Exploring the Accelerating Expansion of the Universe

Tony Yuan
Beihang University, China

December 22, 2022

tony1807559167@gmail.com

Abstract: The relative velocity between objects will affect the effect between them. The effect caused by the chase between objects is called the general Doppler effect. The speed of gravitational field energy transmission is limited, so there is also a chase relationship between the gravitational field energy and the object. This paper explores whether the Doppler effect of the gravitational field can cause the slow expansion of planetary orbits, and then thinks whether the accelerating expansion of the universe also comes from the Doppler effect of this gravitational field.

Keywords: Newtonian gravitation; Doppler effect; gravitational field;

1 Introduce

The accelerating expansion of the universe is a problem that plagues physicists. So far, there is no theory in the world that can explain this phenomenon very reasonably. The earth is moving away from the sun at a rate of 1.5 cm per year. At the current rate, after another 60 billion years, the earth will escape from the solar system. One explanation for the fact that the earth is moving away from the sun is that the mass of the sun decreases every year, which reduces the gravity of the sun and causes the earth's orbit to expand. However, the moon is also moving away from the earth at a rate of 3.8 cm/year, which is obviously not because the mass of the earth is decreasing. Other planets and moons in the solar system experience the same orbital expansion. General relativity [1] proposes a model of the universe that is homogeneous and space-curved, and governed only by gravity, where all matter in the universe must be driven to attract each other. This makes the universe collapse under its own weight, which is clearly not the case. To explain the stability exhibited by the universe, Einstein added the cosmological constant to his formula, which counteracts the gravitational pull of irresistible gravity. The resulting universe neither shrinks nor expands. This is Einstein's static universe. It turns out that static cosmology is wrong. The Hubble telescope has seen the wavelengths of light emitted by the universe, and they are constantly being stretched longer, which means they are getting farther and farther away from us. This is the phenomenon of redshift. Einstein eventually abandoned his static universe theory in favor of an expanding universe theory. However, the universe is not only expanding, but its expansion rate is accelerating. This means that galaxies farther away from us are moving away at a faster rate than galaxies that are closer to us. So, what mysterious force is driving this expansion? The dark energy hypothesis is proposed. It can be said that dark energy is a concept that the current physical theory cannot explain the expansion of the universe and is forced to introduce.

Next, before exploring whether the Doppler effect of the gravitational field [2] will cause the slow expansion of planetary orbits, we first need to deduce the relationship between gravity and velocity.

2 Deriving the Relationship Between Gravity and Velocity Based on Newton's Gravitational Equation

Both Newton and Laplace believed that the speed of gravity, that is, the speed of energy transfer in the gravitational field[6][7] is very huge, but it must be finite, and we use X to represent the finite velocity of the gravitational field. We know that there is a general Doppler effect in the interaction between any object with finite speed, and there is no exception between the gravitational field energy and the object. Mathematically, anything continuous can be discretized, and so can gravitational fields. For easy explanation, it is assumed that the energy of the gravitational field of the gravitational source M propagates around in the form of discretized "energitons". Suppose that at a distance of r from the gravitational source, the flow rate of the energy of the gravitational field is N energitons per second. As long as the energiton reaches the object m, m will be affected by gravity. There is a chase relationship between energiton and m, so you only need to know how many energitons starting from the same position can reach m, so that the mathematical relationship between gravity and velocity can be established. Energiton and graviton [5][6] may be somewhat similar. In order to avoid conceptual conflicts with quantum gravity, the discrete gravitational field energy is called energitons in the paper.

