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Using the Newton's Theory of Gravity to Calculate the Deflection of Light in the Solar System and the Orbital Poles of Light's Motion of General Relativity

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Abstract

In this paper, a standard method is provided to calculate the gravitational deflection of light in the solar system by using the Newtonian theory of gravity. The equation of light's motion in general relativity is compared with that of the Newton's theory of gravity. It is proved that a constant term is missing in the motion equation of general relativity. This constant term is critical to the orbital shape of light's motion in gravity field and causes serious problems so that it can not be correct. The orbital poles of light's motion of general relativity is also calculated. According to the theory of algebraic equation, the orbital poles are determined by a cubic equation of one variable. The calculation of general relativity assumed that light from stars in outer space passed through the solar surface, which was equivalent to assume that the solar radius was a root of the cubic equation. However, it is strictly proved that the solar radius can not be the pole of motion equation of general relativity. The orbital poles of light are located in the interior of the sun which are not far from the center of the sun, so all of lights from stars in outer space would enter the solar interior and disappear. It is impossible for the light to be seen by the observers on the earth surface, but this is not the case. The reason is just that the motion equation of motion in general relativity is missing a constant term. It means that the Einstein's prediction that light's deflection angle was 1.75” in the solar gravitational field can not be correct and general relativity can not hold.

Keywords: General relativity, Newtonian theory of gravity, Gravitational deflection of light, Cubic equations of one variable, Hyperbolic orbit, Orbital poles of light's motion.

1. Introduction

According to the Newtonian theory of gravity, the deflection angle of light from stars in outer space in the solar gravitational field is 0.875’’. Johann von Soldner (1766-1833) of the Munich Observatory in Germany published this result in 1801 [1] . Sodner used a simple method to estimate it without providing the detail, many researchers of gravity theory did not quite understand how the value of 0.875” was calculated at present.

In this paper, a standard calculation method is given based on the hyperbolic orbit of the Newtonian gravity theory for the motion of light, and the result is exactly the same as that Sodner obtained.

The motion equation of light in general relativity is compared with that of the Newton's theory of gravity. It is proved that a constant term is missing in the motion equation of general relativity. This constant term is critical to the orbital shape of light's motion in gravity field, its losing would cause serious problems.

General relativity predicted that the deflection angle of light in the solar gravitational field was 1.75 ", twice of the value predicted by using the Newtonian theory of gravity. Since 1919 , Eddington and others had claimed that actual measurements verified the predictions of general relativity [2,3,4]. It was because of theses measurements that the Einstein's gravity theory of curved space-time was recognized by the scientific community and became the mainstream one of modern physics.

However, the author published a paper in May 2021, proved that the calculation of constant terms in the motion equations of planets of general relativity was wrong. By the strict calculation, the constant term should be equal to zero. Thus general relativity can describe only the parabolic orbital motions (with minor corrections) of celestial bodies in the solar system, but can not describe the elliptical and hyperbolic orbital motions [5].

It is also proved that the time-independent orbital equation of general relativity is wrong. The reason is that a constant term is missing from the equation, so the light's deflection angle $1.75''$ in the solar gravitational field predicted by general relativity is wrong. In addition, according to the time-dependent equation of motion of general relativity, the light's deflection angle is only a minor correction of prediction value $0.875''$ by the Newtonian theory of gravity with the correction magnitude order of 10^{-5} [5]. The time dependent and time independent motion equations of light in general relativity contradict each other.

Since Eddington's observations in 1919, however, there had been more than a dozen astronomical measurements, all of them declared that the predictions of general relativity had been verified, including the deflection measurements of quasar radio waves in the solar gravitational field after 1970. How can astronomers observed the phenomena that general relativity wrongly predicted but did not actually exist in nature?

In August 2021, Mei Xiaochun and Huang Zhixun published a paper to reveal hat the measurements of Eddington et al. on the gravitational deflection of light were invalid [6]. The reasons were that these kinds of measurements did not consider the influences of solar surface gas and other factors on the deflection of light. Several fitting parameters were introduce in the experimental data processing and the least square method and other very complex statistical methods were adopted to make the measured data consistent with the prediction of general relativity. In fact, by using these statistical methods, we can also reconcile the measurements with the predictions of the Newtonian theory of gravity, negating general relativity.

In general relativity, the motion orbits of light coming from stars in outer space was described by a cubic equation of one variable. The calculations of general relativity assumed that the light passedpassespasses across the solar surface, which was equivalent to assume that the solar radius was a root of the cubic equation. It is proved in this paper that the solar radius can not be the orbital poles of light. The orbital poles of light were located in the solar interior not far from the solar center, so the light from stars in outer space would be lost in the solar interior and could not be observed by the observers on the earth. The night sky on the earth would be starless. However, this was not the case.

The reason is just that the motion equation of light in general relativity lost a constant term. It is proved once again that the theoretical prediction of light deflection angle of 1.75 " in general relativity is wrong and is impossible to be observed. The Einstein's gravity theory of curved space-time does not hold.

