Are special relativity and general relativity true?

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Abstract

I would like to talk about the falsity of the theory of relativity. I understand that shouts will now begin: “How long is it possible? Alternatives again.” I’ll answer this. Let’s argue. Just argue without insults. Those who protect Einstein, as a rule, does not provide any evidence and only call names. And their main argument: “You are a fool!” Of course, you can’t argue with this. Well, seriously, let’s figure it out.

Critics of the theory of relativity have appeared since its inception (see for example [1]). There has never been such a period in recent history of science when there were no critics of Einstein. Doesn’t this worry anyone?! Why are there no critics of Newton and the classical mechanics and mathematical analysis he created?!

Not everyone even knows why Einstein received the Nobel Prize. Many people think what kind of theory of relativity. In fact, this is not true. Einstein was given a prize for explaining the two laws of the photoelectric effect. At the same time, the Russian scientist Stoletov made a significant contribution to the research of the photoelectric effect. But in the West they prefer this don’t remember. This is understandable. They rarely give Nobel Prizes to Russians.

It should be noted that at first no one took the theory of relativity seriously. When Einstein was given Nobel Prize, it was said that the prize was awarded despite the dubiousness of his other theories and the presence serious objections to them. I will not list all the contradictions here. Simply because the number of given the arguments are unlikely to convince the most notorious skeptics.

1 Criticism of special relativity

1.1 Einstein's postulate and violation of the law of vector addition in the special theory of relativity

Einstein's postulate:

$$\vec{a} = \vec{a} + \vec{b}, \quad \vec{a} \neq 0, \quad \vec{b} \neq 0,$$

where $\vec{a}$ and $\vec{b}$ are arbitrary non-zero vectors. The Lorentz transformations and the "relativistic" law of addition of velocities are consequences of Einstein's postulate. In turn, Einstein's postulate is derived from the "relativistic" law of addition of velocities.

Humans invented the special theory of relativity. Einstein, Lorentz, Poincaré and others. But the attitude to it in the scientific community is like to Holy Scripture. The special theory of relativity violates the law of vector addition (the parallelogram rule), the axioms of mathematics and common sense. Perhaps this is its "zest", which made it popular. Lorentz transformations are derived from the violation of the law of vector addition at high speeds. But at low speeds, the violated vector addition law "tends to be fulfilled". Therefore, there is nothing surprising in the fact that the Lorentz transformations pass at low speeds into the natural Galileo transformations, which fulfill the law of vector addition. Lorentz transformations imply the invariance of the speed of light, which is the reason for the violation of the law of vector addition.

1.2 About the Michelson-Morley experiment

Let's describe it again. A point source emits light, which is converted by a lens into a parallel beam. A translucent mirror is located in the path of the light beam at an angle of 45° to it. The mirror divides the beam into transmitted and reflected. The separated light beams diverge at right angles. Then they are reflected from mirrors located in the path of each of them. Then each bunch falls on translucent mirror and is divided again into transmitted and reflected, forming thus two interfering beams with a certain phase difference. One of them is directed to the light source, and the other to the receiver, which registers it as an interference pattern.

Why should a beam of light feel, and the result of an experiment depend on where in the orbit are we located? What different reference systems are we talking about? At each moment of time at each point in the orbit we are dealing with *one* system reference — associated with the Earth. Has anyone measured the speed of a light beam in the Michelson-Morley experiment relative to the Sun? No.

1.3 About the speed of light in vacuum

Let's open the university physics textbook ([2]): "Note that this speed could, in fact, be called the maximum speed of propagation of interactions. It determines only the period of time after which a change that occurs in one body begins to manifest itself in another. It is obvious that the presence of a maximum speed of propagation of interactions means at the same time that in nature it is generally impossible for bodies to move at a speed greater than this one. Indeed, if such a movement could occur, then through it it would be possible to carry out interaction at a speed exceeding the greatest possible speed of propagation of interactions." The principle of the limiting speed of light in a vacuum appeared out of nowhere. There has not been a single experiment that has tested this principle. Why can an airplane fly faster than sound, and an electron in a medium fly faster than light?

1.4 About "time dilation"

Let's imagine the situation: a stationary observer is at point $(0, 0)$. The particle was formed at time $t = 0$ at point $(0, a)$ and flew along the straight line $y = a$ with speed v. At moment

$$t = \frac{a}{c},$$

where c is the speed of light in vacuum, the observer saw how it was formed. The particle reached point (b, a) and disintegrated. The observer saw that it disintegrated at moment

$$t = \frac{b}{v} + \frac{\sqrt{a^2 + b^2}}{c}.$$

The observer thought that the particle lived for a time

$$t = \frac{b}{v} + \frac{\sqrt{a^2 + b^2}}{c} - \frac{a}{c}.$$

But we know that it lived time

$$t = \frac{b}{v}.$$

So what kind of "time dilation" are we talking about?

1.5 On the physical meaning of the Lorentz factor

Let's imagine that we are moving along the plane $z = 0$ along the straight line $y = 0$ with speed v. Let us also imagine that the plane $z = a$ is a mirror. Let's also imagine that we are emitting light in all directions. There is a fixed direction to the mirror from where the light emitted by us will always shine. When we are at point $x = b$, this direction will be like this:

$$z = \frac{b - x}{\sqrt{\gamma^2 - 1}}, \quad b - x > 0,$$

where γ is the Lorentz factor. At the same time, the light that we emitted, *in the same time as us*, traveled a distance

$$\frac{c}{v} = \frac{\gamma}{\sqrt{\gamma^2 - 1}}$$

times greater than we did.

1.6 About pions and muons

Let's open the university textbook on electrodynamics ([3]): "In particular, the above-mentioned pions, born at an altitude of $20 - 30$ km in wide atmospheric showers of cosmic particles, safely reach the surface of the Earth, where they are recorded by scientific equipment. And although this fact convincingly confirms formula[1]

$$\tau = \frac{\tau_0}{\sqrt{1 - \frac{v^2}{c^2}}} \geq \tau_0, \tag{1}$$

sometimes one can come across a skeptical remark about what is measured in these experiments the path traveled by the pion, but its speed is not measured. And since the Galileo transformations do not prohibit the movement of particles with superluminal speeds, then pions in this case can have a speed greater than c. However, formula (1) has been tested in experiments repeatedly and under various conditions, when not only the path traveled by the particle is measured, but also its speed. For example, in the famous $g-2$ CERN's experiment, muons were introduced into a ring of radius 5 m and held there in almost circular orbits by a magnetic field. The purpose of the experiment was to accurately measure magnetic moment of the muon, but at the same time formula (1) was also verified. Measurements of the mean travel length and speed of muons showed that their lifetime, in accordance with formula (1), increased 12 times." Compared to what? Opening the corresponding article ([4]), we find the only phrase concerning this: "Smaller muons pulses decay earlier than muons of large pulses." Why was the experimental dependence $\tau(v)$ not constructed? We could compare it with theoretical (1). Why are there no experimental graphs of the dependence of the muon lifetime on its speed $\tau(v)$ in any physics textbook? After all, according to theory, it should have a very characteristic appearance (1). On the other hand, why should an accelerated muon in a magnetic field not decay for the same amount of time as one at rest in a vacuum?

