Substantiation of the Exact Correspondence of Planetary Motion to the Laws of Conservation of Angular Momentum and Energies

Pavlo Danylchenko*
Research and Production Enterprise "GeoSystem", Vinnytsia, Ukraine

The exact correspondence of the trajectories of the planets' motion to the laws of conservation of angular momentum and energies (the Newtonian of inert free rest energy and the Keplerian of ordinary rest energy of matter) is substantiated. The correspondence to the Solar System of not the static Newtonian gravitational field, but the rotational dynamic gravitational field, which is also formed by the motion of the planets and, therefore, adapts to changes in the location of the planets in it, is proven. It is because of this that gravitational pseudo-forces, like centrifugal pseudo-forces of inertia, are orthogonal at all points to the superharmonic oval (pseudo-elliptical) orbits of the planets. And therefore, in the frame of reference of spatial coordinates and time of the Solar System, the lines of force of the rotational adaptive-dynamic gravitational field in the planes of planetary motion are curvilinear. Moreover, the strength of this gravitational field is inversely proportional not to the square, but to the cube of the radial distance of the planet from the local centers of curvature of its superharmonic trajectory of motion. Based on Kepler's Third Law, high-precision orbital values of the gravitational radii have been obtained for all the planets of the Solar System.

Keywords: Theory of Relativity, Newtonian, Keplerian, adaptive-dynamic gravitational field, Solar System.

I. INTRODUCTION

The formulations of the laws of classical physics are very simplified and too straightforward. After all, they, as a rule, do not take into account the presence of negative feedbacks between the physical parameters of matter. But it is precisely these negative feedbacks that ensure the stability of natural formations.

Such simplification was also not avoided in the formulation of the differential equations of the gravitational field of the General Relativity (GR). Therefore, these equations should be taken only as a basis and creatively reinterpreted and supplemented with additional dependencies. After all, the GR equations themselves do not directly take into account the conservation of angular momentum and the corresponding effects of the motion of matter on the gravitational field due to the presence of negative or positive feedbacks. Einstein himself compared the metric tensor of these equations with good-quality marble, and the energy-momentum tensor only with low-quality wood [1]. And indeed, as it turned out much later, the use of ordinary Lorentz transformations of increments of spatial coordinates and time (OLT) in these equations came into conflict with the relativistic and gravitational invariance of thermodynamic parameters and potentials of matter [2-4].

Thus, the equations of the GR did not ensure the absence of the influence of the external gravitational field and motion, both on the of the change in the value of the gravitational thermodynamic state of matter and on the rate of flow of its proper time. After all, the compensation parameter b (the Schwarzschild solution of the GR gravitational field equations [5]) by the motion of matter by inertia ($b_{cj} = b_i + {}^i v_j^2 c^{-2} = b_{0j} = \mathbf{const}(r,t)$) ensures the correspondence to reality of the analogous equations of relativistic gravithermodynamics (RGTD, which is only an improved version of the GR [2-4]). Only according to them, the strength of the gravitational field is directly equal at point i to the gravitational acceleration of the common velocity ${}^i v_j = d^i \hat{r}_j / dt$ of motion of all substances m, which may have unequal values of their hidden thermodynamic parameters ${}^m b_{0j} = {}^m b_{00}\, {}^m T_{00}^2 / {}^m T_j^2$ dependent on the absolute temperature T [2-4,6,7]:

$$ {}^i\bar{g}_j = -b_i c^2 \frac{d \ln b_i}{2 d\hat{r}_i} = -c^2 \frac{d(b_{cj} - {}^i v_j^2 c^{-2})}{2 d\hat{r}_i} = {}^i v_j \frac{d^i v_j}{d\hat{r}_i} = \frac{d^i v_j}{dt}, $$

$$ {}^i\hat{g}_j = -c^2 \frac{d(\ln b_{cj})_v}{2 d\hat{r}_i} = -c^2 \frac{d[\ln(b_i + {}^i v_j^2)]_v}{2 d\hat{r}_i} = $$

$$ = -c^2 \frac{d(b_{cj} - {}^i v_j^2 c^{-2})}{2 b_{cj} d\hat{r}_i} = \frac{{}^i v_j}{b_{cj}} \frac{d^i v_j}{d\hat{r}_i} = \frac{G}{G_{00}} \frac{d^i v_j}{dt} \quad \left(\frac{db_{cj}}{d\hat{r}_i} = 0 \right), $$

where: ${}^i\bar{g}_j$ and ${}^i\hat{g}_j$ are gravitational field strength at point i by the observer's clock and by a hypothetically stationary clock at point i, respectively, $G = G_{00} / b_{cj}$ and G_{00} are true and standard values of the gravitational constant, respectively.