2. Using the Newtonian theory of gravity to calculate the gravity deflection of light's orbit in the solar system

2.1 The motion of a massed particle in the Newton's centered gravitational field

According to the Newtonian theory of gravity, the force acted on a particle with mass m in the spherically symmetrical gravity field is

$$\vec{F} = -\frac{GMm_0\vec{r}}{r^3} \tag{1}$$

By using the polar coordinates, the motion equation of a particle is

$$m_0(\ddot{r} - r\dot{\theta}^2) = F \tag{2}$$

$$m_0(r\ddot{\theta} + 2\dot{r}\dot{\theta}) = \frac{m}{r}\frac{d}{dt}(r^2\dot{\theta}) = 0 \tag{3}$$

We can obtain $r^2\dot{\theta} = h =$ constant from Eq.(3). Let $u = 1/r$, Eq.(2) can be written as [7]

$$\frac{d^2u}{d\theta^2} + u = \frac{GM}{h^2} \tag{4}$$

The solution of Eq.(4) is

$$u = \frac{GM}{h^2} + A\cos\theta \qquad\qquad r = \frac{p}{1 + e\cos\theta} \tag{5}$$

Here p is the half latus rectum and e is the eccentricity of orbit. Their definitions are

$$p = \frac{h^2}{GM} \qquad\qquad e = Ap = \frac{Ah^2}{GM} \tag{6}$$

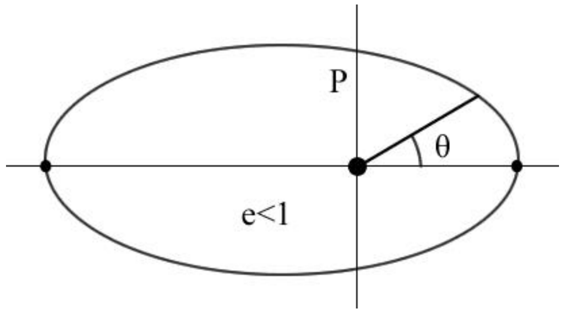

Fig 1. The elliptic orbit of a particle in the Newton's centered gravitational field.

As shown in Fig.1, when $e < 1$, Eq.(5) describes the elliptic orbit. Suppose that the long half axis of elliptic orbit is b, at perihelion we have $\theta = 0$ and $r = b(1-e)$. At aphelion, we have $\theta = \pi$ and $r = b(1+e)$. According to Eqs.(5) and (6), we get

$$p = b(1-e^2) \qquad\qquad h^2 = GMb(1-e^2) \tag{7}$$

The equation of energy conservation of a particle is

$$\frac{1}{2}m_0(\dot{r}^2 + r^2\dot{\theta}^2) - \frac{GMm_0}{r} = E \tag{8}$$

Substituting the values of perihelion $r = b(1-e)$, $\dot{r} = 0$ and $r^2\dot{\theta} = h$ in Eq.(8), the result is

$$E = \frac{m_0 h^2}{2b^2(1-e)^2} - \frac{GMm_0}{b(1-e)} = -\frac{GMm_0}{2b} < 0 \tag{9}$$

So the total energy of a particle which make the motion of elliptic orbit is less than zero.

As shown in Fig.2, when $e = 1$, Eq.(5) describes the parabolic orbit. At perihelion we have $\dot{r} = 0$ and $r = q$, so $p = 2q$ and $h^2 = GM2q$. Substituting them in Eq.(8), the total energy of particle is zero.

$$E=\frac{m_0h^2}{2q^2}-\frac{GMm_0}{q}=0 \tag{10}$$

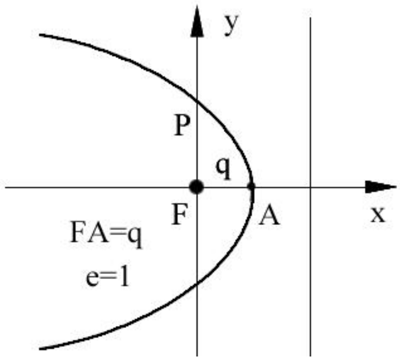

Fig.2 The parabolic orbit of a particle in the Newton's centered gravitational field.

As shown in Fig.3, when $e>1$, Eq.(5) describes the hyperbolic orbit. Different from Eq.(7), in this case , we have

$$p=b(e^2-1) \qquad h^2=GMb(e^2-1) \tag{11}$$

At perihelion we have $\dot{r}=0$ and $r=b(e-1)$. Substituting them in Eq.(8), the total energy of a particle is greater than zero with

$$E=\frac{m_0h^2}{2b^2(e-1)^2}-\frac{GMm_0}{b(e-1)}=+\frac{GMm_0}{2b}>0 \tag{12}$$

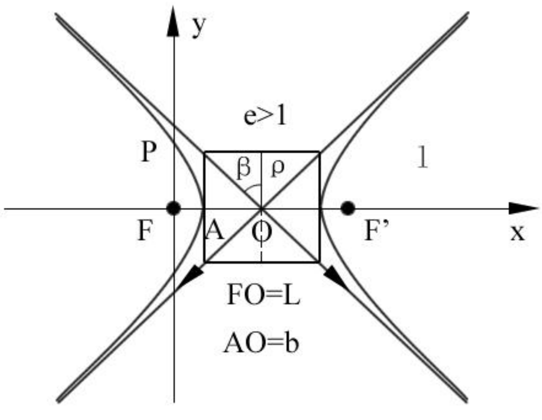

Fig.3 The hyperbolic orbit of a particle in the Newton's centered gravitational field.

