Unveiling the Anisotropic Nature of Universal Gravity under the Influence of Gravitational Waves

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Abstract: Applying Newton's universal gravitational equation, we have been able to calculate the orbit and orbital precession data of the planets in the solar system more accurately, but there are deviations between these data and astronomical observations. For example, the orbital precession of Mercury has a deviation of 43" per century. LIGO has discovered gravitational waves (GWs) from the depths of the universe, confirming that GWs are real, which brings us some new ideas for studying planetary orbits. We know that the disturbance of the gravitational field(GF) will cause GWs, then the sun's shuttle in the Milky Way will also cause disturbances to the GF of the Milky Way, thus forming GWs around the sun, although it is very weak. But because the planets in the solar system are not far from the sun, the planets will feel the influence of GWs, which will affect the orbits of the planets. This article will analyze the specific distribution of GWs around the sun, and derive the dynamic gravitational equation under the influence of GWs, and apply it to the calculation of planetary orbits, and verify the correctness of the dynamic gravitational equation by comparing it with the astronomical observation data released by NASA, and the dynamic gravitational equation shows the anisotropic nature of gravity.

Keywords: Newton's universal gravitation; general relativity; gravitational field; gravitational wave; Mercury precession

1 Introduce

Newton believed that gravity is a force at a distance[1], but the speed of gravity,that is, the speed of energy propagation in the GF must be limited. According to Laplace's calculation, the speed of gravity is at least 7 million times the speed of light, far exceeding the speed of light. Astrophysicists such as Van Flandern also have similar conclusions [2][3] . Newton's gravitational equation is widely used, and we hardly consider the gravitational transfer time between two celestial bodies. We have tacitly accepted such a premise: the speed of gravitational force is very huge. If the gravitational speed is equal to the speed of light c, then we have to consider the effect of gravitational delay. For example, the gravitational force received by planets no longer comes from the current real position of the sun. For example, the diameter of the Milky Way reaches 180,000 light-years, and the gravitational force at the center of the Milky Way takes a long time to reach its edge. Such a large gravitational delay would make the Milky Way very unstable. GR is reduced to Newton's gravitational theory under the weak field approximation, and the resulting Einstein-Infeld-Hoffmann (E-I-H) equation is considered to be a modification of Newton's gravitational equation. The E-I-H equation takes the speed of light c as one of the parameters, but it does not consider the gravitational delay, and the equation also assumes that the gravitational speed is very huge. It can be said that Newton's gravitational theory is still the main means of gravitational research, and our gravitational theory is also based on it.

2 How Gravitational Waves Are Produced

The mass will generate a GF, and the energy will be transmitted outward in the form of longitudinal waves of the GF. The well-known Newtonian gravity refers to the gravitational force generated by the longitudinal waves of the GF, and the direction of the GF refers to the direction of energy transfer. The GF is stationary relative to the gravitational source, that is to say, the GF will not be superimposed on the rotation velocity of the gravitational source, but will be superimposed on the movement velocity of the gravitational source and move with the gravitational source. When an object A is stationary relative to the gravitational source B, the interior and surroundings of A will be filled with the B's GF (GF_B), and remain stationary, and A will not disturb GF_B , there will be no GWs around A. When A starts to move relative to GF_B , A will disturb the GF_B of the space A occupies, and thus, the GWs will be generated with A as the center, and the GWs is a kind of transverse wave. Since the GWs is generated by the disturbance of GF_B , the GWs will be superimposed on GF_B , which is a bit like the "mechanical wave" with GF_B as the medium, so the velocity of the GWs will be superimposed on the velocity of the gravitational source B. The sun revolves around the center of the Milky Way at a speed of 240 km/s, and GWs are continuously formed around the sun. In the direction of the sun's orbital velocity, the sun is chasing the GWs, and this chasing will produce the Doppler effect of the GWs.

The longitudinal wave and the transverse wave are two different ways of energy transmission in the GF. Formally, the longitudinal wave in the GF is similar to the sound wave in water. The energy transmission is realized through the longitudinal vibration of the GF, and its speed is far greater than the speed of light *c*. Of course, we don't know whether it needs a medium like water, maybe the GF itself is the medium; the transverse wave of the GF is like the water wave, and the energy transmission is realized through the lateral vibration of the GF, and its speed is equal to the speed of light *c*. Newton's theory of gravity refers to the longitudinal wave of the GF, and the GWs in the general relativity (GR) refers to the transverse wave of the GF. We believe that it is not a coincidence that the speed of GWs is equal to the speed of light. Maybe we can boldly guess whether it is possible for electromagnetic waves and GWs to use the same medium, which determines that they have the same transverse wave speed.

