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Matter in the Hubble Vacuum

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ABSTRACT

This paper presents a new approach to the expansion of the Metagalaxy, based on the interaction of all matter with the mass of the Hubble vacuum. The calculations are based on a formula that explains the mechanism of gravity using a net force arising in 5-dimensional space. The calculations utilize quantities obtained by the author in his individual research related to the theory of 3-dimensional time. The moment when the newly formed matter and antimatter began to interact with the Hubble vacuum is briefly described.

Further calculations using this formula allowed us to determine the key parameters of the Hubble vacuum within which the Metagalaxy began to expand.

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Introduction

This article examines a seemingly unusual topic. It concerns the interaction of matter with the vacuum that surrounds it. It would seem difficult to interact with a void that contains nothing. Since, according to the definition of classical materialists, matter is an objective reality independent of consciousness and perceived by humans through their senses, a vacuum environment is not matter by this definition.

But science still uses this concept. Cosmology views the Einstein-Gliner vacuum as a medium with negative pressure. Quantum physics considers the vacuum a medium that generates virtual particles. The Casimir effect serves as evidence of their existence. Etherodynamics seeks to fill the vacuum with a special continuous substance, based on which, using the equations of hydrodynamics, one can examine vortex formations comparable in properties to elementary particles, as well as analyze the already known formulas of electromagnetism.

In short, a vacuum in science is a “workhorse” that is exploited in explaining various kinds of phenomena.

The author also uses the concept of vacuum, but through his own approach to this medium. In his opinion, there can be many vacuums. Their main property is the constant density inherent in each vacuum, and the associated cosmological constant.

The presence of this constant indicates the appearance of angular velocity in the vacuum and the associated helical motion. The inclination angle of the constant radius of curvature of the helical line is determined by the square of the sine of this angle, related to a constant corresponding to some field. These are fundamental concepts for every vacuum.

This article will examine the interaction of the mass of all baryonic matter in the Universe with the mass of the Hubble vacuum in which it resides. By the Hubble vacuum we mean a 2-dimensional sphere with a gravitational radius $ct_H = c/H$ expressed in terms of the Hubble constant H. Vacuum mass is distributed over the surface of a sphere. Unlike the gravitational radius $r_g = 2MG/c^2$ used in black hole theory, the Hubble vacuum gravitational radius uses the formula:

$$ct_H = \frac{M_H G}{c^2} \qquad (1)$$

Where M_H - Hubble vacuum mass; G - Newton's constant of gravitation; c - speed of light.

The scenario of the specified interaction is related to the beginning of the simultaneous formation of baryonic and antibaryonic matter, the masses of which are equal to each other. The masses formed in a chronal tunnel with a radius equal to twice the classical radius of an electron $2r_e$. They can be represented as material points that arose spatially at a distance r_e from one another.

The force of interaction between them became equal

$$F = \frac{M_{б} \cdot M_{а.б} G}{r_e^2} \qquad (2a)$$

The antibaryon mass immediately goes into the time direction s_0, in the form of a gravitational radius, and the formula takes the form:

$$F = \frac{M_б c^2 \cdot \dfrac{M_{а.б} G}{c^2}}{r_e^2} = \frac{M_б c^2}{\dfrac{r_e^2}{P_{а.б}}} = \frac{M_б c^2}{s_0} \qquad (2b)$$

Where $P_{а.б} = M_{а.б} G / c^2$ gravitational radius from antibaryon mass;

$s_0 = r_e^2 / P_{а.б}$ - initial proper transition time.

After the transition, the baryon mass immediately began to interact with the Hubble vacuum mass filling the chronal tunnel and included in the square of the speed of light:

$$c^2 = \frac{M_H G}{ct_H}$$

Substituting c^2 into the force formula, we obtain:

$$F = \frac{M_б c^2}{\dfrac{r_e^2}{P_{а.б}}} = \frac{M_б}{\dfrac{r_e^2}{P_{а.б}}} \frac{M_H G}{ct_H} = \frac{M_б \cdot M_H G}{\dfrac{ct_H}{P_{а.б}} r_e^2} = \frac{M_б \cdot M_H G}{l_0^2} \qquad (2c)$$

Where $l_0^2 = \dfrac{ct_H}{P_{а.б}} r_e^2 = ct_H s_0$ is the square of the spatial distance between masses.

