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# GALILEO'S LAW OF FREE FALL OF BODIES AND ITS CONNECTION WITH GRAVITY

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**Keywords:** Atom, core, body, ethereal medium, gradient, gravity, pressure.
**Abstract.** Based on an analysis of Galileo Galilei's experiment with falling bodies of different masses, it is shown that the effect can be explained by the presence of an ethereal medium in which all bodies are immersed. The ethereal medium has a fine structure. It penetrates into the interatomic space and acts directly on the nuclei of atoms, as well as neutrons, protons, and electrons. The reason for the mutual attraction of bodies, - gravitation is the creation of a gradient of elastic pressure of the ether by a physical body in the vicinity of another physical body, which also creates a gradient of elastic pressure of the ether in the vicinity of the first.

# ЗАКОН СВОБОДНОГО ПАДЕНИЯ ТЕЛ ГАЛИЛЕЯ И ЕГО СВЯЗЬ С ГРАВИТАЦИЕЙ

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**Ключевые слова:** атом, гравитация, градиент, давление, тело, эфирная среда, ядро.
**Аннотация.** На основе анализа эксперимента Галилео Галилея с падающими телами разной массы показано, что эффект можно объяснить наличием эфирной среды, в которую погружены все тела. Эфирная среда обладает тонкой структурой. Она проникает в межатомное пространство и воздействует непосредственно на ядра атомов, а также нейтроны, протоны, электроны. Причиной взаимного притяжения тел, - тяготения или гравитации - является создание градиента упругого давления эфира физическим телом в окрестности другого физического тела, также создающего градиент упругого давления эфира в окрестности первого.

According to Vincenzo Viviani, in 1589 Galileo Galilei conducted an experiment by dropping two balls of different masses from the famous leaning tower in Pisa, Italy. It was discovered that the time of fall is almost independent of the mass of the ball; the bodies fell almost simultaneously [1]. At that time, due to the imperfection of clocks, it was almost impossible to study the free fall of bodies.

Galileo continued his experiments by setting up an inclined surface on which balls rolled. They moved at significantly lower speeds and the effect of air resistance was also less. It is noticed that balls of different masses move with the same acceleration. Galileo made the final conclusion that the acceleration in free fall does not depend on either the mass or the material of the ball.

This law is now being demonstrated in all schools around the world, showing the fact that a lead pellet and a bird feather simultaneously accelerate within an evacuated glass tube. This is a very impressive experiment, confirming the fact of equal acceleration of bodies of different masses. The mass of a bird feather is much less than a lead pellet, but the force of gravity equally accelerates the material of the feather and the lead pellet.

We must assume that if we reduce the mass of a falling body, down to elementary particles, Galileo's law will also be effective. This fact was confirmed by American physicists by studying the behavior of an elementary particle - neutron in the terrestrial gravitational field [2]. The neutron is the only particle that has a rest mass and does not have a charge. It is not affected by magnetic and electric fields, which are very difficult to get rid of in laboratory conditions.

During the experiments, under the influence of gravity, a curvature of the trajectory of a well-collimated beam of cold neutrons was observed. The acceleration of neutrons, within the accuracy of the experiment, coincided with the gravitational acceleration of macroscopic bodies [2, 3]. As the experimental conditions showed, an isolated, free neutron in a beam does not have direct mechanical contact with another particle, but is subject to the force of gravity. This experiment showed that gravity acts directly on microscopic bodies such as the neutron, whose mass is $1.6746 \cdot 10^{-27}$ kg.

As is known, the nucleus of an atom substance consists of neutrons and protons [4]. The proton has a mass of $1.6723 \cdot 10^{-27}$ kg, very close to the mass of the neutron. Accordingly, the nucleus of an atom and, in general, atoms of substance, consisting of nuclei and electrons, are accelerated in the gravitational field in the same way as an individual neutron.

