Research on Vacuum Dynamics Theory

Yake Li

Abstract

Based on multiple astronomical observation results, this paper proposes the hypothesis of the principle of relative variation of the speed of light and proves the compatibility between this principle and the principle of the constancy of the speed of light. Based on this principle, this paper constructs an innovative theoretical framework of the vacuum dynamics theory and derives several important conclusions. The core findings are as follows:

1. In a vacuum, an object can obtain an acceleration g_m without the action of any external force, that is: $g_m = -\frac{dc^2(s)}{ds}$, and *gm* is equal to the negative gradient of the square of the speed of light with respect to the change in space. This provides important theoretical support for the manufacture of anti-gravity propulsion systems.

2. The Schwarzschild spacetime factor $\sqrt{1 - 2G\frac{M}{c_1^2 r}}$ of the general theory of relativity is derived, and the prediction of Einstein's field equation is reproduced for the first time within a non-geometric framework. It shows that the light speed gradient effect and the phenomenon of spacetime curvature are essentially equivalent.

3. The spacetime equation of a spherically symmetric object is obtained, which is consistent with the equations of the general theory of relativity. In particular, for the gravitational acceleration equation $\frac{dc^2(r)}{dr} = G\frac{M}{r^2}$, it indicates that an object exerts an influence on other objects by changing the distribution of the speed of light in space, and there is no direct attractive force.

4. Based on the vacuum dynamics theory, the hypothesis of the existence of a gradient distribution of the speed of light in the universe is proposed, that is, the speed of light gradually decreases from the inside to the outside. Celestial bodies spontaneously move towards the regions with a lower speed of light, and this process externally manifests as the expansion of the universe. The increased kinetic energy of celestial bodies is derived from the internal energy they release. Therefore, dark energy is essentially the internal energy released by celestial bodies during their movement towards the space of lower energy states.

Keywords: Vacuum dynamic mechanism, speed of light, spacetime, internal energy, dark energy

1. Introduction

The speed of light is one of the fundamental constants in modern physics, and its invariance forms the core assumption of the special theory of relativity. Since Einstein proposed the principle of the constancy of the speed of light, the scientific community has generally believed that the speed of light is constant in a vacuum. However, the results of multiple experiments in recent years have shown that the speed of light can be variable under specific space-time conditions. For example, the radar echo delay experiments [1-3] and the gravitational lensing effect [4-6] indicate that when electromagnetic waves propagate near massive celestial bodies, their speed will slow down. These phenomena suggest that the speed of light is not absolutely constant. Theoretical and observational studies on the variation of the speed of light have gradually attracted widespread attention in the academic community.

Based on the results of astronomical observations, this paper proposes the principle of the relative change of the speed of light, and further explores the compatibility between this principle and the principle of the constancy of the speed of light. It analyzes the energy differences caused by the relative change of the speed of light in a vacuum, and expounds how this difference leads to the spontaneous accelerated motion of objects, as well as the source of the kinetic energy of objects during the acceleration process. The discovery of the phenomenon of the relative change of the speed of light has expanded a new field for the study of the laws of matter motion. The vacuum dynamic mechanism provides a brand-new physical idea for explaining the dark energy that causes the accelerated expansion of the universe [7-12].

2. Discussion on the Compatibility between the Principle of the Constancy of the Speed of Light and the Principle of the Relative Change of the Speed of Light

2.1 Proposal of the Principle of the Relative Change of the Speed of Light [13-15]

Near massive celestial bodies, the propagation speed of light will slow down, and this phenomenon has been verified by the gravitational lensing effect and the deflection of light rays near the sun. At the same time, the observational results of radar echo delay also support the view that the propagation speed of light in a vacuum slows down. Based on these experimental results, this paper puts forward a hypothesis: in a vacuum environment, there may be a relative difference in the speed of light between two relatively stationary inertial reference frames, which is the principle of the relative change of the speed of light. This principle holds that although the speed of light at each point in a vacuum remains constant, the differences in the space-time structure between different spatial points may lead to the phenomenon of relatively unequal speeds of light.

