An Alternative Theory of Gravitation, Derived from the Fatio-Le Sage Theory

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An alternative theory of gravitation accounting for phenomena generally explained by the General Theory of Relativity, such as the light deflexion by Sun, the gravitational redshift of light, the Shapiro time delay and, in part, the perihelion precession of Mercury, is developed here.

It is based on the model of Fatio-Le Sage, according to which vacuum would be made up of corpuscles several orders of magnitude smaller than the elementary particles of matter, without mutual interaction and moving with great speed. The attraction between two material masses would be due to the shield effect that each one provides to the other, from the impacting gravitation particles.

We hypothesized that the speed of these corpuscles in absence of important material masses was that of light and showed that their acceleration by material masses was twice greater than that of material particles. It was inferred the following expressions for the square of the speed of these gravitational corpuscles near important material masses $V^2 = c^2\left(1+4\frac{GM}{rc^2}\right)$, and the gravitation constant for material particles $G' = G\left(1+4\frac{GM}{rc^2}\right)$, where r is the distance to the centre of the body of mass M, G and c are respectively the common gravitation constant and speed of light, far from important masses.

The validity of this theory and of Fatio-Le Sage's model are discussed.

Keywords: alternative theory, gravitation, Fatio-Lesage's theory. General relativity.

Introduction

The deflection of starlight near the eclipsed Sun, the gravitational signal delay and redshift of light, the anomalous perihelion precession of Mercury, are phenomena well explained by the General Relativity theory of A. Einstein [1], which is the most widely accepted theory of gravitation.

The equations of relativity predict that matter modifies space and flow of time in its vicinity, so that non Euclidean geometry must be used. But common sense does not adhere easily and intuitively to these rules, so we searched for an alternative theory which does not refer to this geometry and gives yet a straightforward explanation of these phenomena.

The basis of our theory is that the gravitation constant *G'* would be expressed as a function of the mass *M* of a body and the distance *r* of its centre, according to the formula

$$G' = G\left(1 + 4\frac{GM}{rc^2}\right) \tag{1}$$

where G and c are respectively the gravitation and the speed of light common constants.

Moreover, the gravitation constant would be doubled when considering the gravitational interaction between a material mass and a photon.

This relationship was not obtained by chance or with the aim of accounting for the experimental results. It proceeds from a model initially proposed by N. Fatio [2], then by G-L. Le Sage [3], in which vacuum would be made up of corpuscles several orders of magnitude smaller than the elementary particles of matter, without mutual interaction and moving with great speed. The attraction between two material masses would be due to the shield effect that each one provides to the other, from the impacting gravitation particles.

We show here that it leads to the above-mentioned formula of gravitation.

Light deflection of starlight by Sun

During the solar eclipse of 1919, the position of stars observed in the Sun vicinity appeared shifted to 1.75 arc seconds, which is the value predicted by the General Relativity theory. The same result is obtained with our theory.

According to (1) applied to a photon, the acceleration due to a mass M is:

$$\gamma = 2\frac{GM}{r^2}\left(1 + 4\frac{GM}{rc^2}\right),$$

The radial acceleration is:

$$\gamma_y = 2\frac{GM}{r^2}(1+4\frac{GM}{rc^2})\frac{R}{r},$$

where R is the Sun radius, M its mass and r is the distance of the photon to the Sun centre.

The elementary deflection di of the trajectory of the photon, at the distance x of the surface of the Sun is $di = \frac{dV_y}{V_x} = \frac{dV_y}{dt}\frac{dt}{dx}\frac{dx}{V_x} = \gamma_y \frac{dx}{V_x^2}$, where V_x is the velocity of the photon, dV_y the velocity variation perpendicular to the trajectory.

In our theory, the speed of light is not constant: the attraction of a photon of mass m by a material mass M is, in a first approximation, $2\frac{GMm}{r^2}$ and its potential energy $-2\frac{GMm}{r}$. As the total energy of a photon, coming from a great distance where no material mass is present, is constant, we have:

$$\frac{1}{2}mc^2 = \frac{1}{2}mV_x^2 - 2\frac{GMm}{r}$$

$$V_x^2 = c^2(1+4\frac{GM}{rc^2}) \tag{2}$$

The speed of light in the vicinity of a material mass would be greater than the common value c.