To find the size l_0, one must know the lengths of the gravitational radii. These radii were obtained by the author based on previous studies [2], [3] and are equal to

$$ct_H = \frac{c}{H} = \frac{3P\alpha_{GU}}{4\sqrt{\pi}} = P\alpha_H \alpha_{GU} = 1,272776861 \cdot 10^{28}\, cm$$

$t_H = 4,24552662 \cdot 10^{17}\, сек = 13,4535498 \cdot 10^9\, years$ - Hubble time.

$H = \dfrac{1}{t_H} = \dfrac{1}{4,24552662 \cdot 10^{17}} = 72,64636584 \dfrac{км}{c \cdot Мпк}$ - Hubble constant

$$P_{а.б} = P_б = P\alpha_{GU} / 18$$

Where; $\alpha_{GU} = 1/4\pi^2$ is the grand unification field constant; $\alpha_H = 3/4\sqrt{\pi}$ is the Hubble vacuum field constant; $P = \ell_0 \alpha_e^2 n_e^3$ is the graviton wavelength; $\alpha_e = 1/137,036$ is the fine structure constant; $n_e = m_0 / m_e$ the number of electron masses in the Planck mass. With their help we find the distance between masses.

$l_0 = 2,072964897\, r_e$.

The resulting distance exceeded the tunnel radius $2r_e$ by a small amount.

But it was enough to disrupt the balance of forces stabilizing this tunnel. It began to rapidly expand exponentially at superluminal speeds in the proper time of space ψ. Following this, the Hubble radius also began to expand at the speed of light. As this expansion occurred, energy levels began to emerge in the antigravity 3-dimensional sphere. The mechanism of their formation is discussed in the next section. The expansion of the spatial sphere created by the baryonic mass reached these levels.

Energy levels in the Hubble vacuum

In the author's work [1], a formula was derived that describes gravity in 3-dimensional space using the resulting force arising in a 5-dimensional sphere.

In another work [2], the same force formula was derived using the velocity formula arising in 5-dimensional space.

It has the form:

$$M_H \frac{d^2 l}{dt_б^2} = F_p = \frac{M_б \cdot M_H G}{l^2} = \frac{M_б M_H G}{l^2} \cdot \left(\frac{l_я^3 - l^3}{2\pi l_я^2 l}\right) \qquad (3a)$$

Describes the interaction of the baryon mass with the positive Hubble vacuum mass in 3-dimensional space at the current spatial distance between them equal to l. The second part of the formula describes the same force from the perspective of an observer located in 5-dimensional space.

In the same work, a formula for the force was obtained, which is a complex projection of the first force and has a Hubble mass smaller than in the first:

$$F_{пр} = F_p \sin^2\alpha_{01} = \frac{2}{9}\bar{F}_p \sin^2\alpha_{01} = \frac{2}{9} \cdot \frac{F_0}{c^2} \frac{u^2}{\dfrac{4\pi}{3}} \cdot \frac{l_я \sin^2\alpha_{01}}{P} = \frac{F_0}{c^2}\frac{u^2}{6\pi} \cdot \frac{l_я \sin^2\alpha_{01}}{P}$$

$$= -\frac{M_б M_H \sin^2\alpha_{01} G}{l^2} \cdot \left(\frac{l^3 - l_я^3}{2\pi l_я^2 l}\right) \qquad (3b)$$

Where: $\sin^2\alpha_{01}$ - constant value of the sine associated with the field constant that reduces the value of the Hubble mass found at the first vacuum level.

The division of the gravitational radius into levels is already laid down at the very beginning of the transition of the Hubble mass to the distance, the square of which was obtained in the form of a formula for l_0^2, which should be written as a ratio

$$\frac{l_0^2}{r_e^2} = \frac{ct_H}{P_{а.б}} = \frac{M_H}{M_{а.б}} = \frac{27}{2\sqrt{\pi}} = 7,616559378 = n_H \qquad (4a)$$

Where: n_H - the number of energy levels located within the Hubble gravitational radius.

