5-dimensional space-time mapping and Planck quantum gravity theory

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Abstract

In 5-dimensional space-time, the Planck quantum gravity theory can be constructed based on standard quantum field theory methods. The 4-dimensional space-time observed by humans is a mapping of the 5-dimensional space-time. The mapping from 5-dimensional space-time to 4-dimensional space-time satisfies the path integration rule. By using the path integration method, the space-time mapping can be deduced and calculated, so as to transform the Planck quantum gravity theory of 5-dimensional space-time into Planck gravity theory in 4-dimensional space-time, and then calculate and explain the gravitational phenomena in 4-dimensional space-time, which is consistent with the experimental results in 4-dimensional space-time. Physically, the mapping from high-dimensional space-time to low-dimensional space-time requires the use of path integration rules, which is the space-time mapping principle. The gravitational mass in 4-dimensional space-time comes from the space-time mapping, and the gravitational mass is just the inertial mass, and there is no independent gravitational mass. The physical meaning of mass in gravity is to denote a new type of probability density. In the 4-dimensional space-time, Planck quantum gravity theory has different calculation results from other gravitational theories in five aspects, and whether Planck quantum gravity theory is consistent with the real universe can be tested experimentally.

Keywords

Planck quantum gravity theory, quantum gravity, intrinsic length, Planck length, 5-dimensional space-time, 4-dimensional space-time, path integration, space-time mapping, space-time mapping principle, gravitational mass, inertial mass, probability density.

1. Introduction

The origin and essence of gravity is always a big question waiting to be solved for human beings. Newton developed Newton gravity theory [1]. Albert Einstein proposed the general relativity theory [2]. However, general relativity cannot be quantized, and general relativity and quantum field theory cannot be unified. Can gravity be quantized? Is gravity a quantized force? Is there a self-consistent theory of quantum gravity? There are great controversies and differences on these issues, which urgently need to be resolved by mankind.

In physics, there are two distinct concepts of mass [1]. One is the inertial mass and the other is the gravitational mass. Humans assume that the numerical values of these two masses are equal. This assumption is also fully consistent with the actual experimental results. However, this is always only a theoretical hypothesis. There are two different mass concepts in physics that are always puzzling. Why can't these two mass concepts be unified? As for the physical origin and essence of gravitational mass, humans do not yet know the answer. A true theory of quantum gravity should be able to reveal the answer to this question, revealing the origin and essence of gravitational mass.

2. Planck quantum gravity theory

In a previous paper, the authors proposed a Planck quantum gravity theory [3]. The Planck quantum gravity theory has two basic concepts.

First, the physical space-time that really exists is 5-dimensional space-time, 4-dimensional space and 1-dimensional time. The 4-dimensional space-time observed by humans is actually a mapping of the 5-dimensional space-time. For humans, the essence of this space-time mapping is still an unknown question. Humans don't know why this space-time mapping exists, or what the property of this space-time mapping is. In 5-dimensional space-time, all particles move at the speed of light. The speed of light can be seen as an intrinsic property of particles, and the speed of light is the intrinsic speed of particles. This phenomenon can be seen as a kind of speed quantization. In 5-dimensional space-time, particles do not have the rest mass. The physical essence of the rest mass of particles in 4-dimensional space-time is the kinetic energy in the 4th spatial dimension. To put it simply, you can think of this space-time mapping as a projection. The kinetic energy in the 4th spatial dimension, projected into the 3-dimensional space, is the rest mass of the particle as observed by humans. The kinetic energy in the 4th spatial dimension is not changed by physical force in the 3-dimensional space. Therefore, when observed in 3-dimensional space, the rest mass of the particle remains constant and is a reference frame invariant. Based on this hypothetical model, all the results and formulas of special relativity can be derived [4].