2.2 Discussion on the Compatibility between the Principle of the Relative Change of the Speed of Light and the Principle of the Constancy of the Speed of Light

On the surface, the principle of the constancy of the speed of light and the principle of the relative change of the speed of light seem to be in conflict. In fact, the two can be compatible, which requires an analysis from the perspectives of space-time changes and the measurement of the speed of light.

The principle of the constancy of the speed of light holds that the speed of light in a vacuum is a constant in any reference frame. Its mathematical expression is:

$$c = \frac{\Delta s_a}{\Delta t_a} = \frac{\Delta s_b}{\Delta t_b} \tag{1}$$

where Δs represents the distance that light travels in a vacuum, and Δt is the time required for light to travel. This principle shows that the numerical value of the speed of light remains the same whether at point A or point B.

Suppose that the space-time at point B undergoes a proportional change of expansion or contraction relative to point A, and the proportionality coefficients are k_t and k_s, that is:

$$\Delta s_b = k_s \Delta s_a \quad , \quad \Delta t_b = k_t \Delta t_a \tag{2}$$

According to the principle of the constancy of the speed of light, the proportionality coefficients should be equal, that is: $k_s = k_t = k$, so as to ensure that equation (1) holds, that is, the consistency of the speed of light. In other words, the proportionality of the expansion or contraction of space and time must be the same at any time.

However, the fact that the speed of light between two points has the same magnitude does not mean that the speed of light between the two points is relatively equal. For example, due to the expansion or contraction of the space between the two points ($k \neq 1$), even if the speed of light at each point is 300,000 kilometers per second, the 300,000 kilometers at point B is actually k times different from the 300,000 kilometers at point A. Therefore, there is also a k -fold difference in the speed of light between point B and point A, and its proportional relationship can be expressed as:

$$k = \frac{\Delta s_b}{\Delta s_a} = \frac{c_b}{c_a} \quad (3)$$

When $k \neq 1$, it indicates that the speeds of light between points A and B are not equal. For example, if (k = 0.5), then the distance of 300,000 kilometers in space B is only equivalent to 150,000 kilometers in space A, even if the speeds of light in both space A and space B are equal (300,000 kilometers per second). By comparison, the speed of light in space B is only half of that in space A. As shown in Figure (1), the passage of time in space B is also only half of that in space A.

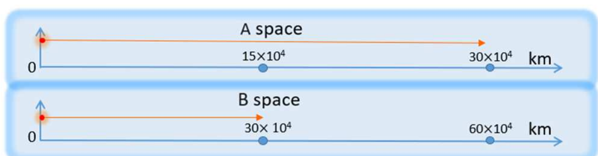

Fig.1. A-B Space Comparison Diagram

In short, although the speed of light at each point in a vacuum is numerically equal, due to the differences in the space-time structure between different spatial points, the speed of light may be different in a relative sense. Therefore, on the basis of the principle of the constancy of the speed of light, the relative change of the speed of light is also valid, and these two principles are not contradictory but compatible with each other.

2.3 The Correlation among Space, Time and the Speed of Light

From formula (2), the following collated result can be obtained:

$$k = \frac{\Delta s_b}{\Delta s_a} = \frac{\Delta t_b}{\Delta t_a} \quad (4)$$

Further combining formula (4) with formula (3), we get:

$$k = \frac{\Delta s_b}{\Delta s_a} = \frac{\Delta t_b}{\Delta t_a} = \frac{c_b}{c_a} \tag{5}$$

Formula (5) shows that in a vacuum, the speed of light, the spatial scale, and the passage of time between any two points follow a fixed proportional relationship, reflecting the internal correlation between the speed of light and space-time. If one of the quantities changes, the other two quantities will inevitably change synchronously in the same proportion. Theoretically, space-time only serves as a background for describing the motion of objects and cannot directly change the speed of light. Therefore, in the subsequent discussions of this paper, the speed of light and its relative changes will still be taken as the dominant factors.

From the above formula (5), we can get:

$$c_b = \frac{\Delta s_b}{\Delta s_a} c_a \tag{6}$$

As can be seen from the above formula, if space B expands n times relative to space A, although the speed of light inside space B is equal to that in space A, the speed of light in space B is n times relatively faster than that in space A. Without violating the principle of the constancy of the speed of light, a relative "superluminal" phenomenon occurs, which shows that an indirect superluminal speed is theoretically possible.

