BIPOLAR LAW OF GRAVITATION

Prof. Etkin V.A.
v_a_etkin@bezeqint.net

Abstract

A new law of gravitation is established for continuous media, which establishes the correspondence of the sign of force to the density gradient of matter. Conditions are found under which it becomes the law of gravitation of Newton. The new law predicts the observed character of the rotation curves of galaxies, the existence of "strong" gravity and gravitational equilibrium. The data of recent astronomical observations confirming the presence of gravitational forces of attraction and repulsion are given.

Keywords: Strong gravitation, modification of Newton's dynamics, gravidynamic potential, gravitation and repulsion, dark matter and energy, observational astronomy, discoveries.

1. Introduction

Since the time of Newton until the end of the twentieth century attraction was considered a hallmark of gravity. Although the theory of relativity allowed the possibility of repulsive gravity, the vast majority of physicists and astrophysicists believed that gravity only slows the expansion of the universe. However, in 1998 it was discovered that the universe is expanding at an accelerating rate [1]. The researchers assigned this responsibility to the "dark energy", which together with the "dark matter" is not less than 95% of the mass of the universe and has a negative pressure [2,3].

Meanwhile, back in the 1960s, the discrepancy between the character of rotational curves of a number of galaxies and the predictions that stemmed from Newton's dynamic laws was found [4]. Therefore, in the 1980s it was proposed to modify the Newtonian dynamics by introducing the correction factor $\mu(\boldsymbol{a})$ into Newton's second law, which increases at small accelerations $\boldsymbol{a}$ to unity as they approach a certain empirically found value [5]. However, such an approach could not eliminate other deficiencies in Newton's dynamics. Dissatisfaction was also caused by considerations of a theoretical nature, due to the fact that the classical theory of gravitation of Newton was based on the concept of gravitational force, whose instantaneous nature of action is incompatible with the concept of the field in modern physics. Newton's theory of gravitation proved incompatible with the fundamental principle of the special theory of relativity – the invariance of the laws of nature in any inertial frame of reference. However, none of the more than 30 theories of gravity proposed so far have not been able to offer an alternative [6].

In this paper, a different path based on a theoretical derivation from the principle of equivalence of mass and energy of a more general bipolar law of gravitation is proposed. This law is valid for continuous media and reveals the existence in them of both the forces of attraction and repulsion, passing under certain conditions into Newton's law. He first explains the origin of the forces of gravity as a consequence of the inhomogeneous distribution of masses in the universe and predicts the observed character of the rotational curves of spiral galaxies.

2. The universal law of attraction and repulsion of the masses

Since the forces of gravity do not depend on the nature of matter, we will proceed from the existence of a single gravitational field, calling it to avoid treating the gravitational field as "masso-dynamic"[1)]. This field is formed by the entire substance of the universe, whose density ρ varies according to modern data from ~ 10^{-27} kg/m^3 in the intergalactic medium to ~ 10^{18} kg/m^3 in celestial bodies such as white dwarfs. To find the strength of such a field, we use the principle of equivalence of the mass *M* and the energy *E*, which has the form $E = Mc^2$, where *c* is the speed of light in vacuum. In this case, the massodynamic potential ψ_m as an analog of the gravitational potential ψ_g is equal to $\psi_m = dE/dM = c^2$. In contrast to the Newtonian gravitational potential, $\psi_g = - GM/R$, where *G* is the gravitational constant equal to $6{,}672\cdot10^{-11}$ H·m^2·kg^2 according to modern data, and *R* are the distances between the centers of gravitating masses *m* and *M*, the massodynamic potential ψ_m - the value is purely positive.

For field values it is more convenient to operate with the concept of energy density $\varepsilon = dE/dV = \rho c^2$ (J/m^3), where ρ is the density of matter. Then the strength of the massodynamical field $H_m = \rho\mathbf{g}$ as the gradient of its energy density ε, taken with the opposite sign, is expressed in terms of the density gradient of matter ∇ρ by the simple relation:

$$\mathbf{H}_m = -\psi_m \nabla\rho \text{ , (kg/ m}^2\cdot c^2\text{)} \ . \qquad (1)$$

This relation expresses the law of massodynamic interaction, since it connects all the quantities that characterize it. According to him, the material carrier of the gravitational (massodynamic) interaction is the mass of substance *M* as a measure of its quantity, and the gravitational (massodynamical) force field $\mathbf{H}_m$ is generated exclusively by the non-uniform distribution of this mass in space. The latter statement did not follow from any theory of gravity, especially from the general theory of relativity, where gravity was explained by the curvature of space.