The equation for the energy of a particle in 5-dimensional space-time is (2.1), where M is the rest mass of the particle in 4-dimensional space-time.

$$E = \sqrt{P_1^2C^2 + P_2^2C^2 + P_3^2C^2 + P_4^2C^2} = \sqrt{P_1^2C^2 + P_2^2C^2 + P_3^2C^2 + M^2C^4} \quad (2.1)$$

$$P_4^2C^2 = M^2C^4$$

Second, in 5-dimensional space-time, all particles do not have rest mass, and all particles can be treated as a unified scalar particle regardless of the differences in spin, charge, and other quantum properties. All particles form a uniform scalar particle field. For this unified scalar particle field, the free particles move at the speed of light. This is the standard $\varphi 4$ quantum field theory method [5][6].

The wave function of the particle field at a point in 5-dimensional space-time(4-dimensional space) satisfies equation (2.2).

$$\varphi(x) = \int \frac{d_p^4}{(2\pi)^4} \frac{1}{\sqrt{2E_p}} (a_p e^{ip\cdot x} + a_p^+ e^{-ip\cdot x}) \quad (2.2)$$

The propagator corresponding to this particle field is (2.3).

$$D(x-y) = \int \frac{d_k^5}{(2\pi)^5} \frac{e^{-ik(x-y)}}{k^2+i\varepsilon} \quad (2.3)$$

The Planck gravity theory proposes that the excited particles of this particle field have an intrinsic length property. We use the symbol ℓ to identify this intrinsic length. This intrinsic length satisfies formula (2.4).

$$\ell = 2\pi L_p \tag{2.4}$$

The L_p is Planck length. The intrinsic length is similar to that of electric charge, both originate from quantization, and both are intrinsic properties of a particle, but this intrinsic property has a dimension of length. For this intrinsic length, it can be handled using a quantum field theory approach similar to that of electric charge.

For the two excitation point sources of the particle field, after adding the intrinsic length property to excited particles, we get the representation formula (2.5).

$$J = J(\overrightarrow{x_1}) + J(\overrightarrow{x_2}) = \ell^2\delta(\overrightarrow{x_1}) + \ell^2\delta(\overrightarrow{x_2}) = 4\pi^2 L_p^2\delta(\overrightarrow{x_1}) + 4\pi^2 L_p^2\delta(\overrightarrow{x_2}) \tag{2.5}$$

This results in an interaction potential between the two point sources. The potential formula is (2.6).

$$E(J) = 4\pi^2 L_p^2 D(\overrightarrow{x_1} - \overrightarrow{x_2}) = 4\pi^2 L_p^2 D(\vec{r}) = 4\pi^2 L_p^2 \int \frac{d_k^4}{(2\pi)^4}\frac{e^{-i\vec{k}\cdot\vec{r}}}{k^2 + i\varepsilon} = \frac{2\pi L_p^2}{r^2} \tag{2.6}$$

The excitation particle subjected to the force satisfies the on-shell condition and has a definite energy E. E satisfies the above equation (2.1). So, the potential energy formula of an excited particle is (2.7).

$$V = \frac{2\pi L_p^2}{r^2}E \tag{2.7}$$

Please pay attention to the distinction. This potential energy formula is represented in 5-dimensional space-time. The distance r is the distance in 4-dimensional space.

The above derivation process uses standard quantum field theory methods. So, we can get a fully quantized potential. What is the relationship between this potential and gravity?

We know that in 4-dimensional space-time, there is the following equation (2.8) for the Planck length.

$$\frac{h}{MC}\frac{GM}{C^2} = \lambda_0 r_0 = \frac{hG}{C^3} = 2\pi L_p^2 \tag{2.8}$$

$$\frac{h}{MC} = \lambda_0$$

$$\frac{GM}{C^2} = r_0$$

The λ_0 is the Compton length of particle. The r_0 is the gravitational radius of particle. The authors hypothesize that there is an unknown mapping between 5-dimensional space-time and 4-dimensional space-time. The real potential exists in 5-dimensional space-time. Under this unknown mapping, the Planck length in the potential (2.7) in 4-dimensional space disappears and becomes the gravitational radius of the particle in 3-dimensional space. At the same time, the 4th spatial dimension disappears, leaving behind three spatial dimensions. The square of a 4-dimensional distance is transformed into the 3-dimensional distance. In 3-dimensional space, this potential is transformed into equation (2.9).

$$V = \frac{GM}{C^2}\frac{E}{r} = \frac{r_0}{r}E \tag{2.9}$$

In equation (2.9), V is the potential in 3-dimensional space. r is the 3-dimensional distance between the stressed particle and the source particle. E is the energy of the stressed particle, satisfying equation (2.1). The r_0 is the gravitational radius of the source particle.