Under the conditions of the $g - 2$ experiment (a uniform magnetic field with a toroidal cross-section), muons of different velocities should be located at different distances from the center. Muon acceleration (in the Gaussian system):

$$w = \frac{eH}{mc} v = \frac{v^2}{r},$$

[1] Here τ_0 is the proper lifetime of the particle (in the reference frame associated with it), τ is the lifetime of the particle in the original reference frame, v is the velocity of the particle in the original reference frame.

where e is the muon charge (equal to the electron charge), H is the magnitude of the magnetic field strength, v is the magnitude of the muon velocity, m is the muon mass, r is the muon's distance from the center. Hence,

$$v = \frac{eH}{mc} r, \quad w = \left(\frac{eH}{mc} \right)^2 r.$$

As a result

$$\tau = \frac{\tau_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\tau_0}{\sqrt{1 - \frac{m^2 w^2}{e^2 H^2}}} = \tau(w).$$

In fact, an accelerated electric charge emits electromagnetic waves. Let's introduce, in addition to the electric charge, a muon charge. Let the accelerated muon charge emit muon waves that are not detected by modern detectors. Such a process cannot but affect its internal properties such as lifetime.

1.7 Expression for photon momentum in classical mechanics

Let's assume that the photon has mass. As is known, the elementary work of all forces acting on a particle is equal to the differential of its kinetic energy. It should be expected that the energy of a free photon that does not interact with anything is equal to:

$$E = \frac{mc^2}{2},$$

where m is the mass of the photon. The photon momentum is

$$p = mc.$$

Therefore, the relationship between momentum and photon energy has the form:

$$p = \frac{2E}{c}. \tag{2}$$

2 Criticism of general relativity

2.1 Equivalence of general relativity and classical mechanics

If parallel lines intersect, then they are not parallel, or not straight. No one has canceled the Pythagorean theorem. Although this is not a theorem, but a formalization of common sense. Unless, of course, length is length and not something else. There is no curvature of space in the general theory of relativity. The general relativistic description is equivalent to the classical-mechanical one. Both the general theory of relativity and classical mechanics postulate the existence of a gravitational potential – a formal function characterizing the gravitational field. In classical mechanics, we use the concept of acceleration to describe the movement of particles. It is not equal to zero where the gradient of the gravitational potential is not equal to zero. In general relativity we use the concept of parallel transport instead. If a vector, when moving from one point in space to another close to it, turns into itself, then we call this parallel transfer. In the general theory of relativity, a *redefinition* of parallel transfer occurs: a vector, moving from one point in space to another close to it, does not transform into itself, but into a slightly displaced one (displaced *in three-dimensional space*). The magnitude of the displacement is a function of the gradient of the gravitational potential. Where it is not zero, there is an offset. Where it is zero, there is no offset.

2.2 Incorrect description of orbital precession and bending of a light beam by a gravitational field in the general theory of relativity

Let's open the tutorial ([5]): "To determine the particle trajectory, we use the Hamilton-Jacobi equation:

$$\left(1-\frac{r_g}{r}\right)^{-1}\left(\frac{\partial S}{c\partial t}\right)^2-\left(1-\frac{r_g}{r}\right)\left(\frac{\partial S}{\partial r}\right)^2-\frac{1}{r^2}\left(\frac{\partial S}{\partial \varphi}\right)^2-m^2c^2=0.$$

We are looking for S in the form:

$$S=-E_0t+M\varphi+S_r\left(r\right).$$

The trajectory is determined by the equation:

$$\varphi+\frac{\partial S_r}{\partial M}=\text{const.''}$$

This is not true. Since S_r and $\frac{\partial S_r}{\partial M}$ are single-valued functions, such an equation cannot describe an ellipse. "Next, we consider the path of a light beam in a centrally symmetric gravitational field. This path is determined by the eikonal equation:

$$\left(1-\frac{r_g}{r}\right)^{-1}\left(\frac{\partial \psi}{c\partial t}\right)^2-\left(1-\frac{r_g}{r}\right)\left(\frac{\partial \psi}{\partial r}\right)^2-\frac{1}{r^2}\left(\frac{\partial \psi}{\partial \varphi}\right)^2=0.$$

For the radial part of the eikonal we have:

$$\psi_r=\psi_r^{(0)}+\frac{r_g\omega_0}{c}\text{Arch}\frac{r}{\rho},$$

where $\psi_r^{(0)}$ corresponds to the classical rectilinear ray. The total change in ψ_r when a ray propagates from some very large distance R to the point closest to the center $r = \rho$ and then again to a distance R is

$$\Delta\psi_r = \Delta\psi_r^{(0)} + 2\frac{r_g\omega_0}{c}\text{Arch}\frac{R}{\rho}.\text{"}$$

This is not true. Since ψ_r is a single-valued function, then

$$\Delta\psi_r = 0.$$

2.3 Orbit precession in classical mechanics

As you know, precessing ellipses appear as solutions to the equations of the general theory of relativity. At the same time, it is generally accepted that in classical mechanics there are only the following equations of orbits: circles, ellipses, parabolas and hyperbolas. However, precessing ellipses also appear in classical mechanics. As you know, orbital precession is observed not only when the planets move in the Solar System. The precession of the periastron of the orbit is also observed in close binary systems, the components of which have evolved into pulsars ([6], [7], [8], [9], [10]). In such systems, the masses of the components – neutron stars – are of the same order of magnitude. Consequently, they will move in similar orbits around their center of mass. The orbits will be uniformly precessing ellipses. We write down the equation of such an orbit and derive from it an expression for the force of attraction acting between bodies. As a result, it turns out that, in addition to the Newtonian force, which is inversely proportional to the square of the distance between the bodies, a term appears in the expression for the force that is inversely proportional to the cube of the distance.

Before obtaining an expression for the force acting between two point bodies (for double pulsars, the "point" condition is well satisfied: the sizes of pulsars are several orders of magnitude smaller than the distance between them) moving in precessing orbits, it is necessary to write the equation of the orbit itself in polar coordinates. The equation for the precessing ellipse is different from the equation for an ordinary ellipse. To describe the precession, it is necessary to introduce a coefficient in the equation of an ordinary ellipse under the cosine of the polar angle.