*Contact author: pavlo@vingeo.com.

Therefore, (based on the law of conservation of energy of a matter moving only by inertia) the gravitational field really determines only the velocity of motion and spatial gradients, and not at all the values of unequal hidden parameters ${}^{m}b_{0j}$ in different substances *m*, which were previously at rest at point *j*, and are now moving together at point *i*. And thus, each substance can have its own spatial distribution of the hidden gravithermodynamic parameter ${}^{m}b={}^{m}v_l^2c^{-2}$, which is equivalent not only to the absolute temperature *T*, but also to the limit velocity v_l of individual (separate) motion of a certain substance used in the RGTD (alternative to the false coordinate velocity of light of the GR [2-6]) [7].

Based on the non-identity of the gravitational mass $m_{gr}=m_{00}/\sqrt{b_c}$ of matter and its inertial mass $m_{inr}=m_{00}\sqrt{b_c}$ (which are equal only at the location of the matter's intrinsic clock) in RGTD, a canonical differential equation of the dynamic gravitational field was derived for discontinuous matter, which does not contain the spatial distribution of the matter's mass density. Due to the definition of the spatial distribution of the local value of the gravitational radius by this equation, on the contrary, it allows to obtain the required spatial distribution of the mass density of the matter [8,9]:

$$S'=\frac{d[r/a(1-b_c)]}{dr}=\frac{1-r_g'-\Lambda r^2}{(1-b_c)}+$$

$$+\frac{(r-r_g-\Lambda r^3/3)}{(1-b_c)^2}b'=-\frac{b_cS}{r(1-b_c)}+\frac{(1-\Lambda r^2)}{(1-b_c)^2},$$

$$S=\frac{r}{a_c(1-v^2c^{-2}/b_c)(1-b_c)}=\frac{r-r_g-\Lambda r^3/3}{1-b_c}=$$

$$=\frac{r}{a(1-b_c)}=\exp\int\frac{-b_cdr}{(1-b_c)r}\times\int\left[\frac{(1-\Lambda r^2)}{(1-b_c)^2}\exp\int\frac{b_cdr}{(1-b_c)r}\right]dr,$$

where the parameter *S* can be abstractly considered as the distance from the pseudo-horizon of the infinitely distant cosmological past and the parameters $a_c=(d\hat{r}/dr)^2=ab_c/b=$ $=a(b+v^2c^{-2})/b=a/(1-v^2c^{-2}/b_0)$ and $b_c=v_{lc}^2c^{-2}=b+v^2c^{-2}=b(1+v^2v_l^{-2})\equiv b_0=\mathbf{const}(t)$ are analogues of the parameters $a=1/(1-r_g/r-\Lambda r^2/3)$ and *b* of the Schwarzschild solution of the equations of the static gravitational field of the GR, *v* is the velocity of the hypothetical circular or real oval (pseudo-elliptical) orbital motion of the planets of the Solar System, $r_g(r)$ is the radial value of the gravitational radius of the dynamic gravitational field of the Solar System, $\Lambda=3H_E^2c^{-2}$ is the cosmological constant, H_E is the Hubble constant, c is the constant of the velocity of light.

This is what allows us to form the proper spatial distribution of the parameter $b_c(r)=v_{lc}^2c^{-2}=b+v^2c^{-2}$ of the adaptive-dynamic gravitational field along the superharmonic orbits of the planets of the Solar System. That is, it allows us to obtain exactly such a distribution of this parameter that would correspond to the conservation of not only the Keplerian of ordinary rest energy of the planet, but also the conservation of the angular momentum of the planet in the process of its orbital motion. The parameter *a* of the gravitational field can be obtained by solving the canonical differential equation of the dynamic gravitational field based on the formed parameter b_c (similar to its obtaining for a flat galaxy [8,9]).