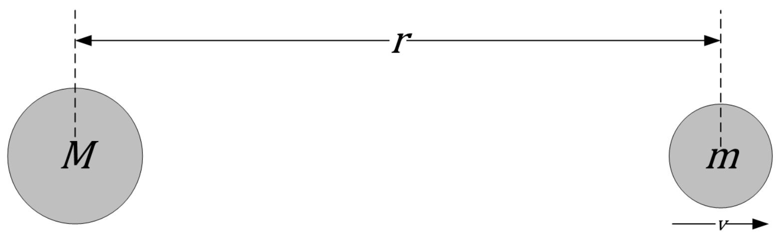

Figure 1: Gravity Calculation Model

As shown in Figure 1, two objects with masses M and m, the initial distance between them is r, m has a moving speed v relative to M, and the speed direction is connected to the center of mass on-line. In the absence of other external forces, due to the gravitational force between M and m, v will change, but this change is very small and can be ignored, so v can be seen in a short time become constant. According to Newton's gravitational equation, we get: $F(t) = G_0Mm/(r + vt)^2$. Assuming that both energiton and m start from the position of r, after a very short time dt, the displacement distance of m is $v * dt$, since $v * dt$ is very small, so $F(dt) = G_0Mm/(r + v * dt)^2$ and $F(0) = G_0Mm/r^2$ can be considered equal. After time dt, the number of energitons that can catch up with m is $n = N * (X * dt – v * dt)/X = N * dt * (X - v)/X$. At equal distances from the gravitational source, the energy of each energiton is the same, so the number of energitons determines the magnitude of the gravitational force on m. When $v = 0$, that is, when M and m are relatively stationary, the number of energitons reaching m is $n0 = N * dt$, and the gravitational force of m is Newton's static gravitational force at this time. By $n/n0 = (X - v)/X$, the equation of universal gravitation with parameter v can be obtained as follows:

$$F(v) = \frac{G_0Mm}{r^2} \times f(v),\ f(v) = \frac{X - v}{X}, \tag{1}$$

As shown in Figure 2, it can be seen that when $v = X$, the energiton cannot catch up with m, and the gravitational force $F(X) = 0$. If we need to keep the form of Newton's gravitational equation, we can write:

$$F(v) = G(v) \times \frac{Mm}{r^2},\ G(v) = G_0 \times \frac{X - v}{X}, \tag{2}$$

That is, the gravitational constant becomes a function $G(v)$ of v. Therefore, we can understand that when the gravitational field has different velocities relative to m, the gravitational constant is also different. Next, we applied the new gravitational equation to planetary orbit calculations to see if it was consistent with actual observations.

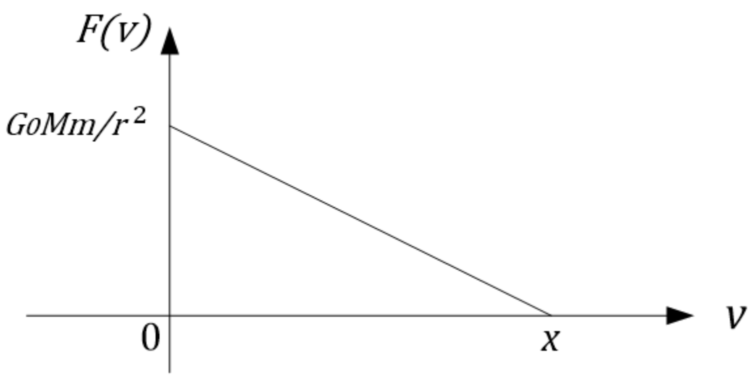

Figure 2: Linear Relationship Between Gravity and Velocity

3 Calculation of the Effect of the New Gravitational Equation on Earth's Orbit

From the above derivation, we get the gravity formula with v as the parameter: $F(v) = \frac{G_0 Mm}{r^2} \times \frac{X-v}{X}$. Considering that the direction of the velocity of the object m may have an angle with the gravitational field, we define v_r as the component of the velocity in the direction of the gravitational field, and then get a general formula:

$$F(v_r) = \frac{G_0 Mm}{r^2} \times \frac{X - v_r}{X}. \tag{3}$$

This equation shows that when an object has a velocity component in the direction of the gravitational field, that is, when there is a motion effect in the same direction between the gravitational field and the object, the gravitational force it receives decreases. When the object has a velocity component opposite to the direction of the gravitational field, that is, when the two have the effect of opposite motion, the gravitational force it receives increases. This leads us to therefore consider what effect it might have on planetary orbits under this general Doppler effect. Can a planet maintain mechanical energy conservation in its orbit?

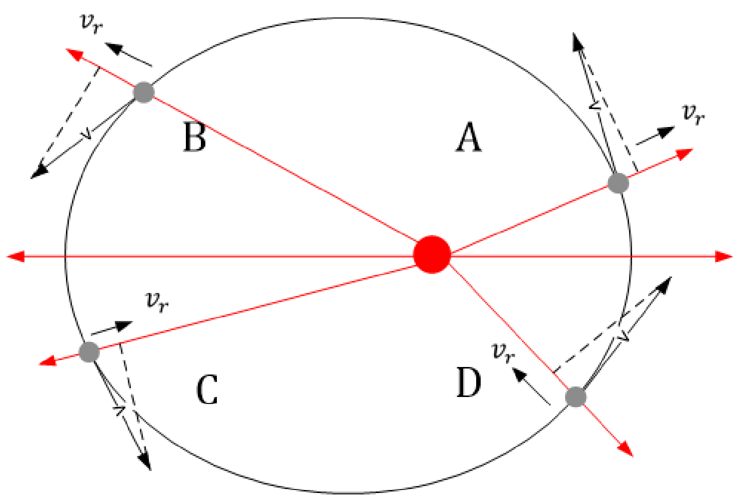

Figure 3: The Velocity Component of the Planet in the Direction of the Gravitational Field