Consider the motion of two point bodies along similar ellipses that are uniformly precessing in the direction of motion of the bodies. The equation of the relative trajectory of bodies:

$$\rho = \frac{p}{1 + e\cos k\varphi}, \quad p = a\left(1 - e^2\right), \quad k = 1 - \epsilon, \quad 0 < \epsilon \ll 1. \tag{3}$$

Here ρ is the distance between the bodies, φ is the polar angle measured from periastron (the moment of closest approach of the bodies), p is the focal parameter of the ellipse, a is the semi-major axis of the ellipse, e is the eccentricity ($0 < e < 1$), k is the precession parameter. Here the precession parameter $k = 1 - \epsilon$, where $0 < \epsilon \ll 1$, which corresponds to a slow shift of the periastron in the direction of movement of the bodies. According to Kepler's second law the product of the square of the distance between the bodies and the angular velocity is constant. Based on this, we can write:

$$\rho^2\dot{\varphi} = v_p a\,(1-e) = h, \tag{4}$$

where v_p is the relative velocity of bodies in the periastron, h is a constant.

Let's calculate the relative acceleration of bodies. It is equal to:

$$\begin{aligned} -\,w_\rho &= \rho\dot{\varphi}^2 - \ddot{\rho} = \frac{h^2k^2}{p\rho^2} + \frac{h^2\left(1-k^2\right)}{\rho^3}, \\ w_\varphi &= \frac{1}{\rho}\frac{d}{dt}\left(\rho^2\dot{\varphi}\right) = 0. \end{aligned} \tag{5}$$

Here the dots above indicate differentiation with respect to time. For force, you can write:

$$\begin{aligned} F\left(\rho\right) &= -\frac{w_\rho}{\frac{1}{m_1}+\frac{1}{m_2}} = \frac{A}{\rho^2} + \frac{B}{\rho^3}, \\ A &= \frac{\mu h^2k^2}{p}, \quad B = \mu h^2\left(1-k^2\right), \end{aligned} \tag{6}$$

where

$$\mu = \frac{m_1m_2}{m_1+m_2} \tag{7}$$

is the reduced mass of two bodies. Thus, we have obtained that the force of attraction between two point bodies moving in precessing orbits consists of two terms. The first term is Newtonian force, inversely proportional to ρ^2, and the second term is inversely proportional to ρ^3. Considering that

$$A = \frac{\mu h^2k^2}{p} = Gm_1m_2,$$

where G is the gravitational constant, we get:

$$\begin{aligned} B &= \frac{1-k^2}{k^2}pA = \frac{1-k^2}{k^2}Gpm_1m_2, \\ h^2k^2 &= Gp\left(m_1+m_2\right) = Ga\left(1-e^2\right)\left(m_1+m_2\right). \end{aligned}$$

Let us derive Kepler's third law for precessing orbits. Integral

$$\int\limits_0^{2\pi}\frac{d\varphi}{\left(1+e\cos\varphi\right)^2}$$

can be calculated by the methods of complex analysis. However, we will consider an ordinary ellipse to calculate it. Let's write for it:

$$\int_0^{2\pi} \rho^2 d\varphi = 2\pi ab,$$

where b is the semi-minor axis of the ellipse. Substituting the expressions here:

$$\rho = \frac{a\left(1-e^2\right)}{1+e\cos\varphi}, \quad b = a\sqrt{1-e^2},$$

we get:

$$\int_0^{2\pi} \frac{d\varphi}{\left(1+e\cos\varphi\right)^2} = \frac{2\pi}{\left(1-e^2\right)^{\frac{3}{2}}}.$$

We apply the resulting integral to the problem:

$$\int_0^{\frac{2\pi}{k}} \rho^2 d\varphi = \frac{2\pi a^2\sqrt{1-e^2}}{k} = hT.$$

Thus,

$$T = \frac{2\pi a^2\sqrt{1-e^2}}{hk} = \frac{2\pi a^2\sqrt{1-e^2}}{\sqrt{Ga\left(1-e^2\right)\left(m_1+m_2\right)}} = \frac{2\pi a^{\frac{3}{2}}}{\sqrt{G\left(m_1+m_2\right)}}.$$

Hence,

$$\frac{T^2}{a^3} = \frac{4\pi^2}{G\left(m_1+m_2\right)}.$$

Thus, we have obtained Kepler's third law, which, as can be seen, is also valid in the case of precessing orbits. However, it should be noted that the period T in this formula means the time elapsed between two periastres, i.e. time during which the polar angle changes by

$$\Delta\varphi = \frac{2\pi}{k}.$$

Considering that

$$\Delta\varphi = 2\pi + \dot{\omega}T,$$

where $\dot{\omega}$ is the rate of change in the longitude of the periastron of the orbit, we find the relationship between the precession parameter k and $\dot{\omega}$:

$$k = \left(1+\frac{\dot{\omega}T}{2\pi}\right)^{-1}. \tag{8}$$

In conclusion, we obtain an expression for the energy integral. The equations of motion of two interacting bodies under the action of the force of attraction are as follows:

$$m_1\vec{w}_1 = -\vec{F}, \quad m_2\vec{w}_2 = \vec{F}.$$

Here m_1 and m_2 are the masses of the bodies, $\vec{w}_1$ and $\vec{w}_2$ are their accelerations, $\vec{F}$ is the force with which the first body acts on the second. Let's assume for definiteness that $m_1 \geqslant m_2$. We scalarly multiply the first equation by $d\vec{\rho}_1$, and the second by $d\vec{\rho}_2$, where $\vec{\rho}_1$ and $\vec{\rho}_2$ are the radius vectors of the bodies. Then we add the resulting equations term by term. As a result, we get:

$$m_1\left(\vec{w}_1 \cdot d\vec{\rho}_1\right) + m_2\left(\vec{w}_2 \cdot d\vec{\rho}_2\right) = \left(\vec{F} \cdot d\left(\vec{\rho}_2 - \vec{\rho}_1\right)\right) = \left(\vec{F} \cdot d\vec{\rho}\right),$$

where $\vec{\rho} = \vec{\rho}_2 - \vec{\rho}_1$ is the relative radius vector (radius vector of the second body relative to the first). Since

$$m_1\left(\vec{w}_1 \cdot d\vec{\rho}_1\right) + m_2\left(\vec{w}_2 \cdot d\vec{\rho}_2\right) = m_1\left(\vec{v}_1 \cdot d\vec{v}_1\right) + m_2\left(\vec{v}_2 \cdot d\vec{v}_2\right) = d\left(\frac{m_1 v_1^2}{2} + \frac{m_2 v_2^2}{2}\right) = d\frac{\mu v^2}{2},$$

where $\vec{v}_1$ and $\vec{v}_2$ are the velocities of the bodies, $\vec{v} = \vec{v}_2 - \vec{v}_1$ is the relative speed of two bodies, and

$$\vec{F} = -\left(\frac{A}{\rho^2} + \frac{B}{\rho^3}\right)\vec{e}_\rho,$$

where

$$\vec{e}_\rho = \frac{\vec{\rho}}{|\vec{\rho}|}$$

is a unit vector drawn in the direction from the first body to the second, then

$$d\frac{\mu v^2}{2} = -\left(\frac{A}{\rho^2} + \frac{B}{\rho^3}\right)d\rho = d\left(\frac{A}{\rho} + \frac{B}{2\rho^2}\right).$$

