Illusions and Reality of Space Objects Caused by Measurement Standards Variability

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Abstract: Proposed approach is based on the idea of variability of measurement standards. This approach permits us to predict some features of the Universe: spontaneous growth of distance between two resting objects detected by an observer at one of these objects, velocity/distance dependence is known to meet the Hubble Law, constancy of any solid body linear dimensions in time and equality of absolute values of gravitational braking and of illusive acceleration of galaxies is believed to be caused by linear measurement standard shortening some 6-8 billion years ago, as well as by mass loss by physical objects. The latter permits us to propose simulators, describing gravity and inertia as different manifestations of reaction forces.

Keywords: Gravitational braking, linear measurement standard shortening, planet shrinking, reaction forces.

I. INTRODUCTION

This paper develops further a concept presented in [1], [2], [3] i.e. ideas based on the linear measurement standards, which are shortening with time. Meter is one of the most popular linear measurement standards, its length is strongly connected with the size of the Earth: designating distance between the North Pole and Equator by the surface of the Earth on the Paris longitude as "*d*", one meter is determined as $10^{-7} \cdot d$. Thus we imply, that diameter of the Earth is shortening with time as well, giving rise to the illusion of galaxies scattering. Below we also show that shortening of the Moon's diameter [4] discovered in August 2010 with the use of the images obtained by the Lunar Reconnaissance Orbiter Camera has similar trait to those of the Mercury. Mass loss resulting this shrinking is used bellow for developing of simulators, describing gravity and inertia as different manifestations of reaction forces.

II. SYMBOLS, ASSUMPTIONS AND DEFINITIONS

Below the following symbols and definitions are used:

t – running time;
T – Universe lifetime;
r – linear measurement standard used;
R_i – true distance between an observer and i-th object;
L_i - distance to be fixed between an observer and i-th object as a ratio of R_i to the linear measurement standard (*r*):

$$L_i = R_i / r\ ; \quad (1)$$

H – Hubble constant [5]:

$$1.618 \cdot 10^{-18} \leq H \leq 3.2 \cdot 10^{-18} (\text{sec.}^{-1})\ ; \quad (2)$$

Below we also use H value meeting (2):

$$H \approx 1/T\ (\text{sec.}^{-1}), \quad (3)$$

γ – gravitational constant;
ρ – average density of the Universe matter;
$\mathfrak{R}$ - radius of visible Universe;
M - mass of matter in the Universe :

$$M = \frac{4}{3}\pi\rho\mathfrak{R}^3; \quad (4)$$

I – a set of space objects indices, for which the Hubble Law is true.

Further we suppose that for each distance measurement process is used linear measurement standard value corresponding to the measurement time. This condition is not important in the case of small distances measurement – in this case it is fulfilled automatically, but for astronomical distances, when information transfer time is comparable with the Universe lifetime, its role is known to grow.

III. GENERAL CONCEPT

Keeping in mind that *r* value is variable, detected by an observer velocity of interval value L_i change due to (1) is equal to:

$$\forall i : r\frac{dL_i}{dt} = \frac{dR_i}{dt} - \frac{R_i}{r} \cdot \frac{dr}{dt}. \quad (5)$$

As for the space objects meeting the Hubble Law detected by an observer velocities are exceeding peculiar velocities of corresponding objects:

$$\forall i \in I: r \cdot \frac{dL_i}{dt} >> \frac{dR_i}{dt}, \qquad (6)$$

system (5) can be transformed as follows:

$$\forall i \in I: r\frac{dL_i}{dt} \approx -\frac{R_i}{r} \cdot \frac{dr}{dt}. \qquad (7)$$

Combining (1), (7) and Hubble Law, we get the system:

$$\begin{cases} \forall i \in I: \dfrac{dL_i}{dt} \approx HL_i; \\ \forall i \in I: r\dfrac{dL_i}{dt} \approx -\dfrac{R_i}{r}\dfrac{dr}{dt}; \\ \forall i: L_i = \dfrac{R_i}{r}, \end{cases} \qquad (8)$$

with the following solution:

$$\begin{cases} r = r_0 \cdot \exp\{-Ht\}; & (9) \\ \forall i \in I: L_i = L_{0,i} \exp\{Ht\}, & (10) \end{cases}$$

where:

$$L_{0,i} = \frac{R_i}{r_0},$$

$L_{0,i}$ - linear measurement standard r value if t=0.