3 Gravitational Wave Energy Analysis

We have to think about such a problem: there are various GFs in the space where the sun is located, such as the GF ($GF_{MWcenter}$) from the center of the Milky Way, the GFs from other galaxies, the GFs from planets, etc., So which GF (GF_X) is disturbed by the sun to cause the largest GWs? To answer this question, we need to figure out what factors affect the energy of GWs. First of all, mathematically speaking, any continuous thing can be analyzed discretely. We discretize the GF into "GF particles". Now suppose the mass of the sun is M, the speed of the sun relative to GF_X is *v*, the energy intensity of GF_X is EI_{GFX} , the volume of the sun is V , V determines the number of "GF particles" of GF_X touched by the sun. According to classical mechanics, the disturbance energy of the sun to GF_X can be simply written as:

$$E_{\text{disturbance}} = KMv^2 * EI_{GF_X} * V \quad , \tag{1}$$

here K is a constant, that is to say, the greater the mass of the sun M, the greater the velocity v of the sun relative to GF_X , the greater the EI_{GFX} , the greater the volume V of the sun, then the GWs energy is greater. Mv^2 embodies the kinetic energy of the sun relative to GF_X , EI_{GFX} embodies the tension of GF_X , V embodies the number of "GF particles" of GF_X . Every "GF particle" of GF_X "touched" by the sun will be disturbed by Mv^2 energy, so Mv^2 , EI_{GFX} , V is a product relationship. Just like a bullet hits many small balls with negligible mass, the greater the kinetic energy of the bullet, the more small balls it hits, and the greater the tension between the small balls, the greater the total wave energy obtained by the small balls .

Since the GFs of other galaxies reaching the sun are very weak compared to $GF_{MWcenter}$, so they can be ignored. But we know that the Earth's GF (GF_{Earth}) received by the sun is 80 times stronger than $GF_{MWcenter}$. Then does it mean that the sun's disturbance to GF_{Earth} is the main source of GWs around the sun? The answer is no, because the speed of the sun relative to GF_{Earth} is very small, only $v_1 = 0.00127$ km/s, and the speed of the sun relative to $GF_{MWcenter}$ is $v_2 = 240\text{km}/\text{s}$, which is substituted into the equation (1), the ratio of their GWs energies is obtained as:

$$v_2^2 / v_1^2 = 240^2 / 0.00127^2 = 3.57 * 10^{10} \tag{2}$$

so the disturbance from GF_{Earth} can be ignored. In the same way, other planets such as Jupiter can also be ignored.

In addition, we also need to pay attention to the GWs generated by the disturbance of the sun's GF (GF_{Sun}) by planets. Taking the earth as an example, the gravitational force of the sun on the earth is 80 times that of the center of the galaxy on the sun, and the mass of the sun is 330,000 times that of the earth. So the intensity of GF_{Sun} received by the earth is 80*330,000 times of the intensity of $GF_{MWcenter}$ received by the sun, and the speed of the earth to GF_{Sun} is 29.8 km/s, so if only consider Mv^2 EI_{GFX} in the equation (1), then the ratio of the sun to the earth is 1:1.248, the sun occupies a little vulnerable, but because the volume of the sun is 1.3 million times that of the earth, therefor, the number of "GF particles" in the space occupied by the sun is far greater than that of the earth, so the GWs energy around the earth is also negligible compared to the sun. In the same way, other planets such as Jupiter can also be ignored.

An explanation needs to be made here. Since the material composition of the sun and the inner planet is different, the mass density of the inner planet is about 4 times that of the sun. So we can simply think that the number of "GF particles" that the inner planetary material can touch is 4 times that of the sun under the same volume, and the energy of GWs will also be greater. For the outer planets, because their material composition is similar to that of the sun, and their density is smaller than that of the sun, the energy of GWs will be smaller under the same volume.

So is $GF_{MWcenter}$ the space where the solar system is located, the strongest GF from the outside? We know that the mass of the center of the Milky Way only accounts for a small proportion of the entire Milky Way, and the mass is mainly distributed on the Galactic disk, so we need to consider the GF generated by the spiral arms on the Galactic disk. We found the sun's position data in the Milky Way galaxy on astronomy.stackexchange[4]. As shown in Figure 1, the sun passed through the galactic plane about 3 million years ago, and at present, the sun moves to a place[5] 17 pc (55 light years) north of the galactic plane. The sun will continue to move northward in the future, until 13 million years later, the distance between the sun and the galactic plane will reach the maximum of 100 pc (326 light-years)[6] . After that, the sun will move towards the plane of the Milky Way and reach the plane of the Milky Way 29 million years from now. That is to say, the sun spirals around the center of the Orion spiral arm of the Milky Way, and crosses the plane of the Milky Way back and forth every 64 million years, which is very similar to the spiral motion of the earth following the sun. The next thing we need to do is to calculate the strength of the GF ($GF_{OrionArm}$) of the Orion spiral arm.