2.2 The deflection of light in the Newton's centered gravity field

Suppose that the equivalent inertial static mass of a photon is m_0, and the gravity mass is equal to the inertial static mass. In the position $r \to \infty$, the speed of a photon in vacuum is $V = c$ and the energy is $E = h\nu$. According to the Newtonian mechanism, the kinetic energy of a photon is

$$T = \frac{1}{2} m_0 V^2 \to \frac{1}{2} m_0 c^2 = h\nu \qquad (13)$$

So the static mass of a photon is $m_0 = 2h\nu / c^2$, and the equation of energy conservation becomes

$$\frac{1}{2} m_0 (\dot{r}^2 + r^2 \dot{\theta}^2) - \frac{GMm_0}{r} = \frac{1}{2} m_0 c^2 \qquad (14)$$

Due to $E > 0$, the motion orbit of a photon in the spherically symmetric gravity field is a hyperbolic. We also have $r^2 \dot{\theta} = h^2 = GMb(e^2 - 1)$. At the perihelion with $\dot{r} = 0$ and $r = b(e-1)$, substituting them in Eq. (14), we get

$$\frac{h^2}{r^2} - \frac{2GM}{r} = \frac{GMb(e^2-1)}{b^2(e-1)^2} - \frac{2GM}{b(e-1)}$$

$$= \frac{GM(e+1-2)}{b(e-1)} = c^2 \qquad (15)$$

For the orbit of hyperbolic with $e > 1$, let $e = 1 + \delta$ and substituting it in Eq.(15), we get

$$b = \frac{GM}{c^2} = \frac{\alpha}{2} \qquad (16)$$

Where $\alpha = 2GM / c^2 = 2.95 \times 10^3$ m is the gravity radius of the sun. On the other hand, according to the theory of conic curve, the equation of hyperbolic can be written as [8]

$$\frac{x^2}{b^2} - \frac{y^2}{\rho^2} = 1 \qquad (17)$$

As shown in Fig. 3, the real half axis of hyperbolic is b, the imaginary half axis is ρ and the focal length is $2L$ with

$$L = \sqrt{b^2 + \rho^2} \qquad e = L / b > 1 \qquad (18)$$

For a photon passingpassespasses across the solar surface, let $R = 6.96 \times 10^8$ m be the solar radius, we have $L \approx R + b$ and get

$$L^2 = b^2 + \rho^2 = (R+b)^2 \qquad \text{or} \qquad \rho = \sqrt{R^2 + 2bR} = R\sqrt{1 + 2b/R} \tag{19}$$

It can be seen from Fig. 3 with

$$tg\varphi = \frac{b}{\rho} = \frac{b}{R\sqrt{1+2b/R}} \tag{20}$$

According to Eq.(16), we have $2b = \alpha << R$, so we get

$$tg\varphi \approx \varphi \approx \frac{b}{R} \tag{21}$$

The deflection angle of light coming from distant stars and passing across the surface of the sun is

$$\Delta\varphi = 2\varphi = \frac{2b}{R} = \frac{2GM}{c^2 R} = 0.875'' \tag{22}$$

It is the half of the prediction value of general relativity and is completely same with the Soldner's calculation. It was only because the wave theory of light prevailed in the eighteenth and the nineteenth centuries that Sodner's calculation were not taken seriously.

3. The motion equation of light of general relativity does not hold

3.1 The time-independent orbital equation of light of general relativity

According to general relativity, the time-independent orbital equation of light coming from stars in outer space in the solar gravitational field is [9]

$$\left(\frac{du}{d\theta}\right)^2 = \frac{c^2\varepsilon^2}{h^2} - u^2 + \alpha u^3 = f(u) \tag{23}$$

Here ε and h are integral constants. If the correction item αu^3 of general relativity does not exist, Eq.(23) becomes

$$\left(\frac{du}{d\theta}\right)^2=\frac{c^2\varepsilon^2}{h^2}-u^2 \qquad (24)$$

By taking the derivative of Eq. (24) with respective to θ, it becomes

$$\frac{d^2u}{d\theta^2}+u=0 \qquad (25)$$

Eq.(25) is different from Eq.(4) of the Newtonian theory with a missing of constant item. In fact, the first integration of Eq. (4) is

$$\left(\frac{du}{d\theta}\right)^2=\frac{2GM}{h^2}u-u^2+A \qquad (26)$$

By taking integral constant $A=c^2\varepsilon^2/h^2$, Eq.(26) has a item containing variable u more than Eq.(24). It was indicated in the author's paper [5] that due to the Einstein's hypothesis that light's motion in gravity field satisfied the metric condition $ds=0$, it leads to the missing of this item and the violation of uniqueness of geodesic equation. Therefore, in the spherically symmetric gravitational field, the motion equation of light in general relativity is not an approximation of the motion equation of the Newtonian gravity.