Equation (9) results in the following features of solid bodies:

- as shortest distance between any two points of a solid body can be used as a linear measurement standard, linear dimensions of any solid body are the exponentially decreasing functions of time meeting (9);
- as linear measurement standards are changing according to the same laws, as the measured objects, observers do not detect these changes directly.

IV. HUBBLE CONSTANT VALUES FOR SHRINKING PLANETS

Below equation (10) is used for the values of Hubble constant determination for three shrinking planets: for the Moon, for the Mercury and for the Earth.

A. The Moon

Shortening of the Moon's diameter D during the Δt period equal to about 0.8 billion years [4] permits us to determine the value of the Hubble constant for the Moon H_L using (9):

$$H_L = \frac{\ln D_0 - \ln D}{\Delta t}, \qquad (11)$$

where D_0 is equal to the Moon's diameter 0.8 billion years ago.

Keeping in mind that during this period D shortening is equal to 110 – 182 m., H_L value being contained in the range $1.255 \cdot 10^{-21}$ - $2.076 \cdot 10^{-21}$ (sec.$^{-1}$).

B. The Earth

Vyacheslav Orlenok, professor of geology at the Kant Russian State University in Kaliningrad, comparing relief structures 4.5 billion years ago, when Earth's surface had just started to solidify, to those of today, found that its average radius was equal to R = 6,956 km, and has since reduced by value ΔR = 585 km.[6]. This permits us to determine the value of the Hubble constant for the Earth similar to (11) keeping in mind that "t" value is equal to 4.5 billion years:

$$H_E = \frac{\ln \dfrac{R}{R - \Delta R}}{t} \approx 3.48 \cdot 10^{-18} (\sec^{-1}). \quad (12)$$

Comparison of H_E with (2) diapason shows that H and H_E values are close.

C. The Mercury

Mariner 10 images allowed us to suggest that the Mercury's radius, which is roughly 2400 km., has shrunk by one to two kilometers since its formation more than four billion years ago. Using the same logic as above, we can determine H_M value of the Hubble constant for Mercury:

$$H_M = 3.25 \cdot 10^{-21} (\text{sec.}^{-1}). \qquad (13)$$

Now, keeping in mind H_L, H_M and H_E values it is possible to determine in the first approximation dependence of the Hubble constant either on planet's diameter D (km.) or on planet's mass m (kg.):

$$H(D) \approx 5.26 \cdot 10^{-19} - 2.59 \cdot 10^{-22} D + 3.13 \cdot 10^{-26} D^2,$$
$$H(m) \approx 2.9 \cdot 10^{-21} - 1.63 \cdot 10^{-44} m + 6.7 \cdot 10^{-64} m^2. \qquad (14)$$

V. LOSS OF MASS AND ITS' AFTEREFFECTS

As the weight measurement standard – kilogram can be determined as the weight of a cubic decimeter of water, thus depending on linear measurement standard value, it is possible to detect a corresponding loss of mass by any solid body proportional to its value each small time unit. With regard to the models to be studied below we assume the following assumptions being valid: mass density in a material point B, is inseparably connected to its mass emission towards the points nearest to B, in which density is lower with the emission intensity towards φ direction depending on t time of this point occurrence and the difference of density at B point and in the near proximity to it in φ direction.

