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RESEARCH ARTICLE

DARK ENERGY IS THE COUPLING EFFECT BETWEEN COSMIC EXPANSION AND GRAVITY

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ABSTRACT

In the Planck Gravity Theory, there is a new coupling between cosmic expansion and gravity. With this new gravitational coupling, we can simply explain the phenomenon of accelerated expansion of the universe. The properties of the new gravitational coupling are consistent with the characteristics of dark energy and experimental measurements. This proves that the new gravitational coupling is dark energy. Dark energy does not exist. This theoretical model is also a method of accurately measuring the total mass of the universe. By making precise measurements of the rate of expansion of the universe, the total mass of the universe can be calculated.

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INTRODUCTION

Since the discovery of the accelerated expansion of the universe (1) (2), how to explain this phenomenon in theory has become a big problem in physics and cosmology. Humans have come up with various theories to explain this phenomenon. The dark energy was also proposed (3).The researchers propose that the force that causes the universe to accelerate its expansion comes from a mysterious energy unknown to human beings, which is called dark energy. Dark energy, in contrast to conventional matter, does not produce gravitational pull, but repulsive force, so it causes the universe to expand at an accelerated rate. The researchers hypothesized an energy unknown to humans and mysterious. It is this energy that causes the universe to expand at an accelerated rate. This energy is called dark energy. Dark energy is the opposite of conventional matter. Dark energy does not produce gravitational pull, but repulsion, so it causes the universe to expand at an accelerated rate. However, humans have not been able to detect dark energy in experiments. Humans have been unable to confirm the existence of dark energy. Whether dark energy really exists, and what kind of properties dark energy has. This becomes a big problem in physics and cosmology. If the cause of the accelerated expansion of the universe is not dark energy, then what will be the reason? Is it possible for humanity to find the cause of the accelerated expansion of the universe within the scope of known physical theories? On the issue of the accelerated expansion of the universe and dark energy, humanity seems to have reached a dead end and cannot find a way out. Humanity desperately needs new ideas to solve this big problem. The authors propose a new Planck Gravity Theory (4) (5). The theory has a lot of new ideas and reveals a lot of new gravitational properties. In Planck Gravity Theory, the author found a theoretical model. This theoretical model can explain the accelerating expansion of the universe simply and clearly, and does not require other additional assumptions. Sowe can solve the problem of dark energy

2. cosmology equation in Planck Gravity Theory

A particle moves in the gravitational field of mass M. The gravitational potential energy of the particle is formula (1.1).

$$U = \frac{GMm}{r} = \frac{r_0}{r} mC^2 \tag{1.1}$$

The r_0 is scale constant of the gravitational field. It identifies the strength of the gravitational field. If the mass of the gravitational source is M, the scale constant is formula (1.2).

$$r_0 = \frac{GM}{C^2} \tag{1.2}$$

In formula (1.1), the m satisfies formula $mC^2 = \sqrt{P^2C^2 + m_0^2C^4}$, which is the mass-energy equation. The gravitational potential energy is negative. So the total energy of particle moving in the gravitational field is formula (1.3).

$$E = (1 - \frac{r_0}{r})mC^2 \tag{1.3}$$

For a particle moving in a gravitational field, its total energy E is conserved, so it is a constant. We use E_0 to identify the total energy. From (1.3), we can get.

$$m = \frac{E_0}{C^2(1 - {r_0}/{r})}$$

So we get.

$$\ln m = \ln(\frac{E_0}{C^2}) - \ln(1 - \frac{r_0}{r})$$

$$\frac{d(\ln m)}{dr} = -\frac{d\left(\ln\left(1 - \frac{r_0}{r}\right)\right)}{dr} = -\frac{r_0}{(r - r_0)r}$$

In the case of a weak gravitational field approximation, $r_0 \ll r$, so get

$$\frac{d(\ln m)}{dr} = -\frac{r_0}{r^2} \tag{1.4}$$

According to the cosmological principles and the law of gravity, a particle moves around a sphere with a radius of r, the gravitational attraction that the particle feel is formula (1.5) (6) (7).

