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Calculation Method the Value of the Gravitational Constant for the Non-Equilibrium System of Mercury-Sun

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Abstract: *Kepler-Newton's observational astronomy allowed to determine the value of the gravitational constant for the planet Mercury leads to a modification of Newton's law of gravity and giving up of Einstein's General Relativity when considering non-equitable systems. In the article the results of numerical modeling of the precession of the perihelion of the orbit of Mercury in the framework of the modification of Newton's law of gravity are given.*

Keywords: *gravitational mass; inert mass; gravitational constant; principle of equivalence*

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1. INTRODUCTION

In 2013, the scientific world was shocked by the article by the Chinese mathematician Academician Hua Di "Einstein's Explanation of Perihelion Motion of Mercury" published in the collection of articles "Unsolved Problems of the Special and General Relativity", edited by Florentin Smarandach USA [1]. In his article, Academician Hua Di showed that, when calculating the magnitude of the precession of the perihelion of the orbit of Mercury, Einstein made a gross error in the integration. As a result, the deviation was 71.5", and not 43".

The theory is completely useless if it is not confirmed by experiment. From the time of Einstein to verify the reliability of the theory of gravity, the calculation of the motion of the perihelion of Mercury was used. It has long been known in astronomy that because of its proximity to the Sun and under the influence of the gravity of other planets, Mercury is moving not just along an ellipse, but an ellipse which itself slowly rotates in 575" within a hundred years. This is an abnormal precession for the planets of the solar system. The corrections calculated on the basis of Newton's theory gave a rotation of the perihelion 532". It is believed that the remaining value of 43"cannot be explained within the framework of Newton's theory. In 1915 A.Einstein calculated the precession of the perihelion of the orbit of Mercury and obtained the expected value 43", using the field equations of general relativity [2], it became his triumph. However, in 2013 it turned out that Einstein made a mistake in his calculations. The shock of Hua Di's article quickly forgotten, five years have passed since the article was published, and no one wondered why, in the framework of the field GR equations, the calculation of the precession of the Mercury orbit perihelion gives 503.5΄ over 100 years. The result ~ 71.63" was also obtained by direct numerical simulation of the precession of the perihelion of the orbit of Mercury in the field of the spherical Sun within the framework of GR, conducted by Professor N.V. Kupryaev in 2018 [3]. The time has come to say that Einstein's error is not accidental and GR only works in equilibrium integrable systems with reversible processes for which there is performed of the equivalence principle. Non-equilibrium systems are characterized by violation of the equivalence

principle and conservation laws and must be described by other theories of physics within the framework of the new scientific paradigm [4]. To calculate the new value of the gravitational constant G_M for the non-equilibrium system of Mercury-Sun, it was proposed to use the basic value of the precession of the perihelion of the orbit of Mercury 575" for 100 years, which established experimentally in of observational astronomy and the values of Kepler's constant for planets Earth and Mercury, calculated by Kepler [5].

2. Calculation Method the Value of the Gravitational Constant for the Planet Mercury

Johannes Kepler formulated his laws of celestial mechanics on the basis of analysis of long-standing astronomical observations of Tiho de Braga in 1609-1619 and Isaac Newton fifty years later received Kepler's third law, as a consequence of the law of universal gravitation and the second law of dynamics, introducing into the spatial model of the universe the forces of gravity and inertia. This was a brilliant confirmation of the correctness of Newton's theory of gravitation.

$$K = G_0 M_0 \frac{m\ g}{m\ i} = \frac{R^3}{T^2}. \tag{1}$$

where

m g. is the planet gravitational mass, interacting with the Sun, the M_0 mass, produces a centripetal force of gravity;

m i. is the inertial mass of the planet. It is rotating around a circle of R radius and producing a centrifugal force of repulsion,

R is a average value distance from the centre of the planet to the centre of the Sun,

T is a period of the planet rotation around the Sun,

G_0 is the gravitational constant, K is Kepler’s constant.

Johannes Kepler calculated the value of the constant K for 8 planets:

Earth, Venus, Mars $K = 3.35 \cdot 10^{24}\ km^3 \cdot year^{-2}$

Saturn, Jupiter, Uranus $K = 3.34 \cdot 10^{24}\ km^3 \cdot year^{-2}$

Mercury, Pluto $K = 3.33 \cdot 10^{24}\ km^3 \cdot year^{-2}$

Note the difference in the meaning of Kepler's constant. For planets of the terrestrial group, rotating along stable, slightly perturbed orbits, K = 3.35, and for Mercury, whose orbit is subject to strong perturbations due to its proximity to the Sun, the value of K = 3.33, that is, less [5].