As shown in Fig. 3, under the new gravitational equation, the gravitational force decreases because the planetary velocity has the same directional component v_r in the direction of the gravitational field of orbits A and B. Therefore, the planet gains an additional force in the direction of the gravitational field, which is in the same direction as v_r. According to the power calculation formula $P = F \times v_r > 0$, the planetary mechanical energy increases.

For regions C and D, the gravitational force increases because the planet's velocity has a reverse component v_r in the direction of the gravitational field. Therefore, the planet gains additional force in the opposite direction of the gravitational field, which is in the same direction as v_r. According to the power calculation formula $P = F \times v_r > 0$, the planetary mechanical energy increases.

Therefore, under the new gravitational equation, the mechanical energy of the planet continues to increase throughout its orbit, and the mechanical energy is larger and larger. This will cause the planets to gradually move away from the sun and eventually the solar system. Using the new gravitational equation, taking the Earth as an example, after how many revolutions does the Earth begin to escape from the solar system? Below we will carry out theoretical analysis and calculations.

3.1 Introduction of Polar Coordinates

Let the Sun, mass M, lie at the origin. Consider a planet, mass m, in orbit around the Sun. Let the planetary orbit lie in the $x - y$ plane. Let $\mathbf{r}(t)$ be the planet's position vector with respect to the Sun. The planet's equation of motion is

$$m\ddot{\mathbf{r}} = -\frac{G_0 M m}{r^2} \times \frac{X - v}{X} \times e_r, \tag{4}$$

where $e_r = \mathbf{r}/r$ and $v_r = e_r.\dot{\mathbf{r}}$.Let $r = |\mathbf{r}|$and $\theta = \tan^{-1}(y/x)$ be plane polar coordinates. The radial and tangential components of (4) are

$$\ddot{r} - r\dot{\theta}^2 = -\frac{G_0 M}{r^2}\Big(1 - \frac{\dot{r}}{X}\Big) \tag{5}$$

$$r\ddot{\theta} + 2\dot{r}\dot{\theta} = 0 \tag{6}$$

(6) can be integrated to give

$$r^2\dot{\theta} = h \tag{7}$$

where h is the conserved angular momentum per unit mass. (5),(7) can be combined to give

$$\ddot{r} - \frac{h^2}{r^3} = -\frac{G_0 M}{r^2}\Big(1 - \frac{\dot{r}}{X}\Big) \tag{8}$$

3.2 Energy Conservation

Multiply (8) by $\dot{r}$. We obtain

$$\frac{d}{dt}\Big(\frac{\dot{r}^2}{2} + \frac{h^2}{2r^2} - \frac{G_0 M}{r}\Big) = \frac{G_0 M \dot{r}^2}{r^2 X} \tag{9}$$

or

$$\frac{d\epsilon}{dt} = \frac{G_0 M \dot{r}^2}{r^2 X} \geq 0 \tag{10}$$

where

$$\epsilon = \frac{1}{2}(\dot{r}^2 + r^2\dot{\theta}^2) - \frac{G_0 M}{r} \tag{11}$$

is the energy per unit mass. (10) demonstrates that the Doppler shift correction to the law of force causes the system to cease conserving energy. The orbital energy grows without limit. This means that the planet will eventually escape the Sun's gravitational pull (when its orbital energy becomes positive).

3.3 Solution of Equations of Motion

Let $1/r = u[\theta(t)]$. It follows that

$$\dot{r} = -h\frac{du}{d\theta}, \tag{12}$$

$$\ddot{r} = -u^2 h^2 \frac{d^2 u}{d\theta^2}, \tag{13}$$

thus, Eq. (8) becomes

$$\frac{d^2 u}{d\theta^2} - \gamma\frac{du}{d\theta} + u = \frac{G_0 M}{h^2}, \tag{14}$$

where

$$\gamma = \frac{G_0 M}{hX}, \tag{15}$$

is a small dimensionless constant. To first order in γ, an appropriate solution of (14) is

$$u \approx \frac{G_0 M}{h^2}(1 + e\exp(\gamma\theta)\cos\theta), \tag{16}$$

where e is the initial eccentricity of the orbit. Thus

$$r(\theta) = \frac{r_c}{1 + e\exp(\gamma\theta)\cos\theta}, \tag{17}$$

where

$$r_c = \frac{h^2}{G_0 M}. \tag{18}$$

It can be observed that the orbital eccentricity grows without limit as the planet orbits the Sun. Eventually, when the eccentricity becomes unity, the planet will escape the Sun.