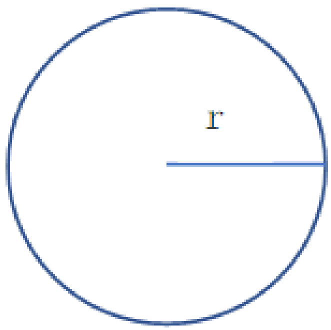

Figure 1

$$F = \frac{dP}{dt} = \frac{d(mV)}{dt} = \frac{dU}{dr} \tag{1.5}$$

$$\frac{d(mV)}{dt} = m\frac{dV}{dt} + V\frac{dm}{dt} \tag{1.6}$$

In the case of a weak gravitational field approximation, the second item is small, we can omit it. So we get.

$$\frac{d(mV)}{dt} = m\frac{dV}{dt} \tag{1.7}$$

$$\frac{dU}{dr} = \frac{d(\frac{r_0}{r} mC^2)}{dr} = -\frac{r_0 mC^2}{r^2} + \frac{r_0 C^2}{r}\frac{dm}{dr}$$

So we get.

$$m\frac{dV}{dt} = -\frac{r_0 mC^2}{r^2} + \frac{r_0 C^2}{r}\frac{dm}{dr}$$

Both sides are divided by m, so get.

$$\frac{dV}{dt} = -\frac{r_0 C^2}{r^2} + \frac{r_0 C^2}{r}\frac{dm}{mdr} = -\frac{r_0 C^2}{r^2} + \frac{r_0 C^2}{r}\frac{d(\ln m)}{dr}$$

Take formula (1.4) into above, so get.

$$\frac{dV}{dt} = -\frac{r_0 C^2}{r^2} - \frac{r_0 C^2}{r}\frac{r_0}{r^2} = -\frac{r_0 C^2}{r^2}\left(1 + \frac{r_0}{r}\right) = -\frac{GM}{r^2}\left(1 + \frac{r_0}{r}\right) \quad (1.8)$$

In the case of a weak gravitational field approximation, the second item is small, so we can omit it. So we get.

$$\frac{dV}{dt} = -\frac{GM}{r^2} \quad (1.9)$$

This is the Newton gravity. So the Newton gravity is the result of the weak gravitational approximation of Planck gravity theory. From the Newton gravity and the cosmological principles, we can get the Friedmann equation, and the fluid equation, and the acceleration equation. Please refer to the literature for detailed derivation (6).

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G\rho}{3} - \frac{kC^2}{a^2} \quad (1.10)$$

$$\dot{\rho} + 3\frac{\dot{a}}{a}\left(\rho + \frac{P}{C^2}\right) = 0 \quad (1.11)$$

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3P}{C^2}\right) \quad (1.12)$$

The dark energy is coupling effect between cosmic expansion and gravity. In the acceleration equation (1.12), except for the earliest stages of the universe, the subsequent time stages are based on matters mainly. The pressure of matters is zero(6) (7). So, in the equation (1.2), the main acceleration effect is the density ρ.So get.

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\rho$$

This equation is actually the Newton gravity equation (2.1).

$$m\frac{dV}{dt} = -\frac{GMm}{r^2} \quad (2.1)$$

The acceleration is negative, so it is deceleration expansion. But actual experimental testing found that the universe is accelerating its expansion actually. Obviously, the physical significance of accelerated expansion is that there is another force which is greater than Newton gravity. So that the acceleration is positive, and so cause the universe to expand at an accelerated rate. As long as we find a force that is greater than Newton gravity, we find the reason for the accelerated expansion of the universe and reveal the truth about dark energy.

During the above derivation, to the formula (1.6), that is formula (2.2).

$$\frac{d(mV)}{dt} = m\frac{dV}{dt} + V\frac{dm}{dt} \quad (2.2)$$

We think the second item is small, and omit it. After considering the expansion of the universe, the second term is not small again, but on the contrary has important significance.

$$V\frac{dm}{dt} = V\frac{dm}{dr}\frac{dr}{dt}$$

So, to the formula (1.5), the complete formula is actually below.

$$m\frac{dV}{dt}+V\frac{dm}{dr}\frac{dr}{dt}=-\frac{r_0 mC^2}{r^2}+\frac{r_0 C^2}{r}\frac{dm}{dr}$$

Both sides are divided by m, so get.

$$\frac{dV}{dt}+V\frac{dm}{mdr}\frac{dr}{dt}=-\frac{r_0 C^2}{r^2}+\frac{r_0 C^2}{r}\frac{dm}{mdr}$$

$$\frac{dV}{dt}+V\frac{d(\ln m)}{dr}\frac{dr}{dt}=-\frac{r_0 C^2}{r^2}+\frac{r_0 C^2}{r}\frac{d(\ln m)}{dr}$$

Take formula (1.4) into above formula. So get.

$$\frac{dV}{dt}-V\frac{r_0}{r^2}\frac{dr}{dt}=-\frac{r_0 C^2}{r^2}\left(1+\frac{r_0}{r}\right)$$

$$\frac{dV}{dt}=-\frac{r_0 C^2}{r^2}\left(1+\frac{r_0}{r}\right)+V\frac{r_0}{r^2}\frac{dr}{dt}$$