The equivalence principle (PE) predicts the same acceleration for bodies of different composition in the same gravitational field and allows us to consider gravity as a geometric property of space-time, which leads to the interpretation of gravity from the standpoint of the General Relativity [2]. As a result of this, the gravitational mass of A. Einstein became equal to the inertial mass under any conditions and all the planets in the solar system have a gravitational constant equal to the gravitational constant of the Earth $G_0=6.67408 \cdot 10^{-8}\ dyn \cdot cm^2/g^2$ [5]. Although the Einstein's General Relativity believes that the equivalence principle is never not violated, alternative gravity theories using scalar fields predict a violation of PE [4]. In the most famous alternative theory of Brans-Dicke, the intensity of the gravitational interaction depends on the additional scalar field. Within this theory, it is possible to formulate the Mach principle, according to which the inertia of bodies manifests itself due to interaction with distributed matter in the Universe [6]. Analysis of the formula (1) of Newton - Kepler allows you to assess the approximate value of the gravitational constant for the Mercury G_M from solving the proportion (2) (we neglected the violation of the equivalence principle for the planet Mercury [4]):

$$3.35 \cdot 10^{24}\ km^3 \cdot year^{-2} = G_0 M_0 \left[\frac{mg\ Earth}{m_i\ Earth}\right], \quad \text{for Earth} \quad \frac{m\ g}{m\ i} = 1 \tag{2}$$

$$3.33 \cdot 10^{24}\ km^3 \cdot year^{-2} = G_M M_0 \left[\frac{mg\ Mercury}{m_i\ Mercury}\right], \quad \text{for Mercury} \quad \frac{m\ g}{m\ i} \sim 1$$

$G_M \sim 0.994\ G_0$ or $G_M \sim 6.63403 \cdot 10^{-8}\ dyn \cdot cm^2 / g^2$,

This value of the gravitational constant should be used in the modified Newton's law of gravity $F = Gm_1 m_2 / r^2$, when referring to the Sun-Mercury system.

In view of the extreme weakness of gravity, test bodies to test the strong principle of gravity must have astronomical dimensions. To date, the Earth-Moon-Sun system seems to be the best model in the solar system for testing the strong principle of gravity. Experiments of the laser rangefinder of the

Moon (LRM) were associated with the reflection of laser beams from an array of angular reflectors mounted on the moon by astronauts of the Apollo program and Soviet lunar rovers. The latest experimental data made it possible to establish that the possible inequality with respect to gravitational and inertial masses for the Earth and the Moon has a value $(0.8 \pm 1.3) \times 10^{-13}$ [7]. But for Mercury, whose orbit is subject to strong perturbations due to its proximity to the Sun,, there is a violation the strong principle of gravity , as it happens when spherical bodies move in a superfluid turbulent medium dark energy and dark matter in new cosmological models [8,9]. A macroscopic approach, the hydrodynamic behavior of the added weight of spherical bodies of any nature (including those of charged clusters) in superfluid ^{3}He-B (analogue of dark energy) is the primary source of job Stokes. It is a complex force F (ω), exerted by the fluid on the sphere of radius R, performs periodic oscillations with a frequency ω. Within the low Reynolds numbers we have:

$$F(\omega)= 6\pi\eta R\left(1+\frac{R}{\delta(\omega)}\right)V(\omega)+3\pi R^2\sqrt{\frac{2\eta\rho}{\omega}}\left(1+\frac{2}{9}\frac{R}{\delta(\omega)}\right)i\omega V(\omega), \tag{3}$$

$\delta(\omega) = (2\eta/\rho\omega)^{1/2}$

where ρ - fluid density, η - the viscosity, V - velocity amplitude sphere, δ (ω) - the so-called viscous penetration depth, which increases with an increase in viscosity and a decrease of the oscillation frequency.