For a shrinking planet with mass m, radius R and with average density ρ true is**:**

$$\begin{cases} m = \dfrac{4}{3}\pi R^3 \rho = \dfrac{4}{3}\pi R_0^3 \rho \cdot \exp(-3Ht) = m_0 \cdot \exp(-3Ht); \\ \dfrac{dm}{dt} = -3Hm. \end{cases} \tag{15}$$

If the space adjacent to A planet is isotropic, i.e. A does not experience any external effects, then the F forces resultant of F_s reaction being the consequence of mass emission from each unit of A planet S surface is determined by $F = \oint F_S ds.$

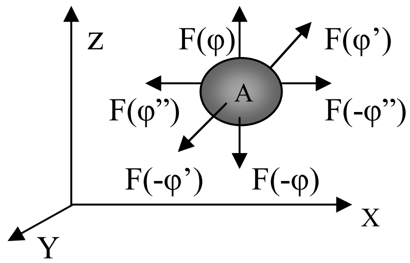

Fig.1. Reaction forces in isotropic medium.

A. First Newton Law

«Spanning» planet A into a point A it is easy to see that for any reaction force vector of F(φ) corresponding to φ direction in relation to A there is a similar force in value and in opposite in direction F(-φ) = - F(φ), i.e. resultant of reaction forces F = 0 (Fig. 1). In other words reaction forces in the isotropic medium are unable to change the state of A material point if there are no external effects. This is found to correspond to the First Newton Law.

B. Reaction Forces and the Law of Gravity

Let two losing mass bodies A and B to be located at R distance from each, the interaction being manifested by mass flow from one body which reaches the layer closest to the surface of the cocoon formed by emitted mass by another body (Fig. 2), this flow is added to the cocoon energy formed by emitted mass of this body.

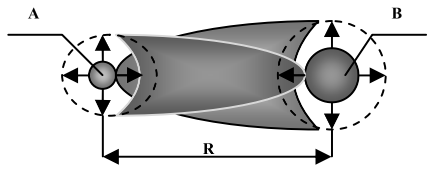

Fig. 2. Remote interaction of A and B bodies

Thereby reactive force F_A of A body depends on two factors: on loss of mass per a time unit by A body y_1 and on reaching this body flow y_2 of mass emitted by B body. Keeping in mind (15) F_A value in the first approximation looks as follows:

$$F_A = f_0 + f_1 y_1 + f_2 y_2 + f_3 y_1 y_2, \tag{16}$$

where:

$$\begin{cases} y_1 = \dfrac{dm_A}{dt} = -3H_A m_A; \\ y_2 = \dfrac{1}{4\pi R^2} \cdot \dfrac{dm_B}{dt} = -\dfrac{3H_B m_B}{4\pi R^2}; \\ \forall \mathrm{i} : \mathrm{f_i} - \text{unknown function.} \end{cases} \tag{17}$$

As equality to zero of mass of any of these bodies results in equality to zero of reactive force F_A, it is easy to show that $f_0 = f_1 = f_2 = 0$, thus transforming (16) polynomial into the following equation:

$$F_A = \mathrm{f}_3 \frac{9H_A H_B}{4\pi} \cdot \frac{m_A m_B}{R^2}. \tag{18}$$

Comparison of (18) with the law of gravity reflects their coincidence if function f_3 is determined as follows:

$$f_3 = \frac{4\pi\gamma}{9H_A H_B}, \tag{19}$$

where for H_A and H_B determination can be used (14). It is obvious that reaction forces F_A and F_B have coinciding values and opposite directions. Moreover, system (18) - (19) coincidence with the law of gravity permits us to interpret gravitation as reaction forces caused by the physical objects mass loss.