In the cosmic space, space-time always has relative changes, so the speed of light also has relative changes. Then, when measuring the distance of cosmic celestial bodies, there must be a difference between the observed geometric distance of the celestial body and the actual physical distance.

3. The Energy Difference Caused by the Speed of Light Difference in the Vacuum Space

3.1 The Energy Difference of Photons Caused by the Speed of Light Difference

If there is a speed of light difference between space A and space B, then there must be a time difference between the two points accordingly. The time difference further leads to a frequency difference, and the frequency difference in turn causes an energy difference of photons.

Next, we will prove the corresponding conversion relation formula of the frequencies between the two points. According to the proportional relation formula, it can be obtained from formula (5):

$$\Delta t_b = \frac{c_b}{c_a} \Delta t_a \qquad (7)$$

Let T_a and T_b be the frequency periods respectively, and the definitions are:

$$T_a = \Delta t_a \quad , \quad T_b = \Delta t_b$$

From the relation formula between frequency and period $f = 1/T$, we can get:

$$f_a = \frac{1}{T_a} \quad , \quad f_b = \frac{1}{T_b}$$

Substitute the above relations into formula (7), and we can obtain the conversion relation formula of the frequencies between the two spaces:

$$f_a = \frac{c_b}{c_a} f_b \qquad (8)$$

For example: If $c_b/c_a = 0.5$, then the frequency of 1000 Hz in space B is only 500 Hz when observed from space A, and its frequency is reduced by half.

According to the relation between frequency and photon energy E = hf , combined with the proportional relation formula of frequency (8), we can derive the conversion relation of photon energy between the two spaces:

$$E_a = \frac{c_b}{c_a} E_b \qquad (9)$$

If $c_b/c_a = 0.5$, then after the photon energy in space B is converted to that in space A, its energy is reduced by 50%. It is worth noting that the energy difference of photons between the two spaces has nothing to do with the photons themselves, but is only related to the speed of light difference between the two spaces.

If the ratio of the speeds of light is still 0.5, this means that photons in space B will produce a redshift phenomenon when entering space A. In other words, when photons radiate from a space with a lower speed of light to a space with a higher speed of light, a redshift will occur. Since the speed of light on the side of the sun is relatively lower than that on the earth, the light radiated from the sun to the earth will also exhibit a redshift phenomenon [16-19].

3.2 The Speed of Light Difference and the Internal Energy Difference of Objects

According to Einstein's mass-energy equation:

$$E_0 = m_0 c^2 \quad (10)$$

We can obtain the relationship between the internal energy of an object, its rest mass, and the speed of light. Suppose there are objects with the same mass m_0 in two spaces A and B, and their internal energies in the two spaces are respectively:

$$E_{0a} = m_0 c_a^2 \quad , \qquad E_{0b} = m_0 c_b^2$$

From this, we can derive the conversion relationship of the internal energy of the object in the two spaces:

$$E_{0b} = \left(\frac{c_b}{c_a}\right)^2 E_{0a} = k^2 E_{0a}$$

When the speeds of light in spaces A and B are equal, the internal energies of the objects are also equal. However, when the speeds of light are not equal, the internal energy of the object will change, and this change is a multiple of the square of the speed of light ratio k. For example, if the speed of light ratio k = 0.5, then the difference in internal energy between the two spaces is:

$$E_{0b} = k^2 E_{0a} = (0.5)^2 E_{0a} = 0.25 E_{0a}$$

This means that in space B, the internal energy of this object is only 25% of the internal energy of an object with the same mass in space A. Thus, it can be seen that the internal energy of an object in a space with a higher speed of light is higher, while the internal energy of an object in a space with a lower speed of light is lower.

The influence of the speed of light difference on the internal energy of an object reveals the profound relationship between the speed of light and the internal energy of an object, which is of great significance for the research in the fields of vacuum dynamics and cosmology.