II. PARAMETERS OF THE MOTION OF PLANETS THAT ARE CONSISTENT WITH THE LAWS OF CONSERVATION OF ENERGY AND ANGULAR MOMENTUM

According to Kepler's laws, which are actually based on Newton's theory of gravity, it is not the Hamiltonians and the Lagrangians that are conserved (due to $v_{lc}^2=v_l^2+v^2=\mathbf{const}(t,r)$) in the process of planetary motion, but the Newtonians of inert free rest energy:

$$\mathrm{N}=E_0v_{lc}/c=m_{00}cv_{lc}=m_{00}c\sqrt{v_l^2+v^2}\approx$$

$$\approx m_{00}c^2\sqrt{1-r_g/(r_1+r_2)}=\mathbf{const}(t,r)$$

and the Keplerians of ordinary rest energy:

$$\mathrm{K}=W_0c/v_{lc}=m_{00}c^3/v_{lc}=m_{00}c^3/\sqrt{v_l^2+v^2}\approx$$

$$\approx m_{00}c^2/\sqrt{1-r_g/(r_1+r_2)}=\mathbf{const}(t,r)$$

of the planetary matter [8-12]. Here r_1 and r_2 are the radii of the planet's orbit at aphelion and perihelion, respectively, and r_g is the orbital gravitational radius of the planet.

Apparently, the gravitational field is formed by converging spiral waves of space-time modulation

of the dielectric and magnetic permeability of the physical vacuum, which (with the de Broglie frequency) support (ensure) the continuous existence of the Solar System [2,3,8-15]. And therefore, it is not the Sun that forms orbital gravitational fields, but they themselves are formed in the process of forming and maintaining the existence of the Solar System.

The values of the velocities v of orbital motion of independent objects of the Solar System at aphelions and perihelions are determined by the initial conditions of their inclusion inside the Solar System, or even by the conditions of their formation directly inside the Solar System.

Based on the mutual equality of the values of all parameters at aphelion and perihelion of the planet (precisely values of the both Newtonians, values of the both Keplerians, and the values of the both Newtonian angular momenta ($m_{in}v_2r_2 = m_{in}v_1r_1$; $v_2r_2 = v_1r_1$ due to: $\rho_1 = r_1$, $\rho_2 = r_2$, $m_{in} = \mathbf{const}(r,t)$):

$$b_c = v_{lc}^2c^{-2} \approx (1 - r_g / r_2) + v_1^2r_1^2r_2^{-2}c^{-2} =$$

$$= (1 - r_g / r_2) + v_2^2c^{-2} \approx (1 - r_g / r_1) + v_1^2c^{-2}),$$

we can find the orbital gravitational radii of the planets of the Solar System:

$$r_g \approx v_1^2c^{-2}r_1(1 + r_1 / r_2) = v_2^2c^{-2}r_2(1 + r_2 / r_1).$$

Gravitational pseudo-forces are clearly compensated in the adaptive-dynamic gravitational field of the Solar System by centrifugal pseudo-forces of inertia [8,9]:

$$\mathbf{F}_{gr} = m_{0gr}\hat{g} = -\frac{m_{0in}c^2}{2}\frac{d\ln b}{d\rho} = -\frac{m_{0in}c^2}{2b} \times$$

$$\times \frac{d(b_c - v^2c^{-2})}{d\rho} = -\frac{m_{0in}c^2}{2b}\frac{d(b_c - v_1^2c^{-2}\rho_1^2\rho^{-2})}{d\rho} =$$

$$= -\frac{m_{0in}v_1^2\rho_1^2}{b\rho^3} = -\frac{m_{0in}v^2}{b\rho} = -\mathbf{F}_{in},$$

where: $r = \frac{2r_0\rho^2}{r_1r_2 + \rho^2} = \frac{(r_1 + r_2)\rho^2}{r_1r_2 + \rho^2}$;

$\hat{g} = -L^2m_{in}^{-2}\rho^{-3} = -v_1^2\rho_1^2\rho^{-3} = -c^2r_g(2r_0 / r - 1)^{3/2} / 2r_0\sqrt{r_1r_2}$;

$b = 1 - r_g / r = 1 - r_g/(r_1 + r_2) - r_1r_2r_g/(r_1 + r_2)\rho^2$;

$L = m_{in}v\rho = m_{in}\omega\rho^2 = \mathbf{const}(r,t)$ is angular momentum; $\rho^2 = r_1r_2r/(r_1 + r_2 - r)$ is the square of the radius of curvature of the planet's orbit ($\rho_1 = r_1$, $\rho_2 = r_2$, $\rho_0 = \sqrt{r_1r_2}$, $r_0 = a_o = (r_1 + r_2)/2$) corresponds to the maximum value of the planet's angular pseudo-momentum $m_{in}vr$, which is equal to the angular momentum of the planet in the case of its circular rotation ($v^2r^2 - v_0^2r_0^2 = -c^2r_g(r - r_0)^2 / 2r_0 \le 0$; $v_0^2r_0^2 = c^2r_g(r_1 + r_2)/4 > c^2r_gr_1r_2/(r_1 + r_2) = v_1^2r_1^2$; $\rho_{cir} \equiv r$).