C. Second Newton Law

Let A mass emitting body correspond to a certain material point A, moving with a_A constant acceleration during a time interval (t). Keeping in mind the first equation of system (15), F_A acceleration force is equal to:

$$F_A = a_A m_{A,0} \exp(-3H_A t). \qquad (20)$$

Denoting the $a_A m_{A,0}$ product by $F_{A,0}$ variable, equation (20) which characterises a force affecting *a* acceleration to A body can be changed to:

$$F_A = F_{A,0} \exp(-3H_A t). \qquad (21)$$

It means that the force imposing a constant acceleration on A body is not constant. Nevertheless it is not possible to find directly the inconstancy of this force by comparing two such forces affecting mass emitting A and B bodies, one of them being force measurement standard, which have coinciding Hubble constants $(H_A = H_B = H)$, due to their ratio being constant:

$$\frac{F_A}{F_B} = \frac{F_{A,0}\exp(-3Ht)}{F_{B,0}\exp(-3Ht)} = \frac{F_{A,0}}{F_{B,0}}. \qquad (22)$$

Thus for an internal observer in the K coordinate system with physical bodies for which an external observer is fixing that their Hubble constants have similar values, the second Newton's law is valid: a body moving with a uniform acceleration in the K coordinate system during a certain time period (t) is under the impact of a constant force (F).

D. Third Newton Law

To analyse the inertia we shall substitute A material body by a sphere B with m_B mass and R radius (Fig. 3). It is then easy to see that the geometry of distribution of mass emitting sphere both within the shell and outside it coincides with its distribution within an emitted mass cocoon formed by A body with the same mass, with the exception of points belonging to the sphere surface and sphere's centre.

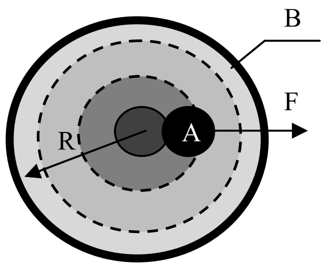

Fig. 3. Reaction force initiation under accelerated motion.

Denoting density of emitted mass distribution at distance R_i, $(\forall i \geq 1, R_i < R)$ from the centre of the sphere as $\theta(R_i)$ we can show that:

$$\begin{cases} \forall 0 < R_i \neq R, \ \theta(R_i) = \dfrac{H_B m_B}{4\pi R_i^2}; \\ \theta(0) = H_B m_B. \end{cases} \qquad (23)$$

It allows us to formally detach the emitted mass cocoon surrounding motionless material point (A) from the particle proper, substituting the cocoon's layers (which are concentric hollow spheres) by the distribution of mass emitted by B sphere, the distribution being determined by system (23) provided that $m_A = m_B$, $H_A = H_B$ (Fig. 3). The accelerated motion of A material point during a short time interval (*t*) results in the cocoon's shift relative to A in the direction opposite to that of the acceleration, which in turn results in anisotropy of the space around A and according to (23) leads to reduction of mass concentration density dispersed in front of A body in the direction of movement and a similar growth of mass dispersed in the space abandoned by this body (Fig. 3). The latter distorts the reaction forces equilibrium, their resultant now differs from zero and according to the above assumption above the anisotropy leads to a higher intensity of A material point mass emission towards the acceleration direction and reduction of that acting in the opposite direction. Assuming *t* time during which F force imposes *a* acceleration to A particle and sphere radius (R) being $\frac{at^2}{2} < R$ the *F* value according to [8] will be described by:

$$F = a\left(m_A + \gamma \frac{m_A m_B}{Rc^2}\right), \qquad (24)$$

where "γ" is the gravitational constant and "c" is the velocity of light.

Considering that the masses of B sphere and A physical body are equal we can express (24) as:

$$F = am_A\left(1 + \gamma \frac{m_A}{Rc^2}\right). \qquad (25)$$

Then the value of *I* impulse equals to:

$$I = atm_A\left(1 + \gamma \frac{m_A}{Rc^2}\right). \qquad (26)$$

Let us define by m_e the non-balanced mass emitted with V_e velocity by A physical body in a time unit (*t*) during this body motion. We shall further assume m_e to be a polynomial function of the mass and of its acceleration expressed as:

$$m_e = \sum_{i\geq 0}\sum_{j\geq 0} k_{i,j} m_A^i a^j, \qquad (27)$$

i.e. in the first approximation if t→0, we can transform (27) as

$$m_e = k_{0,0} + k_{1,0}m_A + k_{0,1}a + k_{1,1}am_A, \quad (28)$$

where each coefficient $k_{i,j}$ (i=1,0; j=1,0) value does not depend on the acceleration and mass of A body.