In an ordinary solid, the atoms touch each other with their electron shells. It is known that the ratio of the mass of the nucleus to the sum of the masses of the electrons of the atom is approximately 2000/1 [4]. Therefore, the bulk of an atom is concentrated in its nucleus [4-5]. A directly proportional relationship has been noted between the mass and volume of the atomic nucleus [6]. Accordingly, gravity mainly affects the nuclei of atoms.

For metals, there is a strict relationship between their density and the sizes of the nuclei and electron shells [7]. In the space between shells of electrons and the nucleus of an atom, nuclear and electromagnetic fields operate. The modern model of the atom does not provide for the transfer of gravitational force to the nuclei of atoms through any direct mechanical contact with another nucleus or body [4].

There is one more feature in the behavior of accelerated microscopic and massive bodies in a gravitational field. According to Newton's second law, the acceleration of a body ($a$) is proportional to the force ($F$) applied to the body and inversely proportional to its mass ($m$),

$$a = - F/m. \tag{1}$$

During mechanical contact, the acceleration imparted to the body is proportional to the force $F$ and inversely proportional to the mass of the body. According to Galileo's law, small and massive bodies in a gravitational field accelerate equally. Thus, with the same observed acceleration and with different masses of bodies, the force $F$ should change in proportion to this mass. If a neutron, the nucleus of an atom, the atom itself and a massive body are accelerated equally, then the force acting on these bodies should be proportional to their mass. It follows that there are conditions other than for mechanical contact for the transfer of gravitational force to a body.

Based on the principle of short-range action and taking into account the condition that Newton's second law imposes, it is logical to assume that there is an agent (mediator) that transmits the force of gravity directly to the neutron, the nucleus of an atom and to other particles that make up the physical body. Such an intermediary can be the material environment in which all microscopic particles and massive bodies are immersed. This medium must have a high penetrating ability in order to act through the vacuum directly on neutrons, protons and, accordingly, on the nuclei of atoms. The medium must have a changing (gradient) pressure in order to induce the body immersed in it to move in the direction of reducing such pressure.

Taking into account the above conditions, the mechanism of transfer of gravity to the nucleus of an atom is, to a certain extent, similar to the action of force on a body immersed in a liquid (water) [8]. It is known that there is a directly proportional relationship between the mass and size of the nuclei of substances [4, 5]. We can assume that the nuclei of atoms have a spherical shape [5, 6].

Taking into account the directly proportional relationship between mass and size, we can imagine the nucleus of an atom as an empty sphere with volume $V$, Fig. 1. Let the pressure gradient in this medium increase according to a linear law, $P = nt$, where $n$ is a certain constant, $t$ is the normal distance from a flat surface on which $P = 0$. Equipotential surfaces of equal pressure of the medium are parallel to the free flat surface. In the diagram shown in Fig. 1, the pressure increases in the direction from point $l$ to point $h$, and the upper edge of the sphere is flush with the plane (free surface) with $P = 0$.

As is known, the volume of a sphere with radius $R$ is equal to

$$V = \frac{4}{3}\pi R^3 . \tag{2}$$

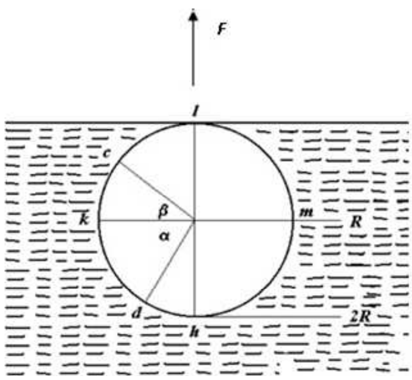


Fig. 1. Diagram of the action of forces on a body located in a gradient medium

We assume that the capacitance is located in a medium whose density is $\delta$. We will also assume that the walls of the sphere are strong enough and so thin that their weight can be neglected. The medium will exert a gradient pressure on the outer wall of the sphere. It will increase as the depth of the point in question on the side surface of the sphere increases. At depth *h*, the force applied to each point of the body will be equal to $F_h = - 2q\delta \cdot R$, where *q* is some acceleration that is given to the body for a given pressure increase gradient in a medium with density δ.