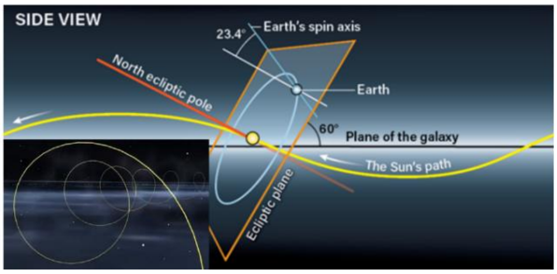

Figure 1: The path of the sun across the galactic disk

According to the centripetal force formula $F = m\omega^2 R$, it can be estimated that the strength of

$GF_{OrionArm}$ is $\left(2.2*10^8\right)^2/\left(6.4*10^7\right)^2*326/26000=0.145$ times of $GF_{MWcenter}$, and the disturbance speed of the sun to $GF_{OrionArm}$ is only $326/26000*2.2*10^8/6.4*10^7*240=10.3\text{km/s}$

So the sun's disturbance to $GF_{OrionArm}$ can be ignored. Here $2.2*10^8$ years is the period of the sun around the Milky Way; $6.4*10^7$ years is the period of the sun around the Orion spiral arm, 326 ly is the radius of this circle; 26000 ly is the distance from the sun to the center of the Milky Way; 240 km/s is the orbital speed of the sun.

Now we can draw the conclusion that the GWs produced by the sun's disturbance to other GFs can be neglected, and the sun's disturbance to $GF_{MWcenter}$ is the main source of GWs around the sun.

Factoring in the density of the planet, we can also roughly estimate the contribution of GWs around the earth to the gravitational force of the earth, assuming that the contribution ratio of GWs around the sun to the gravitational force of the sun is 1, then for the earth, the ratio is:

$$1.248/1300,000 * 330,000 * 5514/1408 = 1.25, \tag{3}$$

it can be seen that although the GWs around the earth are weaker than the sun, only 1.248/1300,000 of the sun, but because the mass of the earth is only 1/330,000 of the sun, plus the density ratio of the earth and the sun is 5514/1408, the resulting ratio was 1.25. GWs around Earth are also of interest if we are to study satellite orbits around Earth. In the same way, we can calculate the data of other planets: Mercury 1.16, Venus 2.68, Earth 1.25, Mars 0.038, Jupiter 3.02, Saturn 0.15, Uranus 0.0026, Neptune 0.00079. It can be seen that Jupiter is 3 times that of the sun. At the same distance, since the GF strength of Jupiter is only 1/1000 of that of the sun, relative to the sun, the GWs around Jupiter can be ignored, but its influence on Jupiter's satellites will be very big.

So if we want to study the orbits of planets in the solar system, we only need to consider the

GWs caused by the disturbance of the sun to $GF_{MWcenter}$. If it is necessary to calculate the satellite orbit of a planet, then in addition to the GWs around the sun, the GWs around the planet must also be considered. GR believes that the greater the mass, the greater the curvature of space-time, the curvature of space-time caused by the sun will be much greater than that of planets, and the degree of curvature of planets will be much greater than that of their satellites. So from the final conclusion, our analysis is more consistent with GR.

4 Effects of Gravitational Waves on Gravity Around Sun

The GWs around the sun are mainly from the disturbance of $GF_{MWcenter}$, so we take the center of the Milky Way as the reference object for studying the GWs around the sun. The sun shuttles in $GF_{MWcenter}$, if the direction of the sun's velocity is regarded as the axial direction, then the distribution of GWs around the sun is axisymmetric, we only need to study the distribution of GWs on a tangent plane passing through the axis.

In this way, we turn the three-dimensional space problem into a two-dimensional plane problem. As shown in Figure 2, it looks somewhat similar to water waves.

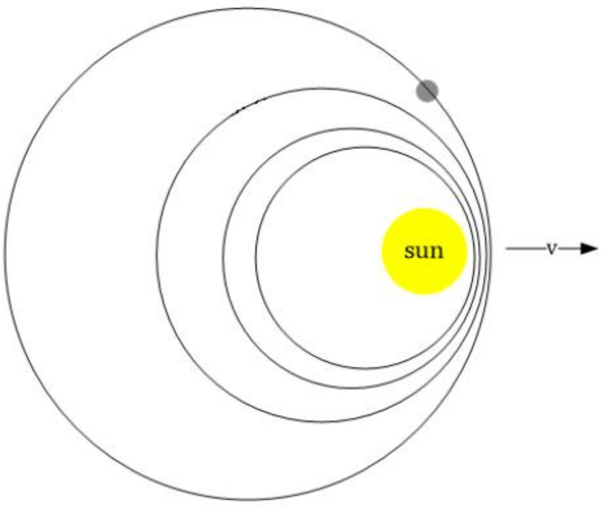

Figure 2: A model of gravitational waves generated by the motion of the sun

Figure 2 shows that, due to the Doppler effect, GWs have the greatest energy in the direction of the sun's velocity and have the greatest impact on gravity. Since the planet's orbital plane is perpendicular to the direction of the sun's velocity, the effect is relatively small.