Hence,

$$\frac{\mu v^2}{2} - \frac{A}{\rho} - \frac{B}{2\rho^2} = C,$$

where C is a constant. Thus,

$$T = \frac{\mu v^2}{2}$$

is the kinetic energy of the bodies,

$$U = -\frac{A}{\rho} - \frac{B}{2\rho^2}$$

is the potential energy of their interaction. Let us find the constant C. To do this, we substitute into the expression for the square of the relative speed of the bodies:

$$v^2 = \dot{\rho}^2 + \rho^2 \dot{\varphi}^2,$$

the equation of the relative orbit:

$$\rho = \frac{p}{1 + e \cos k\varphi}, \quad \rho^2 \dot{\varphi} = h.$$

After the transformations, we get:

$$\frac{\mu v^2}{2} - \frac{A}{\rho} - \frac{B}{2\rho^2} = -\frac{A}{2a}. \tag{9}$$

Thus, the total energy of the system is:

$$E = T + U = -\frac{A}{2a}.$$

2.4 Testing the equivalence principle in a strong gravitational field

The principle of equivalence is formulated as follows: in the same gravitational field, each body acquires the same acceleration, i.e. the acceleration of a body in a gravitational field does not depend on its mass and composition. The principle of equivalence in a weak gravitational field (Earth's field) was tested by Galileo Galilei when he threw balls of different masses from the Leaning Tower of Pisa. To test the equivalence principle in a strong gravitational field, let us turn to close binary systems, the components of which have evolved into pulsars ([6], [7], [8], [9], [10]). As was shown in the previous subsection, the force of attraction between two point bodies moving along ellipses that precess uniformly and slowly in the direction of motion of the bodies is described by formula (6). If the principle of equivalence in a strong gravitational field is satisfied, then the constants A and B from formula (6) should be proportional to the product of the inertial masses of the bodies:

$$A = G m_1 m_2, \quad B = J m_1 m_2, \tag{10}$$

where J is a certain fundamental constant. In this case, the ratio

$$\delta = \frac{B}{A} = \frac{J}{G}$$

is also a fundamental constant. Taking the expressions for A and B from formula (6), taking into account formula (3), we get:

$$\delta = a\left(1 - e^2\right) \frac{1 - k^2}{k^2}. \tag{11}$$

Currently we have three double pulsars with measured orbital parameters ([6], [7], [8], [9], [10]). Substituting into formulas (11) and (8) the values of the semi-major axis of the orbit a, the eccentricity of the orbit e, the rate of change in the longitude of the periastron of the orbit $\dot{\omega}$ and the orbital period T, we obtain the values of δ for each double pulsar. If the equivalence principle is satisfied, then δ is a universal constant for all three pulsars.

2.5 Gauss's theorem for the gravitational field

In the two previous subsections, when describing the motion of bodies in precessing orbits, we assumed that the bodies were point bodies. But what if their sizes are comparable to the distance between them? Let us first consider the calculation of the gravitational field of a homogeneous spherical shell in the simplest case, when the law of gravity has the Newtonian form of inverse squares:

$$F(r) = \frac{Gm_1m_2}{r^2}, \quad \vec{g} = -\frac{Gm}{r^2}\vec{e}_r.$$

Here $F(r)$ is the force of attraction between two gravitating material points of masses m_1 and m_2, $\vec{g}$ is the gravitational field strength, m is the mass of the gravitating material point, r is the distance from it to the point at which the gravitational field strength $\vec{g}$ is observed, or the distance between two gravitating material points, $\vec{e}_r$ is the unit vector directed from the gravitating material point to the point, in which the gravitational field strength $\vec{g}$ is observed. We assume that the equivalence principle is satisfied and the masses m, m_1 and m_2 are inert. Gauss's theorem in this case has a particularly simple form:

$$\int\limits_{\Phi} (\vec{g} \cdot \vec{n})\, dS = -4\pi Gm,$$

where Φ is some closed surface, $\vec{n}$ is the unit vector of the external normal to it, dS is the element of surface area Φ, m is the mass contained inside the surface Φ. Applying Gauss's theorem for a homogeneous spherical shell, we find that the gravitational field strength is equal to:

$$\vec{g} = 0, \quad r < r_s,$$
$$\vec{g} = -\frac{Gm}{r^2}\vec{e}_r, \quad r > r_s.$$

Here m is the mass of a homogeneous spherical shell, r is the distance from the center of the shell, $\vec{e}_r$ is the unit vector directed from the center of the shell, r_s is the radius of the shell. As we see, in the case of the inverse square law of gravity, inside a homogeneous spherical shell, the gravitational field strength is zero. It is easy to prove that two spherical bodies with variable density, depending only on the distance to the center of each body, are attracted according to the same law as material points:

$$F(r) = \frac{Gm_1m_2}{r^2}.$$

Here m_1 and m_2 are the masses of the bodies, r is the distance between their centers. Here we neglect the fact that as a result of tidal interaction, the shape of bodies can change and differ from spherical.

Let us now consider the case when the law of gravity has the form (6), (10). In this case, we assume that the equivalence principle is satisfied. Consider again the closed surface Φ. Let $\vec{e}_r$ be the unit vector of direction from some material point M of mass dm to some point N on the surface Φ, and $\vec{n}$ be the unit vector of the external normal to the surface Φ at point N. Then the surface element Φ containing point N is visible from point M at a positive solid angle $d\Omega > 0$, if the scalar product $(\vec{e}_r \cdot \vec{n}) > 0$, and at a negative solid angle $d\Omega < 0$, if the scalar product $(\vec{e}_r \cdot \vec{n}) < 0$ (see Figure 1). Gauss's theorem in the case of the law of gravitation (6), (10) takes the form:

$$\int\limits_{\Phi} (\vec{g} \cdot \vec{n})\, dS = -4\pi G m_i - J \int\limits_{m_i + m_o} dm \int\limits_{\Phi} \frac{d\Omega}{r},$$

where m_i is the mass contained inside the surface Φ, m_o is the mass located outside the surface Φ, dm is the elementary mass, $d\Omega$ is the solid angle at which the surface element Φ is visible from the gravitating material point of mass dm, r is the distance from the surface element Φ to the gravitating material point of mass dm. In this case, it can be shown that the field inside a homogeneous spherical shell is not zero, but has a centrally symmetrical form and is directed towards the shell at each point (see Figure 2). The interaction of two spherical bodies with variable density, depending only on the distance to the center of each body, will be described by a much more complex function than (6), (10).

2.6 "Time dilation" in a strong gravitational field

As is known, as pulsars approach each other, their rotation slows down. In the general theory of relativity, this is explained by the fact that when pulsars approach each other, the passage of time slows down due to an increase in the gravitational field acting between them. Therefore, their rotation slows down.