We also believe that at each point in the medium, pressure (force) is transmitted hydrostatically, i.e. equal in magnitude in all directions, on each outer area of the sphere, with the exception of the surface with point *l*, on which the pressure will be zero. The magnitude of the force at each point on the surface of the sphere can be calculated using the formula $F_t = -q\delta t$.

The value of the force $F_t$ according parallelogram rule can be decomposed into two components, horizontal and vertical. The magnitude of the horizontal component of the force $F_g$ will be completely balanced by the same component at the opposite point located at the same distance *t*. Vertical component of force, $F_v$, at points located on the lower hemisphere, Fig. 1, will be only partially compensated by the vertical component acting in the upper hemisphere, since the distance *t* of points on the surface of the upper hemisphere to the free surface is less than the points of the lower one.

To estimate the magnitude of the force acting on the body, we determine the sum of forces *F* on the lower and upper hemispheres, Fig. 1. The vertical component of the force on the lower hemisphere when moving along an arc from point *h* to point *k* will change as

$$F_{vu} = -q\delta R \cdot \sin\alpha\,(1 + \sin\alpha). \quad (3)$$

The sum of forces on the lower hemisphere $F_l$ will be equal to a certain integral of the product $F_{vu}$ by the area of the lower hemisphere *S*, taking into account the changing value of the vertical projection from point *h* to point *k*, which is affected by the force $F_{vu}$

$$S = 2\pi R^2 \cdot \cos\alpha. \quad (4)$$

Thus,

$$F_l = -2\pi q\delta R^3 \{ \int_0^{\pi/2} \sin\alpha\cos\alpha d\alpha + \int_0^{\pi/2} \sin^2\alpha\cos\alpha d\alpha \} = -\frac{5}{3}\pi q\delta R^3 . \quad (5)$$

In a similar way, we determine the vertical component of pressure $F_u$ on the upper hemisphere, Fig. 1. Applying similar actions, we get:

$$F_u = -2\pi q\delta R^2 \{ \int_0^{\pi/2} \sin\beta\cos\beta d\beta - \int_0^{\pi/2} \sin^2\beta\cos\beta d\beta \} = -\frac{1}{3}\pi q\delta R^3 . \quad (6)$$

It should be taken into account that the $F_u$ vector is directed opposite to the force $F_l$ acting on the lower hemisphere. Therefore, to obtain the magnitude of the force *F* on the entire sphere, it is necessary to subtract expression (6) from expression (5). As a result we get:

$$F = F_l - F_u = -\frac{4}{3}\pi q\delta \mathrm{R}^3, \ \mathrm{kg \cdot m\ s^{-2}}. \quad (7)$$

The value *F* expresses the total force acting on a sphere of radius *R* located in a gradient medium with density δ. Comparison of formula (7) with formula (2) shows that if the body (fig. 1) is filled with a medium, then the weight of this medium will be exactly equal to the buoyant force applied to the empty body.

One can imagine that a sealed empty sphere (fig. 1) is moved in the direction of increasing pressure gradient at a distance, for example, $t = 100R$ from the free plane. Then its lowest point $h$ will be at a depth of $102R$. Simple calculations show that here, too, the force $F$ will (if the medium is incompressible) also be determined by expression (7).

Thus, a body located in a gradient environment will be acted upon by a force of constant magnitude (within certain conditions), oriented perpendicular to the equipotential surfaces of equal gradient and directed towards decreasing the gradient. If the medium has density $\delta$, then the force acting on the body will be equal to the product of the volume of the body $V$, acceleration $q$ and density δ,

$$F = -V \cdot q\delta,\ \mathrm{kg \cdot m\ s^{-2}}. \qquad (8)$$

This law was proved by Archimedes for a body in a liquid located in the gravitational field of the Earth. Capacity free from external mechanical connections, Fig. 1, under the influence of force $F$ it will move accelerated in the direction of decreasing pressure gradient. The magnitude of this acceleration $q$ (if we neglect the effects of viscosity, internal friction of the medium, etc.) will be equal to