4.1 Calculation of Influence Factors of Gravitational Waves in the Direction of the Sun's Velocity

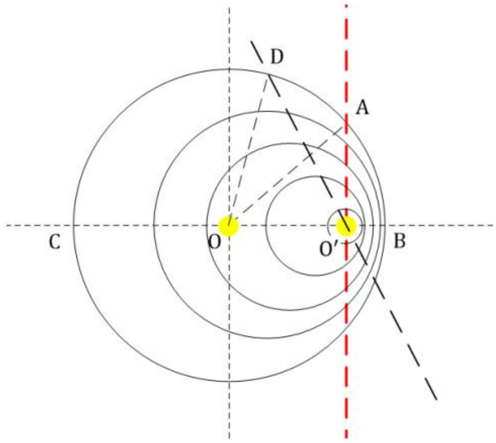

Figure 3: Solar Gravitational Wave Computation Model

Assume the sun's orbital speed is v_s. As shown in Figure 3, after the time T, the sun moves from the position O to the position O', then the GWs generated along the sun velocity direction during this period are all located between $O'B$. According to the Doppler effect, the influence factor of GWs in this direction is as follows: (we use f_ω to represent the influence factor of GWs)

$$f_w = \frac{c + v_s}{c} > 1.0 \tag{4}$$

4.2 Calculation of Influence Factors of Gravitational Waves in the Direction of the Sun's Velocity

GWs perpendicular to the direction of the sun's velocity are located between $O'A$; only need to calculate the ratio of $O'B$ and $O'A$ to determine the GWs density relationship between the two directions.

$$O'B = cT - v_s T \tag{5}$$

$$O'A = \left[(cT)^2 - (v_s T)^2 \right]^{\frac{1}{2}} \tag{6}$$

so get:

$$f_w = \frac{c + v_s}{c} \times \left(\frac{c - v_s}{c + v_s} \right)^{\frac{1}{2}} = \left(\frac{c^2 - v_s^2}{c^2} \right)^{\frac{1}{2}} \tag{7}$$

Substituting the sun's revolution speed $v_s = 240 \times 10^3 \mathrm{m/s}$ and GWs speed $c = 2.998 \times 10^8 \mathrm{m/s}$, we get $\frac{O'B}{O'A} = \left(\frac{c - v_s}{c + v_s} \right)^{\frac{1}{2}} \approx 0.9992$. Figure 2 shows that the GWs density in the vertical direction is less than that in the direction of the sun's velocity. The density of GWs gradually decreases from the direction of the sun's velocity to the vertical direction. If the GWs density is equivalent to the depth of the depression in the plane, then this GWs density model is somewhat similar to the space-time depression model described by GR. As shown in Figure 4, the density of GWs presents a non-uniform distribution; the density of GWs is the highest in the direction of the sun's velocity (bottom of Fig. 4), and gradually decreases towards the surroundings.

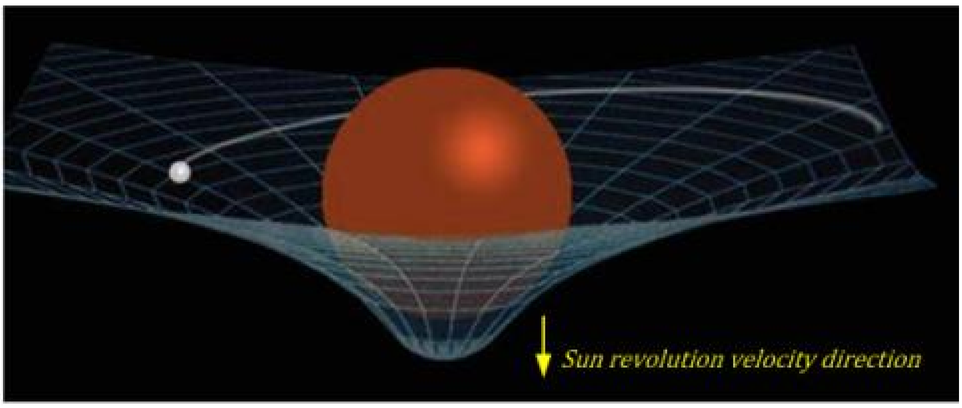

Figure 4: Gravitational Wave Density Model

4.3 Calculation of Influence Factors of Gravitational Waves on Planetary Orbital Plane

We know that the orbital plane of the planet is roughly perpendicular to the direction of motion of the sun; therefore, the red line in Figure 3 represents the ideal orbital plane of the planet. According to equation (7), we can calculate the influence factor of GWs on the orbital plane, and thus determine that the value will be less than 1.0.