Since $\mathbf{H}_m = \rho\mathbf{g}$, in accordance with (1), the acceleration in the gravitational (massodynamic) field **g** is proportional to the relative gradient ∇ρ/ρ of the density of matter:

$$\mathbf{g} = -\psi_m \nabla\rho/\rho \text{ , m/}c^2 . \qquad (2)$$

This position also did not follow from Newton's law, in which the gravitational force $\mathbf{F}_g = m\mathbf{g}$ and the acceleration $\mathbf{g} = \mathbf{F}_g/m$ disappears only in the absence of the "field-forming" mass *M*. Therefore, the law of massodynamic interaction (1) is not a generalization of Newton's law, A fundamentally new position, which has an ideological character.

It is equally important that the acceleration in the intergalactic medium can have a different sign depending on the sign of the density gradient of this medium, which is confirmed by the conclusion [8] made on the basis of energy dynamics [9]. This means that the massodynamic interaction itself is bipolar in this respect and does not differ from the electric or magnetic interaction in this respect. This circumstance reveals new opportunities for observational astronomy, allowing for the density of star clusters in the current time mode predicts the direction of their evolution. For example, if the density of matter in a cluster of stars or galaxies falls to their periphery ($\nabla\rho < 0$), then the massodynamic forces acting in them are gravitational forces, i.e. directed toward the center of the galaxy or their congestion. In this case, the spatial inhomogeneity, arising from any causes, causes a further increase in spatial inhomogeneity in the same direction. This explains not only the concentration of non-baryonic

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[1)] The term "massodynamical" reflects the role of the mass as a material carrier of gravitational interaction and its dynamic (power) character. For the first time this term occurs, as far as we know, in [7].

(invisible) matter in this region of the Universe with the formation of "black holes" in it, but also the accelerated formation in this area of space of baryonic (structured) matter consisting of protons, electrons, neutrons, quarks, etc. [8]. This is also explained in a new way by the final stage of the evolution of a star or galaxy, when their density increases so much that the relative gradients of its density $\nabla\rho/\rho$ become insignificant and do not withstand the more internal pressure due to the thermonuclear reactions taking place in them. Then comes what is called a "supernova explosion" with the release of accumulated energy and the spread of their matter.

On the contrary, if on the approaches to any cluster of galaxies there is an increase in the concentration of stars or their clusters ($\nabla\rho > 0$), then the massodynamical forces $\mathbf{F}_m$, according to (2), take in the same frame the direction opposite to the gravitational forces $\mathbf{F}_g$, i.e. will acquire the character of repulsive forces. To make this more obvious, we take into account that in mechanics the gravitational forces $\mathbf{F}^g$ and the acceleration **g** are considered positive if they are directed toward the center of the "field-forming" body of mass *M*, for example, of the Earth. Therefore, in the reference frame (RF) connected to the Earth, the force $\mathbf{F}_m$ has the opposite sign to $\mathbf{F}_g$, as well as the acceleration $\boldsymbol{a} = \mathbf{F}_m/m$, which can no longer be associated with gravity to the Earth. Then it becomes clear that as the mass *m* approaches another clusters, where $\nabla\rho > 0$, the acceleration a and the force $\mathbf{F}_m = - \mathbf{F}_g$ acting on it in this FR become positive. This means that in one and the same FR, the force $\mathbf{F}_m$ has acquired the character of repulsive forces. The existence of the forces of attraction and thawing in the same intergalactic medium is easy to understand if we adhere to the concept of the existence in this environment of gravitational (and essentially acoustic) waves [10]. In such environments, the stable location of the antinodes of the wave at a certain distance from each other, equal to the wavelength, is quite natural. However, from the standpoint of the Newtonian dynamics, which considers only the pair interaction of massive bodies separated by an empty space, the appearance of such forces is completely inconceivable. It also follows from expression (2) that the magnitude of the acceleration **g** or ***a*** acting on the body from the side of the intergalactic medium essentially depends on the degree of its inhomogeneity $\nabla\rho/\rho$. This gives a natural explanation for the anomalous acceleration of the space probes "Pioneer" and "Voyager 1 and 2" by their transition to the universe with a more uniform distribution. Another important advantage of bipolar law (4) is that it predicts the possibility of establishing a gravitational equilibrium in a continuous medium, the condition of which is the equality of its relative density to zero:

$$\nabla\rho/\rho = 0 \,. \tag{3}$$

The existence of such an equilibrium is evidenced by the phenomenon of libration [11], while Newton's law of gravitation does not recognize it. Nevertheless, it is of interest to show that this law does not contradict the bipolar law (2) and can be regarded as its particular case.