3.3 Three Types of Energy Spaces Formed by the Speed of Light Difference

When exploring the influence of the speed of light difference on the energy distribution of space, the vacuum spaces under different speeds of light conditions are now divided into three types of energy spaces: high-energy space, low-energy space, and variable-energy space. The specific definitions are as follows:

The vacuum region with a relatively faster speed of light is called the "high-energy space". In this space, the speed of light is higher, and the internal energy of an object is correspondingly higher. This means that the internal energy of an object with the same mass in the high-energy space is higher than that of objects in other energy spaces.

The vacuum region with a relatively slower speed of light is called the "low-energy space". In the low-energy space, the speed of light is lower, and the internal energy of an object is correspondingly lower. Therefore, the internal energy of an object with the same mass in the low-energy space is lower than that of an object in the high-energy space.

The space between the high-energy space and the low-energy space is called the variable-energy space. In this region, the speed of light c changes with the spatial position, resulting in the internal energy of an object being different with the change of the spatial position.

Both the high-energy space and the low-energy space are inertial spaces. In the inertial space, space-time remains flat. The variable-energy space belongs to a non-inertial space. Since the speed of light changes with the spatial position, the space-time structure will change accordingly. This change may lead to a space-time curvature effect similar to that in a gravitational field. The motion trajectory of an object and the propagation path of light in this type of space will be affected. Therefore, the physical effects in the variable-energy space deserve special attention.

The division of the three energy spaces is shown in Figure (2). This division is helpful for systematically studying the influence of the speed of light difference on the motion of matter.

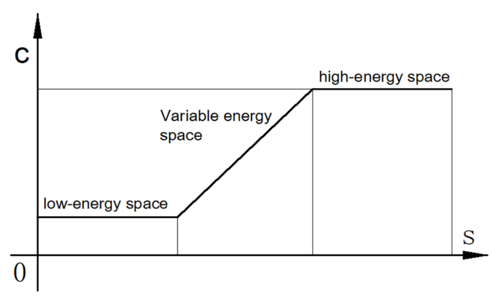

Fig.2. Energy space partitioning

4. The Principle of the Lowest Energy

The principle of the lowest energy [20-22] is a fundamental law of physics, which is widely applicable in various physical fields and serves as the core for understanding the behavior of objects and systems in nature. This principle states that objects or systems will spontaneously tend towards the lowest energy state under ideal conditions. Whether at the macroscopic scale of celestial bodies or the microscopic level of atoms and molecules, objects and systems tend to develop towards the state with the lowest energy.

The core idea of this principle is that when a physical system is in a state of equilibrium, it will be in the state with the lowest energy among all possible states. The system adjusts itself to a stable state with the minimum energy through the exchange, conversion, or transfer of energy. For example, the phenomenon of liquid surface tension is an instance of the principle of the lowest energy. The molecules on the surface of a liquid have relatively high energy, so the liquid will spontaneously contract to reduce the surface tension. In chemistry, atoms form chemical bonds to lower their energy and achieve a more stable state. In astrophysics, the formation of stars and planets also follows the principle of the lowest energy.

As a fundamental law of physics, the principle of the lowest energy clearly reveals the material property of objects and systems spontaneously tending towards a low-energy state in nature. In future research on the vacuum dynamic mechanism, this principle will continue to play a crucial role and become an important theoretical pillar for understanding and explaining related physical phenomena and laws.

5. The Spontaneous Motion of Objects and the Acceleration Field

5.1 Spontaneous Motion and Energy Conversion

In the variable-energy vacuum space where the speed of light changes continuously, objects will spontaneously move towards the region with lower internal energy. This kind of motion conforms to the principle of the lowest energy and is essentially a natural manifestation of the object's tendency towards the state with the minimum energy.

Suppose that the object is not affected by any external force and does not do work externally during this spontaneous motion process. Then the total energy of the object should remain unchanged, and the change amount of its total energy ΔE should be zero. This means that the sum of the change amount of the object's internal energy ΔEi and the change amount of its kinetic energy ΔEv is zero, that is:

$$\Delta E = \Delta Ei + \Delta Ev = 0$$

Therefore, we can obtain:

$$\Delta Ev = -\Delta Ei \tag{11}$$

From the above derivation process, it can be seen that the kinetic energy increased by the object during the spontaneous motion process completely comes from the decrease of the object's internal energy. If it is assumed that the increased kinetic energy of the object comes from the outside, then it is no longer spontaneous motion but forced motion, that is, external force does work. Therefore, the energy source of the increased kinetic energy of the object during spontaneous motion can only be inside the object. In this process, only the excess internal energy released when the object moves towards the state with lower internal energy is the sole source of the object's kinetic energy. This not only ensures the spontaneity of the entire motion process but also satisfies the law of conservation of energy.