$$q = -F/(V\delta). \qquad (9)$$

Let's imagine that there is another body, the volume of which differs by a factor of $K$-times from the body of volume $V$. According to formula (8), the force $F_k$ acting on this body will also differ exactly by a factor of $K$:

$$F_k = -KV \cdot q\delta. \qquad (10)$$

At the same time, its acceleration will remain the same, since the force has changed by $K$-times and the volume has also become different by $K$-times:

$$q = -F_k/(KV\delta) = -KV \cdot q\delta/(KV\delta) = q. \qquad (11)$$

An important conclusion follows from this, - bodies of different volumes, located in the same gradient medium, acquire the same acceleration in free motion. This conclusion is valid for bodies located in a gradient medium, the pressure in which decreases (increases) according to a linear law. A body free from external connections will move at an accelerated rate. The vector of its motion will be directed normal to equipotential surfaces of equal pressure of the medium.

Thus, the force $F$ (Fig. 1) changes in proportion to the volume $V$, providing the same acceleration of bodies of different volumes. In this case the conditions imposed by Newton's second law are fulfilled. At the same time, without mechanical contact with another body, the principle of short-range action is observed.

As described above, when bodies of various masses and volumes fall in the Earth’s gravitational field under conditions where the influence of air resistance is minimized (or eliminated), the bodies acquire the same acceleration. This fact was first established by Galileo. The gravitational field equally accelerates large and small bodies, acting on every elementary particle of bodies.

So, the gradient gravitational field affects bodies through the material environment in which they are immersed. Moreover, this medium has such a fine structure that it can penetrate into the interatomic space and act directly on atomic nuclei, neutrons and protons. It is logical to assume that such a medium is ether or the ethereal medium.

Scientists of Ancient Greece gave the name “ether” to that all-pervading, elusive matter that is not subject to our senses. Subsequently, the doctrine of ether was actively developed by Augustine Fresnel, James Maxwell, Michael Faraday, Hendrik Lorenz, Joseph Thomson and others [9]. They all considered the ether an indispensable and essential part of the universe.

The first reasonable attempt to give a mathematical description of the ether was made by MacCullagh in 1839. According to McCullagh, the ether is a medium rigidly fixed in space. This medium provides elastic resistance to rotational deformations and is described by an antisymmetric tensor of the second rank, the terms of the main diagonal of which are equal to zero [10]. Arnold Sommerfeld showed that McCullagh's ether is described by D. Maxwell's equations for empty space [11].

Developing McCulag's and A. Sommerfeld’s ideas, F. Gorbatsevich created a model of the ether, consisting of a three-dimensional spatial lattice of particles [12]. The lattice is based on two geometrically equal spherical particles with opposite electric charges (Fig. 2). Particles are in close contact with each other. There is no doubt that in order to form a spatial lattice, these elementary particles must be attracted to each other with great force. Since they are capable of exerting pressure on neutrons, the particle size is less than $\sim 1.6 \cdot 10^{-16}$ *m*. In this three-dimensional ethereal environment, microbodies with mass (electrons, atomic nuclei, etc.), as well as macrobodies, can move completely without friction and phenomena associated with the manifestation of viscosity, etc.

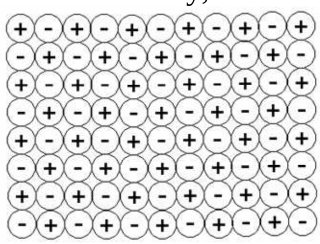

Fig. 2. The structure of an ether consisting of two types particles opposite in charge (projection on a plane)

Ethereal medium (Fig. 2) is the basis for the propagation of radio waves, light, x-rays and other types of electromagnetic waves. These waves propagate both in free ether and in physical (gaseous, liquid, solid, etc.) bodies consisting of elementary particles. As shown above, an etheric medium is also present in the intraatomic space. At the same time, elementary particles with mass (electrons, atomic nuclei, etc.) are inclusions in this medium. This, for example, is indicated by the effects of diffraction, scattering of hard X-ray waves on electrons and atomic nuclei [13, 14].