The $\frac{r_0 C^2}{r^2}\frac{r_0}{r}$ is small item, omit it. So get.

$$\frac{dV}{dt}=-\frac{r_0 C^2}{r^2}+V\frac{r_0}{r^2}\frac{dr}{dt} \tag{2.3}$$

If there is no cosmic expansion, $\frac{dr}{dt}$ is small item obviously, $V\frac{r_0}{r^2}$ is small item also. So $V\frac{r_0}{r^2}\frac{dr}{dt}$ is small item, and can be omitted. But let's analyze $\frac{dr}{dt}$ carefully. This item is radial velocity. Particle make approximate circular orbital motions in the gravitational field. Its radial velocity is small and can be ignored. But because the universe is expanding, the radial distance is increasing. $\frac{dr}{dt}$ is actually the rate at which the universe is expanding. According to Hubble's law, the rate of expansion increases with distance. When the distance is large, the expansion rate will become very large. $V\frac{r_0}{r^2}\frac{dr}{dt}$ will be a lot, and it will not be able to be omitted. This is a special effect of the expansion of the universe. This effect can be seen as a coupling between cosmic expansion and gravity.

According to Hubble's law, we get formula (2.4).

$$\frac{dr}{dt}=Hr \tag{2.4}$$

The H is Hubble constant. Take (2.4) into (2.3), so get.

$$\frac{dV}{dt}=-\frac{r_0 C^2}{r^2}+\frac{HVr_0}{r} \tag{2.5}$$

There is the kinetic energy formula (6).

$$\frac{GMm}{r}=\frac{mV^2}{2}$$

Take (1.2) and the kinetic energy formula into (2.5), so get.

$$\frac{dV}{dt}=-\frac{r_0 C^2}{r^2}+\sqrt{2}HC\left(\frac{r_0}{r}\right)^{\frac{3}{2}} \tag{2.6}$$

Obviously, $\sqrt{2}HC\left(\frac{r_0}{r}\right)^{\frac{3}{2}}$ is a repulsive item. This item will have a dark energy effect. We look at the ratio of these two items in (2.6). We define a new scale factor A.

$$A=\frac{\sqrt{2}HC\left(\frac{r_0}{r}\right)^{\frac{3}{2}}}{\frac{r_0 C^2}{r^2}}$$

$$A=\frac{\sqrt{2}H}{C}\sqrt{r_0 r} \tag{2.7}$$

Obviously, in formula (2.6), when A is less than 1, the first item on the right is greater than the second item, the whole on the right is negative, so the acceleration is negative, so the gravitational effect is presented, and so the expansion of the universe decelerates. When A is greater than 1, the second item will be greater than the first item, so the acceleration will be positive, so showing a repulsive effect, so the expansion of the universe will accelerate, and the dark energy effect will appear. At A = 1, the acceleration is zero, which is the inflection point of the expansion rate of the universe, and the expansion rate of the universe reaches the lowest. The universe continues to expand, A exceeds 1, and a positive acceleration occurs, and the universe begins to expand at an accelerated rate.

We use r_i to identify this inflection radius. So get.

$$r_i = \frac{c^2}{2H^2 r_0} = \frac{c^2}{2H^2}\frac{c^2}{GM} = \frac{c^4}{2H^2 GM} \tag{2.8}$$

First, we found that this inflection radius is very large. Second, the inflection radius is inversely proportional to r_0. The smaller the r_0, the greater the inflection radius. $r_0 = \frac{GM}{c^2}$, the smaller the radius of the sphere, the smaller the mass of the sphere, and the greater the inflection radius. Therefore, in a small range, this repulsive effect does not occur. This repulsive effect must be manifested at great cosmic distances. The total mass of the universe is currently estimated to be about 10^{54} kg (8). The Hubble constant is about 67km/s/Mpc. Take H, M, G and C into formula (2.8), so we can calculate that the inflection radius of the universe is the following value.

$$r_i \approx 1.38 \times 10^{25} \text{ m}$$

The redshift of the expansion of the universe is roughly estimated as Z=V/C and V=Hr. So we can convert the inflection radius to a redshift value.

$$Z_i = \frac{r_i H}{c} \tag{2.9}$$

So with a rough calculation, we get the inflection red shift of the expansion rate of the universe $Z_i \approx 0.1$.The experiment measured this red shift value at about 0.4 (3), so it is close to the experimental result. Because the total mass of the universe is only a rough estimate, so it is not accurate. If we equate this repulsion item to a gravitational item, then we get following formula.

$$\frac{GM_e}{r^2} = \sqrt{2}HC\left(\frac{r_0}{r}\right)^{\frac{3}{2}}$$

The M_e is equivalent mass.