Then,

$$di = 2\frac{GMR}{r^3c^2}dx$$

$$i = 2\frac{GMR}{c^2}\int_{-\infty}^{+\infty}\frac{1}{r^3}dx = 2\frac{GMR}{c^2}\int_{-\infty}^{+\infty}\frac{1}{\left(\sqrt{x^2+R^2}\right)^3}dx$$

If $u=\frac{x}{R}$ $\quad i=2\frac{GM}{Rc^2}\int_{-\infty}^{+\infty}\frac{du}{\left(\sqrt{1+u^2}\right)^3}=\left|2\frac{GM}{Rc^2}\frac{u}{\sqrt{1+u^2}}\right|$, between $-\infty$ and $+\infty$

$$i=4\frac{GM}{Rc^2}$$

This gives the value of 1.75 arc seconds predicted by the General Relativity and observed during the solar eclipse.

The gravitational redshift of light

This effect was described and measured by Pound and Snider [4] with γ rays from radioactive iron 57, in a 21.6 meters high tower. They found that the frequency of the rising γ rays was less than the natural ones by a fractional amount of $2.45\ 10^{-15}$. The General Relativity accounts for this value, as well as our theory.

According to (2), the velocity of the photons in the vicinity of a material mass is

$$V=c\sqrt{1+4\frac{GM}{rc^2}}\approx c\left(1+2\frac{GM}{rc^2}\right)$$

If V_x is the velocity at the altitude x, V_0 the velocity at ground level, R the Earth radius and M, the Earth mass,

$$V_x=c\left(1+2\frac{GM}{(R+x)c^2}\right) \quad V_0=c\left(1+2\frac{GM}{Rc^2}\right)$$

$$V_0-V_x=2\frac{GMx}{cR(R+x)}\approx 2\frac{GMx}{cR^2} \text{ and } V_x=V_0-2\frac{GMx}{cR^2}$$

The photons take a time t to reach the altitude x:

$$t=\int_0^x \frac{dx}{\left(V_0-2\frac{GMx}{cR^2}\right)}\approx\int_0^x\left(1+2\frac{GMx}{cV_0R^2}\right)\frac{dx}{V_0}$$

$$t=\frac{x}{V_0}+2\frac{GM}{R^2cV_0^2}\int_0^x xdx=\frac{x}{V_0}+\frac{GM}{R^2cV_0^2}x^2$$

The Earth's mass induces a delay $\Delta t=\frac{GMx^2}{R^2cV_0^2}$

and

$$\frac{\Delta t}{t}\approx\frac{GMx}{R^2cV_0}\approx\frac{GMx}{R^2c^2}$$

The same relative variation would be observed at the altitude x for the period of the emitted light, and the variation of its frequency ν would be the opposite:

$$\frac{\Delta\nu}{\nu}=-\frac{GMx}{R^2c^2}$$

This relationship is identical to that given by the General Relativity, and is coherent with the measure of Pound and Snyder.

Shapiro time delay effect

Light signals are slowed down by gravitational field. The effect was discovered through the observation of radar signals sent to planets when they are in conjunction with the Sun and reflected back. This phenomenon is known as the Shapiro effect [5].

In our theory, the speed of light passing near the Sun or a planet is given by (2):

$$V=c\sqrt{1+4\frac{GM}{rc^2}}\approx c\left(1+2\frac{GM}{rc^2}\right),$$

where M is the mass of the object and r, the distance of the photon to its centre. The contributions of the planets to the second term in brackets are negligible (at the maximum, 1.39 10^{-9} for Earth, 2.8 10^{-10} for Mars), compared to the contribution of Sun (0.423 10^{-5}).