And thus, it is precisely the law of conservation of angular momentum that determines the radii ρ of curvature of the orbit.

And thus, not only in perihelion and aphelion, but even in the hypothetical circular motion of astronomical bodies, the centrifugal pseudo-forces of inertia compensate for the gravitational pseudo-forces, which are inversely proportional not to the square, but to the cube of the distance ρ to the instantaneous orbital center of gravity. And this, of course, is a paradox of the gravitational field. After all, it acts differently on bodies that fall freely and on bodies that move in orbits in this field.

This points to the four-dimensional nature of the space of planetary orbits, which is analogous to the pseudo-Euclidean four-dimensional space-time of special relativity (SR) and arises from the compensation of gravitational time dilation by the inertial orbital motion of celestial bodies.

At the same time, since:

$$b_c = \frac{v_{lc}^2}{c^2} = b + \frac{v^2}{c^2} = 1 - \frac{r_g}{r} + \frac{v^2}{c^2} =$$

$$= 1 - \frac{r_1r_2r_g}{2r_0\rho^2} - \frac{r_g}{2r_0} + \frac{v^2}{c^2} = 1 - \frac{r_g}{2r_0},$$

according to the adaptive-dynamic gravitational field the squares of the true velocities of the planets:

$$v^2 = \frac{c^2b\rho}{2}\frac{d\ln b}{d\rho} = \frac{c^2\rho}{2}\frac{d(1 - r_1r_2r_g\rho^{-2} / 2r_0)}{d\rho} =$$

$$= \frac{c^2r_1r_2r_g}{2r_0\rho^2} = c^2r_g\left(\frac{1}{r} - \frac{1}{r_1 + r_2}\right)$$

significantly differ from their values in a static gravitational field:

$$v_s^2 = (c^2r\sqrt{ab}/2)d\ln b / d\hat{r} =$$

$$= (c^2/\sqrt{b})(r_{gs}/2r - \Lambda r^2/3) \approx c^2r_{gs}/2r.$$

The centrifugal pseudo-forces of inertia determined by these velocities are directed away from the instantaneous centers of curvature of the trajectory of the planet's motion and, therefore, are orthogonal to this trajectory. Therefore, the gravitational pseudo-forces, which are compensated by the centrifugal pseudo-forces of inertia, are also orthogonal to the trajectory of the planet's motion.

And it is because of this that the rotational lines of pseudo-forces of the adaptive-dynamic gravitational field (in contrast to the static gravitational field) are rotationally curved. And this curvature of theirs is related to the rotation of the Sun about its axis together with its spiral-wave formation in the surrounding "empty" space [13-15]. That is why all the planets revolve around the Sun in exactly the same direction as the Sun rotates about its axis. Therefore, the planets revolve not in circular, but in superharmonic oval orbits precisely because they are dragged by the external spiral-wave formation of the Sun.

Thus, the superharmonic trajectory of the planet, like an ellipse, has two major semiaxes $a_{so} = (r_1 + r_2)/2$ and two minor semiaxes $b_{so} = \sqrt{r_1 r_2}$. But unlike an ellipse, it is asymmetric with respect to the minor axis and has only one focus, which is located within the Sun. In addition, the superharmonic orbit has a multitude of instant local foci (centers of gravity) located in the centers of local curvatures of the orbit. It is to these instantaneous centers of gravity of the rotational adaptive-dynamic gravitational field that gravitational pseudo-forces are directed, the strength of which is inversely proportional to the cube of the distance ρ to the corresponding instantaneous center of rotation of the planet and, consequently, of its angular momentum $L = m_{in} v \rho$. And therefore, after the planet passes perihelion, its instantaneous centers of gravity begin to gradually migrate from the center of the Solar System to the minor axis. And then they gradually return to the center of the Solar System and reach it again at aphelion. And such their continuous migration occurs cyclically.