Suppose an object with a mass of 1 kg accelerates to 1000 m/s by using its internal energy. Then the ratio of the consumed internal energy to the total internal energy of the object is 5.55×10^{-10}. It can be seen that the internal energy consumed by the object is almost negligible compared with the total internal energy of the object.

5.2 The Spontaneous Force Triggered by the Internal Energy Difference

In a variable-energy vacuum environment, objects will spontaneously accelerate towards the direction of the lower energy state. Since it is an accelerated motion of the object, there must be an acting force. As this is a spontaneous motion without the action of external forces, this force is defined as the spontaneous force F_m of the object.

Suppose the displacement of the object during the accelerated motion is Δs. According to the definition of work, the work ΔA done by the force F_m can be expressed as:

$$\Delta A = F_m \cdot \Delta s$$

From this, the acting force F_m can be obtained:

$$F_m = \frac{\Delta A}{\Delta s}$$

where the work ΔA represents the increment of kinetic energy ΔEv, and is also equal to the decrement of internal energy $-\Delta Ei$,

$$\Delta A = \Delta Ev = -\Delta Ei$$

Based on this, it can be further deduced that:

$$F_m = \frac{\Delta A}{\Delta s} = \frac{\Delta Ev}{\Delta s} = -\frac{\Delta Ei}{\Delta s} \quad (12)$$

Substituting the specific change form of internal energy, we get:

$$F_m = -\frac{\Delta Ei}{\Delta s} = -\frac{\Delta\left(\mathrm{m}c_b^2 - \mathrm{m}c_a^2\right)}{\Delta s} = -\mathrm{m}\frac{d(c^2)}{ds} \quad (13)$$

It can be seen from formula (12) that the value of the spontaneous force F_m is equal to the negative gradient of the change in the object's internal energy with respect to space. Just as in formula (13), in a space with a variable speed of light, even if the object is in a stationary state, there is still a spontaneous force moving towards the lower energy state, which is similar to the gravitational force of an object in a gravitational field.

Through the above discussion, we can have a clearer understanding of the relationship between the change in the object's internal energy and the spontaneous force, and reveal the dynamic mechanism of spontaneous motion in a variable-energy environment.

5.3 The Acceleration Caused by the Speed of Light Difference

To find the acceleration obtained by an object in a variable-energy space, for an object with mass m, let the acceleration generated by the spontaneous force F_m be g_m:

$$g_m = \frac{F_m}{m}$$

Substitute formula (13) into the above formula, and we can get:

$$g_m = -\frac{dc^2}{ds} \qquad (14)$$

Suppose $c^2 = g(x, y, z)$, the acceleration g_m is the negative gradient of the change of the square of the speed of light c^2 with respect to space:

$$g_m = -\nabla g \qquad (15)$$

The square of the speed of light c^2 forms a scalar field in space, while g_m forms a vector field in space. The acceleration g_m obtained by the object is only related to the rate of change of the square of the speed of light c^2 in space, and has nothing to do with the mass of the object. This physical characteristic is consistent with this property of the gravitational field.

Although the continuous change of the speed of light in space does not directly exert any force on the object, it provides the necessary environmental conditions for the spontaneous movement of the object, which is similar to the spontaneous movement of an object in a curved space-time in the general theory of relativity. The difference is that the increased kinetic energy in the former case comes from the internal energy of the object.

5.4 Related Calculations about the Difference in the Speed of Light

In a given vacuum space, assume there is a constant acceleration field $g_m = 10\ m/s^2$. The distance between point A and point B is 1m, and the speed of light at point A is $c_a = 299792458\ m/s$. Now, we will calculate the speed of light c_b at point B, as well as the changes in time and space caused thereby.