In equation (2.9), E is the energy of the stressed particle. When the velocity of the particle in 3-dimensional space is small, there is equation (2.10).

$$E \approx m_0 C^2 \tag{2.10}$$

Take (2.10) into (2.9), so we get the Newton gravitational potential formula (2.11).

$$V = \frac{GM}{C^2}\frac{E}{r} = \frac{GM}{C^2}\frac{m_0 C^2}{r} = \frac{GMm_0}{r} \tag{2.11}$$

So, we can draw a conclusion. This potential in 5-dimensional space-time is the gravitational potential in 4-dimensional space-time. Therefore, the force that exists in the particle field in 5 dimensions of space-time is just the gravitational force.

The gravitational force observed by humans in 4-dimensional space-time is actually a mapping effect of gravity in 5-dimensional space-time. In 5-dimensional space-time, gravity has a fully quantum field-theoretic property. Mapped into 4-dimensional space-time, the quantum properties of gravity disappear, and gravity seems to become a purely classical force. But this is just an illusion, and this illusion misleads humanity. The truth of gravity actually exists in 5-dimensional space-time, and gravity is actually a purely quantized force.

We can also find a conclusion. In 5-dimensional space-time, gravitational potential energy is equation (2.7). This formula has nothing to do with the gravitational mass of the particle. The gravitational strength of a gravitational source is identified by the L_p^2 . The gravitational mass M of the gravitational source is brought in during the space-time mapping. Therefore, the physical essence of gravitational mass is closely related to this space-time mapping. Just by uncovering the property of this space-time mapping, the truth about gravitational mass can be revealed.

In Planck quantum gravity theory, a space-time mapping needs to be assumed in order to bring about equation (2.8), and we can deduce the gravitational force in 4-dimensional space-time. This mapping space-time is a theoretical assumption, which is also a big flaw of this theory of gravity. This space-time mapping will be described in detail below, and the equation (2.8) can be reasonably derived, so that the final piece of the puzzle of Planck quantum gravity theory can be completed.

3. Mapping from 5-dimensional space-time to 4-dimensional space-time

Through careful analysis, we can find that the mapping relationship between 5-dimensional space-time and 4-dimensional space-time is actually not a simple projection relationship. Geometrically, a 3-dimensional space can be thought of simply as a projection of a 4-dimensional space. However, gravity in 5-dimensional space-time is a quantized process that follows the rules of quantum mechanics. There is a well-known Feynman path integral rule in quantum mechanics [5][6][7]. For a physical result, if we can't strictly distinguish between the different paths that lead to the result, then we need to integrate all the different possible paths to get the result. Based on the path integration rules, we carefully analyze and find one result. For one result in a 3-dimensional space, there are several different situations in a 4-dimensional space that can lead to results in the same 3-dimensional space. Then, for the physical results in the 3-dimensional space, all possible paths in the 4-dimensional space need to be integrated to get the physical results in the 3-dimensional space.

In 3-dimensional space, a stressed particle B and a gravitational source particle A have a distance of r between them, and they are unique. However, in a 4-dimensional space, we can find that several different cases can be mapped to the same situation in a 3-dimensional space, which is not unique in a 4-dimensional space. This is shown in Figure 1 below.