A superharmonic orbit can be defined by the following equations:

$$\varphi = \psi - \alpha = \int_{r_1(0)}^{r(\varphi)} \frac{p dr}{r\sqrt{r^2 - p^2}},$$

$$\cos\alpha = \cos(\psi - \varphi) = \frac{p}{r} = \sqrt{\frac{r_1 r_2}{r(r_1 + r_2 - r)}},$$

where: $d\varphi = \rho\cos\alpha d\alpha/(r - \rho\cos\alpha)$; $d\psi = (r^2/\rho p)d\varphi =$ $= (r/\rho\cos\alpha)d\varphi = d\varphi + d\alpha = r d\alpha/(r - \rho\cos\alpha)$;

ψ is the angle of inclination, relative to the orbit's major axis, of both the radius ρ of curvature and the normal p to the tangent at the point on the orbit; $\alpha = \psi - \varphi = \arccos(p/r)$ is the angle between the normal p to the tangent and the radius vector r of a point on the orbit; φ is the angle of inclination of the radius vector r to the orbit's major axis; $p^2 = \rho^2 = r_1 r_2 r/(r_1 + r_2 - r)$.

Thus, despite the fact that, in the general case, $\rho \neq p$ leads to $dp = (r/\rho)dr$, in the superharmonic oval the lengths of the radii of curvature are equal to the lengths of the pedal functions at every point ($\rho \equiv p$). This makes the superharmonic oval just as unique a closed curve as a circle.

Therefore, only the following equation corresponds to the stationary orbits of all astronomical bodies:

$$\varphi = \int_{r_1}^{r} \frac{p dr}{r\sqrt{r^2 - p^2}} = \int_{r_1}^{r} \sqrt{\frac{r_1 r_2}{(r_1 - r)(r - r_2)}} dr = \arccos\frac{(r_1 + r_2)r - 2r_1 r_2}{r(r_1 - r_2)}.$$

Hence, we obtain the equation for the superharmonic oval, which is essentially identical to the equation describing the intersection of a conical surface with an inclined plane and is still conventionally referred to as the equation of an elliptic curve, despite the fact that it has only one focus:

$$r = \frac{2r_1 r_2}{r_1 + r_2 - (r_1 - r_2)\cos\varphi} =$$

$$= \frac{d\sin\gamma\cos\gamma}{\cos\gamma - \cos\beta\cos\varphi} = \frac{b_{so}^2}{a_{so}(1 - e\cos\varphi)},$$

where: γ – is angle of the conical surface ($\sin\gamma = b_{so}^2/a_{so}d$), β is angle of inclination of the cutting plane to the axis of the conical surface ($\cos\beta = e\cos\gamma = e\sqrt{1 - b_{so}^4 a_{so}^{-2} d^{-2}}$); $e = (r_1 - r_2)/(r_1 + r_2)$ is orbital eccentricity.

Since the velocities v_1 and v_2 of the orbital motion of the planets at aphelion and perihelion are currently calculated without taking into account the orbital values of the gravitational radius, their calculated values may therefore be insufficiently reliable. And it is not reliably known how quickly the gravitational radius r_g of the Solar System increases radially due to the presence of the mass of the planets in it. Therefore, in the calculations it is advisable to use more reliable values of the radial distances of the planets at perihelion and at aphelion and to calculate not the orbital rotation period T, but a parameter that additionally takes into account the radial growth of the gravitational radius r_g of the Solar System:

$$\varsigma = T\sqrt{r_g} = 2\sqrt{r_g}\int_0^{\pi}\frac{d\psi}{\omega} = \frac{2\sqrt{r_g}}{\omega_1\rho_1^2}\int_0^{\pi}\rho^2(\psi)d\psi =$$

$$= \frac{\kappa}{\sqrt{r_1 r_2}} \int_0^{\pi} r^2(\varphi) d\varphi = -\kappa \int_{r_1}^{r_2} \chi dr = \frac{\pi (r_1 + r_2)^{3/2}}{c},$$

where: $\int_{r_1}^{r} \chi dr = \int_{r_1}^{r} \frac{rdr}{\sqrt{(r_1 - r)(r - r_2)}} = -\frac{\pi (r_1 + r_2)}{4} -$

$$- \sqrt{(r_1 - r)(r - r_2)} - \frac{r_1 + r_2}{2} \arcsin \frac{r_1 + r_2 - 2r}{r_1 - r_2};$$

$\omega = v / \rho = \omega_1 \rho_1^2 \rho^{-2}$ is angular velocity of the planet's orbital motion; $\rho^2 d\psi = \rho p d\psi =$

$$= r^2 d\varphi = -\frac{pdr}{\sqrt{1 - p^2 r^{-2}}} = -\sqrt{\frac{r_1 r_2}{(r_1 - r)(r - r_2)}} rdr;$$

$\kappa = 2\sqrt{r_g r_1 r_2}\, \rho_1^{-2} / \omega_1 = 2\sqrt{r_1 + r_2} / c$; $\rho = p$.