We further analyse three combinations of these variables values:

1. $m_A = 0$, $a \neq 0$. Obviously in this case m_e=0, from which it follows $k_{0,0} + k_{0,1}a = 0$.

2. $m_A \neq 0$, $a = 0$. Obviously in this case m_e=0, from which it follows $k_{0,0} + k_{1,0}m = 0$.

3. It follows from $m_A = a = 0$ that $m_e = 0$ and we further obtain $k_{0,0} = 0$.

System:

$$\begin{cases} k_{0,0} + k_{0,1}a = 0; \\ k_{0,0} + k_{1,0}m = 0; \\ k_{0,0} = 0, \end{cases} \qquad (29)$$

is compatible only if equalities $k_{0,0} = k_{1,0} = k_{0,1} = 0$ are valid. This corresponds to the change of (28) by:

$$m_e = k_{1,1}am_A. \qquad (30)$$

For value k_{11} determination we shall determine the change of linear momentum (Q) caused by mass m_e emission during *t* time with a speed of V_e:

$$Q = k_{1,1}am_A tV_e. \qquad (31)$$

We can determine the value of $k_{1,1}$ coefficient by equating second members of equality (26) and

$$k_{1,1} = \frac{1}{V_e}\left(1 + \gamma\frac{m_A}{Rc^2}\right). \qquad (32)$$

Now we shall determine R value with which the developed model is adequate. Since the first time derivative of A body linear momentum is equal to F force under impact of which this body is moving with a constant acceleration (a) in a time interval (t) and reaches v velocity, value of F can be presented as:

$$F = am_{0,A}\frac{1+\dfrac{v^2}{C^2}}{\left[1-\dfrac{v^2}{C^2}\right]^{\frac{3}{2}}}. \qquad (33)$$

Equating second members of equations (25) and (33), we can determine R value:

$$R = \frac{\gamma m_A}{c^2}\left[\frac{1+\dfrac{v^2}{c^2}}{\left(1-\dfrac{v^2}{c^2}\right)^{\frac{3}{2}}} - 1\right]^{-1}. \qquad (34)$$

By substituting the second member of (34) in (32), we get:

$$\lim_{t\to 0} k_{1,1} = \frac{1}{V_e}. \qquad (35)$$

Now by substituting the second member of (34) in (31), and of (35) – in (26), it is easy to see that within the framework of the developed model for short time intervals the values of *I* and *Q* coincide, while the acceleration and reaction forces are equal and are acting in opposite directions, which corresponds to the third Newton's Law.

VI. RESULTING ILLUSIONS

Illusion of constancy in time of any solid body linear dimensions is not the only product of (9) - (10) system. Below are presented examples of resulting system (9) – (10) illusions in measurement of distances, velocities and acceleration in astronomy.

A. Distance

Analyzing fixed L_0 distance between two resting in coordinate system O_1 space objects when one or both of them have shortening linear measurement standard values meeting (9), an observer at the one of shrinking objects using shortening linear measurement standard r of "his" object, will detect growing with time distance value $L = \frac{R_0}{r}$, coinciding with (10). In other words, if there is no external influence upon each of two resting in coordinate system O_1 space objects, one of them being shrinking, an observer at the latter, using coordinate system O_2 of "his" object, and its shortening linear measurement standard, will discover spontaneous growth of distance between these objects meeting (10).

B. Velocity

Substituting the equation of (9) in (6), and denoting the velocity of real distance value *R* change as *V*, while denoting fixed by an observer velocity $r\frac{dL}{dt}$ as V_0, we can determine *V* value as follows:

$$V = V_0 - HR. \tag{36}$$

The dependence of the galaxies velocities values V_0 on R corresponds to the Hubble Law [4], whereas dependence V on R is corresponding to the peculiar velocities (Fig. 4).