However, we can explain this effect without going beyond classical mechanics. As pulsars approach each other, the law of gravity changes. In addition, pulsars become less point-like compared to the distance between them. Therefore, the rotation of pulsars slows down.

2.7 Eddington's "observations"

"Einstein created the theory. Wrote a letter to Eddington. Eddington went to watch the solar eclipse." The results of Eddington's observations were "in complete agreement with Einstein's theory". What stars did Eddington observe against the background of the solar corona? Supernovae? Why are such observations not currently being carried out?

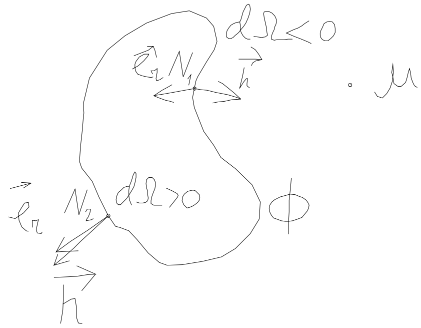

Figure 1: Signs of solid angles at which different surface elements Φ are visible from a gravitating material point.

2.8 Bending of a light beam by a gravitational field in classical mechanics

Let us assume that the photon has mass and describe its motion in the gravitational field of the Sun within the framework of classical mechanics. The photon moves along a hyperbola:

$$\rho = \frac{p}{1 + e\cos\varphi}, \quad p = a\left(e^2 - 1\right), \quad e = \frac{1}{\sin\frac{\Delta\varphi}{2}}. \tag{12}$$

Here ρ is the distance from the photon to the center of the Sun, φ is the polar angle measured from perihelion (the moment of the photon's closest approach to the Sun), p is the focal parameter of the hyperbola, a is the semi-major axis of the hyperbola, e is eccentricity ($e > 1$), $\Delta\varphi$ is photon deflection. The distance from the photon to the center of the Sun at perihelion is approximately equal to the radius of the Sun:

$$\rho_p = a\,(e - 1) = R_\odot. \tag{13}$$

According to Kepler's second law, we can write:

$$\rho^2\dot{\varphi} = \rho_p v_p = h, \tag{14}$$

where v_p is the photon speed at perihelion, h is a constant. Photon acceleration:

$$\begin{aligned} -w_\rho &= \rho\dot{\varphi}^2 - \ddot{\rho} = \frac{h^2}{\rho^3} - \frac{h^2}{p\rho^2}\left(\frac{p}{\rho} - 1\right) = \frac{h^2}{p\rho^2}, \\ w_\varphi &= \frac{1}{\rho}\frac{d}{dt}\left(\rho^2\dot{\varphi}\right) = 0. \end{aligned} \tag{15}$$

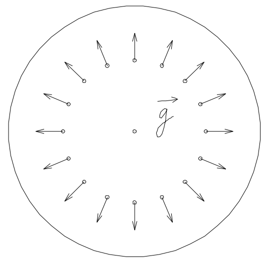

Figure 2: The gravitational field strength inside a homogeneous spherical shell in the case of the law of gravity (6), (10).

Since

$$\frac{h^2}{p} = GM_\odot,$$

where $M_\odot$ is the mass of the Sun, then

$$h^2 = GM_\odot a \left(e^2 - 1\right).$$

Let's write down the law of conservation of energy for a photon:

$$\frac{v^2}{2} - \frac{GM_\odot}{\rho} = C,$$

where v is the photon velocity modulus, C is a constant. Let's find the constant C. To do this, we substitute into the expression for the square of the photon speed:

$$v^2 = \dot{\rho}^2 + \rho^2\dot{\varphi}^2,$$

the equation of the photon orbit (hyperbola):

$$\rho = \frac{p}{1 + e\cos\varphi}, \quad \rho^2\dot{\varphi} = h.$$

After transformations we get:

$$\frac{v^2}{2} - \frac{GM_\odot}{\rho} = \frac{GM_\odot}{2a}. \tag{16}$$

On the other hand, at a great distance from the Sun, the speed of the photon is equal to the speed of light in vacuum c. Therefore

$$\frac{c^2}{2} = \frac{GM_\odot}{2a}. \tag{17}$$

Next, we have:

$$e - 1 = \frac{R_\odot}{a} = \frac{R_\odot}{GM_\odot}\frac{GM_\odot}{a} = \frac{R_\odot c^2}{GM_\odot}.$$

Hence, for the photon deflection we get:

$$\Delta\varphi = 2\arcsin\frac{1}{e} = 2\arcsin\frac{1}{\frac{R_\odot c^2}{GM_\odot} + 1}.$$

Substituting here the numerical values:

$$\begin{aligned}
R_\odot &= 6.9634 \cdot 10^8 \text{ m},\\
c &= 2.99792458 \cdot 10^8 \ \frac{\text{m}}{\text{s}},\\
G &= 6.6743 \cdot 10^{-11} \ \frac{\text{m}^3}{\text{s}^2 \cdot \text{kg}},\\
M_\odot &= 1.98892 \cdot 10^{30} \text{ kg},
\end{aligned} \tag{18}$$

we get:

$$\Delta\varphi = 0.875''.$$

As is known from observations, the numerical value of the deflection of a photon in the gravitational field of the Sun is twice as large as what we obtained and is:

$$\Delta\varphi = 1.75''. \tag{19}$$

Why should a photon interact with the gravitational field in the same way as particles of matter? Even in the formalism of general relativity, various energy-momentum tensors are introduced to describe matter and radiation. Let us assume that the interaction of a photon with a gravitational field is described by the same function as for particles of matter, but with different constants. Substituting the value of photon deflection $\Delta\varphi$ from formula (19) into the expression for eccentricity e from formula (12) and using the values of the constants from formula (18), we find the value of the gravitational constant of the interaction of the photon with the gravitational field:

$$\tilde{G} = \frac{R_\odot c^2}{M_\odot\,(e-1)} = 1.33484 \cdot 10^{-10}\frac{\text{m}^3}{\text{s}^2 \cdot \text{kg}}.$$

It must be emphasized that the magnitude of the deviation $\Delta\varphi$ depends *only* on the value of the gravitational constant G and *does not depend* on the description method we choose:

classical-mechanical or general relativistic. Thus, the spherically symmetric solution of Einstein's equations in the void

$$R_{\mu\nu} = 0$$

Schwarzschild metric:

$$ds^2 = \left(1 - \frac{r_g}{r}\right) c^2 dt^2 - r^2 \left(\sin^2 \theta d\varphi^2 + d\theta^2\right) - \frac{dr^2}{1 - \frac{r_g}{r}},$$

is absolutely insensitive to the renormalization of the constant:

$$\tilde{r}_g = A r_g, \quad A > 0.$$

2.9 "Problems" of dark matter and dark energy

The atom does not radiate, and the electron does not fall onto the nucleus, because the laws of Coulomb, Bio-Savart-Laplace and Faraday were established on a macroscale. Physics is an experimental science. It should not explain why the law of gravity on the scale of the Galaxy is not the same as on the scale of the Solar System. And at intergalactic distances, repulsion generally takes place. Let's remember Lennard-Jones' potential. Is there an explanation why it is like this?