It is obvious that Eq.(25) is unrelated to the solar mass. Its solution is

$$u=\frac{\sin\theta}{D} \qquad D=r\sin\theta \qquad (27)$$

Eq.(27) indicates that a photon moves along the straight line $y=D$ as shown in Fig.4. So according to Eq.(25), if the correction item of general relativity does not exist, a photon would move along a straight line. But this is not true. A photon can not move along a straight line in the solar gravity field. So Eq. (23) can not hold. Based on this point alone, we can claim that the motion equation of light of general relativity is invalid.

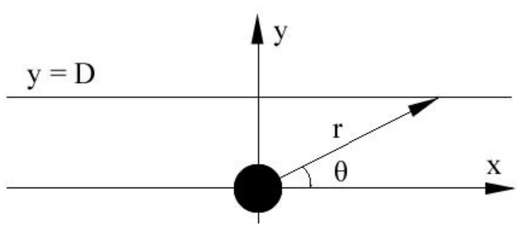

Fig.4 Light' orbit in the solar gravity field when the correction item of general relativity did not exist.

According to Fig4. at the point $x=0$, we have $\theta=\pi/2$, $du/d\theta=\cos\theta/D=0$, $u=1/D$, $r=D$. Substituting them in Eq.(23), we get $c^2\varepsilon^2/h^2=1/D^2$, and the constant item is determined. Eq. (23) becomes

$$\left(\frac{du}{d\theta}\right)^2=\frac{1}{D^2}-u^2+\alpha u^3=f(u) \qquad (28)$$

There are two measurements which are related to light's motions in the solar gravitational field of the sun in the four experimental tests of general relativity, namely the deflection of light and the radar wave delay. It is assumed in both measurements that the orbit poles of light or radar were near the surface of the sun with $D=r\sin\theta$ as shown in Fig.5 [9]. Taking the derivative of Eq.(28) with respect to θ, it becomes

$$\frac{d^2u}{d\theta^2}+u=\frac{3\alpha}{2}u^2 \qquad (29)$$

Based on Eq.(29), the deflection angle of light was calculated in general relativity with

$$\Delta\theta=\frac{2\alpha}{R}=\frac{4GM}{c^2R}=1.75'' \qquad (30)$$

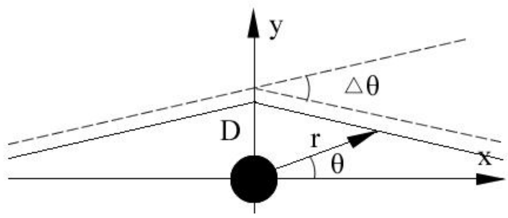

Fig.5 The deflection of Light's orbit in the solar gravity field.

3.2 The time-dependent motion equation of light of general relativity

The time-dependent motion equation of light in general relativity had not been seriously discussed up to now. When it is used to calculate the gravitational deflection of light in the solar gravitational field, the deflection angle can not be 1.75", which is inconsistent with that calculated by using Eq.(29). We discuss this problem below.

By solving the Einstein's equation of gravity in spherically symmetric gravitational field, the Schwarzschild metric is obtained

$$ds^2 = c^2 A(r)dt^2 - B(r)dr^2 - r^2(d\theta^2 + \sin^2\theta d\varphi^2) \tag{31}$$

Here

$$A(r) = 1 - \alpha / r \qquad\qquad B(r) = (1 - \alpha / r)^{-1} \tag{32}$$

Einstein assumed that objects moved in a gravitational field along a geodesic. The equations of geodesic were calculated by using Riemann geometry. According to the standard method of Riemann geometry, based on the the Schwarzschild metric, four geodesic equations can be obtained. Take $\theta = \pi / 2$, one of these equations is equal to zero on the both sides of equal sign. The other three independent equations are [9,10]

$$\frac{d^2 r}{ds^2} + \frac{B'}{2B}\left(\frac{dr}{ds}\right)^2 - \frac{r}{B}\left(\frac{d\varphi}{ds}\right)^2 + \frac{A'}{2B}\left(\frac{dx^0}{ds}\right)^2 = 0 \tag{33}$$

$$\frac{d^2\varphi}{ds^2} + \frac{2}{r}\frac{dr}{ds}\frac{d\varphi}{ds} = 0 \tag{34}$$

$$\frac{d^2 x^0}{ds^2} + \frac{A'}{A}\frac{dr}{ds}\frac{dx^0}{ds} = 0 \qquad \text{or} \qquad \frac{d}{ds}\left(A\frac{dx^0}{ds}\right) = 0 \tag{35}$$

Where $x^0 = ct$, $B' = dB(r)/dr$ and $A' = dA(r)/dr$. The integrals of Eqs.(34) and (35) are

$$r^2 \frac{d\varphi}{ds} = J \tag{36}$$

$$\frac{dx^0}{ds} = \frac{K}{A(r)} \tag{37}$$

Where J and K are integral consents. By considering Eq.(36) and (37) and taking the integral of Eq.(33), we get【9】:

$$B\left(\frac{dr}{ds}\right)^2 + r^2\left(\frac{d\varphi}{ds}\right)^2 - \frac{K^2}{A} = -E \tag{38}$$