1. Calculate the speed of light c_b at point B: According to the relationship formula between acceleration and the difference in the square of the speed of light:

$$g_m = -\frac{dc^2}{ds} = -\frac{\Delta c^2}{\Delta s} = -\frac{{c_b}^2 - {c_a}^2}{\Delta s}$$

Calculate the speed of light c_b at point B:

$$c_b = \sqrt{{c_a}^2 - \mathrm{g} \cdot \Delta \mathrm{s}} = 299,\ 792,\ 457.\ 99999998$$

This shows that the speed of light at point B is slightly lower than that at point A, and the difference is extremely small.

2. The relative change in the speed of light Δc:

$$\Delta c = c_2 - c_1 = -1.66782 \times 10^{-8}\ m/s$$

This shows that an extremely small difference in the speed of light can cause an object to obtain an acceleration of 10 m/s^2. Only when the distance between the two points is as large as 100,000 kilometers will there be a difference of 1.66782m/s in the speed of light. The above calculation results indicate that a small difference in the speed of light can generate a considerable acceleration. At the same time, the difference in the speed of light also causes changes in time and space, which, to a certain extent, is consistent with the spacetime curvature in the general theory of relativity.

6. The Spacetime Structure of Spherically Symmetric Objects and the General Theory of Relativity

By applying the vacuum dynamics theory, this paper deeply explores the influence of spherically symmetric objects on the spacetime structure, which is of great significance for understanding the physical mechanism of gravitational phenomena. The corresponding relationship with the Schwarzschild solution of the general theory of relativity has been discovered, revealing the profound internal connection between spacetime curvature and the relative variation of the speed of light.

Theoretical Framework

1. Foundation of Classical Gravitation

The Law of Universal Gravitation: $F = G\frac{m_1 m_2}{r^2}$

The expression of gravitational acceleration: $g = G\frac{M}{r^2}$

2. Hypotheses of Vacuum Dynamics

As is well known, the gravitational interaction between objects is not an action at a distance, but is realized through changes in the physical state of space. Astronomical observations show that celestial bodies can affect the propagation speed of light: the closer to an object and the greater its mass, the relatively slower the speed of light in that region. Based on the vacuum dynamics theory, the relative change of the speed of light in space can enable an object to obtain an acceleration g_m. Therefore, we hypothesize that the spatial change of the speed of light is precisely the physical cause of the generation of gravitational acceleration g that is:

$$g_m = g$$

Let $Z(r) = c^2(r)$, and establish the differential relationship:

$$\frac{dZ(r)}{dr} = G\frac{M}{r^2} \tag{18}$$

This hypothesis and its corresponding differential relationship constitute an important bridge connecting classical gravitation and vacuum dynamics. Next, we will explore the influence of spherically symmetric objects on the spatial distribution of the speed of light, as well as on space and time.

Mathematical Deduction

1. Solving for the Light Speed Field

Integrating equation (18) above, we obtain:

$$Z(r) = \int G\frac{M}{r^2}dr = D - 2G\frac{M}{r}$$

Let $r \to \infty$, then $D = Z(\infty) = c_1^2$

$$Z(r) = c_1^2 - 2G\frac{M}{r}$$

Note: c_1 is the background speed of light in the vacuum far from the influence of the mass of the sphere, which is consistent with the speed of light c in the Schwarzschild solution of relativity.

The ratio of the squares of the speeds of light:

$$\frac{c^2(r)}{c_1^2} = \frac{Z(r)}{c_1^2} = 1 - 2G\frac{M}{c_1^2 r} \tag{19}$$

The above formula shows that in the case of a spherically symmetric vacuum, the vacuum dynamics theory can reproduce the classical structure in the general theory of relativity, that is, the form of the Schwarzschild metric [23-25]. Specifically, this consistency affirms the correctness of the vacuum dynamics theory, indicating that under basic symmetry and boundary conditions, this theory can achieve the same results as the general theory of relativity. Obtaining the above results shows that the previous hypothesis is correct.