As we can see, their number is close to seven. This can be viewed as the distance between energy levels with thickness. The thickness δ of one energy level can be determined by the formula:

$$\delta = \frac{7,616559378 - 7}{7} = 0,088079911 \qquad (4b)$$

From (4a) it follows that the antibaryon mass moved from the time coordinate S_0 to the spatial coordinate l_0 and became the cause of the appearance of energy levels.

Let us show that these energy levels are related to the electromagnetic constant. The coupling formula obtained above contains the constant $\alpha_e^{\,2}$. It follows from the representation of the radius $r_e = \ell_0 \alpha_e n_e$. From the formula l_0^2 obtained above it follows^

$$l_0^{\,2} = r_e^{\,2}\frac{M_H}{M_{a.\text{б}}} = \alpha_e^{\,2}(n_e\ell_0)^2\frac{M_H}{M_{a.\text{б}}} = (n_e\ell_0)^2\frac{M_H\alpha_e^{\,2}}{M_{a.\text{б}}} \qquad (4c)$$

Let's transform the formula to the following form:

$$M_{a.\text{б}} = M_H\alpha_e^{\,2}\cdot\frac{(n_e\ell_0)^2}{l_0^{\,2}}$$

Moving on to gravitational radii, we obtain:

$$P_{a.\text{б}} = ct_H\alpha_e^{\,2}\cdot\frac{(n_e\ell_0)^2}{l_0^{\,2}} \qquad (4d)$$

We substitute into the number of levels:

$$n_H = \frac{ct_H}{P_{a.\text{б}}} = \frac{ct_H}{ct_H\alpha_e^{\,2}\cdot\dfrac{(n_e\ell_0)^2}{l_0^{\,2}}} = \frac{l_0^{\,2}}{\alpha_e^{\,2}\cdot(n_e\ell_0)^2}$$

The formula shows the number of levels for the first orbit of the hydrogen atom.

$$n_H\cdot\frac{(n_e\ell_0)^2}{l_0^{\,2}} = \frac{1}{\alpha_e^{\,2}} = \frac{r_e}{r_e\alpha_e^{\,2}} = \frac{r_{1am}}{r_e}$$

Where: $r_{1am} = \dfrac{r_e}{\alpha_e^{\,2}}$ -the radius of the first orbit in a hydrogen atom.

From the obtained dependence follows the connection of the first orbit with all energy levels in the Hubble vacuum.

$$r_{1am} = \frac{r_e}{\alpha_e^{\,2}} = r_e n_H\cdot\frac{(n_e\ell_0)^2}{l_0^{\,2}} = r_e\frac{ct_H}{l_{a.\text{б}}}\cdot\frac{(n_e\ell_0)^2}{l_0^{\,2}}$$

The formula establishes the relationship between an atom and the Hubble vacuum. It also defines the constant $\alpha_e^{\,2}$ in terms of the vacuum's energy levels.

$$\frac{1}{\alpha_e^{\,2}} = \frac{ct_H}{P_{a.\text{б}}}\cdot\frac{(n_e\ell_0)^2}{l_0^{\,2}} \quad \text{или} \quad \frac{l_{a.\text{б}}}{ct_H}\frac{l_0^{\,2}}{(n_e\ell_0)^2} = \alpha_e^{\,2}$$

The formula implies a relationship.

$$\frac{ct_H\alpha_e^{\,2}}{P_{a.\text{б}}} = \frac{l_0^{\,2}}{(n_e\ell_0)^2} = \frac{l_0^{\,2}}{(n_e\ell_0)^2\alpha_e^2}\alpha_e^2 = \frac{l_0^{\,2}}{r_e^2}\alpha_e^2 = n_H\alpha_e^2 \qquad (4e)$$

Thus, we have arrived at a ratio between the first gravitational radius $ct_H\alpha_e^{\,2}$ of the vacuum level and the radius of the antibaryon mass. As we can see, this ratio is much less than unity.