We write Eq.(38) as

$$\frac{dr}{ds} = \frac{1}{B^{1/2}}\sqrt{-E - \frac{J^2}{r^2} + \frac{K^2}{A}} \tag{39}$$

To eliminate ds from Eqs.(36), (37) and (38), the time-dependent motion equation of light in general relativity can be obtained as below[5]

$$\left(\frac{dr}{dt}\right)^2 + r^2\left(\frac{d\varphi}{dt}\right)^2 = c^2\left(1-\frac{E}{K^2}\right) + c^2\left(\frac{3E}{K^2}-2\right)\frac{\alpha}{r}$$

$$+c^2\left(1-\frac{3E}{K^2}\right)\frac{\alpha^2}{r^2} + \frac{c^2E}{K^2}\frac{\alpha^3}{r^3} + \frac{\alpha L^2}{K^2 r^3}\left(1-\frac{\alpha}{r}\right)^2 \qquad (40)$$

On the other hand, substituting Eq.(36), (37) and (39) in Eq.(31), we can get $ds^2 = Eds^2$. Einstein assumed that the motion of light satisfied $ds^2 = 0$ in gravitational field, so we have $E = 0$. Meanwhile, we have $K = 1$. Let $cJ = L$, Eq. (40) becomes

$$\frac{1}{2}m_0\left[\left(\frac{dr}{dt}\right)^2 + r^2\left(\frac{d\varphi}{dt}\right)^2\right] + U(r) = \frac{1}{2}m_0 c^2 \qquad (41)$$

$$U(r) = \frac{2GMm_0}{r}\left[1-\frac{\alpha}{2r}-\frac{L^2}{2c^2r^2}\left(1-\frac{2\alpha}{r}+\frac{\alpha^2}{r^2}\right)\right] \qquad (42)$$

Where $U(r)$ is the gravity potential energy of a photon and $E_0 = h\nu_0 = m_0c^2/2$ is the kinetic energy of a photon when $r \to \infty$, corresponding to the inertial mass $m_0 = 2h\nu_0/c^2$ for a photon. In the weak gravity field of the sun, we have $\alpha / r << 1$. For the deflection of light coming from out side space, the angle moment $L = cR$, here R is the solar radius. So on the surface of the sun (where gravitational potential energy is most great), Eq. (42) becomes

$$U(R) = \frac{GMm_0}{R}\left(1+\frac{\alpha}{R}-\frac{\alpha^2}{R^2}\right) \qquad (43)$$

Ignoring the correction term containing $\alpha / R \sim 10^{-5}$ of general relativity, Eq.(43) is just the Newtonian gravitational potential on the solar surface. Therefore, according to Eqs.(41) and (42), the deflection of light in the solar gravitational field can only be the prediction value $0.875''$ of the Newton's theory of gravity by adding a mall correction with the magnitude order of 10^{-5}. It can not be $1.75''$ unless taking $m_0 \to 2m_0$ in Eq.(42). The result indicates that the two motion equations of light in general relativity contradict each other.

In addition, according to Eq.(42), the gravitational potential energy of photon is positive. So light is deflected by a repulsive force in a opposite direction as predicted in the solar gravitational field, also inconsistent with the Newton's theory of gravity. Observing from the earth, the wavelength of light omitted from the sun is violet shift, rather than red shift, which is not consistent with actual observations. All these show that the motion equation of light in general relativity is not valid.

4. The orbit poles of light's motion equation of general relativity

4.1 The orbit pole of light's motion equation of Newtonian theory of gravity

The orbital poles of light in a spherically symmetric gravitational field are described by $du/d\theta = 0$. According to Eq.(26), the orbital poles of light satisfies below equation

$$u^2 - \frac{2GM}{h^2}u - A = 0 \qquad (44)$$

This is a quadratic equation with two roots. One is positive and another is negative. The negative root is meaningless, and the positive root is the point A of hyperbolic shown in Fig.3, meaning that lightpassespasses across near the solar surface.

By comparing Eq.(23) with Eq.(26), it can be seen that the motion equation of general relativity loses a term containing u and has one more term containing u^3 than that of Newtonian gravity. So the motion equation of general relativity is not a modification of the equation of Newtonian gravity. In fact, if the motion equation of general relativity is the modification of the equation of Newtonian gravity, Eq.(26) would be written as

$$\left(\frac{du}{d\theta}\right)^2 = \frac{c^2\varepsilon^2}{h^2} + \frac{2GM}{h^2}u - u^2 + \alpha u^3 \qquad (45)$$

According to Eq.(45), the orbital poles of light should be described by bellowing formula

$$\frac{c^2\varepsilon^2}{h^2} + \frac{2GM}{h^2}u - u^2 + \alpha u^3 = 0 \qquad (46)$$

According to Eq.(46), the orbital pole of light is a slight modification of the orbital pole of Eq.(44). However, as mentioned above, the motion equation of light in general relativity is not a modification of the motion equation of the Newton's theory. Because of the lack of a term containing u in Eq.(23), the poles are not near the point A in Fig.3, but a point far distance from the point A, so that lights coming from stars in outer space can notpassespasses across the solar surface. All of them enter inside the sun and disappear in it, so that the observers on the earth can not observed them. Now let's do the specific calculation below.