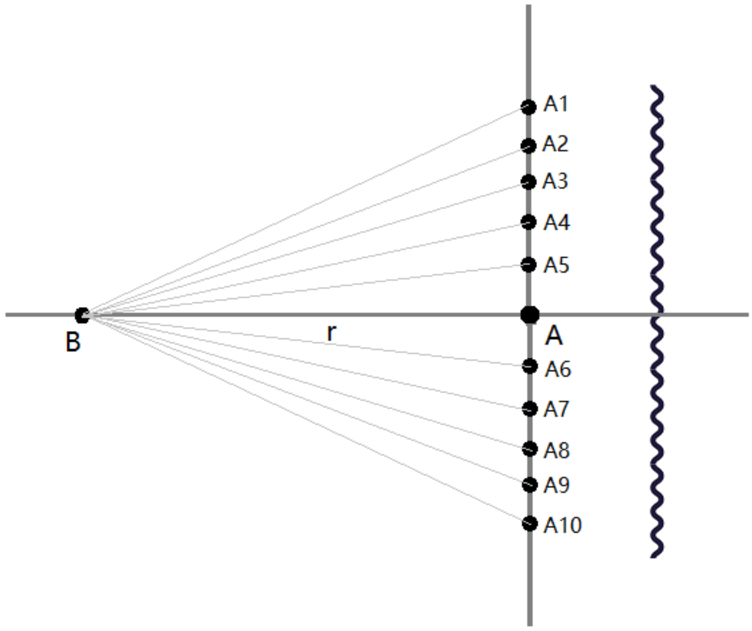

Figure 1

In Figure 1, there is stressed particle B and gravitational source particle A in three-dimensional space, and the 3-dimensional distance between the two is r. However, in 4-dimensional space, particle B may be subject to the gravitational pull exerted by many particles. For example, A1 to A10 can be sources of particles that exert a gravitational pull on B. A1 to A10 have different coordinates in the 4th dimension, but the kinetic energy in the 4th dimension is the same, and the corresponding rest mass M is the same. Mapped to 3-dimensional space, they are all the same gravitational source particle A. In 3-dimensional space, it is impossible to distinguish the difference between these gravitational source particles. In fact, in 4-dimensional space, there are an infinite number of gravitational source particles, all mapped to the same gravitational source particle in 3-dimensional space. According to the path integration rule, the gravitational force exerted by particle B in 3-dimensional space needs to be integrated with the gravitational force exerted by all these gravitational source particles to obtain the gravitational force exerted by particle B in 3-dimensional space. Therefore, the gravitational potential energy of particle B in 3-dimensional space should be summed and integrated by equation (2.7).

However, path integration in quantum mechanics is the sum of all possibilities, not the numerical sum of physical quantities. In 4-dimensional space, particles still have the properties of particle waves. Particle waves characterize the probability of particles appearing in space. Obviously, because of the existence of particle waves, the probability of particle A excitation in the 4th dimension is related to the wavelength of the 4th dimension. The probability of particle A excitation over the length of ds is obviously inversely proportional to the wavelength of the particle wave. The smaller the wavelength, the greater the probability that the particle will be excited within the length of ds. Conversely, the larger the wavelength, the smaller the probability that the particle will be excited within the length of ds. Therefore, the probability of a particle being excited within the length of ds is given in the following equation (3.1).

$$dp = \alpha \frac{ds}{\lambda_4} \tag{3.1}$$

The α is a proportionality constant. The λ_4 is the wavelength of the particle in the 4th spatial dimension. The dp actually represents the probability density within the length of ds.

On the basis of the formula for gravitational potential energy in 4-dimensional space (2.7), the sum of all the probabilities gives equation (3.2).

$$V = 2\pi L_p^2 E \int \frac{dp}{r^2+s^2} = 2\pi L_p^2 E \int \frac{\alpha}{r^2+s^2} \frac{ds}{\lambda_4} \tag{3.2}$$

The E is the energy of the stressed particle, s is the coordinate length in the 4th dimension, and r is the coordinate length in the 3-dimensional space. The square of the distance R in 4-dimensional space satisfies $R^2 = r^2 + s^2$.

The wavelength of the particle in the 4th spatial dimension is just the Compton wavelength, and there is a formula (3.3).

$$\lambda_4 = \frac{h}{P_4} = \frac{h}{MC} \tag{3.3}$$

The M is the rest mass of particle A in 3-dimensional space, which actually represents the kinetic energy of particle A in the 4th spatial dimension.