The travel time from Earth to Mars, passing near Sun, and back to Earth is:

$$t=2\int_{Earth}^{Sun}\frac{dx}{V}+2\int_{Mars}^{Sun}\frac{dx}{V}$$

$$t\approx 2\int_{Earth}^{Sun}\frac{1}{c}\left(1-2\frac{GM}{rc^2}\right)dx+2\int_{Mars}^{Sun}\frac{1}{c}\left(1-2\frac{GM}{rc^2}\right)dx$$

The light delay due to the presence of Sun is:

$$\Delta t=4\frac{GM}{c^3}\int_{Earth}^{Sun}\frac{dx}{r}+4\frac{GM}{c^3}\int_{Mars}^{Sun}\frac{dx}{r}$$

As $r=\sqrt{x^2+R^2}$ and $\int\frac{dx}{\sqrt{x^2+R^2}}=\ln\left(x+\sqrt{x^2+R^2}\right)$,

where R is the Sun radius, and if r_1 and r_2 are respectively the distances of Earth and Mars to the Sun, it comes:

$$\Delta t=4\frac{GM}{c^3}\left(\ln\left(\sqrt{r_1^2-R^2}+r_1\right)-\ln R+\ln\left(\sqrt{r_2^2-R^2}+r_2\right)-\ln R\right)$$

As r_1 and r_2 are much greater than R,

$$\Delta t=4\frac{GM}{c^3}\ln\left(4\frac{r_1r_2}{R^2}\right)$$

This delay is identical to that predicted by the General Relativity, and experimentally measured.

Perihelion precession of Mercury

The orbit of Mercury (as those of the other planets) slowly moves around the Sun: 5600 arc seconds per century. The major part of the precession, 5557 arc seconds per century, is due, on the one hand, to the fact that Earth is not an inertial frame of reference and, on the other hand, to the pull from the other planets. There is a discrepancy of 43 seconds of arc per century, which has been exactly accounted for by the theory of the General Relativity.

Our theory predicts also a precession, but smaller, and the difference will be discussed.

Let a planet of mass *m*, orbiting a star of mass *M*, *V* its velocity, *dθ/dt* its angular velocity, *L* its angular momentum and r its distance to the star.

$$L = mrV = mr^2 \frac{d\theta}{dt}$$

$$V^2 = \left(\frac{dr}{dt}\right)^2 + \left(r\frac{d\theta}{dt}\right)^2$$

$$\frac{dr}{dt} = \frac{dr}{d\theta}\frac{d\theta}{dt} = \frac{dr}{d\theta}\frac{L}{mr^2} = -\frac{L}{m}\frac{du}{d\theta}\text{, where } u = \frac{1}{r}$$

$$r\frac{d\theta}{dt} = \frac{rL}{mr^2} = \frac{uL}{m}$$

$$V^2 = \frac{L^2}{m^2}\left(u^2 + \left(\frac{du}{d\theta}\right)^2\right)$$

The total energy *E* of this planet remaining constant during orbiting,

$$\frac{1}{2}mV^2 + \int \frac{G'Mm}{r^2} dr = E$$

According to our theory, $G' = G\left(1 + 4\frac{GM}{rc^2}\right)$, for material masses.

$$\frac{1}{2}mV^2 - \frac{GMm}{r} + \int 4\frac{G^2M^2m}{c^2r^3}dr = E$$

$$\frac{1}{2}mV^2 - \frac{GMm}{r} - 2\frac{G^2M^2m}{c^2r^2} = E$$

$$V^2 - 2\frac{GM}{r} - 4\frac{G^2M^2}{c^2r^2} = 2\frac{E}{m}$$

$$\frac{L^2}{m^2}\left(u^2 + \left(\frac{du}{d\theta}\right)^2\right) - 2GMu - 4\frac{G^2M^2u^2}{c^2} = 2\frac{E}{m}$$

$$u^2 + \left(\frac{du}{d\theta}\right)^2 - 2\frac{GMm^2}{L^2}u - 4\frac{G^2M^2m^2u^2}{L^2c^2} = 2E\frac{m}{L^2}$$

After differentiation with respect to θ and division by $2\, du/d\theta$, as done by Fleck [6], we have:

$$u + \frac{d^2u}{d\theta^2} - \frac{GMm^2}{L^2} - 4\frac{G^2M^2m^2u}{L^2c^2} = 0$$

$$u\left(1 - 4\frac{G^2M^2m^2u}{L^2c^2}\right) + \frac{d^2u}{d\theta^2} = \frac{GMm^2}{L^2}$$

The trajectory of the planet is then an ellipse, with a perihelion precession. The equation of this ellipse is $r = \frac{p}{1 + e\cos B(\theta - \theta_0)}$, with e =eccentricity, $B^2 = 1 - 4\frac{G^2M^2m^2}{L^2c^2}$ and $p = \frac{L^2}{GMm^2}$.