The spacetime components of the Schwarzschild metric in the general theory of relativity are:

$$g_{tt} = -\left(1 - \frac{2GM}{c^2 r}\right) \quad , \quad g_{rr} = \left(1 - \frac{2GM}{c^2 r}\right)^{-1}$$

2. Understanding Universal Gravitation from the Spatial Distribution of the Light Speed Field

The spatial distribution formula of the light speed field:

$$c(r) = \sqrt{Z(r)} = \sqrt{c_1^2 - 2G\frac{M}{r}} \qquad (20)$$

The above formula reflects the spatial distribution of the speed of light c(r) caused by the mass of the sphere. Obviously, this light speed $c(r)$ field is monotonically decreasing from far to near. It is precisely this distribution of the speed of light that forms the universal gravitation between objects. Because this distribution forms a variable energy space with a decreasing trend, lower inside and higher outside, centered on the sphere. Objects spontaneously accelerate towards the low-energy space (towards the center of the sphere), and its acceleration is the negative gradient of the light speed field. The equivalent force that the object is subjected to is traditionally called gravity, but essentially it is a spontaneous force generated by the object to reduce its internal energy. The increased kinetic energy of the object comes from the reduced internal energy of the object itself. Therefore, there is only a direct mutual influence between objects, and there is no direct mutual attractive force. This is the preliminary explanation of the physical cause of the formation of universal gravitation by spherically symmetric objects according to the vacuum dynamics theory.

Derivation of the Spacetime Expansion Effect

1. Time Dilation Effect

According to equation (5), the ratio of the speeds of light is equal to the ratio of time:

$$\frac{\Delta t_2}{\Delta t_1} = \frac{c(r)}{c_1} \quad (21)$$

Calculate the ratio of the speeds of light $\frac{c(r)}{c_1}$:

$$\frac{c(r)}{c_1} = \frac{\sqrt{c_1^2 - 2G\frac{M}{r}}}{c_1} = \sqrt{1 - 2G\frac{M}{c_1^2 r}} \quad (22)$$

Substitute equation (22) into equation (21):

$$\Delta t_2 = \Delta t_1 \sqrt{1 - 2G\frac{M}{c_1^2 r}} \quad (23)$$

Where Δt_1 is the time interval at the point corresponding to c_1, and Δt_2 is the time interval at the position r. This formula quantitatively describes the difference in the rate of time passage at different positions r in the space of a spherically symmetric object compared with Δt_1. The above formula shows that the closer to the object, the slower the passage of time. When r approaches $2G\frac{M}{c_1^2}$ infinitely, the passage of time Δt_2 approaches a stop, and at this time, r is called the Schwarzschild radius r_s. The Schwarzschild radius is an important concept in the general theory of relativity, especially crucial when studying black holes and gravitational singularities. This is also an important achievement of the vacuum dynamics theory.

Equation (22) is completely consistent with the Schwarzschild time dilation formula:

$$\Delta t(r) = t_\infty \sqrt{-g_{tt}}$$

2. Space Expansion Effect

Based on the principle of the constancy of the speed of light, the speed of light at any point in a vacuum must remain the same, which means that the scaling ratios of time and space must be the same. Therefore, the scaling ratio of time is the scaling ratio of space, and the relationship formula for the scaling of the vacuum space can be obtained:

$$\Delta s_2 = \Delta s_1 \sqrt{1 - 2G\frac{M}{c_1^2 r}} \qquad (26)$$

Where Δs_1 is the spatial interval at the point corresponding to c_1, and Δs_2 is the spatial interval at the position r. This relationship is applicable to the scale comparison between the local spaces of static observers, and has the following corresponding relationship formula with the Schwarzschild space expansion:

$$\Delta s(r) = s_\infty \sqrt{g_{rr}^{-1}}$$

In conclusion, from the perspective of vacuum dynamics, the influence of spherically symmetric objects on the distribution of time, space, and the speed of light has been verified, and the corresponding calculation formulas have been obtained. The physical cause of the generation of universal gravitation has been clarified.

The consistency between the Schwarzschild spacetime factor derived from the vacuum dynamics theory and the general theory of relativity, as well as the spacetime calculation formulas, indicates that although the two theoretical paths are very different, they reach the same conclusion when describing static spherically symmetric spacetime, and reveals the deep-seated consistency between the two theories. In other words, the light speed gradient effect and the phenomenon of spacetime curvature are essentially equivalent. Importantly, the light speed field plays a key role in connecting the matter distribution and the spacetime structure, and at the same time highlights the fundamental position of the properties of the vacuum in basic physical theories. This research achievement not only deepens the understanding of the nature of spacetime, but also equation (18) once again reflects the famous assertion that "matter tells space how to curve, and space tells matter how to move".