Near an elementary particle a regular lattice (Fig. 2) due to distortions introduced by inclusions, cannot be preserved. Schematic diagram, Fig. 3, demonstrates how the regular lattice structure of the ether is distorted by the presence, for example, of an atomic nucleus. As you move away from the inclusion, the degree of loosening of the structure will decrease.

Comparison of Fig. 2 and Fig. 3 shows that the ether structure has the highest density, near which there are no inclusions. A structure distorted by the presence of inclusions has a lower density. The spatial network structure (regular lattice) formed by dissimilar particles attracting each other develops high pressure at their contacts. Pressure will also be exerted on the spherical inclusion (Fig. 3). Moreover, this pressure will add up due to the opening of contacts of unlike particles directly adjacent to the spherical inclusion.

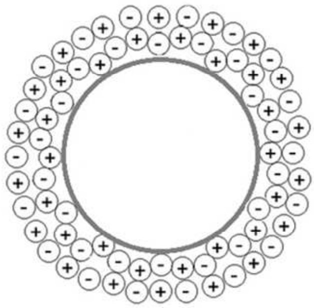

Fig. 3. The structure of the ethereal medium around the spherical inclusion (projection on the plane)

The pressure on the spherical mass will be increased due to distortions of the second, third, fourth, etc. rows of the structural lattice, located, respectively, in the second, third, fourth, etc. row from inclusion. This pressure is due to the desire of particles located in the second, third, etc. rows to be as close to each other as possible and restore the undisturbed structure (Fig. 2).

At a certain, greater distance from the center of the spherical inclusion, the general appearance of the structural medium can be conventionally represented in the form of concentric spheres nested one inside the other. Purely conditionally, we will assume that in the middle concentric sphere, Fig. 4, all particles of the opposite kind are in contact with each other directly, without gaps. Then in the concentric sphere located further from the inclusion, due to the need for the number of opposite particles to correspond to each other, gaps will appear between them.

In the concentric sphere, located closer to the inclusion, the packing of particles will also be less dense, since it is impossible to place the same number of particles here as in the middle sphere. A certain number of particles from the near sphere will be displaced, and empty spaces will take their place. It is not difficult to imagine that, as move away from the inclusion, the density of the ethereal medium will increase, and its “looseness” will decrease in proportion to the distance from this inclusion.

From the ideas developed above, it is relatively easy to derive the law of the inverse square dependence of the ether pressure on distance. Let us assume that along the circumference $L_1$, concentric layer 1, Fig. 4, formed around inclusion $M_1$, fits the exact number $n$ of particles of opposite signs with diameter $d$, or $L_1 = n_1 d$.

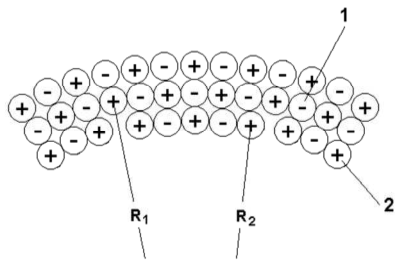


Fig. 4. Scheme for calculating the number of particles of the etherial medium

We will assume that $L_1 >> d$. The radius of such a circle will be equal to $R_1 = n_1 d/2\pi$, and the number of particles $n_1 = 2\pi R_1/d$. The next concentric layer, closer to the inclusion, with a circumference length $L_2$, as follows from our model, will have a radius $R_2$ that is smaller by exactly the same amount as the particle size $d$ than the first, $R_2 = R_1 - d$. The circumference of layer 2 will be equal to $L_2 = 2\pi R_2 = d(n_1 - 2\pi)$, and the number of particles $n_2 = 2\pi(R_1 - d)/d$. Otherwise, $n_2 = n_1 - 2$. Accordingly, in layer 2 there will be $2\pi$ fewer particles stacked than along the circumference $L_1$.