4.4 Calculation of the Influence Factor of Gravitational Waves in the Reverse Direction of the Sun's Velocity

Behind the vertical plane (to the left of the red line in Figure 3), it is shown that the density of GWs will continue to decrease and reach a minimum in the direction opposite to the velocity of the sun. At this time $\frac{O'B}{O'C}=\frac{c-v_B}{c+v_B}$, the influence factors of GWs are as

$$f_w=\frac{c+v_s}{c}\times\frac{c-v_s}{c+v_s}=\frac{c-v_s}{c} \tag{8}$$

Substituting $v_s=c$ into equation (7) and (8), it can be determined that when the velocity of the sun reaches *c*, at the position perpendicular to the direction of the sun's velocity (the position of the red line in Figure 3) and the position behind, they will not be again affected by GWs.

4.5 Calculation of Influence Factor of Gravitational Waves at Any Position

As shown in Figure 3, assuming that the angle between $O'D$ and the red line is θ (D is at any position), then

$$OD^2=O'D^2+OO'^2-2O'D\times OO'\cos\left(\frac{\pi}{2}-\theta\right), \tag{9}$$

get: $O'D=\frac{2OO'\cos\left(\frac{\pi}{2}-\theta\right)+\left[4\left(OO'\cos\left(\frac{\pi}{2}-\theta\right)\right)^2-4\left(OO'^2-OD^2\right)\right]^{\frac{1}{2}}}{2}$

then,

$$\frac{O'B}{O'D}=\frac{2O'B}{2OO'\cos\left(\frac{\pi}{2}-\theta\right)+\left[4\left(OO'\cos\left(\frac{\pi}{2}-\theta\right)\right)^2-4\left(OO'^2-OD^2\right)\right]^{\frac{1}{2}}} \tag{10}$$

then,

$$f_w=\left(\frac{c+v_s}{c}\right)\times\frac{c-v_s}{v_s\cos\left(\frac{\pi}{2}-\theta\right)+\left[\left(v_s\cos\left(\frac{\pi}{2}-\theta\right)\right)^2-\left(v_s^2-c^2\right)\right]^{\frac{1}{2}}} \tag{11}$$

4.6 Gravitational Equation under the Influence of Gravitational Waves

We define the gravitational ratio r_w of the sun, which is the ratio of the gravitational force (F_{GW}) caused by the GWs to the gravitational force (F_{GF}) caused by the longitudinal wave of the GF without considering the GWs Doppler effect (ie $f_\omega = 1$). We know that the gravitational constant G_0 is measured by two relatively stationary balls. Although the ball will not cause disturbance of GF_{Earth} , the disturbance of the ball to GF_{Sun} must be considered , so it already includes the influence of GWs, we first need to make corrections to G_0 to remove the influence of GWs.

According to Equation (3), we can get the earth's gravitational ratio $r_{w0} = 1.25 * r_w$. Since we don't know the positions of the two stationary balls, we can't calculate f_ω , but since the speed of the earth is only 1/8 of the sun, the Doppler effect of GWs around the balls will be much smaller. In addition, the current measurement accuracy of G_0 cannot perceive the change of f_ω , so $f_\omega \approx 1$, and the universal gravitational constant is corrected as: $G_0 / \left(1 + r_{w0}\right)$. This way we can separate out F_{GW} and F_{GF} :

$$F_{GF} = \frac{G_0 Mm}{r^2} / \left(1 + r_{w0}\right), \tag{12}$$

$$F_{GW} = r_w \times f_w \times F_{GF}, \tag{13}$$

using F to represent the total gravitational force under the influence of GWs, we get:

$$F = F_{GF} + F_{GW} = F_{GF} + r_w \times f_w \times F_{GF}, \tag{14}$$

next, we take the position of the orbital surface of a planet as an example to illustrate the gravitational calculation under the influence of GWs:

$$F = F_{GF} + r_w \times f_w \times F_{GF} = F_{GF} \times \left(1 + r_w \times \left(\frac{c^2 - v_s^2}{c^2}\right)^{\frac{1}{2}}\right) \tag{15}$$