3. Newton's law of gravitation as a special case of bipolar law

As is known, Newton's law of gravitation allows us to find the gravitational potential ψ_g as a function of the mass of the field-forming body $M \gg m$ and the position of the test body m outside this body at a distance *R* from its center, i.e. $\psi_g = \psi_g(M, R)$. We now pose the problem of finding the potential ψ_g at the same distance from the center of mass of the celestial body, (for example, on the surface of a sphere of unit volume V with radius R = const) in the density function of this body ρ, i.e. $\psi_g = \psi_g(\rho)$, as in expression (1). Then, in accordance with Newton's law

$$\mathbf{g} = -\nabla\psi_g = -(GV/R)\nabla\rho/\rho = -\psi_g\nabla\rho/\rho. \quad (4)$$

Thus, in this case, too, the acceleration **g** is related to the density gradient by the same expression as (2). Consequently, Newton's law should be considered as a special case of a more general law of mass-dynamic interaction (2). There arises, however, a logical question, why in this case Newton's law does not reflect the presence of repulsive forces? The answer to this lies in the existing arbitrariness in the choice of the origin of the energy in mechanics, when it is entirely permissible to take the position of the center of mass $M = \rho V$ of the "field-forming" body for it, and the total potential energy for the interacting bodies is entirely attributed to another body in its "field ". Then the gradient or density drop in the direction of any of the bodies interacting with it will be a positive quantity, and the gravitational force will be only by the force of gravity.

It is of interest to compare the Newtonian gravitational potential ψ_g for specific celestial bodies with its value, which follows from the equivalence principle $\psi_m = c^2$. To do this, it is first of all necessary to eliminate the difference in the signs of these potentials. To do this, we take into account that the magnitude of the gravitational potential as the specific value of the gravitational energy E is determined by the work performed by the test body upon its fall onto the field-forming body. If the radius of the latter is equal to R_o, then this energy turns out to be zero at a distance to the point test body $R = R_o$. This state should be taken as the origin of the potential ψ_g. With such a calibration, their gravitational energy of the pair of bodies M and m under consideration is determined by the expression:

$$E = GmM(1/R_o - 1/R). \quad (5)$$

In this case, the gravitational energy becomes a purely positive quantity, and the divergence of the forces $\mathbf{F}_g$, the energy E, the potential ψ_g and the acceleration $\mathbf{g} = -\nabla\psi_g$ in Newton's laws does not arise, since $R_o > 0$. It follows from (5) that in this case the maximum potential $\psi_g = E/m$ is attained at $R = \infty$ and equal to the potential on the surface of the field-forming body $\psi_g^{max} = GM/R_o$. This maximum value for the Sun with a mass $M = 1.989\cdot10^{30}$ kg and a radius $R_o = 6.9599\cdot10^8$ m is $1.906\cdot10^{11}$ J/kg, and for the Earth with a mass $M = 5.976\cdot10^{24}$ kg and a radius R_o = 6.36· 106 m is $6.27\cdot10^7$ J / kg, while the mass-dynamic potential $\psi_m = c^2 \sim 9\cdot10^{16}$ J/kg. Thus, this potential exceeds the Newtonian by many orders of magnitude, indicating the existence of "strong" gravity [12]. The reason for this discrepancy is apparently the same arbitrariness in the choice of the starting point, as a result of which the Newtonian potential ψ_g turns out to be relative, while $\psi_m = c^2$ is a quantity that remains unchanged in any frame of reference. Indeed, according to (5), the Newtonian potential ψ_g is determined by the work of transferring a single test mass from one point of the space R_o to another R, which is generally zero if the field ψ_g is homogeneous. The potential ψ_m is defined as the derivative of the energy of the system E with respect to the parameter conjugate to the potential ψ_m (in this case, by mass M), i.e. In the same way as the absolute temperature T, the absolute pressure p, and the like [13]. Thus, Newton's law is valid only for the case when the density of matter between gravitating bodies is negligible.