3.4 Estimation of Escape Time

The planet escapes when its orbital eccentricity becomes unity. The number of orbital revolutions, n, required for this to happen is

$$e \exp(\gamma n 2\pi) = 1, \tag{19}$$

where e is the initial eccentricity. Thus, $n = \frac{1}{2\pi\gamma}\ln(\frac{1}{e})$,

$$\gamma = \frac{2\pi a}{TX(1-e^2)^{\frac{1}{2}}}, \tag{20}$$

where a is the initial orbital major radius and T is the initial period. Hence,

$$n = \frac{TX(1-e^2)^{\frac{1}{2}}\ln(\frac{1}{e})}{4\pi^2 a}. \tag{21}$$

For Earth, $T = 3.156 \times 10^7$ s, $X = c = 2.998 \times 10^8$ m/s, $a = 1.496 \times 10^{11}$ m, and $e = 0.0167$. Hence, Earth would escape from the Sun's gravitational influence after

$$n = \frac{(3.156 \times 10^7)(2.998 \times 10^8)(1 - 0.0167^2)^{\frac{1}{2}}\ln(\frac{1}{0.0167})}{4\pi^2(1.496 \times 10^{11})} \approx 6.6 \times 10^3 \tag{22}$$

revolutions. If each revolution takes approximately 1 year, then the escape time is a few thousand years. However, the age of the solar system is 4.6×10^9 years. The escape time is smaller than this by a factor of approximately one million. Therefore, the speed of a gravitational field X must be much greater than the speed of light c; this is more in line with Newton's argument that the force of gravity acts at a distance. If we know the speed at which the earth is moving away from the sun, and thus estimate the time it takes for the earth to escape the solar system, we can then calculate the speed of the gravitational field. If the earth escapes the solar system after 60 billion years, then based on this data, it can be calculated that the speed of the gravitational field is at least 10^7 times the speed of light c (assuming that each revolution takes approximately 1 year). Laplace also did calculations, and he calculated that the speed of the gravitational field is 7 million $(0.7 * 10^7)$ times the speed of light c. Astronomer Tom van Vranden also calculated the gravitational speed. He calculated the speed to be 20 billion $(2 * 10^{10})$ times the speed of light c, which are far greater than the speed of light c.

4 Conclusion

The general Doppler effect of the gravitational field causes the planet's orbital mechanical energy to continue to slowly increase until the planet escapes the solar system. If we know the speed at which the planet is escaping, we can calculate the speed of the gravitational field. Likewise, if we know the speed of the gravitational field, we can calculate the escape speed of the planet. We can verify the correctness of this theory through astronomical observations. Humans have not observed the existence of dark energy, perhaps it is limited to human technology, or it may not exist. The Doppler effect of the gravitational field provides us with ideas for studying the accelerating expansion of the universe. Our solar system is slowly accelerating expansion, our galaxy is also accelerating expansion, and our universe is also accelerating expansion. The Doppler effect of the gravitational field provides the impetus for the expansion.

5 Data Availability Statement

All data generated or analysed during this study are included in this published article (and its supplementary information files).

References:

[1] Einstein, A.; Infeld, L.; Hoffmann, B. (1938). "The Gravitational Equations and the Problem of Motion". Annals of Mathematics. Second series. 39 (1): 65–100. Bibcode:1938AnMat..39...65E. doi:10.2307/1968714. JSTOR 1968714. [2] "Physics: Fundamental Forces and the Synthesis of Theory — Encyclopedia.com". www.encyclopedia.com.

[3] Michal Krizek, Numerical experience with the finite speed of gravitational interaction, Mathematics and Computers in SimulationVolume 50Issue 1-4Nov. 1999 pp 237–245 https://doi.org/10.1016/S0378-4754(99)00085-3

[4] Tom Van Flandern, The Speed of Gravity – What the Experiments Say December 1998Physics Letters A 250(s 1–3) DOI: 10.1016/S0375-9601(98)00650-1

[5] Kiefer, Claus (2007). Quantum Gravity. Oxford University Press. ISBN 978-0-19-921252-1.

[6] Rovelli, Carlo (2004). Quantum Gravity. Cambridge University Press. ISBN 978-0-521-83733-0.