Since there is also a Doppler effect between planets and GWs, the influence of this factor also needs to be considered. Assuming that the speed of the planet is v_p, and the speed of the planet in the direction of the GWs is v_{pw}, then the chasing factor between the planet and the GWs can be obtained $\frac{c-v_{pw}}{c}$, adding this factor to equation (15), get:

$$F = F_{GF} \times \left(1 + r_w \times \left(\frac{c^2 - v_s^2}{c^2}\right)^{\frac{1}{2}} \times \frac{c - v_{pw}}{c}\right), \tag{16}$$

substituting F_{GF}, we get:

$$F = \frac{G_0 Mm}{r^2} / \left(1 + r_{w0}\right) \times \left(1 + r_w \times \left(\frac{c^2 - v_s^2}{c^2}\right)^{\frac{1}{2}} \times \frac{c - v_{pw}}{c}\right), \tag{17}$$

here $r_w \approx 0.000575$, the value comes from program simulation. Because the earth is 1.25 times the sun, get $r_{w0} = 1.25 * r_w \approx 0.00072$. We can write the gravitational equation for any position:

$$F = \frac{G_0 Mm}{r^2} / \left(1 + r_{w0}\right) \times \left(1 + r_w \times \frac{c + v_s}{c} \times \left(\frac{c - v_s}{v_s \cos\left(\frac{\pi}{2} - \theta\right) + \left[\left(v_s \cos\left(\frac{\pi}{2} - \theta\right)\right)^2 - \left(v_s^2 - c^2\right)\right]^{\frac{1}{2}}} \times \frac{c - v_{pw}}{c}\right)\right), \tag{18}$$

the θ here is related to the position of the planet, it changes with the time period, and the equation contains the velocity term of the planet, so the modified Newton gravity equation can be called dynamic gravitational equation. It can be seen from this equation that the gravitational force between two objects not only depends on the distance *r*, but also is related to their velocity and their positions. The universal gravity under the influence of GWs reflects anisotropy.

We can also calculate gravitational ratios for other planets: Mercury: 0.00067, Venus: 0.0015, Earth: 0.00072, Mars: 0.000022, Jupiter: 0.0017, Saturn: 0.000087, Uranus: 0.0000015, Neptune: 0.000000045.

Next, we need to analyze whether GWs will affect the conservation of mechanical energy in planetary orbits? Will it cause the planetary orbits to become unstable?

4.7 Conservation Analysis of Planetary Orbital Mechanical Energy under the Influence of Gravitational Waves

The directions of the planet's velocity in the four regions A, B, C, and D of the planet's elliptical orbit are shown in Figure 5. The following will analyze the mechanical energy of the planet's orbit in the four orbit regions respectively.

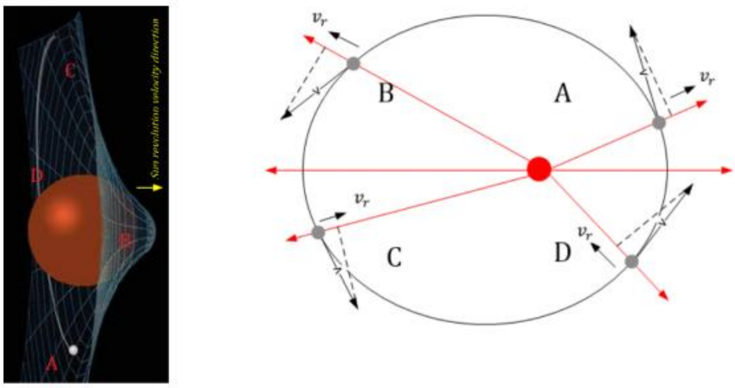

Figure 5: Conservation of mechanical energy in planetary orbits

When the planet enters from the red orbital plane to the high-density GWs region on the right in the A orbital region, the gravitational force increases, but there is a velocity component in the direction of the GF, $P = F \times v < 0$, and the mechanical energy decreases.

When the planet returns to the red orbital plane from the highest GWs density region in the B orbital region, the gravitational force decreases, but there is a velocity component in the direction of the GF, $P = F \times v > 0$, and the mechanical energy increases. (A and B cancel each other out)

When the planet enters from the red orbital plane to the low-density GWs region on the left in the C orbital region, the gravitational force decreases, but there is a velocity component in the opposite direction of the GF, $P = F \times v < 0$, and the mechanical energy decreases.

When the planet returns to the red orbital plane from the lowest GWs density region in the D orbital region, the gravitational force increases, but there is a velocity component in the opposite direction of the GF, $P = F \times v > 0$, and the mechanical energy increases. (C and D cancel each other out)

Conclusion: The mechanical energy of planetary orbits under the influence of GWs remains conserved, and the results of software simulation also confirm this conclusion.

