In actuality, time influences the motion of matter universally, given that $\mu_0\varepsilon_0$ is ubiquitous. Essentially, the concept of time merely signifies the motion rate of matter. Actually, $\mu_0\varepsilon_0$ does not directly impact time but rather affects the motion rate of all matter within a local area. Therefore, any timer within a specific local area must be related to $\mu_0\varepsilon_0$ specific to that area.

5. Important physical significance of $\mu_0\varepsilon_0$

Imagine a scenario where a photon is radiated from Space B to Space A. The frequency of this photon, as measured in Space A, is lower than that measured in Space B. Importantly, the photon itself does not undergo any change during its journey from Space B to Space A. The decrease in frequency occurs because the clock in Space A is faster than that in Space B, as depicted in Figure 2. Based on the equation E=hγ, the energy of a photon is directly proportional

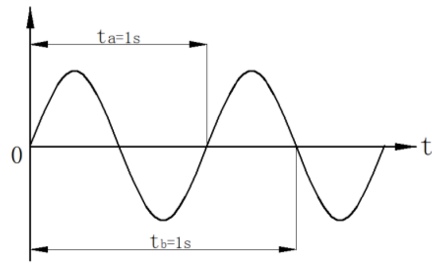

Figure 2: Schematic diagram of change in photon frequency

to its frequency. Consequently, the energy of this photon in Space A is not as high as that in Space B. This discrepancy arises due to the differing values of $\mu_0\varepsilon_0$. Moreover, $\mu_0\varepsilon_0$ not only affects the energy of photons but also impacts the energy of all matter, as indicated by the mass energy formula (4-8).

Mass energy formula[37]:

$$E_0 = m_0 c^2 \tag{4-8}$$

Substituting Equation (4-1) into Equation (4-8), we can obtain the relationship between the energy of an object and $\mu_0\varepsilon_0$:

$$E_0 = \frac{m_0}{\mu_0 \varepsilon_0} \tag{4-9}$$

Based on the aforementioned analysis, we can ascertain that $\mu_0\varepsilon_0$ determines the energy state of all matter in a local area. A space with relatively low $\mu_0\varepsilon_0$ is considered a high-energy space, while a space with relatively high $\mu_0\varepsilon_0$ is deemed a low-energy space. The transition from a high-energy space to a low-energy space, $\mu_0\varepsilon_0$ produces curved space-time and universal gravitation, as illustrated in Figure 3. The logical relationship between $\mu_0\varepsilon_0$ time, and space becomes apparent through this analysis. $\mu_0\varepsilon_0$ influences the energy of matter, in turn, affects the motion rate and interaction of matter, thereby influencing the relative speed of time course and the relative expansion and contraction of space.

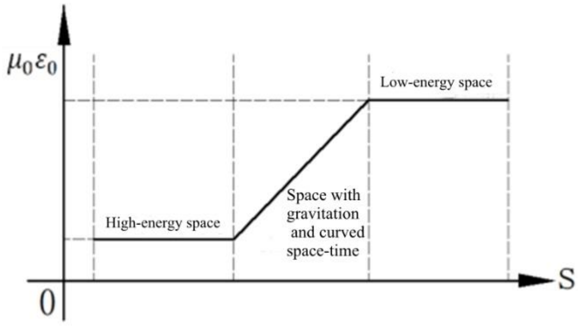

Figure 3: Schematic diagram of energy interval

So far, someone may have questions regarding the practical function of $\mu_0\varepsilon_0$. In reality, from Maxwell's equations to the principles of constant speed of light, Lorentz transformation, special relativity, and general relativity, any relativistic formula is intricately linked to the physical quantity of the speed of light (*c*). However, it is $\mu_0\varepsilon_0$ that determines the speed of light. The success of relativity fully confirms the vital role of $\mu_0\varepsilon_0$, the physical properties of matter in a vacuum in the existence and motion of matter. Relativity deals with situations where $\mu_0\varepsilon_0$ is a constant, yet this paper delves into scenarios where $\mu_0\varepsilon_0$ is both an absolute constant and a relative variable. The aforementioned research, based on relative change of $\mu_0\varepsilon_0$ also expands and continues the research on relativity.

6. "Superluminal" motion that is not against the principle of constant speed of light

Through the aforementioned research, we have discovered that space is scalable. In a space where mass density is high, the value of $\mu_0\varepsilon_0$ is large. Conversely, the value of $\mu_0\varepsilon_0$ is small in a space where mass density is low. In the vast expanse of the universe, far from the solar system, where matter density is extremely low, $\mu_0\varepsilon_0$ will be very small. Equation (4-6) elucidates that space expands by a factor of 100 times relative to the geospace when k = 100. 3.0×10^8m in that space is 100 times that in the geospace. Without violating the principle of constant speed of light, the travel distance of light in one second there is 3.0×10^{10}m on Earth. By Earth's standards of space and time, a phenomenon akin to "superluminal" motion occurs. Therefore, the fluctuations in space, its expansion and contraction, ignite contemplations of interstellar travel.

We now designate the distance to a specific place in the universe, as measured by the triangle method, as the geometric distance. However, since the expansion and contraction of cosmic space are not accounted for in this measurement approach, this geometric distance may significantly deviate from the actual physical distance. The actual physical distance traversing cosmic space may be much shorter than the geometrical distance measured.

7. The scope of application of the concepts of time and space

The concepts of time and space emerged during quantitative research on the motion of matter, such as the distance between Point A and Point B and the time taken by an object to travel from Point A to Point B. The matters mentioned here are characterized by having mass and energy. Consider another type of matter devoid of mass, filling the cosmic space. Since massless matter exists in a state of zero energy and remains stable indefinitely, time is perpetual for it. In addition, as the motion of massless matter is unrestricted by classical mechanics and relativity, it can instantaneously reach any position in the universe. Consequently, spatial distance and duration hold no significance for massless matter. Upon comprehending the scope of the application of space and time, individuals can acknowledge the existence of certain physical phenomena unrestricted by time and space, such as quantum entanglement[38]. If a spacecraft could attain a state of zero mass, human interstellar travel would be unhindered by time and space constraints.

8. Conclusion

Matter with mass and matter without mass in the vacuum together form the material world of humans. The physical properties of vacuum ($\mu_0\varepsilon_0$) influence the energy of matter, thereby impacting the interaction between matter and its motion rate. This influence is also evident in the alteration of spatial intervals and the speed of time . While space and time serve as crucial methods for studying the motion of matters with mass, they hold no relevance in the analysis of the motion of matters without mass. The limitations inherent in the concepts of space and time provide a new physical perspective for comprehending certain special physical phenomena. Due to the oversight of the expansion and contraction of interstellar space, the geometrical distance between stars in the universe as measured by people may vastly exceed the actual physical distance between them. This phenomenon of space expansion also renders human interstellar travel feasible.

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