7. The Source of Dark Energy

Dark energy [26-27] drives the accelerated expansion of the universe, yet its nature and origin remain mysterious. Based on the vacuum dynamics theory, this paper proposes that dark energy may be closely related to the distribution characteristics of the speed of light in the universe.

The vacuum dynamics theory hypothesizes that the speed of light in the universe presents a gradient distribution of "higher in the center and lower at the edges": the speed of light is relatively fast in the central region of the universe, corresponding to a high-energy space; while the speed of light is relatively slow in the edge region, corresponding to a low-energy space. Since the speed of light gradually decreases from the center to the edges, celestial bodies spontaneously move towards the regions with a lower speed of light, which macroscopically manifests as the expansion of the universe. In this process, the increase in the kinetic energy of objects does not rely on external forces, but is converted from their internal energy, and this release of internal energy may be the source of dark energy.

This distribution pattern of the speed of light, which is "higher inside and lower outside", is consistent with the evolutionary process of energy diffusion from the center to the outside after the Big Bang. Many astronomical observations show that the time it takes for light from distant celestial bodies to reach the Earth significantly exceeds the predictions of traditional theories [29-30], which, to a certain extent, verifies the view that "the farther away from us, the slower the speed of light".

In addition, astronomical observations have also found that as the distance of celestial bodies increases, their redshift effect becomes more significant. This not only conforms to Hubble's law but also fits the above hypothesis of the speed of light distribution. Since the speed of light is faster in the center of the universe and slower at the edges, as the distance of celestial bodies increases, the decrease in the speed of light leads to an increase in the wavelength of the light emitted by celestial bodies, thereby enhancing the redshift effect of celestial bodies. That is to say, the redshift of celestial bodies not only reflects their receding speed but also contains the redshift component caused by the decrease in the speed of light. If all redshifts are attributed to the motion of celestial bodies, there will be calculation errors in speed. Especially when the distance exceeds 5 billion light-years, it is highly likely to derive the unreasonable conclusion that the motion speed of celestial bodies exceeds the speed of light [28].

Although the hypothesis that dark energy originates from the conversion of the internal energy of objects still needs further verification, this idea provides a new perspective for understanding the nature of dark energy. It is recommended that in future research on dark energy, more attention should be paid to the changes in the speed of light in different regions of the universe, and in-depth analysis should be conducted on the cosmic microwave background radiation (CMB) and redshift distribution data to provide more observational evidence for the distribution pattern of the speed of light being "higher in the center and lower at the edges".

8 Conclusion

The vacuum dynamics theory is established on the basis of the principle of relative variation of the speed of light, constructing a self-consistent theoretical system. This theory holds that the relative gradient change of the light speed parameter in the vacuum space is the fundamental cause of the accelerated motion of objects, thus providing a unified interpretive framework for universal gravitation, the phenomenon of celestial bodies accelerating away during the expansion of the universe, and the source of dark energy.

Similar to the theory of universal gravitation and the general theory of relativity, the vacuum dynamics theory also studies the motion laws of objects in a vacuum and has many similarities with them in various aspects. However, the key difference lies in that this theory believes that the inhomogeneous distribution of the light speed field in the vacuum space causes objects to spontaneously move towards a state of lower internal energy, and the kinetic energy required for their motion directly comes from the release and conversion of the internal energy of the objects.

In addition, the vacuum dynamics theory provides a theoretical framework for the unification of the gravitational field and the electromagnetic field, and lays a solid theoretical foundation for the research on anti-gravitational field technology.

This paper aims to expound the basic physical ideas of the vacuum dynamics theory. Although there are still many issues that require in-depth study, it is hoped that this paper can arouse the academic community's attention to the vacuum dynamic mechanism, promote the further development and improvement of this theory, and thus contribute to the progress of the fundamental theories of physics.

Corresponding author：Li Yake , Email:liyk29@163.com

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