Thus, not only has the correspondence of the derived equation for the superharmonic oval orbits of astronomical bodies with reality been confirmed, but the operation of all three of Kepler's empirical laws has also been mathematically substantiated.

However, this is fundamentally possible only in non-Euclidean space possessing not only gravitational but also rotational curvature. Indeed, in Euclidean space, a superharmonic orbit ($\rho \equiv p$) inevitably degenerates into a circle ($\rho dp = rdr = \rho d\rho$).

Furthermore, for the values of the orbital radii of curvature $\rho = \sqrt{r_1 r_2 r / (r_1 + r_2 - r)} \neq p$ (which correspond to the law of conservation of angular momentum), in Euclidean space we obtain a correspondence of the length of the pedal function also only to a circle:

$$p = \int \sqrt{\frac{r(r_1 + r_2 - r)}{r_1 r_2}} dr = \frac{1}{4\sqrt{r_1 r_2}} \left[(2r - r_1 - r_2) \sqrt{r(r_1 + r_2 - r)} + \right.$$

$$\left. + \frac{(r_1 + r_2)^2}{2} \arcsin \left(\frac{2r - r_1 - r_2}{r_1 + r_2} \right) \right] + \sqrt{r_1 r_2}$$

Indeed, for the sum of the lengths of the pedal functions at aphelion and perihelion, we have:

$p_1 + p_2 = 2\sqrt{r_1 r_2} = r_1 + r_2$ (that is to say $r_2 = r_1$).

And therefore, it was Johann Kepler who, in fact, was the first to predict the possibility that the space of the Universe might be non-Euclidean, although he was not aware of this.

Moreover, thanks to his Third Law, the dependence of the orbital periods of astronomical bodies on the orbital value of the gravitational radius has also been revealed.

This makes it possible to obtain more accurate orbital values of the gravitational radius not only for planets but also for any other astronomical bodies.

Table I shows that the calculated values of the orbital gravitational radii of Solar System planets are almost identical. But these values, although not very significantly, still increase with distance from the center of gravity due to the presence of peripheral matter in the Solar System.

TABLE I. Orbital periods of planets and orbital gravitational radii

Planet	T days	ς 10^{-6} s $km^{1/2}$	r_g km
Mercury	87.97	13.0617	2.95325
Venus	224.70	33.3639	2.95335
Earth	365.26	54.2336	2.95326
Mars	686.67	102.008	2.95625
Jupiter	4331.87	643.626	2.95722
Saturn	10783.1	1601.63	2.95411
Uranus	30688.3	4558.80	2.95613
Neptune	60185.9	8942.63	2.95739
Pluto	90472.4	13454.2	2.96244

And this takes place despite the neglect of the presence of both a slight evolutionary weakening (Λ-reduction) of centrifugal pseudo-forces of inertia, and the influence of planets on each other. And this confirms not only the correspondence of the Newtonians and the Keplerians to these planets, but also the absence of relativistic time dilation in them.

TABLE II. Parameters of the planet.

Planet	r_1 mln. Km	r_2 mln. km	v_1 km/s	v_2 km/s
Mercury	69.817	46.001	38.86	58.98
Venus	108.94	107.48	34.78	35.26
Earth	152.10	147.10	29.29	30.29
Mars	249.23	206.67	21.98	26.51
Jupiter	816.00	740.68	12.45	13.72
Saturn	1507.2	1351.0	9.125	10.18
Uranus	3006.3	2735.0	6.488	7.132
Neptune	4537.0	4460.8	5.389	5.482
Pluto	7375.9	4436.8	3.682	6.121

Thus, according to Kepler's third law, planets (the parameters of which are obtained in the JPL SBDB and calculated according to the JPL Solar System Dynamics) have the following orbital velocities at aphelion and perihelion..

All planets in the Solar System have $1 - b_c >> 1 - b_{\max} = 3(\Lambda r_g^2 / 12)^{1/3} = 1.387 \cdot 10^{-15}$

($r_{\max} = (3r_g / 2\Lambda)^{1/3}$; $\Lambda = 3H_E^2 c^{-2} = 1.35457 \cdot 10^{-52}\ m^{-2}$). This means that they did not enter the Solar System from outside, but formed directly on its outskirts. Moreover, although the planets influence each other, they do not experience any violation of the laws of conservation of energy and angular momentum, nor any non-gravitational influence on the thermodynamic characteristics of their matter. Therefore, their motion (from the very beginning of the formation of Solar System) is formed by de Broglie high-frequency spiral waves (converging towards the center of gravity) of the space-time modulation of the dielectric and magnetic permeability of the physical vacuum [13-15].