Between two passages at the nearest point from the star, the ellipse has turned of an angle δ, in such a way that $\cos B(2\pi+\delta)=1$, then $\delta=2\pi\left(\frac{1}{B}-1\right)$.

$$B\approx1-2\frac{G^2M^2m^2}{L^2c^2},\ \delta=2\pi\left(2\frac{G^2M^2m^2}{L^2c^2}\right)=4\pi\left(\frac{GMm}{Lc}\right)^2$$

As $p=a\left(1-e^2\right)$, where a is the half major axis,

$$\delta=4\pi\frac{\left(GMm^2\right)}{L^2}\frac{GM}{c^2}=4\pi\frac{GM}{a\left(1-e^2\right)c^2}$$

In the case of Mercury, a= 5.79. 10^{12} cm, e= 0.205 and the mass of the Sun is 1.99. 10^{33} g. As there are 415 revolutions per century and as 1 radian = 2.06. 10^5 arc seconds, δ =28.6 arc seconds and not 43 as predicted by the General Relativity theory.

However, Mercury moves around the Sun and this movement, according to the Special Relativity, gives a correction term of $\pi\frac{GM}{a\left(1-e^2\right)c^2}$ = 7.15 arc seconds per century [6]. When this term is added, δ = 35.75 seconds of arc.

7 seconds are still missing.

The theory of General Relativity predicts exactly the value of 43 seconds, but without taking account of the correction term of the Special Relativity. The total precession would be of 50 seconds. A new phenomenon, which has not been addressed yet, could perhaps settle the question.

Demonstration of the formula $G' = G(1 + 4\frac{GM}{rc^2})$

This theory is based on the model initially proposed by N. Fatio [2], then by G-L Le Sage [3]. It has been perhaps rediscovered by Bourbon [7], who did not mention any preceding authors. Vacuum would be made up of gravitational corpuscles, several orders of magnitude smaller than the elementary material particles, moving with great speed and without mutual interactions. An elementary material particle alone, surrounded by this medium which is supposed isotropic, would receive momentum from these corpuscles on all sides, and the resultant force would be null.

When there are two elementary material particles A and B, the resultant of the forces would be a mutual attraction, as shown by Le Sage: any point of B would be protected by the mass of A from the corpuscles circulating within the solid angle $d\omega$, that A subtends at a point of B, but would be subjected to the bombardment of corpuscles from the opposite solid angle. The resultant of the momentum from corpuscles circulating in all other directions would be null. By reciprocity, B would protect the points of A from the corpuscles of the solid angle $d\omega'$, that B subtends at the points of A, and these points are then subjected to the action of the gravitation particles from the opposite solid angle.

From the Fatio-Le Sage's basis hypothesis, we developed the following gravitation theory:

The momentum of the gravitational corpuscles striking the surface ds' of B during the time dt is:

$$Vdt\,\rho V d\omega ds' = \rho V^2 dt d\omega ds' = dFdt \quad ,$$

where dF is the force exerted on ds', V^2 is the quadratic velocity of the gravitational corpuscles and ρ the specific mass of the vacuum constituted of these corpuscles. As the distance between A and B, for which gravitation is measured, is several orders of magnitude greater than the diameters of A or B, $d\omega$ is the same for all points of B. Then, we have $F_B = \rho V^2 d\omega S'$, where F_B is the force exerted on B and S' is the cross section area of B. As $d\omega = \frac{S}{r^2}$, where S is the cross section area of A and r the distance between A and B, it comes :

$$F_B = \frac{\rho V^2 S S'}{r^2},$$

and by symmetry, $F_A = F_B$.

Keller and Keller [8] and de Boisbaudran [9] supposed that gravitational forces were due to longitudinal waves propagating in every direction and losing some of their momentum after the impact on material masses.