This means that the radius of the antibaryon mass is affected by some field that arose within the vacuum level. We will show that this field is a weak interaction field. The field constant is determined by the formula:

$$\alpha_{\text{сл}} = \frac{\alpha_e^2}{5} = 1{,}065027076\cdot10^{-5}$$

In 5-dimensional space, the weak field increases by 5 times and becomes equal to:

$$\alpha_{5\text{сл}} = 5\alpha_{\text{сл}} = \alpha_e^2 \qquad (4f)$$

Then the resulting relation can be written in the form.

$$\frac{ct_H\alpha_e^{\,2}}{P_{a.\text{б}}} = n_H\alpha_{5\text{сл}}$$

Taking into account the found constant, the square of the sine in the force formula (3b) is equal to

$$\sin^2\alpha_{01} = \alpha_{5\text{сл}} = \alpha_e^2$$

Expansion of the Metagalaxy inside the Hubble vacuum
Based on the discussed theory of energy levels in the Hubble vacuum, we will consider the expansion of the Metagalaxy, which has a variable radius related to the baryonic mass, from the perspective of an observer located in 5-dimensional space. For the calculation, we will use the force formula (3b). We will use the Hubble gravitational radius as the radius of the core. Since the radius of the core is greater than the radius, the gravitational force changes sign and becomes an antigravitational force. The formula for this force takes the form:

$$F_p = \frac{M_{\text{б}}M_H\alpha_e^2 G}{l^3}\cdot\left(\frac{l_{\text{я}}^{\,3}-l^3}{2\pi l_{\text{я}}^{\,2}}\right) = \frac{M_{\text{б}}\cdot M_H\alpha_e^2 G}{l^2} = F_{a.\text{гр.}} \qquad (5a)$$

As we can see, the antigravity force in 5-dimensional space is equal to the antigravity force in 3-dimensional space.

To solve the resulting equation, we write the formula for the gravitational radius of the core through the Hubble vacuum mass $M_H\alpha_e^2$ at the first energy level, taking into account that the

limiting gravitational speed for it will be the speed $v_e = c\alpha_e$.

$$l_{\text{я}} = \frac{M_H\alpha_e^2 G}{v_e^2} = \frac{M_H\alpha_e^2 G}{c^2\alpha_e^2} = \frac{M_H G}{c^2} = ct_H \qquad (5b)$$

Then the resulting equation can be transformed for 5-dimensional space as follows:

$$F_p = \frac{M_{\text{б}}c^2 M_H\alpha_e^2 G}{c^2 l^3}\cdot\left(\frac{l_{\text{я}}^{\,3}-l^3}{2\pi l_{\text{я}}^{\,2}}\right) = \frac{M_{\text{б}}c^2\cdot\alpha_e^2}{\frac{4}{3}\pi l^3}l_{\text{я}}\cdot\frac{4}{3}\pi\cdot\left(\frac{l_{\text{я}}^3-l^3}{2\pi l_{\text{я}}^{\,2}}\right) = \frac{M_{\text{б}}c^2\cdot\alpha_e^2}{\frac{4}{3}\pi l^3}\cdot\frac{4}{3}\pi\cdot\left(\frac{l_{\text{я}}^3-l^3}{2\pi l_{\text{я}}}\right) =$$

$$= \frac{M_{\text{б}}c^2\cdot\alpha_e^2}{\frac{4}{3}\pi l^3}\cdot\left(\frac{1}{\dfrac{2\pi}{\frac{4}{3}\pi(l_{\text{я}}^3-l^3)}\dfrac{M_H\alpha_e^2 G}{v_e^2}}\right) = \frac{M_{\text{б}}c^2\cdot\alpha_e^2}{\frac{4}{3}\pi l^3}\cdot\left(\frac{v_e^2}{2\pi\dfrac{M_H}{\frac{4}{3}\pi l_{\text{я}}^3(1-\frac{l^3}{l_{\text{я}}^3})}\alpha_e^2 G}\right) = \frac{M_{\text{б}}c^2}{\frac{4}{3}\pi l^3}\cdot\left(\frac{v_e^2}{\dfrac{4\pi\rho_V}{2(1-\frac{l^3}{l_{\text{я}}^3})}\cdot\dfrac{G}{c^2}c^2}\right) = \frac{\rho_{\text{б}}c^2 v_e^2}{\frac{\Lambda_V}{2}c^2}\left(1-\frac{l^3}{l_{\text{я}}^3}\right)$$