4. Correspondence of rotational curves of galaxies to bipolar law

The new law of gravitation allows us to remove the contradiction of the observed rotational curves of galaxies with the law of gravitation of Newton. If the stationary rotation of the galaxies is due to the equality of the gravitational forces, expressed by the bipolar law (2), and the forces of the central acceleration $\mathbf{g}_r = \upsilon^2/R$, then

$$-c^2(\nabla\rho/\rho) + \upsilon^2/R = 0 \,. \tag{6}$$

It follows that the rotation speed of stars in a galaxy is subject to the distribution

$$\upsilon = c\,(R\nabla\rho/\rho)^{½} \tag{7}$$

This distribution differs from the one predicted by Newton's dynamics $\upsilon = (GM/R)^{½}$ by the nature of the dependence on the radius of rotation R and allows experimental verification. Moreover, theoretically, this dependence makes it possible to verify Einstein's postulate that there are no velocities for the propagation of interactions exceeding the speed of light in vacuum c, putting in (7) instead of c the propagation velocity of gravity c_g and measuring the rotation speed of stars υ at a distance R from the center at experimentally found distribution of their density ∇ρ/ρ. However, due to the lack of accuracy of existing observational means, we are forced to confine ourselves to qualitative conclusions. According to (7), the velocity distribution along the radius depends on how quickly the relative density ∇ρ/ρ of the matter of the Universe decreases, in which the non-baryonic (invisible, non-structured) matter predominates (and, moreover, significantly). We can judge its movement only from the behavior of the visible (baryonic) matter, which is the product of its condensation. If the relative density of matter in the universe ∇ρ/ρ increases with the radius or changes insignificantly, the influence of radius prevails in expression (7), and the rotation of the galaxy approaches the laws of rotation of the solid body. However, when the relative density begins to decrease significantly as we approach the periphery of the galaxy, the growth of the product R∇ρ/ρ slows down and stops, which is revealed by observational astronomy [4]. However, the drop in the rotational speed, predicted by Newton's dynamics, is not observed anywhere.

5. Conclusion

This result complements the conclusions of the previous work [8], where it is shown that the law of mass-dynamic interaction (2) is in good agreement with the nature of the distribution of visible matter in the Universe, recently discovered in the compilation of a three-dimensional map of the star sky by the Lawrence Laboratory in Berkeley (USA) [14]. These data indicate the presence in the Universe of the density gradients of matter of both signs and the existence in the Universe of the most extensive "libration zones", where the equality of the attractive and repulsive forces is observed, i.e. the equilibrium state (∇ρ = 0) [15] is maintained, which confirms the validity of the bipolar law of gravitation.

The foregoing allows us to draw the following conclusions:

1. The necessity of correction of the theory of gravitation is due to the data of observational astronomy, which testify to the presence in the Universe of forces opposing gravitational forces.

2. Existing attempts to correct the situation do not affect the nature of gravity and are limited to the introduction of a hypothetical "dark energy" compensating the gravitational force, or a modification of Newton's law of gravitation by introducing empirical corrections weakening the gravitational forces.

3. The approach based on taking into account the inhomogeneous distribution of the density of non-baryonic matter and the unified determination of the strength of any nature as a gradient of the corresponding form of energy is fundamentally different.

4. The more general, bipolar law of gravitation can be found from the understanding of gravity as a consequence of the uneven distribution of mass in space and is obtained as a consequence of the principle of equivalence of mass and energy, according to which the density of gravitational energy is proportional to the mass density in a continuous medium.

5. Newton's law of gravitation is a consequence of bipolar law, and the absence of repulsive forces in it is explained by the use of a frame of reference, proceeding exclusively from the "field-forming" body under the assumption of pair interaction.

6. The potential of the Newtonian gravitational field is many orders of magnitude smaller than the mass dynamics found from the equivalence principle, which indicates the need to take into account the influence of the surrounding intergalactic medium and the existence of "strong" gravity.

7. The bipolar law of gravitation predicts and explains the character of the rotational curves of galaxies, which differ in the constancy of the rotation speed of their peripheral regions, and in the decrease in the relative gradients of their density.

8. The results of this article supplement the earlier corollaries of the bipolar law of gravitation on the existence in the Universe of gravitational forces of repulsion and gravitational equilibrium, which ensures a stable and ordered distribution of clusters of galaxies in it.

9. The existence of gravidynamic forces of both signs reveals the unity of their nature with electromagnetic forces and opens a direct path to the construction of a unified field theory.

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