There is an integral formula (3.4).

$$\int \frac{ds}{r^2+s^2} = \frac{1}{r} \arctan\left(\frac{s}{r}\right) \tag{3.4}$$

The 3-dimensional spatial distance r is a fixed value. The integral range of the 4th dimensional coordinates s is positive infinity to negative infinity. So, the integral value of $\arctan\left(\frac{s}{r}\right)$ is π. Taking the integral values of (3.3) and (3.4) into (3.2), so gives equation (3.5). Equation (3.5) is the equation (2.9) for the potential energy of particle B in 3-dimensional space. There is only one constant difference between the two formulas.

$$V = \frac{\pi\alpha GM}{C^2} E \tag{3.5}$$

The $\pi\alpha$ is constant. This constant requires experiments to determine its value. Based on the experimental results, it can be assumed that the value of this constant is 1. If the intrinsic length of the particle is not $2\pi L_p^2$ in the gravitational equation (2.7) in 5-dimensional space-time, but is something else, the constant of $\pi\alpha$ in equation (3.5) is not equal to 1.

From the above derivation, it can be seen that. The equation (2.8) that exists in 3-dimensional space is actually the result of the summation of the gravitational effect in the 4-dimensional space. From this summation process, this formula can be derived naturally. This formula is no longer just an experimental summary formula, nor is it a hypothetical formula, but there is a corresponding physical process.

We can see that the path integral rule in quantum mechanics plays a key role in this derivation process. The gravitational force in a 4-dimensional space is mapped to a 3-

dimensional space, satisfying this path integration rule. For a quantum physical process, the mapping of 5-dimensional space-time (4-dimensional space) to 4-dimensional space-time (3-dimensional space) is not a purely geometrical projection, but satisfies the path integral rule. At this point, a huge difference between geometry and physics can be seen.

Physically, there is a more complex relationship between high-dimensional space-time and low-dimensional space-time, and the mapping between high-dimensional space-time and low-dimensional space-time needs to be calculated using path integration rules. This can be seen as the space-time mapping principle. This result has implications for other physics problems of space-time mapping.

In equation (3.1), particle wavelengths show an important role. In conventional physical processes, it seems that the role of wavelength is only to produce phase interference effects, and wavelength is not related to the distribution probability, only the probability amplitude is related to the distribution probability. In the mapping from 5-dimensional space-time to 4-dimensional space-time, there is no interference and diffraction of particle waves, but particle wavelength shows an important role. When we talk about the probability of distribution of particles in space, in this case, it is not only the probability amplitude that is related to the probability of distribution, but also the wavelength of the particle. Therefore, particle wavelengths in quantum mechanics are not only mathematically significant, but also physically significant. In quantum mechanics, the relationship between particle wavelength and distribution probability is a topic that needs to be studied in depth.

In this space-time mapping, the path integration rule shows a very important significance. Path integration is applied to space-time mapping, which is a very surprising result. Behind the path integral theory, there are many secrets hidden that are not known to humans.

In the above derivation process, there is a question, why is the path integration only performed on the gravitational source particle A, but not on the stress particle B? For stressed particles, only their energy is embodied in the gravitational equation (2.7). The energy of the stressed particles is the same in both 5-dimensional and 4-dimensional space-time. There is no direct correlation between the energy of the stressed particles and the 4th spatial dimension. Therefore, the energy of the stressed particles is not treated as path integral. Here we can draw another conclusion. For a certain physical quantity, its presentation in high-dimensional space-time is different from that of low-dimensional space-time, that is, there is a direct correlation between the physical quantity and the high-dimensional space dimension, and only in this case can use the path integration method to the physical quantity in the space-time mapping. This should be another rule of the space-time mapping.