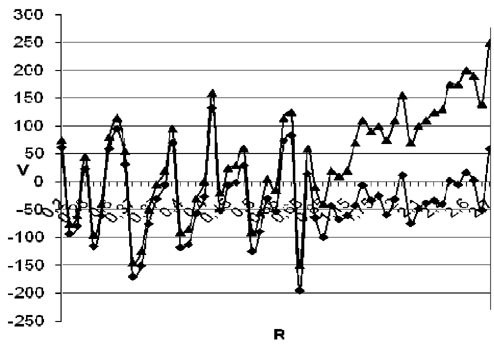

Fig. 4. Diagram of velocity/distance illustrates velocities values V_0 (triangles) and V (rhombuses) (R < 3 Mpc.).

Growth of R distance reflects growing difference between V and V_0 values . Diagrams, presented at Fig. 5, are corresponding to the case, when the Hubble constant is determined according to (3) .

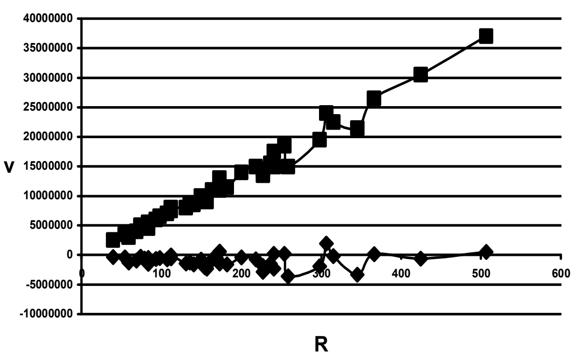

Fig. 5. Diagram of velocity/distance illustrating velocities values V_0 (squares) and V (rhombuses) for distances 50<R < 500 (Mpc.).

Thus the Hubble Law can be explained by shortening of the Earth linear measurement standard values, resulting in comparatively stable Universe.

C. Acceleration

We shall further analyze two components of accelerated movement of galaxies at the edge of visible Universe: component "g" of acceleration vector, caused by the gravitational braking, and opposite directed component "*a*" being resultant of linear measurement standard shortening:

$$\begin{cases} a = -H^2\Re; \\ g = \frac{3}{4}\pi\gamma\Re\rho, \end{cases} \tag{37}$$

Keeping in mind (3) the total acceleration value (α) can be determined as follows:

$$\alpha = \Re(\frac{1}{T^2} - \frac{4}{3}\pi\gamma\rho)\ . \tag{38}$$

As about 6 – 8 billion years ago α had value equal to zero, true is the following equality:

$$\frac{4}{3}\pi\gamma\rho(T_1) = \frac{1}{T_1^2}\ , \tag{39}$$

where T_1 is equal to the Universe lifetime 6 – 8 billion years ago ($T_1 \approx 6 \div 7$ billion years). Designating nowadays lifetime of the Universe as T_2 and taking into account that:

$$\begin{cases} \rho(T_2) = \frac{3}{8\pi\gamma T_2}; \\ T_2 \approx 2T_1, \end{cases} \tag{40}$$

it's easy to show that $\rho(T_1) \approx 8\rho(T_2)$. (41)

Now it's possible to show that according to system (39) – (41) absolute values of the gravitational braking "g" and of illusive acceleration "*a*" caused by the Earth linear measurement standards shortening, coincided 6 – 8 billion years ago.

D. Constancy of weight

Measured with help of a physical body consisting of n_2 tiny spheres - weight measurement standard "μ", weight "m" of another body, consisting of n_1 tiny spheres, does not depend on time - due to (15) true is the ratio:

$$M = \frac{m}{\mu} = \frac{n_1 \frac{4}{3}\pi R_1^3 \rho_1 \cdot \exp(-3Ht)}{n_2 \frac{4}{3}\pi R_2^3 \rho_2 \cdot \exp(-3Ht)} = \frac{m_0}{\mu_0} = const., \quad (42)$$

where:

R_1 - radius of a tiny sphere belonging to a measured physical body;