III. CONCLUSION

1. The gravitational field is only a manifestation of the spatial inhomogeneity of the thermodynamic state of matter, and therefore, is not an independent form and a special type of matter. The emergence of the spatial inhomogeneity of the thermodynamic state of matter is not due to gravity, but due to the electromagnetic interaction of micro-objects of matter due to the non-conservation of momentum by quanta of electromagnetic radiation in the process of the origin of this inhomogeneity. Therefore, a hypothetical ideal gas is fundamentally unable to form a spatial inhomogeneity of its thermodynamic state, and, thus, is unable to have a gravitational field [2,3]. And therefore, the search for a special gravitational interaction of micro-objects of matter and attempts to combine it with other types of interactions is as naive as the search for "dark energy" and "non-baryonic dark matter" [9].

2. The gravitational field initiates only the desire of matter to achieve a more stable spatially inhomogeneous thermodynamic state of its own. After all, it only stimulates the motion of matter, without changing its thermodynamic state in the process of the motion. And therefore, the gravitational field determines only the velocities of motion and spatial gradients, and not at all the values of the hidden thermodynamic parameters that are different in different substances [2,3,6]. And this may be associated with the spiral-wave nature of both matter and the Universe as a whole [13-15].

3. But the parameters of the motion of any matter itself, and therefore the planets of the Solar System, are not determined by the gravitational field at all. They are determined by the laws of conservation of the thermodynamic state of matter and the stability of the main parameters of its motion. Namely, they are determined by the laws of conservation of the Newtonian of inert free energy and the Keplerian of ordinary rest energy of matter and the Newtonian angular momentum $L = m_{in} v \rho = \mathbf{const}(r,t)$ of matter, respectively. After all, the gravitational field strength $\hat{g} = -L^2 m_{in}^{-2} \rho^{-3} = -g_{00}(2r_0 / r - 1)^{3/2}$ is determined differently everywhere. It can be inversely proportional not only to the square of the radial distance or to the distance itself (as in flat galaxies [8,9]), but also to the cube of a radial distance ρ, which determines the angular momentum conserved in the process of motion. And it is even fractional (3/2), with respect to the radial distance *r* from the center of gravity. In addition, the fact that gravitational forces exhibit not only an inverse-square but also an inverse-cube dependence on radial distance constitutes a paradox of the gravitational field, which indicates the primacy (priority) of conservation laws over a field-based interpretation of the phenomenon of gravity. At the edge of the Solar System, this is what could have led to the anomalous motion of the "Pioneer spacecrafts" [16-18].

4. The gravitational field of the Solar System is not stable. After all, it is forced to adapt to changes in the spatial arrangement of the planets, thereby guaranteeing the flawless operation of the conservation laws. And therefore, as the planets approach the Sun, its strength increases. And thus, it is the motion of the planets that forms the adaptive-dynamic gravitational field they need, which is actually a consequence of not only the spatially inhomogeneous thermodynamic state of the entire gravithermodynamically bound matter of the Solar System, but also the motion of the planets (and not at all the cause of both the spatial inhomogeneity of the thermodynamic state of the matter of the Solar System and the motions of its planets) [2,3].

5. More resistant to external influences is not a circular, but a superharmonic oval orbit, which cyclically expands (until reaching aphelion), and then narrows while maintaining the location of the orbital focus. Even the Moon rotates in a superharmonic oval (pseudo-elliptical) orbit due to the influence on it not only of the Earth's gravitational field, but also of the Sun's gravitational field. And this is due to the significantly smaller angular momentum of bodies

moving in a superharmonic oval, rather than a circular, orbit.

6. The curved field lines of the adaptive-dynamic gravitational field of the Solar System are orthogonal precisely to the superharmonic oval orbits of its planets.

7. Due to the absence of the influence of both the external gravitational field and the motion on the thermodynamic state of matter, along with the conservation (not related to the absorption of solar radiation) of the thermodynamic state of matter, the rate of flow of the planets' proper time is also conserved. And this is due to the conservation of the Newtonian and the Keplerian respectively (instead of the Hamiltonian and the Lagrangian), in the process of their inertial motion in the gravitational field [8-12].