As can be seen from the derivation process above. The formula for gravitational potential in 5-dimensional space-time is (2.7). In 5-dimensional space-time, gravity is completely independent of the mass of the particle, and there is no gravitational mass. The intrinsic length of a particle is the only characteristic of gravity. In the process of space-time mapping from 5D to 4D, the path integration of probability is processed, and the probability is (3.1). The probability is related to the wavelength λ_4 of the particle in the 4th spatial dimension, and λ_4 is introduced by equation (3.1). The λ_4 is related to the rest mass of the particle. Thus the rest mass of the particle is introduced in the gravitational force. Therefore, the gravitational mass in 4-dimensional space-time is the rest mass of the particle. The rest mass of the particle is the inertial mass. So, gravitational mass is inertial mass. The two masses are essentially the same physical quantity, and there is no separate gravitational mass. This leads to a plausible explanation for the equality of gravitational mass and inertial mass. In Planck quantum gravity theory, the equality of gravitational mass and inertial mass is no longer just a hypothesis, but the result of a theoretical derivation.

Combining equations (3.1) and (3.3), we get a probability density formula (3.6).

$$\frac{dp}{ds} = \frac{\alpha}{\lambda_4} = \frac{\alpha MC}{h} = \mu M \tag{3.6}$$

where μ is a probability density coefficient. As can be seen from this formula, the true physical meaning of gravitational mass in gravitational force is to denote probability density. The greater the gravitational mass of the gravitational source, the greater the probability density during space-time mapping. The higher the probability density, the stronger the gravitational force generated in 4-dimensional space-time after the path integral summation. However, be careful about the distinction. The probability density here is only the probability density in the process of path integration of gravity, and it is only the probability density in the process of space-time mapping. In 4-dimensional space-time (3-dimensional space), this probability density no longer exists. In 4-dimensional space-time, only the final result of the path integration can be observed, and the intermediate state of the path integration cannot be observed.

It can be seen from here. In 4-dimensional space-time, the gravitational intensity generated by the gravitational source is only related to the rest mass of the gravitational source, not the energy of the gravitational source. Particles of the same type, such as neutrons, produce the same gravitational force regardless of whether they are moving or not, regardless of whether their speed is high or low. Energy cannot act as a source of gravitational force. This is completely different from the conclusion of general relativity. Taking advantage of this difference, in 4-dimensional space-time, the gravitational strength of high-speed moving objects and static objects can be measured and compared, and it is possible to test which theory is consistent with the real situation.

From the above derivation, we can solve another important problem. Since the real gravitational force exists in the 5th dimension of space-time, it must have an influence on the kinetic energy of the particle in the 4th dimension, so the gravitational field will bring about changes in the rest mass of the particle. However, this result has not been measured in the gravitational field in 4-dimensional space-time. Why? Because the path integration result of the 4th dimensional space is $\arctan\left(\frac{s}{r}\right)$. The result of this integration is a finite value, and the maximum is π. In 3-dimensional space, this integral result is exactly a constant. Therefore, the gravitational effect in the 4th dimension of space is only an integral constant in the 3-dimensional space, so humans cannot distinguish it. Path integration plays a key role in this. The real gravitational force exists in the 5-dimensional space-time, but due to the path integration, the change of gravity in the 4th spatial dimension cannot be observed in the 4-dimensional space-time. This is a very surprising result.

Based on the 5-dimensional space-time, we can obtain a self-consistent and valid theoretical model of quantum gravity. Based on this gravitational model, we can calculate the gravitational results observed in 4-dimensional space-time. Therefore, human beings must think about the real existence of 5-dimensional space-time, and how to experimentally detect

5-dimensional space-time will become a practical problem in physics.

4. Experimental verification of Planck quantum gravity theory

According to Planck quantum gravity theory, the theory can be experimentally verified in the following five aspects.

(1). In 4-dimensional space-time, the rest mass of the photon is zero, and the photon does not have kinetic energy in the 4th spatial dimension, so the photon does not have the path integration process of space-time mapping, so the gravitational force generated by the photon in the 4-dimensional space-time is still equation (2.7). The gravitational potential produced by a photon is inversely proportional to the square of the distance, and the gravitational strength is inversely proportional to the cube of the distance. The gravitational intensity produced by photons is independent of the energy of the photons, and all photons produce the same gravitational intensity. By measuring and comparing the gravitational strength generated by low-frequency photons and high-frequency photons, it is possible to test whether Planck quantum gravity theory is true to the real situation.