On the other hand, each particle of the circle $L_1$ must correspond to another, opposite in sign, particle $L_2$. This means that due to $n - 2\pi$ the number of particles in the second concentric layer, 7 particles of the first layer will not be compensated. Therefore, the particles of layer 2 will be at a slightly greater distance from each other than the particles of the first layer. Thus, within the concentric layer 2 (Fig. 4) a certain rarefaction of the ethereal medium is formed.

In a certain $k$-layer located closer to the center by an amount $kd$, the number of particles $n_k = n_1 - 2k\pi$ will fit along the circumference. The magnitude of the rarefaction of the ethereal medium in the $k$-layer in relation to the first layer can be expressed by a coefficient reflecting the ratio of the number of particles in each layer to their circumferences:

$$\Delta_k = (n_1 - 2\kappa\pi\pi)/n_1 = 1 - 2\kappa\pi/n_1. \qquad (12)$$

Formula (12) essentially, for large numbers $n$, expresses the change in diameter (radius) or curvature of concentric layers, within which, ideally, ether particles are located. It is easy to show that with increasing distance from the center, the curvature (for spherical surfaces) decreases in proportion to the radius of the sphere. Accordingly, the degree of “loosening” of the vacuum medium will decrease as much as the distance from the sphere disturbing the ether increases.

Let us imagine the presence of inclusion $M_1$ in a homogeneous, undisturbed ether. As has already been shown, with increasing distance from the inclusion $M_1$, the degree of “loosening” of the ether will decrease in proportion to the first power from the distance $R$ to the center of the inclusion, that is, $M_1/R$. Now let us introduce the second inclusion $M_2$ at a point located at a distance $R_L$ from the first mass, Fig. 5. The inclusion of $M_2$ will produce a “loosening” of the ether in the area where the inclusion of $M_1$ is located, equal to $M_2/ R_L$. Thus, the mutual attraction of inclusions (mass) $M_1$ and $M_2$ will be proportional to the product of the two above expressions,

$$T = -\frac{M_1 \cdot M_2}{R^2}. \tag{13}$$

As you know, the law of universal gravitation is formulated as follows: two material points with masses $M_1$ and $M_2$ are attracted to each other with a force $F$,

$$F = -g\frac{M_1 \cdot M_2}{R^2}, \tag{14}$$

where $R$ is the distance between points, and $g$ is the gravitational constant equal to $6.6742 \cdot 10^{-11}$ $nm2/kg2$ [15].

From this example it is clear that the law of universal gravitation is directly derived from the proposed model of the ethereal medium. The adequacy of formulas (13) and (14) is due to the fact that the number n of particles of the ethereal medium in any real closed surface surrounding a physical body is very large due to the extreme smallness of the particles themselves.

So, the presence of inclusions shown in Fig. 3, 5, and their clusters distort the configuration of the spatial-mesh structure of the ethereal medium. Due to its very fine structure, the ether is present in the intra-atomic space and exerts pressure on the particles, electrons and nuclei that make up the atoms of the substance.

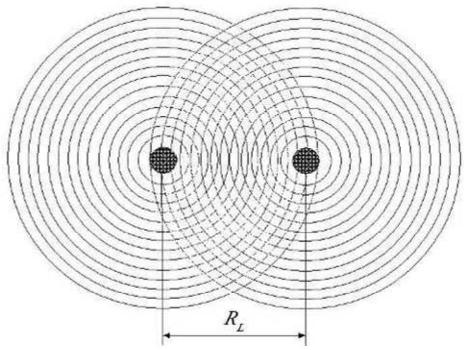


Fig. 5. The gravitational field produced by two gravitating masses

It was noted above that the ratio of the mass (volume) of the nucleus to the sum of the masses of the electrons of the atom is approximately 2000/1. Therefore, the sum of the nuclei of matter contained in any physical body is mainly responsible for the decrease in the density of the ether in the vicinity of the body. The more atomic nuclei there are in a physical body, the lower the density of ether in its vicinity. This density is low in the vicinity of the planets. It is further reduced in the vicinity of the massive star. The gradient of this density creates a gravitational force on the bodies in the vicinity. It is proportionally larger near a massive star and smaller in the space of a minor planet.