9. The forces of evolutionary self-contraction of matter in the frame of reference of spatial coordinates and time comoving with the expanding Universe, which are determined mainly by the cosmological constant Λ, are negligibly small in the Solar System. The hypothesis regarding the compensation of two pseudo-forces (namely of the gravitational pseudo-force and additionally of the almost equivalent pseudo-force of evolutionary self-contraction of another origin) by the centrifugal pseudo-force of inertia has not found reliable substantiated confirmation [8-12]. Therefore, the gravitational field of the Solar System should actually be considered not just dynamic, but adaptive-dynamic.

CONFLICTS OF INTEREST

The author declares no conflicts of interest regarding the publication of this paper.

FUNDING STATEMENT

The research was carried out without financial support.

[1] Albert Einstein, Physik und Realität, *Journal of The Franklin Institute: Devoted to Science and the Mechanic Arts*, vol. 221, no. 3, pp. 313-347 (1936).

[2] Pavlo Danylchenko, Foundations and consequences of Relativistic Gravithermodynamics, Vinnytsia, Ukraine: *Nova knyga*, 5 (2020).

[3] Pavlo Danylchenko, Foundations of Relativistic Gravithermodynamics. Vinnytsia, Ukraine: *TVORY* (2022).

[4] Pavlo Danylchenko, Relativistic Transformations of Coordinate Increments and Metric Segments of Bodies Moving in a Gravitational Field by Inertia, in Proceed. VI Int. Conference APFS'2025. Lutsk, Ukraine: *Volyn University Press "Vezha"*, 26 (2025).

[5] Christian Möller, The Theory of Relativity, Oxford: *Clarendon Press* (1972).

[6] Pavlo Danylchenko, Thermodynamics with Nonspecific Hidden Variables. *Eng OA*, *4*(4), 01-18 (2026).

[7] Richard Tolman, Relativity thermodynamics and cosmology. Oxford: *Clarendon press* (1969).

[8] Pavlo Danylchenko, Solutions of the Standard Differential Equation of the Dynamic Gravitational Field of a Flat Galaxy, *Crystal Journal of Physics*, 1, Iss. 1, 1-16 (2025).

[9] Pavlo Danylchenko, Ignoring the Compensation of Gravitational Time Dilation by Inertial Motion of Matter and Other Theoretical Misconceptions and Imaginary Entities in Physics, Astronomy, and Cosmology. *Int Nat Sci Int Rese*, *1*(1), 01-46 (2026).

[10] Pavlo Danylchenko, Alternatives to the Hamiltonian and Lagrangian, *Curr Res Traffic Transport Eng*, *4*(1), 01-05 (2026).

[11] Pavlo Danylchenko, On the justification for using a dynamic gravitational field in an expanding Universe, in Proceed. XIII Int. Conference RNAOPM2026. Lutsk, Ukraine: *Volyn University Press "Vezha"*, 128 (2026).

[12] Pavlo Danylchenko, Ordinary synchronization-compensation transformations of coordinate and time increments, in Proceed. XIII Int. Conference RNAOPM2026. Lutsk, Ukraine: *Volyn University Press "Vezha"*, 131 (2026).

[13] Pavlo Danylchenko, The spiral-wave nature of elementary particles. Proceedings of International scientific conference "D.D. Ivanenko – outstanding physicist-theorist, pedagogue", ed. Rudenko O.P., Poltava, Ukraine: *PDPU*, 44 (2004).

[14] Pavlo Danylchenko, Spiralwave model of the Universe, in Proceedings of all-Ukrainian seminar on theoretical and mathematical physics: in honour of 85th anniversary of Anatoly Swidzynski. Lutsk, Ukraine: *Volyn Univer*sity *Press "Vezha",* 21 (2014)

[15] Pavlo Danylchenko, About possibilities of physical unrealizability of cosmological and gravitational singularities in General relativity and Relativistic Gravithermodynamics. *Curr Res Traffic Transport Eng*, *4*(1), 01-23 (2026).
[16] John D. Anderson, Philip A. Laing, Eunice L. Lau, Anthony S. Liu, Michael Martin Nieto, Slava G. Turyshev, Study of the anomalous acceleration of Pioneer 10 and 11. *Physical Review D*. Vol. 65, no. 8, 4322–4329 (2002).
[17] Carl Johan Masreliez, A cosmological explanation to the Pioneer anomaly, *Ap&SS*, 299, no. 1, 83-108 (2005).
[18] Robert A. Jacobson, The orbits of the Neptunian satellites and the orientation of the Neptune. *The Astronomical Journal*, **137**, N. **5,** 4322 (2009).