(2). Planck quantum gravity theory is a theoretical model expressed using the standard quantum field theory method. Therefore, the theoretical model is actually a theoretical framework. The authors predict that for quasiparticle systems suitable for quantum field theory, there should be similar gravitational effects between quasiparticles. If similar gravitational effects between quasiparticles are measured in condensed matter physics, it can be verified that Planck quantum gravity theory is true. This was described in detail in the previous paper [3]. Please read the paper for a detailed explanation.

(3). In the four-dimensional space-time, in Planck quantum gravity theory, the gravitational strength generated by the gravitational source is only related to its rest mass, not to the energy of the gravitational source. Therefore, the gravitational force of the same type of particle, high-speed particles and low-speed particles is the same. Therefore, by measuring the gravitational strength generated by high-speed moving objects and measuring the gravitational strength generated by static objects, and comparing the differences between the two, we can test whether Planck quantum gravity theory is consistent with the real situation.

(4). In another paper [8], the author applied Planck gravity theory in 4-dimensional space-time to cosmology and derived a new Friedmann equation. From this equation, a formula (4.1) for the proportional relationship between dark energy and matter in the universe can be derived.

$$\rho_A = (1 + Z_i)^2 \rho \tag{4.1}$$

The ρ_A is the density of dark energy, the ρ is the density of matter in the universe, and Z_i is the value of the cosmic redshift at the inflection point of the universe's expansion. The inflection point of cosmic expansion is the transition period of the universe from deceleration to accelerated expansion. This formula is in perfect agreement with the results of cosmological experimental measurements.

From this new Friedmann equation, the evolutionary equation (4.2) for dark energy density is also calculated

$$\rho_A = \frac{3A^2 M}{4\pi C^2 r} \tag{4.2}$$

The A is a constant, M is the total mass of matter in the universe, and r is the radius of the universe. The equation predicts that as the universe continues to expand, the density of dark energy will gradually decrease. By measuring the change about the density of dark energy, it is possible to test whether Planck quantum gravity theory is true.

(5). In 4-dimensional space-time, using Planck gravity theory to calculate the orbits of stars, the orbit equation (4.3) will be obtained.

$$\frac{d^2u}{d\theta^2}+u=\frac{GM}{L^2}+3\frac{GM}{C^2}u^2+\frac{V_r^2}{V_\theta^2}u^2 \tag{4.3}$$

For a detailed calculation of this equation, please refer to equation (3.1.12) in paper [9]. Based on Newton gravity theory, there are two first-order corrections in this equation. There is a new correction here. This correction is related to the eccentricity of the orbit. The equation predicts that the greater the orbital eccentricity of a star, the stronger the gravitational pull on the star. Compared with the results of general relativity, the orbital precession is stronger. The greater the eccentricity of the orbit of the star, the greater the difference. By measuring the orbits of stars with large eccentricities, compare the results of the two theories, we can test which theory is more in line with the real situation.

5. Conclusion

In this paper, the author derives and calculates the space-time mapping of gravity according to the path integral rule of quantum field theory. Based on Planck quantum gravity theory in 5-dimensional space-time, and using the path integration method of quantum field theory, the gravitational results observed by humans in 4-dimensional space-time can be deduced and calculated. It proves that Planck quantum gravity theory is a self-consistent and complete theory about gravity. Planck quantum gravity theory also reveals the physical essence of gravitational mass. Gravitational mass is actually inertial mass. Independent gravitational masses do not exist. We can also find that there is a big difference between the geometric and physical methods for the problem of mapping high-dimensional space-time to low-dimensional space-time. The physical process of mapping high-dimensional space-time to low-dimensional space-time must be calculated using path integration rules. This is the space-time mapping principle. Planck quantum gravity theory differs from general relativity in five aspects. Experiments in these five aspects can be used to test whether Planck quantum gravity theory is in line with the actual situation of the universe. Humanity needs to examine the true existence of 5-dimensional space-time.

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