4.2 The roots of a cubic equation of one variable

According to the theory of cubic equation of one variable, the function $f(u)=0$ shown in Eq.(28) has three real roots (poles), or one real root and two conjugate complex roots. It can not have two real root and one complex root. Therefore, when distant light passes near the solar surface, its orbit at least has one pole,or has three poles.

Let $b=-1/\alpha$, $g=1/(\alpha D^2)$ in Eq. (28) , from $f(u)=f(u_1)=0$, we get

$$u_1^3-\frac{1}{\alpha}u_1^2+\frac{1}{\alpha D^2}=u_1^3+bu_1^2+g=0 \tag{47}$$

Then let

$$u_1=y_1-\frac{b}{3} \tag{48}$$

Eq.(47) is written in the standard form of cubic equation

$$y_1^3+py_1+q=0 \tag{49}$$

Where $$p=-\frac{1}{3}b^2=-\frac{1}{3\alpha^2}$$

$$q=\frac{2}{27}b^3+g=-\frac{1}{\alpha^3}\left(\frac{2}{27}-\frac{\alpha^2}{D^2}\right) \tag{50}$$

The three solutions of Eq.(49) are [8]

$$y_1=\left[-\frac{q}{2}+\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}\right]^{1/3}+\left[-\frac{q}{2}-\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}\right]^{1/3} \tag{51}$$

$$y_2 = \frac{-1-i\sqrt{3}}{2}\left[-\frac{q}{2}+\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}\right]^{1/3} + \frac{-1+i\sqrt{3}}{2}\left[-\frac{q}{2}-\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}\right]^{1/3} \qquad (52)$$

$$y_3 = \frac{-1+i\sqrt{3}}{2}\left[-\frac{q}{2}+\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}\right]^{1/3} + \frac{-1-i\sqrt{3}}{2}\left[-\frac{q}{2}-\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}\right]^{1/3} \qquad (53)$$

Based on theses three roots, we discuss the orbital poles of light of general relativity in the solar gravity field.

4.3 The poles of light's orbit when $D > R >> \alpha$

The radius of the sun is $R = 6.96\times 10^8$ m， and the gravity radius or the Schwarzschild radius of the sun is $\alpha = 2.95\times 10^3$ m. For the light coming from distance place as shown in Fig.4, we take $D > R >> \alpha$, $\alpha^2 / D^2 \le 10^{-10} << 1$. By ignoring the item α^2 / D^2 , from Eq. (50), we get

$$\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3} = \sqrt{\frac{1}{27^2\alpha^6}-\frac{1}{9^3\alpha^6}} = 0 \qquad (54)$$

Substituting the result in Eqs.(51) ~ (53), we get

$$y_1 = \frac{2}{3\alpha} \qquad u_1 = y_1 - \frac{b}{3} = \frac{1}{\alpha} \qquad r_1 = \frac{1}{u_1} = \alpha \qquad (55)$$

$$y_2 = y_3 = -\frac{4}{3\alpha} \qquad u_2 = u_3 = -\frac{1}{\alpha} \qquad r_2 = r_3 = -\alpha \qquad (56)$$

In this case, Eq.(49) has three real roots, but only one $r_1 = \alpha$ has positive value, indicating that the orbital pole of light is almost at the Schwarzschild radius. Another two are negative and meaningless.

Due to the existence of material inside the sun, this result means that all lights from distant stars on the positions $D > R$ would enter the sun and disappear inside it. The observers on the earth can not see them and the earth's night sky would be dark, but it is not true.

4.4 The pole of light's orbit when $D = R$

When $D = R$, if the item α^2 / D^2 was not ignored, let's calculate the roots of Eq.(49). The radius of the sun is $R = 6.96\times 10^8$ m. Let $D = R = 2.36\times\alpha\times 10^5$, from Eq.(50), we have

$$q = -\frac{2}{27\alpha^3}\left(1-\frac{27\alpha^2}{2D^2}\right) = -\frac{2}{27\alpha^3}(1-\varepsilon_1) \qquad (57)$$

Here $\varepsilon_1 = 2.43\times 10^{-10}$ is a small quantity. We have

$$\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3} = \frac{1}{2\alpha D^2}\sqrt{1-\frac{4D^2}{27\alpha^2}} \qquad (58)$$

Substituting $D = 2.36\alpha\times 10^5$ in Eq.(58), we get

$$\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3} = \frac{\sqrt{1-8.25\times 10^9}}{1.11\times 10^{11}\alpha^3} = \frac{i\varepsilon_2}{\alpha^3} \qquad (59)$$

Here $\varepsilon_2 = 3.72\times 10^{-2}$. Let $\varepsilon = 27\varepsilon_2$. By considering $\varepsilon_1 = 2.43\times 10^{-10} << 1$, Eq.(51) becomes

$$y_1 = \frac{1}{3\alpha}(1+i\varepsilon)^{1/3} + \frac{1}{3\alpha}(1-i\varepsilon)^{1/3} \qquad (60)$$