So, if another physical body is in the vicinity of, say, a massive star, then the force of gravity does not affect the outer shell of the body, but the sum of the nuclei of the atoms contained in the body. Figure 6 very roughly depicts the effect of the gravitational field gradient on a physical body. The force $F$g is applied to each atomic nucleus of an element that makes up the body. Potential theory [16] allows, based on a given mass distribution, to determine mutual gravitational forces in planetary and more complex systems.

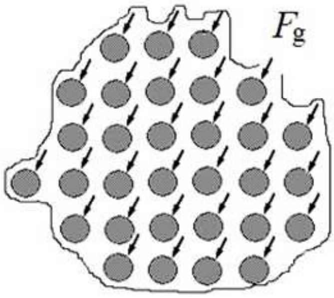


Fig. 6. Effect of the gravitational field gradient on the physical body. The force $F_g$ is applied to each nucleus of the atom of the element that makes up the body

An explanation of the nature of the mutual attraction of physical bodies, in our opinion, is one of the most important consequences of the concept of the ethereal medium. As already mentioned, the presence of a quasi-rigid ether deformed by physical bodies was previously indicated by MacCullagh, A. Sommerfeld and F. Gorbatsevich [10-12]. There are experimental data confirming such deformation. For example, light passing in the vicinity of a massive body travels at a lower speed than at the distance from it. In radar sounding of Mercury and Venus, during the passage of the planets beyond the disk of the Sun, the additional signal delay due to the gravitational field of our star was about $2{\cdot}10^{-4}$ sec [17]. This confirms the decrease in rigidity, "loosening" and distortion of the ethereal medium near large physical bodies.

**Conclusion**

Gravitational interaction is one of the four fundamental interactions in our world. Despite more than three centuries of attempts, gravity is the only fundamental interaction for which a consistent theory has not yet been constructed. Currently, there is no general approach to explaining the phenomenon of gravity. We should not talk about the theory of gravity as such, but about theories of gravity, even the classification of which requires not one, but several catalogs compiled according to different principles ("pragmatic", "cosmological", geometric", etc.) [18, 19].

The latest edition of the "Physical Encyclopedia" [20, p. 188] describes the phenomenon of gravity as follows: "Gravity (gravity) is a universal interaction between any types of matter. If this interaction is relatively weak, then gravity is described by Newton's theory. In the case of rapidly changing fields and rapid movements of bodies, gravity is described by the general theory of relativity, created by A. Einstein. Gravity is the weakest of the 4 types of fundamental interactions and in quantum physics is described by the quantum theory of gravity, which is still far from complete." As follows from the above, a satisfactory and comprehensive explanation of the phenomenon of gravity has not yet been found.

This happened because the presence of the ethereal medium in which all bodies are immersed was ignored.

According to our concept, the ethereal medium is a three-dimensional spatial lattice consisting of spherical particles. The lattice is based on two geometrically equal particles with opposite electrical charges. These particles attract each other with great force. Physical bodies move in the ethereal environment without the manifestation of friction and viscosity phenomena.

The ethereal medium has a fine structure. It penetrates into the interatomic space and acts directly on the nuclei of atoms, as well as neutrons, protons, electrons, etc. In its environment, a physical body, large or small, creates a rarefaction of the ethereal environment. This rarefaction has a gradient of elastic pressure whose vector is directed towards the body. The reason for the mutual attraction of bodies, - gravitation, - is the creation of a gradient of elastic pressure of the ether by a physical body in the vicinity of another physical body. Another physical body also creates a gradient of elastic pressure of the ether in the vicinity of the first.

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