ρ_1 - density of each tiny sphere belonging to a measured physical body;

R_2 - radius of each tiny sphere belonging to the physical body - weight measurement standard;

ρ_2 - density of each tiny sphere belonging to the physical body - weight measurement standard;

$$m_0 = n_1 \frac{4}{3}\pi R_1^3 \rho_1;$$

$$\mu_0 = n_2 \frac{4}{3}\pi R_2^3 \rho_2.$$

VII. CONCLUSIONS AND QUESTIONS

The above presented approach allows us to formulate a few questions and to make the following conclusions:

1. Solid bodies on the Earth are spontaneously shrinking: shortest distance between any two points of such a body is spontaneously shortening according to equation (9).
2. In the case of absence of any external influence upon each of two resting bodies, one of them being shrinking, an observer at the latter will discover spontaneous growth of distance between these bodies as in (10).
3. Hubble Law can be explained by shortening of the Earth diameter D_E , thus ignoring the idea of dark energy distribution in the Universe [7].
4. Taking into account only the velocities of galaxies, it is possible to say that the Universe is more stable than it was earlier assumed.
5. Constancy of mass of shrinking physical objects is resultant of similar processes of mass loss in these objects and in mass measurement standard used.
6. Gravity and inertia can be explained by reaction forces caused by physical bodies' spontaneous mass loss.

And finally four questions:

a) Is it possible to expand the above findings, such as equation (14) to other space objects?
b) Is it possible to detect mass loss directly, if measured object and mass measurement standard used are from the planets with different Hubble constants?
c) Is loss of mass always accompanied by shrinking of a planet?
d) What features of a solid body except presented above (real and illusive) can follow such a loss of mass?
e) What are the carriers of the lost mass?

References:

[1] Groppen V.O. Optimization in physical modeling. *Proceedings of the IV-th International Conference on Adaptive Modeling and Simulation*, Bruxelles, Belgium 25 – 27 May 2009, p.p. 105 – 108.

[2] Groppen V.O. Kinematics in space with variable linear measurement standards. *Proceedings of the International Conference "Mathematics and Astronomy: a Joint Long Journey",* Madrid, Span 23-27 November 2009, pp. 149 – 155.

[3] Groppen V.O. Measurement of distances by variable linear measurement standards in astronomy. *Proceedings of the XI International Conference "IT-technologies: development and applications",* Vladikavkaz, Russia, 10-11 of December 2010, pp. 19-29 *(rus).*

[4] Thomas R. Watters, Mark S. Robinson, Ross A. Beyer, Maria E. Banks, James F. Bell, III, Matthew E. Pritchard, Harald Hiesinger, Carolyn H. van der Bogert, Peter C. Thomas, Elizabeth P. Turtle, Nathan R. Williams**.** Evidence of Recent Thrust Faulting on the Moon Revealed by the Lunar Reconnaissance Orbiter Camera. *Science* 20, August 2010: Vol. 329. no. 5994, pp. 936 – 940.

[5] Michael S. Turner, Antony Tyson. Cosmology at the Millennium. *Rev. Mod. Phys.* 71, 1999, pp. 145 – 164.

[6] V.V. Orlenok. Reduction of the Radius and Heat Losses within the Earth and Other Planets in Light of Recent Data. *Reports of the Russian Academy of Sciences*, vol. 427, # 1, 2009, pp. 106-111.

[7] L.A. Martinez-Vaquero, G. Yepes, Y Hoffman and G. Gottlober. Near Field Cosmological Simulations: Is Dark Energy Playing a Role in Our Local Neighborhood? *Proceedings of the International Conference "Mathematics and Astronomy: a Joint Long Journey",* Madrid, Spain 23-27 November 2009, pp. 166 – 174.

[8] A. Einstein. Gibt es eine Gravitationswirkung, die der elektrodynamischen Induktionswirkung analog ist? *Vierteljahrschr., Med.,* 1912, Ser. 3, 44, s. 37 – 40.

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