Eq.(60) can be written as

$$y_1 = \frac{1}{3\alpha}(Qe^{i\varphi/3} + Qe^{-i\varphi/3}) = \frac{2Q\cos(\varphi/3)}{3\alpha} \qquad (61)$$

Here

$$Q = \left(\sqrt{1+\varepsilon^2}\right)^{1/3} \qquad \varphi = arctg\,\varepsilon \qquad (62)$$

Because of $\varepsilon = 27\times 3.72\times 10^{-2} \approx 1.00$, we have $\varphi = 45^0$ and

$$Q = 2^{1/6} = 1.12 \qquad \cos\varphi/3 = \cos 15^0 = 0.96 \qquad (63)$$

From Eq.(55), we get

$$u_1 = \frac{1.12\times 0.96}{3\alpha} + \frac{1}{3\alpha} = \frac{0.69}{\alpha} \qquad r_1 = \frac{1}{u_1} = \frac{\alpha}{0.69} = 4.28\times 10^3\,\text{m} \qquad (64)$$

Then, we calculate other two roots. By considering the formula

$$\frac{1}{3\alpha}(1+i\varepsilon)^{1/3}-\frac{1}{3\alpha}(1-i\varepsilon)^{1/3}=Q(e^{i\varphi/3}-e^{-i\varphi/3})=2iQ\sin(\varphi/3) \qquad (65)$$

Eqs.(52) and (53) become

$$y_2=\frac{(-1-i\sqrt{3})(1+i\varepsilon)^{1/3}}{6\alpha}+\frac{(-1+i\sqrt{3})(1-i\varepsilon)^{1/3}}{6\alpha}$$

$$=-\frac{1}{6\alpha}\left[(1+i\varepsilon)^{1/3}+(1-i\varepsilon)^{1/3}\right]-\frac{i\sqrt{3}}{6\alpha}\left[(1+i\varepsilon)^{1/3}-(1-i\varepsilon)^{1/3}\right]$$

$$=\frac{-Q\cos(\varphi/3)+\sqrt{3}Q\sin(\varphi/3)}{3\alpha}=-\frac{1.12}{3\alpha}(0.96-\sqrt{3}\times 0.26)=-\frac{0.19}{\alpha} \qquad (66)$$

$$y_3=\frac{(-1+i\sqrt{3})(1+i\varepsilon)^{1/3}}{6\alpha}+\frac{(-1-i\sqrt{3})(1-i\varepsilon)^{1/3}}{6\alpha}$$

$$=-\frac{1}{6\alpha}\left[(1+i\varepsilon)^{1/3}+(1-i\varepsilon)^{1/3}\right]+\frac{i\sqrt{3}}{6\alpha}\left[(1+i\varepsilon)^{1/3}-(1-i\varepsilon)^{1/3}\right]$$

$$=\frac{-Q\cos(\varphi/3)-\sqrt{3}Q\sin(\varphi/3)}{3\alpha}=-\frac{1.12}{3\alpha}(0.96+\sqrt{3}\times 0.26)=-\frac{0.51}{\alpha} \qquad (67)$$

So we have

$$u_2=-\frac{0.19}{\alpha}+\frac{1}{3\alpha}=\frac{0.14}{\alpha} \qquad r_2=\frac{1}{u_2}=\frac{\alpha}{0.14}=2.11\times 10^4\,\text{m} \qquad (68)$$

$$u_3=-\frac{0.51}{\alpha}+\frac{1}{3\alpha}=-\frac{0.18}{\alpha} \qquad r_3=\frac{1}{u_3}=-\frac{\alpha}{0.18}=-1.64\times 10^4\,\text{m} \qquad (69)$$

For $D=R=6.69\times 10^8$ m, the function $f(u)$ has three roots with two being real and one being negative as shown in Eqs.(64), (68) and (69).

Since the negative root has no physical meaning, this result means that the orbit of light entering the solar system has two poles, one is at $r_2=4.28\times 10^3$ m and the other is at $r_2=2.11\times 10^4$ m. Both roots are inside the sun, not far from the sun's gravitational radius, meaning that light entering inside the sun can no escape from the sun and be seen by the observers on the earth.

4.5 The pole of light's orbit when $D=\alpha\times10^2$

If the original position of light is at $D=\alpha\times10^2=2.95\times10^5$ m, we have $\varepsilon_1=1.35\times10^{-3}$ in Eq.(57) and $\varepsilon_2=i1.44\times10^{-6}$ in Eq.(59), so we have $\varepsilon=27\varepsilon_2=i3.89\times10^{-5}$. From Eq .(62), we get

$$Q=\left(1+(3.89\times10^{-5})^2\right)^{1/6}=(1+1.51\times10^{-9})^{1/6}=1+1.89\times10^{-10} \quad (70)$$