3 Gravity speed and gravitational aberration

3.1 The influence of gravitational aberration on the orbital motion of the Earth around the Sun

Let us neglect the ellipticity of the Earth's orbit. Since the mass of the Earth is 333030 times less than the mass of the Sun, we also neglect the movement of the Sun around the center of mass of the Sun – Earth system and assume that the Earth moves in a circular orbit exactly around the center of the Sun. It is logical to assume that the speed of the Earth's orbital motion is much less than the speed of gravity: $v_\oplus \ll v_g$. Consequently, the angle of displacement of the gravitational force acting on the Earth from the Sun relative to the direction to the Sun in the direction of the Earth's movement is:

$$\alpha = \frac{v_\oplus}{v_g} \ll 1.$$

Thus, as a result of gravitational aberration, the gravitational force acting on the Earth from the Sun acquires a small transverse component directed towards the Earth's orbital motion. This leads to a gradual removal of the Earth from the Sun. The Earth's orbit is a slowly unwinding spiral.

Let's consider this issue in more detail. The gravitational force acting on the Earth from the Sun is equal to:

$$\vec{F} = -\frac{GM_\odot m_\oplus}{a^2}\left(\vec{e}_a - \frac{v_\oplus}{v_g}\vec{e}_\varphi\right) = -F_a\vec{e}_a + F_\varphi\vec{e}_\varphi, \tag{20}$$

where $m_\oplus$ is the mass of the Earth, a is the distance from the Earth to the Sun, $\vec{e}_a$ is a unit vector directed from the Sun to the Earth, $\vec{e}_\varphi$ is a unit vector orthogonal to $\vec{e}_a$ and directed towards the orbital motion of the Earth. Thus, the gravitational force consists of a large radial component F_a and a small transverse component F_φ. The speed of the Earth's orbital motion is determined by the action of the radial component of the gravitational force and is equal to:

$$v_\oplus = \sqrt{\frac{GM_\odot}{a}}. \tag{21}$$

With a small movement along a slowly unwinding spiral, the elementary work of the radial component of the gravitational force is equal to:

$$\delta A_G = -\frac{GM_\odot m_\oplus}{a^2}da = d\frac{GM_\odot m_\oplus}{a}. \tag{22}$$

The elementary work of the transverse component of the gravitational force associated with gravitational aberration is equal to:

$$\delta A_{GA} = F_\varphi v_\oplus dt = \frac{G^2 M_\odot^2 m_\oplus}{a^3 v_g}dt. \tag{23}$$

The sum of these elementary works is equal to the differential of the Earth's kinetic energy:

$$\delta A_G + \delta A_{GA} = d\left(\frac{m_\oplus v_\oplus^2}{2}\right). \tag{24}$$

Therefore,

$$d\left(\frac{m_\oplus v_\oplus^2}{2} - \frac{GM_\odot m_\oplus}{a}\right) = \delta A_{GA}.$$

Substituting formulas (21) and (23) here, we get a simple differential equation:

$$da^2 = \frac{4GM_\odot}{v_g}dt. \tag{25}$$

Let's get equation (25) in another way. To do this, we write down the expression for the modulus of the angular momentum of the Earth relative to the center of the Sun:

$$L_\oplus = m_\oplus a v_\oplus = m_\oplus\sqrt{GM_\odot}\sqrt{a}.$$

The modulus of the moment of gravitational force acting on the Earth from the Sun, relative to the center of the Sun due to gravitational aberration, is equal to:

$$N_{\oplus} = aF_{\varphi} = \frac{(GM_{\odot})^{\frac{3}{2}}\, m_{\oplus}}{a^{\frac{3}{2}} v_g}.$$

Since

$$\frac{dL_{\oplus}}{dt} = N_{\oplus},$$

we get formula (25). Note that the modulus of the radial component of the Earth's acceleration is equal to:

$$-w_{\oplus a} = a\omega_{\oplus}^2 - \ddot{a} = \frac{GM_{\odot}}{a^2},$$

where

$$\omega_{\oplus} = \frac{v_{\oplus}}{a} = \sqrt{\frac{GM_{\odot}}{a^3}} \qquad (26)$$

is is the angular velocity of the Earth's revolution around the Sun. It is easy to show that the relation

$$-\frac{\ddot{a}}{a\omega_{\oplus}^2} = \left(\frac{2v_{\oplus}}{v_g}\right)^2,$$

i.e. $-\ddot{a}$ compared to $a\omega_{\oplus}^2$ is a term of second order of smallness. This means that the model that we chose to describe the movement of the Earth around the Sun, taking into account gravitational aberration, is adequate.

Let at time $t = 0$ the Earth be at a distance $a_0 = 1$ au[2] from the Sun. Integrating equation (25), we obtain the time after which the distance from the Earth to the Sun becomes equal to a:

$$t = \frac{v_g}{4GM_{\odot}}\left(a^2 - a_0^2\right). \qquad (27)$$

Let $a = 2$ au, and $v_g = c$. Substituting numerical values into formula (27), we get:

$$t \approx 1201.2 \text{ years}.$$

Thus, if the speed of gravity is equal to the speed of light in vacuum, then in a time $t \approx 1200$ years the Earth will move away from the Sun to a distance twice the current distance. Since nothing like this happens in the Solar System, in accordance with formula (27) we can conclude that the speed of gravity is several orders of magnitude higher than the speed of light in vacuum.

[2] 1 au = 149597870700 m.

Let's pay attention to one more point. Since, as a result of gravitational aberration, the distance a gradually increases, the period of revolution of the Earth around the Sun also increases in accordance with the formula:

$$T = 2\pi\sqrt{\frac{a^3}{GM_\odot}}.$$

Let's differentiate the left and right sides of this formula with respect to time. Taking into account formulas (25) and (21) we get:

$$\dot{T} = 6\pi\frac{v_\oplus}{v_g}.$$

Thus, the rate of increase in the Earth's orbital period is directly proportional to the ratio of the speed of the Earth's orbital motion to the speed of gravity.