We considered the corpuscles as a perfect gas, which allows longitudinal wave propagation, the velocity of which is given by the formula $c' = \sqrt{\frac{\gamma k T}{m}}$, where γ, k, T and m are respectively the equivalents for this medium of the adiabatic coefficient, the Boltzmann's constant, the absolute temperature and the mass of the gravitation corpuscles.

$$\gamma = 2 + \frac{1}{n},$$

where n is the number of degrees of freedom of the gravitation particles. As they circulate in straight line, they have only one degree of freedom and $\gamma = 3$.

On the other hand, according to the theory of perfect gas, the mean quadratic velocity of the corpuscles is: $V = \sqrt{\frac{3kT}{m}}$, then $V = c'$.

Let us suppose that these longitudinal vibrations have the speed of light, $c' = c$. Then,

$$F = \frac{\rho c^2 SS'}{r^2} \tag{3}$$

The possibility that this kind of vibrations could have polarisation properties will be discussed below.

The common gravitational constant G is defined by the relationship:

$$F = \frac{GMM'}{r^2} \tag{4},$$

and is measured between masses relatively small (in laboratory), or sufficiently far from one another (between Sun and planets). The acceleration due to a mass M is then $\frac{GM}{r^2}$, and the potential energy $-\frac{GM}{r}$, according to Newton's theory of gravitation.

The gravitational corpuscles are supposed to have a mass m and to be subjected to gravitation by the material masses, the effect being only visible when the latter are very large, such as stars or planets.

However, the acceleration produced by a material mass M on a gravific corpuscle would be twice greater than that produced on another material mass M': M' is several orders of magnitude larger than m, the momentum of the corpuscles circulating in the solid angle opposite to $d\omega$ is entirely absorbed, while there is elastic collision between the gravitational corpuscle coming from M and those, of the same mass, circulating in the solid angle opposite to $d\omega$. There is change of the sense of propagation of m which receives an acceleration double of that received by the material masses.

Its attraction by M would be $F = 2\frac{GMm}{r^2}$ and the potential energy $-2\frac{GMm}{r}$.

The energy of the particle m is $\frac{1}{2}mc^2$ when m is far from M and it becomes $\frac{1}{2}mV^2 - 2\frac{GMm}{r}$, when m is submitted to the attraction of M.

As the total energy is constant, it comes

$$V^2 = c^2\left(1 + 4\frac{GM}{rc^2}\right),$$

which is the relationship (2).

Consequently, the gravitation constant near important material masses, G', would be the following:

$$\frac{\rho V^2 SS'}{r^2} = \frac{G'MM'}{r^2}$$

$$\frac{\rho c^2\left(1 + 4\frac{GM}{rc^2}\right)SS'}{r^2} = \frac{G'MM'}{r^2}$$

According to (3) and (4),

$$\frac{\rho c^2 SS'}{r^2} = \frac{GMM'}{r^2} \tag{5}$$

It comes $G' = G\left(1 + 4\frac{GM}{rc^2}\right)$, which is the relationship (1).

Discussion

The theory described here was deduced from the model of Fatio-Le Sage, according to which the vacuum would be made up of corpuscles of mass several orders of magnitude smaller than that of elementary material particles, without any mutual interactions and circulating at high speed

We showed that the acceleration of the gravitational corpuscles *m* by material masses was double of that of other material masses and that their velocity was that of light *c* in the absence of neighbouring important material mass. The square of the velocity of these corpuscles, near an important material mass *M* was: $V^2=c^2\left(1+4\frac{GM}{rc^2}\right)$, where *G* is the common gravitation constant, measured far from important material masses and *r* the distance of the corpuscle to the centre of the material mass *M*. When considering the gravitational attraction between an important material mass and another body, the gravitation constant would be expressed by $G'=G\left(1+4\frac{GM}{rc^2}\right)$ and would be doubled when considering the interaction between an important material mass and a photon.

As the General Relativity, this theory accounts for the deflection of the starlight in the vicinity of the Sun, for the gravitational redshift of light and for the Shapiro time delay effect. In the case of Mercury, our theory predicts a perihelion precession of around 29 seconds of arc per century and of 36 seconds, when the correction term of the Special Relativity is taken into account. The value predicted by the General Relativity is exactly the expected 43 seconds of arc per century, but is 7 seconds of arc too high if the correction term is to be added.