The real part of the expression (3) is a known Stokes force derived from the movement of fluid in the sphere. Imaginary component (coefficient of iωV) is naturally identified with the effective mass of the cluster added:

$$Meff\,(\omega R)=2\pi\rho R^3/3\left[1+\frac{9}{2}\frac{\delta(\omega)}{R}\right] \tag{4}$$

Origin added (attached) mass Meff (ωR), depending on the frequency ω and the radius R of the sphere of the cluster associated with the excitation of the field around a moving cluster of hydrodynamic velocity υ_i (r) and the appearance in connection with this additional kinetic energy. In superfluid additional mass has two components: superfluid and normal [10]. Professor I. Prigogine, winner of the Nobel Prize called this effect "an active influence on the system from the outside, with the transition of the system in a non equilibrium state." I. Prigogine clarifying Mach's Principle and came to the conclusion that in a steady condition, an active influence from the outside on the system is negligible, but it can become of major importance when the system goes into a non-equilibrium condition [11]. As a result of this effect the value of the gravitational constant for the non-equilibrium system Mercury-Sun is different with the value of the gravitational constant for equilibrium the Earth-Moon-Sun system. Geometric theory of Einstein's General Relativity, which requires compliance with the equivalence principle, does not allow this, and Newton's law can be modified for different values of the gravitational constant.

3. Calculation of the Movement of the Perihelion of Mercury and the of Einstein's Error

Academician Hua Di showed that, in calculating the precession of the perihelion of the orbit of Mercury, Einstein made a gross error in the integration. As a result, the result was 71.5", and not 43" [1, p. 5]. And indeed when integrating the equation (5)

$$\varphi=[1+\alpha(\alpha_1+\alpha_2)]\int_{\alpha_1}^{\alpha_2}\frac{dx}{\sqrt{-(x-\alpha_1)(x-\alpha_2)(1-\alpha x)}} \tag{5}$$

where is α_1 and α_2 are the inverse values of the maximum and minimum distances of Mercury from the Sun; $\alpha = 2G_0m_0/c^2$ is gravitational radius, where G_0 is the gravitational constant; m_0 is mass the Sun; c is the speed of light

If confined to a member of the first order of smallness in $(\alpha_1+\alpha_2)$ we get a result:

$$\varphi = \pi\left[1+\frac{3}{4}\alpha(\alpha_1+\alpha_2)\right] \tag{6}$$

that is different from the result that A. Einstein received:

$$\varphi = \pi[\,1 + \tfrac{5}{4}\alpha(\alpha_1 + \alpha_2)] \quad (7)$$

Those, in square brackets, α should be a factor of 5/4, not 3/4. And as a result for the displacement of the perihelion of the orbit of Mercury over 100 years, if we substitute (7) in the formula for calculating the displacement of the perihelion of the Mercury orbit $\varepsilon = 2 \cdot (\varphi - \pi) \cdot 415.2 / 4.8481368110953599141 \cdot 10^{-6}$, and for G_0 take $6.67408 \cdot 10^{-8}$ dyn · cm² / g², for m_0 $1.9885 \cdot 10^{33}$g, for c $2.99792458 \cdot 10^{10}$ cm / s, for r_1 $6.9817445 \cdot 10^{12}$ cm, and for r_2 $4.600109 \cdot 10^{12}$ cm, it turns out not ~ 43 ", but ~ 71.63".

The result ~503.5 " was also obtained by direct numerical simulation of the precession of the perihelion of the orbit of Mercury in the field of the spherical Sun within the framework of GTR, conducted by Professor N.V. Kupryaev in 2018 [3]. This is less than the observed displacement of the perihelion of the orbit of Mercury by ~ 71.63". A numerical simulation of the precession of the perihelion of the orbit of Mercury, conducted by Professor N.V. Kupryaev in 2019 in the framework of the modified Newton's law gravity taking into account the ellipticity of the orbits of the planets as well as taking into account the compression of the Sun is ~ 555" [12]. This is less than the observed displacement of the perihelion of the orbit of Mercury by ~ 20".

Direct numerical simulation of the precession of the perihelion of the orbit of Mercury taking into account all the planets, as well as taking into account the compression of the Sun conducted by in the framework of the modified Newton's law gravity with a value of $G_M \sim 6.63403 \cdot 10^{-8}$ dyn·cm²/g ² allows you to evaluate the result with an accuracy ~ 570" ±5". This is the most accurate result received for the entire history of the calculation of the precession of Mercury.

4. Conclusion

Thus, Kepler-Newton's observational astronomy came into conflict with Einstein's abstract speculative theory. The consequences of this can not overcome so far. The historical role of Mercury in front of science is that the violation of the principle of equivalence when the planet moves in a strongly perturbed orbit requires a revision of the theoretical constructions of the Einstein's General Relativity. A new gravitational constant for Mercury and Pluto Gm ~ Gp ~ $6.63403 \cdot 10^{-8}$ dyn · cm² / g², will be in demand in practical astronomy and space navigation. For other planets of the solar system, the value of the gravitational constant is equal to or close to the generally accepted value $G_0 = 6.67408 \cdot 10^{-8}$ dyn · cm² /g².

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