Let's return to formula (27). Let at time $t = 0$ the Earth be at a distance $a_0 = 1$ au from the Sun. Let us assume, however, that $v_g = c$. Let's calculate the time it takes for the Earth to complete one full revolution in a spiral. Let us express the distance a from formula (27):

$$a = \sqrt{a_0^2 + \frac{4GM_\odot}{v_g}t}. \tag{28}$$

The differential of the polar angle, which characterizes the position of the Earth in orbit, is equal to:

$$d\varphi = \omega_\oplus dt.$$

Substituting formulas (26) and (28) here and integrating, we get:

$$\Delta\varphi = \frac{v_g}{\sqrt{GM_\odot}}\left(\sqrt{a} - \sqrt{a_0}\right), \tag{29}$$

where $\Delta\varphi$ is the increment of the polar angle. Taking into account formula (21), we get:

$$\Delta\varphi = v_g\left(\frac{1}{v_\oplus} - \frac{1}{v_{\oplus 0}}\right),$$

where $v_{\oplus 0}$ is the speed of the Earth's orbital motion at time $t = 0$. Let us express from formula (29) the distance a through $\Delta\varphi$:

$$a = \left(\sqrt{a_0} + \frac{\sqrt{GM_\odot}\Delta\varphi}{v_g}\right)^2. \tag{30}$$

Substituting

$$\Delta\varphi = 2\pi$$

and the numerical values of the constants into formula (30), we find the value of a after one revolution:

$$a = 149784723209.45 \text{ m}.$$

Substituting the found value of a into formula (27), we find the time during which the Earth will make one full revolution in a spiral:

$$t \approx 365.5522 \text{ days}.$$

As you can see, the resulting value is greater than the sidereal year.

3.2 The influence of gravitational aberration on the orbital motion of pulsars in close binary systems

Let us consider the motion of two point bodies in circular orbits around their center of mass. In the law of gravitation (6), (10) we neglect the second term, inversely proportional to the cube of the distance, and assume that bodies are attracted under the action of Newtonian force. Taking into account gravitational aberration, the gravitational force acting on the second body from the first is equal to:

$$\vec{F}_2 = -\frac{Gm_1m_2}{a^2}\left(\vec{e}_a - \frac{v}{v_g}\vec{e}_\varphi\right). \tag{31}$$

Here m_1 and m_2 are the masses of the bodies, a is the distance between them, $\vec{e}_a$ is the unit vector directed from the first body to the second, v is the module of the relative velocity of the bodies, $\vec{e}_\varphi$ is the unit vector orthogonal to $\vec{e}_a$ and directed towards the movement of the second body. Here we assume that $v \ll v_g$. Similarly, the force acting on the first body from the second is equal to:

$$\vec{F}_1 = \frac{Gm_1m_2}{a^2}\left(\vec{e}_a - \frac{v}{v_g}\vec{e}_\varphi\right). \tag{32}$$

Here we are faced with a case when a pair of forces is applied to a system of material points – two equal in magnitude and oppositely directed forces $\vec{F}_1$ and $\vec{F}_2$, not acting along the same straight line. Consequently, the acceleration of the center of mass of the bodies is zero:

$$\vec{w}_C = \frac{\vec{F}_1 + \vec{F}_2}{m_1 + m_2} = 0.$$

This means that the speed of the center of mass is constant:

$$\vec{v}_C = \text{const}.$$

Thus, the C-system (see [11]) in this case is inertial. Let us write down expressions for the accelerations of bodies in the C-system (and in any inertial reference system):

$$\vec{w}_1 = \frac{Gm_2}{a^2}\left(\vec{e}_a - \frac{v}{v_g}\vec{e}_\varphi\right), \quad \vec{w}_2 = -\frac{Gm_1}{a^2}\left(\vec{e}_a - \frac{v}{v_g}\vec{e}_\varphi\right). \tag{33}$$

Since the accelerations of the bodies are oppositely directed and their modules satisfy the relation

$$\frac{w_2}{w_1} = \frac{m_1}{m_2},$$

the bodies will move in similar orbits with a similarity coefficient

$$\frac{w_2}{w_1} = \frac{v_2}{v_1} = \frac{a_2}{a_1} = \frac{m_1}{m_2} \tag{34}$$

around their center of mass. Here v_1 and v_2 are the velocity modules of the bodies in the C-system, a_1 and a_2 are the distances of the bodies to their center of mass. Since the gravitational forces $\vec{F}_1$ and $\vec{F}_2$ due to gravitational aberration have small transverse components, this leads to a gradual removal of the bodies from each other. Their orbits are similar slowly unwinding spirals. In this case, the following relations are satisfied:

$$a = a_1 + a_2, \quad v = v_1 + v_2, \quad w = w_1 + w_2, \tag{35}$$

where w is the module of the relative acceleration of the bodies. From formulas (34) and (35) the following relationships are obtained:

$$\begin{aligned} a_1 &= \frac{m_2 a}{m_1 + m_2}, \quad a_2 = \frac{m_1 a}{m_1 + m_2}; \\ v_1 &= \frac{m_2 v}{m_1 + m_2}, \quad v_2 = \frac{m_1 v}{m_1 + m_2}; \\ w_1 &= \frac{m_2 w}{m_1 + m_2}, \quad w_2 = \frac{m_1 w}{m_1 + m_2}. \end{aligned} \tag{36}$$

The speeds of movement of bodies in spirals around the center of mass – in the C-system – are determined by the radial components of the forces $\vec{F}_1$ and $\vec{F}_2$:

$$w_1 = \frac{v_1^2}{a_1} = \frac{Gm_2}{a^2}, \quad w_2 = \frac{v_2^2}{a_2} = \frac{Gm_1}{a^2}.$$

Substituting formulas (36) here, we get:

$$w = \frac{v^2}{a} = \frac{G\left(m_1 + m_2\right)}{a^2},$$

whence

$$v = \sqrt{\frac{G\left(m_1 + m_2\right)}{a}}. \tag{37}$$

With small movements of bodies along similar slowly unwinding spirals, the elementary work of the radial components of gravitational forces in the C-system is equal to:

$$\delta A_G = -\frac{Gm_1m_2}{a^2}da = d\frac{Gm_1m_2}{a}. \tag{38}$$

The elementary work of the transverse components of gravitational forces associated with gravitational aberration in the C-system is equal to:

$$\delta A_{GA} = \frac{Gm_1m_2}{a^2}\frac{v}{v_g} \cdot vdt = \frac{G^2m_1m_2\left(m_1+m_2\right)}{a^3v_g}dt. \tag{39}$$

The sum of these elementary works is equal to the differential of the kinetic energy of the system of bodies in the C-system:

$$\delta A_G + \delta A_{GA} = d\left(\frac{m_1v_1^2}{2} + \frac{m_2v_2^2}{2}\right) = d\frac{\mu v^2}{2}, \tag{40}$$

where

$$\mu = \frac{m_1m_2}{m_1+m_2} \tag{41}$$

is the reduced mass of two bodies. From formulas (40) and (38) we get:

$$d\left(\frac{\mu v^2}{2} - \frac{Gm_1m_2}{a}\right) = \delta A_{GA}.$$

Substituting formulas (37), (41) and (39) here, we get:

$$da^2 = \frac{4G\left(m_1+m_2\right)}{v_g}dt. \tag{42}$$

Let's get equation (42) in another way. To do this, we write down an expression for the modulus of the intrinsic angular momentum (see [11]) of the system of bodies:

$$\tilde{L} = m_1a_1v_1 + m_2a_2v_2 = \mu av = \mu\sqrt{G\left(m_1+m_2\right)}\sqrt{a}.$$