As well as $\varphi=5.02\times10^{-3}$, $\cos\varphi/3\approx1$, $\sin\varphi/3\approx1.67\times10^{-3}$. According to Eqs.(61), (66) and (67), we obtain

$$y_1=\frac{2(1+1.89\times10^{-10})}{3\alpha} \qquad u_1=\frac{2(1+1.89\times10^{-10})}{3\alpha}+\frac{1}{3\alpha}\approx\frac{1}{\alpha} \qquad r_1=\alpha \quad (71)$$

$$y_2=\frac{-(1+1.89\times10^{-10})}{3\alpha} \qquad u_2=\frac{-(1+1.89\times10^{-10})}{3\alpha}+\frac{1}{3\alpha}=-\frac{1.89\times10^{-10}}{\alpha}$$

$$r_2=-\frac{\alpha}{1.89\times10^{-10}}=-1.56\times10^{13}\,\text{m} \quad (72)$$

$$y_3=\frac{-(1-1.89\times10^{-10})}{3\alpha} \qquad u_3=\frac{-(1-1.89\times10^{-10})}{3\alpha}+\frac{1}{3\alpha}=\frac{1.89\times10^{-10}}{\alpha} \quad (73)$$

$$r_3=\frac{\alpha}{1.89\times10^{-10}}=1.56\times10^{13}\,\text{m} \quad (74)$$

The function $f(u)=0$ has three real roots, two are positive and one is negative. One of positive roots is located at the gravity radius of the sun and another is located at the position of 2.24×10^4 m from the center of the sun. The result is the same as $D=R$.

4.6 The orbital pole of light when $D=\alpha$

If the original position of light is at $D=\alpha$, according to Eq.(50), we have

$$q=-\frac{1}{\alpha^3}\left(\frac{2}{27}-1\right)=\frac{0.9259}{\alpha^3}$$

$$\sqrt{\left(\frac{q}{2}\right)^2+\left(\frac{p}{3}\right)^3}=\frac{1}{2\alpha^3}\sqrt{1-\frac{4}{27}}=\frac{0.4615}{\alpha^3} \tag{75}$$

$$y_1=-\frac{1}{\alpha}(0.4630-0.4615)^{1/3}-\frac{1}{\alpha}(0.4630+0.4615)^{1/3}=-\frac{1.0887}{\alpha} \tag{76}$$

$$u_1=-\frac{1.0887}{\alpha}+\frac{1}{3\alpha}=-\frac{0.7554}{\alpha} \qquad r_1=-1.3238\alpha<0 \tag{77}$$

$$y_2=\frac{0.1145(-1-i\sqrt{3})}{2\alpha}+\frac{0.9742(-1+i\sqrt{3})}{2\alpha}=-\frac{0.5444-i0.7436}{\alpha} \tag{78}$$

$$y_3=\frac{0.1145(-1+i\sqrt{3})}{2\alpha}-\frac{0.9742(1+i\sqrt{3})}{2}=-\frac{0.5444+i0.7436}{\alpha} \tag{79}$$

The equation $f(u)=0$ has a negative root and two conjugate complex roots. For the motion of light, this kind of poles can not exist. However, it is normal for light moves stating from the original position $D=\alpha$. Meanwhile, we can assume that the sun is a black hole, light passes across the surface of the black hole, how does the pole of light's orbit not exist?

4.7 The Calculation of radar wave delay

According to general relativity, the time delay of radar waves between Earth and Mercury is [9]

$$\Delta t=\frac{2\alpha}{c}\left[1+\ln\frac{4rr'}{R^2}\right]=\frac{4GM}{c^3}\left[1+\ln\frac{4rr'}{R^2}\right]=2.4\times10^{-4}\,\mathrm{s} \tag{80}$$

Here r and r' are the distances between Earth, Mercury and the solar center.

This calculation also assumed that radar waves passed across the surface of the sun. For the same reason, the orbital poles of radar wave was also inside the sun, so the calculation result of Eq.(80) was also impossible. In fact, there are some other serious problems in the radar wave delay calculation of general relativity, but we do not discuss them in this paper.

5. Conclusions

Johann von Soldner of Munich Observatory proved in 1801 that the gravity field of the sun would deflect the light from distant stars and the deflection angel was 0.875 ". But Sodner' proof was to simple to understand.

In this paper, a standard calculation method is given according to the hyperbolic orbit equation of the Newton's theory of gravity, and the same result is obtained. Then the motion equation of light in general relativity is compared with that in the Newton's theory of gravity. The result shows that a constant term is missing in the motion equation of general relativity. The loss of this term would cause serious problems, so that the motion equation of light in general relativity can not be the modification of the Newton's equation of motion and can not be correct.

Einstein assumed that the light passed across the sun's surface when he calculated the deflection of light in the solar gravitational field. It indicated that the orbital pole of light was on the solar surface. Based on the theory of cubic equation of one variable, it is proved in this paper that the solar radius can not be the root of the motion equation of light in general relativity, and all poles of the motion equation of light are located inside the sun. The lights coming from stars in outer space would go into the sun and disappear in it. It is impossible for the observers on the earth to see them, but this is not the case.

The reason is just that comparing with the motion equation of the Newtonian gravity theory, the motion equation of light of general relativity lost a constant term. It is proved once again that the prediction value 175'' of general relativity for the deflection of light is impossible. General relativity can not correctly describe the motion of light in the gravitational field of the sun, indicates that the Einstein's gravity theory of curved space-time can not hold.

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