4.8 Gravitational Waves Caused by the Sun's Rotation

The sun is also slowly rotating around the center of mass of the solar system (about 15 m/s), and at the same time the sun is also rotating, which will cause disturbances to the GF, thus generating GWs, but the sun's revolution speed of 240 km/s is much greater than its 2 km/s rotation speed. Therefore, this physical model does not consider the influence of GWs caused by rotation, etc. We must take these factors into account if we need to obtain more accurate calculations.

5 Analysis of the Influence of Gravitational Waves on Planetary Orbits

If the planet's orbital plane is not perfectly perpendicular to the velocity of the sun's disturbing gravitational field, then the GWs will affect the planet unevenly, which will affect the orbit and contribute part of the force to the orbital precession. The closer the planet's orbit is to the sun, the greater the GWs density gradient on the orbit, and the more obvious the precession effect. The farther the distance, the smaller the change in GWs density in the orbit, and the less pronounced the precession effect. It can be seen from Fig. 3 that within a certain range, the larger the angle between the real planetary orbital plane and the ideal orbital plane represented by the red line in Fig. 3, the more obvious the precession will be.

In 1915, Albert Einstein published in [1915, p. 839] the formula for the relativistic perihelion shift, for a planetary cycle,

$$\varepsilon = 24\pi^3 \frac{a^2}{T^2 c^2 \left(1-e^2\right)} \quad , \tag{19}$$

here, T is the orbital period of the planet, e is the eccentricity of its elliptical orbit, a is its corresponding semi-major axis length, and c is the speed of light in vacuum.

$$\delta\varphi = \varepsilon \frac{\tau}{T} \frac{180}{\pi} 3600'' , \tag{20}$$

here $\tau = 3155814954$ s is the number of seconds in a century. GR constructs an idealized 1-Body model, GR ignores the effect of planetary gravity on the sun when calculating planetary precession. It can be seen from the above formula that GR does not consider the angle between the planetary orbital plane and the vertical plane of the sun (red line in Figure 3), but this factor is very important in our gravitational equation. In addition, for GR, the smaller the orbital eccentricity, the smaller the orbital precession, but our gravitational equation is just the opposite, the smaller the orbital eccentricity, the more unstable the orbit will be, resulting in greater orbital precession. These factors are probably the biggest differences between the two. We calculated the orbital precession[7] of the eight planets in the solar system according to the precession equation provided by GR: Mercury 41.06"; Venus 8.6"; Earth 3.83"; Mars 1.34"; Jupiter 0.062"; Saturn 0.0136"; Uranus 0.00238"

We did not ignore the influence of planetary gravity on the sun, under the 1-Body model, calculated the orbital precession of each planet, and gave the comparative data in Figure 6 (from the calculation results, the influence of planetary gravity on the sun can be ignored). We can see that the planetary precession is zero without adding the influence of GWs (that is, only considering the gravitational force produced by the GF). If the influence of GWs is added, the planetary precession in the 1-Body system is relatively close to the result calculated by GR, except for Venus. (The precession data in the paper are calculated after the perihelion is projected onto the x-y plane.)

Condition	Planet	Gravity wave on	Gravity wave off	GR
1-Body	Mercury	43	0	41.06
	Venus	169	0	8.6
	Earth	0.35	0	3.83
	Mars	-5.6	0	1.34
	Jupiter	-1.35	0	0.062
	Saturn	-0.33	0	0.0136
	Uranus	0.1	0	0.00238
	Neptune	-0.64	0	

Figure 6: 1-body planetary orbital precession (” per century)

Let’s look at the characteristics of Venus: Venus has an unusually low eccentricity (e = 0.0068), which makes its perihelion extremely sensitive to small disturbances. However, its orbit is at a very large angle (3.39°) to the vertical plane of the Sun’s velocity; therefore, we have reason to believe that GWs would have a significant effect on the orbital precession of Venus. However, it is inappropriate to negate the gravitational equation just because the data of Venus (169”/century) and GR (8.6”/century) are inconsistent under the 1-Body model. Later we will use the N-Body system to calculate the orbital precession of each planet, and then compare it with the astronomical observation data given by NASA.

We know that the famous Mercury precession deviation of 43” comes from comparing the orbital data of the solar system planets calculated by Newtonian classical mechanics with astronomical observation data[8] . This requires calculating the gravitational force between all the planets in the solar system and the sun, the gravitational force between the planets, and the orbit of the sun. The rotation of the center of mass of the solar system, construct a real N-body system, and then calculate the planetary precession data under the influence of GWs and without the influence of GWs. It can be seen from the data in Figure 7 that the orbital precession data of the eight planets are relatively close to astronomical observations. Especially for Venus, if the influence of GWs is not added, the total orbital precession will deviate far from the astronomical observation data, but with the influence of GWs, the orbital precession of Venus is more consistent with astronomical observations. (The initial coordinates (x, y, z) and initial velocities (vx, vy, vz) of the planets and sun used in this article are from NASA's Horizon System[9])