The modulus of the moment of gravitational forces relative to the center of mass due to gravitational aberration is equal to:

$$N_C = \frac{Gm_1m_2}{av_g}\sqrt{\frac{G\left(m_1+m_2\right)}{a}}.$$

Since (see [11])

$$\frac{d\tilde{L}}{dt} = N_C,$$

we get formula (42). Note that the modulus of the radial component of the relative acceleration of bodies is equal to:

$$-w_a = a\omega^2 - \ddot{a} = \frac{G(m_1 + m_2)}{a^2},$$

where

$$\omega = \frac{v}{a} = \sqrt{\frac{G(m_1 + m_2)}{a^3}} \tag{43}$$

is the angular velocity of motion of bodies around their center of mass. It is easy to show that the relation

$$-\frac{\ddot{a}}{a\omega^2} = \left(\frac{2v}{v_g}\right)^2,$$

i.e. $-\ddot{a}$ compared to $a\omega^2$ is a term of second order of smallness. This means that the model that we chose to describe the motion of two point bodies taking into account gravitational aberration is adequate.

Thus, due to gravitational aberration, the distance between the bodies increases over time. Consequently, in accordance with the formula

$$T = 2\pi\sqrt{\frac{a^3}{G(m_1 + m_2)}}$$

the period of revolution of the bodies T also increases. Let's differentiate the left and right sides of this formula with respect to time. Taking into account formulas (42) and (37) we get:

$$\dot{T} = 6\pi\frac{v}{v_g}.$$

Thus, the rate of increase in the period of revolution of bodies is directly proportional to the ratio of the relative speed of bodies to the speed of gravity.

However, from observations of binary pulsars ([6], [7], [8], [9], [10]), it follows that their orbital period decreases with time, rather than increases. But we'll talk about the reasons for this in the next subsection.

3.3 Orbital period reduction in close binary systems

Let's consider a model of the motion of two point bodies in similar quasi-circular orbits – slowly twisting spirals – around their center of mass. Let us assume that bodies are attracted under the action of Newtonian force, and in addition to gravitational aberration, we also take into account the force of radiation braking associated with the emission of gravitational waves. Let us assume that a body with variable acceleration emits gravitational waves in a narrow beam in the direction opposite to the acceleration derivative. Then the body will receive additional (radiative) acceleration in the direction of the derivative of the initial acceleration. The radiative acceleration induced by the initial acceleration must in turn induce a second-order radiative acceleration, second-order radiative acceleration - third-order acceleration, etc. We expect that the induced radiative acceleration of each order is small compared to its initial acceleration. In this regard, we will take into account only first-order radiative acceleration. Assuming that the equivalence principle is satisfied, we represent the total acceleration of the body in the form:

$$\vec{w}_t = \vec{w}_i + \frac{\vec{F}_r}{m} = \vec{w}_i + \frac{r\left(m, v_g\right)}{m}\dot{\vec{w}}_i, \tag{44}$$

where $\vec{w}_i$ is the initial acceleration of the body, $\vec{F}_r$ is the radiation braking force acting on the body, m is the inertial mass of the body, $r\left(m, v_g\right)$ is some function of the inertial mass of the body and the speed of gravity. Neglecting terms of the second order of smallness, we write down the total accelerations of bodies taking into account gravitational aberration and radiation braking:

$$\begin{aligned} \vec{w}_1 &= \frac{Gm_2}{a^2}\vec{e}_a + \frac{Gm_2}{a^2}\left(\frac{r\left(m_1, v_g\right)}{m_1}\omega - \frac{v}{v_g}\right)\vec{e}_\varphi, \\ \vec{w}_2 &= -\frac{Gm_1}{a^2}\vec{e}_a + \frac{Gm_1}{a^2}\left(\frac{v}{v_g} - \frac{r\left(m_2, v_g\right)}{m_2}\omega\right)\vec{e}_\varphi. \end{aligned} \tag{45}$$

Here m_1 and m_2 are the masses of the bodies, a is the distance between them, $\vec{e}_a$ is the unit vector directed from the first body to the second, ω is the angular velocity of motion of bodies around their center of mass, v is the module of the relative velocity of the bodies, $\vec{e}_\varphi$ is the unit vector orthogonal to $\vec{e}_a$ and directed towards the movement of the second body. In this case, the bodies move along similar slowly twisting spirals with a similarity coefficient

$$\frac{w_2}{w_1} \approx \frac{m_1}{m_2}.$$

The modulus of the radial component of the relative acceleration of bodies is equal to:

$$-w_a = a\omega^2 = \frac{G\left(m_1 + m_2\right)}{a^2}, \tag{46}$$

where we neglect the second-order term of smallness $-\ddot{a}$. The transverse component of the relative acceleration of bodies is equal to:

$$w_\varphi = \frac{1}{a}\frac{d}{dt}\left(a^2\omega\right) = \frac{G\left(m_1 + m_2\right)}{a^2}\frac{v}{v_g} - \frac{GR\left(m_1, m_2, v_g\right)\omega}{a^2}, \tag{47}$$

where

$$R\left(m_1, m_2, v_g\right) = \frac{m_1}{m_2}r\left(m_2, v_g\right) + \frac{m_2}{m_1}r\left(m_1, v_g\right) \tag{48}$$

is the radiation function of the close binary system. From equation (46), taking into account that

$$\omega = \frac{2\pi}{T},$$

where T is the period of revolution of the bodies, we obtain Kepler's third law:

$$\frac{T^2}{a^3} = \frac{4\pi^2}{G\left(m_1 + m_2\right)}.$$

Differentiating this equation with respect to time, we obtain[3]:

$$\frac{\dot{a}}{a} = \frac{2}{3}\frac{\dot{T}}{T}.$$

Substituting this relationship into equation (47) and taking into account that

$$v = \omega a,$$

we find:

$$\dot{a} = \frac{2G\left(m_1 + m_2\right)}{v_g a} - \frac{2GR\left(m_1, m_2, v_g\right)}{a^2}.$$

Let $v_g = c$. Then from observations of double pulsars (see [6], [7], [8], [9], [10]) it follows:

$$|\dot{a}| \ll \frac{2G\left(m_1 + m_2\right)}{v_g a}.$$

Therefore,

$$\frac{2G\left(m_1 + m_2\right)}{v_g a} \approx \frac{2GR\left(m_1, m_2, v_g\right)}{a^2}.$$

This situation is unlikely. Therefore let

$$|\dot{a}| \sim \frac{2G\left(m_1 + m_2\right)}{v_g a} \sim \frac{2GR\left(m_1, m_2, v_g\right)}{a^2}.$$

This situation is more logical. Then from the observations it follows:

$$v_g \sim 10^{10} c.$$

Thus, from observations of double pulsars we have obtained an estimate for the speed of gravity, which is several orders of magnitude higher than the speed of light in vacuum.

[3]Note that the model under consideration assumes that $\left|\dot{T}\right| \ll 1$.

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