$$M_e = \frac{4\pi\rho_e r^3}{3}$$

So we can get an equivalent mass density.

$$\rho_e = \sqrt{2}HC\left(\frac{r_0}{r}\right)^{\frac{3}{2}}\frac{3}{4\pi Gr} = \frac{3\sqrt{2}H}{4\pi GC^2 r}\left(\frac{GM}{r}\right)^{\frac{3}{2}} \tag{2.10}$$

The current known universe is about 13.8 billion years. The radius of universe is about 4.3×10^{26} m. The total mass is approximately 10^{54} kg. Take these values into (2.10), so we can roughly calculate the equivalent mass density of the repulsion item is about $1.7 \times 10^{-29} g/cm^3$.The dark energy density now estimated is about $10^{-29} g/cm^3$.The two values are close (3) (8). To the repulsive item, its changing trend, its inflection point value, and its equivalent mass density are all similar to the properties of dark energy. So we can think that the repulsive item is the theoretically assumed dark energy. The dark energy is just the coupling effect between cosmic expansion and gravity. Because the universe is expanding, and because gravity exists, the two are coupled, bringing about a new gravitational effect.

The new coupling gravitational effect is the dark energy. Dark energy is not an independent, unknown energy. Dark energy does not exist. Planck Gravity Theory does not require other assumptions to explain the accelerating expansion of the universe, and reveal its physical essence. This explanatory model is very simple and clear. We also found that this new gravitational coupling effect is related to the total mass of the universe closely. With precise measurements of the acceleration of the expansion of the universe, the total mass of the universe can be calculated. Therefore, the different measurement results of different experiments can be verified with each other to judge the rationality of the theoretical model. From formula (2.8) and (2.9), we can get the formula (2.11) for calculating the total mass of the universe.

$$M = \frac{c^3}{2Z_i HG} \tag{2.11}$$

This is a method that measure the total mass of the universe directly. Using this method, humans can weigh the universe directly. The inflection red shift value of the expansion rate of the universe can be measured accurately, the Hubble constant can be measured accurately, and the speed of light and the gravitational constant can be measured accurately. Measuring the four values accurately, it is possible to calculate the total mass of the universe accurately. The inflection red shift measured by the experiment is about 0.4, so we can calculate the total mass of the universe $M \approx 2.4 \times 10^{53}$ kg. This value is more accurate than the estimate of 10^{54} kg. Then take this value into formula (2.10), we can calculate a more accurate equivalent mass density. It is $2 \times 10^{-30} g/cm^3$.This value is closer to the estimated density of dark energy. According to the total mass of this universe, it can be calculated that the more accurate density of matter in the universe is $7.2 \times 10^{-31} g/cm^3$. Obviously, the gravitational coupling effect is related to the cosmic radius. The equivalent density of dark energy is related to the cosmic radius also. The equivalent density of dark energy will no longer be a constant. The equivalent density of dark energy varies with the cosmic radius. Obviously, this will have an impact on Friedmann equations, acceleration equation and other computational models of cosmology. This impact needs to be further studied in depth. Let's look at the physical origin of this gravitational coupling effect further. This can further deepen our physical understanding of the coupling item. This coupling effect is derived from the formula (2.2). Compared with Newton gravity, there is one more item $V\frac{dm}{dt}$ in the formula (2.2). The first item is Newton gravitational acceleration. The second item is a correction for the Newton gravitational acceleration actually. In Planck Gravity Theory, the momentum of the particle P=mV. Both m and V are variations. So there is a correction to the gravitational acceleration. This gravitational acceleration correction item brings the coupling between cosmic expansion and gravity, bringing about the effect of accelerated expansion of the universe. There does not exist the gravitational acceleration correction itemin Newton gravity, so this coupling item does not exist. The equivalence principle of the General Relativity is based on Newton gravitational acceleration. In the General Relativity, there does not exist the gravitational acceleration correction item also, so this coupling item does not exist in the General Relativity also. Therefore, neither Newton gravity nor General Relativity can make a reasonable explanation for the accelerating expansion of the universe. But Planck Gravity Theory can explain it.Planck Gravity Theory shows its great power.

Conclusion

Planck Gravity Theory does not require other assumptions to explain the accelerating expansion of the universe, and reveal its physical essence. The phenomenon of accelerated expansion of the universe is a coupling effect between the expansion of the universe and gravity actually. Dark energy does not exist. This new coupling effect provides a way for humans to measure the total mass of the universe directly. By making precise measurements of the rate of expansion of the universe, the total mass of the universe can be calculated. Planck Gravity Theory deserves further study. There are many misconceptions about the universe and gravity. For the universe and gravity, there are many problems waiting for human beings to think about and study.

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