Condition	Planet	Gravity wave off	Gravity wave on	NASA
N-Body	Mercury	531	570~572	575
	Venus	-270~-120	200~270	204
	Earth	1080~1160	1140~1170	1145
	Mars	1560~1600	1560~1600	1628
	Jupiter	600~1000	600~1000	655
	Saturn	1600~2200	1600~2200	1950
	Uranus	140~600	140~600	334
	Neptune			36

Figure 7: N-Body planetary orbital precession (" per century)

It needs to be explained here that the astronomical observation data provided by NASA are calculated by fitting and calculating the real planetary data obtained by the satellite under the E-I-H equation model. In particular, the orbital precession of the planets will change greatly in each orbital period, and the data given by NASA are calculated and averaged over a long period of time. In addition, it should be emphasized that the common orbital period of the eight planets in the solar system is very large, so it is difficult for us to obtain the orbital precession law of planets with small eccentricities through short-term calculations. Through 200 years of astronomical observations, we cannot obtain the orbital precession laws of all planets, and it takes a longer period of observation to obtain statistical average data. But for Mercury and Mars, their eccentricity is relatively large, through calculation or astronomical observation, we can obtain their approximate general laws within thousands of planetary cycles.

6 Conclusion

Now there is such a picture in front of us: 1. The sun has a GF, and the energy of the GF propagates around in the form of longitudinal waves, and its speed is very huge. 2. The sun disturbs other surrounding GF, thus forming a GF transverse wave (gravitational wave) around the sun. The GW will be superimposed on the moving velocity of the disturbed GF, and spread around at the speed of light *c*. The planets around the sun will not only be affected by the GF from the sun, but also be affected by the GWs around the sun.

Judging from the calculation results of the orbits of the planets in the solar system, the gravitational equation under the influence of GWs shows the correctness, and provides a new method for the precise calculation of planetary orbits. Perhaps the gravitational force $F = F_{GF} + F_{GW}$ under the joint action of the longitudinal wave and the transverse wave of the GF is the whole of the universal gravitation. At present, almost all celestial orbit calculations rely on Newton's gravitational equation and E-I-H equation, but almost all calculations do not consider gravitational delay, and the calculated celestial orbits are very stable. This has actually admitted that the gravitational speed is far greater than the speed of light, if this is not recognized, if the gravitational speed is considered to be equal to the speed of light, then when using Newton's gravitational equation or E-I-H equation, gravitational delay must be added, which will cause the calculated celestial body's orbit to become very unstable. This is inconsistent with the fact that the solar system and the Milky Way are very stable. According to the laws of nature, the speed of longitudinal waves is always much greater than that of transverse waves. GR uses space-time curvature to explain gravity, and GR reduces to Newton's theory of gravity under the weak field approximation, and we have added the influence of GWs on the Newton's gravity, which has also revised the Newton's gravity equation very well, and it has shown good practicability and correctness in the calculation of N-Body celestial orbits. Finally we give the Law of Dynamic Gravitation:

1. Any object M with mass has a gravitational field, and the gravitational field moves with M.

2. The energy of M is transmitted outward in the form of longitudinal waves in the gravitational field.

3. Newtonian gravitation refers to the force produced by the object subjected to the longitudinal wave of the gravitational field.

4. The speed of the longitudinal wave in the gravitational field is much greater than the speed of light, but it must be limited.

5. There is a chasing effect between the object and the longitudinal wave of the gravitational field, which will cause the mechanical energy of the planet's orbit to increase slowly, thus making the planet's orbit slowly accelerate and expand.

6. If there is a relative velocity between M and the gravitational field from Mx , then M will

disturb the gravitational field of Mx, so that a gravitational wave will be generated around M, which is the transverse wave of the gravitational field of Mx, and it will be superimposed on the gravitational field of Mx movement velocity.

7. The speed of gravitational waves is equal to the speed of light, and there is a Doppler effect between M and the surrounding gravitational waves, so that the gravitational wave density around M is no longer uniform, showing anisotropy.

8. The gravitational wave also has a force effect on the object, but the gravitational wave will not change the planetary mechanical energy conservation, but the anisotropy of the gravitational wave will cause the precession of the planetary orbit.

9. The universal gravitation under the joint action of gravitational field longitudinal wave and gravitational wave is complete, we call it dynamic universal gravitation.

We can also find a lot of research[10][11][12][13][14][15][16][17][18] about GWs. GWs have brought more imaginations to the human study of the universe. Especially after LIGO confirms the existence of GWs, the research on GWs will become more valuable.

7 Data Availability Statement

The data that supports the findings of this study are available within the article [and its supplementary material].

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