On the other hand, the Fatio-Le Sage's theory itself has raised several critics, such as drag, aberration, absorption of energy or mass accretion and gravitational saturation [10].

It was objected that a material mass moving in the vacuum as defined by Fatio-Le Sage must be submitted to a drag force proportional to SuV where S is the cross sectional area of the elementary particles of matter, u their velocity, V the velocity of the gravitational corpuscles. In order to maximize the ratio of the gravitational force (proportional to V^2) to the drag force, it was assumed that V was several orders of magnitude higher (up to 10^{18}) than the speed of light[11].

However, in our opinion, the gravitational drag would be null: according to the Special Relativity, inside a material mass in movement, the speed of light, then the speed of the gravitation corpuscles, in the vacuum surrounding the elementary material particles, is independent of u and equal to c in any direction,. The total momentum of the gravitational corpuscles striking the material particles would then be null.

The absence of aberration can be explained in the same way: the speed of light in the vacuum around the material particles of Earth moving around the Sun remains constant and isotropically distributed, as if our planet was motionless, and the direction of the attraction force of Sun is that given by simple geometry, or as if the propagation speed of the gravitational corpuscles was infinite.

Another objection to the Le Sage's theory is that the absorption of energy by the material masses would be so huge that it would rapidly destroy them [11]. The energy received per second by a material particle A (for instance a proton, of radius $0.87\ 10^{-13}$ cm), from gravitational corpuscles of velocity c is: $\frac{1}{2}\rho c^2 c \times 4\pi \times (0.87)^2 10^{-26}$.

According to (5), $\rho c^2\left(\pi(0.87)^2 10^{-26}\right)^2 = GM^2$, and as the energy of the proton is Mc^2, the relative increase of energy (or of mass) per second is:

$$2\frac{GM}{\pi c(0.87)^2 10^{-26}} = 3.12\ .10^{-16}$$

The energy absorbed by A can be re-radiated in an isotropic flux of radiation, as has been hypothesized by Thomson [12]. More recently, the cosmological redshift of light has been ascribed by Jaakkola [13] and Edwards [14] to the interconversion of graviton energy and photon energy.

Because of its isotropic character, this emitted radiation would not give rise to any additional force on A. In the presence of another particle B, the re-radiated flux would be the flux received in the $(4\pi\text{-}d\omega)$ solid angle. The fraction sent back to B would be negligible in front of the flux of the gravitational corpuscles directed towards A, which are absorbed by B.

Le Sage himself has discussed the problem of the gravitational saturation. In order to have proportionality between the attraction force and the masses, no overlapping of the shadows of the elementary particles must occur, in any direction. This requirement is fulfilled. The concentration of the material particles is maximal in the atomic nucleus. For instance, there are 200 nucleons in the atomic nucleus of mercury, which has a radius of $0.157.\ 10^{-7}$ cm. The probability for a proton to be behind another one in a given direction is approximately $0.92.\ 10^{-8}$ and four times this value, if a part only of a proton is behind another one. On the other hand, the precision of the experimental determination of the gravitational constant is on the order of 10^{-4}. At this level of precision, there is no measurable effect of gravitational shielding due to alignment of material elementary masses.

It was supposed, in the demonstration of the formulae (1) and (2), that the propagation of longitudinal vibrations in the vacuum has the speed of light. Are these vibrations also responsible for the luminous phenomena? In these conditions, how any polarisation of light could occur? The phase of the vibrations emitted by the ordinary light sources changes every 10^{-9} seconds. If in a particular plane all the trains of waves have the same phase at the front of the waves, their effects would be added at this place. Conversely, a mean effect would be observed with the natural light and no addition would occur. Relationships identical to those of Fresnel's theory for refraction and reflection at the surface between two media can be obtained, for light in incident plane or perpendicular to it. It must be assumed that the two media have the same compressibility and that the displacement and the dilatation in the direction perpendicular to the separation plane of the incident vibration are the sum of those due to the reflected and refracted vibrations. Then, the longitudinal vibrations of light can present, in particular planes, properties analogous to polarized vibrations.

The theory presented here does not need non Euclidean geometry and the calculations are simpler than those of the General Relativity. The discrepancy of 7 arc seconds per century concerning the perihelion precession of Mercury requires further consideration or experiment.

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