Where:

$\rho_V c^2 = \dfrac{M_H c^2}{\frac{4}{3}\pi l_{\text{я}}^3}$ - Hubble vacuum energy density in the volume of

the gravitational ball.

$\Lambda_V = \dfrac{4\pi\rho_V G}{c^2}$ - Hubble's cosmological vacuum constant; $\dfrac{M_{\text{б}}c^2}{\frac{4}{3}\pi l^3} = \rho_{\text{б}}c^2$ -

the current energy density of baryonic matter located at the center of a ball of radius l .

From the resulting equation we find находим $\Lambda_V c^2/2$

$$\frac{\Lambda_V c^2}{2} = \frac{\rho_{\text{б}} c^2 v_e^2}{F_p}(1-\frac{l^3}{l_{\text{я}}^3}) \qquad 6(a)$$

Since $l < l_{\text{я}1}$, the constant is positive.

The resulting expression includes the magnitude of the resulting force. This force is balanced by the antigravitational force $F_{a.\text{гр.}}$ in three-dimensional space.

Substituting it into 6(a), we get:

$$\frac{\Lambda_V c^2}{2} = \frac{\rho_{\text{б}} c^2 v_e^2}{F_p}(1-\frac{l^3}{l_{\text{я}}^3}) = \frac{\rho_{\text{б}} c^2 v_e^2}{\frac{M_{\text{б}} \cdot M_H \alpha_e^2 G}{l^2}}\cdot(1-\frac{l^3}{l_{\text{я}}^3}) = \frac{M_{\text{б}} c^2 v_e^2}{\frac{4}{3}\pi l^3 \frac{M_{\text{б}} \cdot M_H \alpha_e^2 G}{l^2}}\cdot(1-\frac{l^3}{l_{\text{я}}^3})$$

$$= \frac{v_e^2}{\frac{4}{3}\pi l \frac{M_H \alpha_e^2 G}{c^2}}\cdot(1-\frac{l^3}{l_{\text{я}}^3}) = \frac{v_e^2}{\frac{4}{3}\pi l \cdot l_{\text{я}} \alpha_e^2}\cdot(1-\frac{l^3}{l_{\text{я}}^3}) \qquad (6b)$$

The resulting formula connects the cosmological constant with the radius of the space of the expanding Metagalaxy.

We bring the formula to the form:

$$\frac{1}{3}\Lambda_V c^2 = \frac{v_e^2}{2\pi l \cdot l_{\text{я}} \alpha_e^2}\cdot(1-\frac{l^3}{l_{\text{я}}^3}) = \frac{v_e^2 l_{\text{я}1}}{2\pi l \cdot l_{\text{я}}^2 \alpha_e^2}\cdot(1-\frac{l^3}{l_{\text{я}}^3}) \qquad (6c)$$

Let's transform the left side to the square of the angular velocity:

$$\frac{1}{3}\Lambda_V c^2 = \frac{1}{3}\cdot\frac{4\pi\rho_V G}{c^2}c^2 = \frac{4\pi}{3}\cdot\frac{M_H G}{\frac{4}{3}\pi l_{\text{я}}^3 c^2}c^2 = \frac{l_{\text{я}}}{l_{\text{я}}^3}c^2 = \frac{c^2}{l_{\text{я}}^2} = \Omega_V^2 \qquad (6d)$$

Where: $\Omega_V = \frac{c}{l_{\text{я}}} = \frac{c}{\frac{M_H G}{c^2}} = \frac{c}{ct_H} = \frac{1}{t_H} = H$ is the angular velocity

of rotation of the Hubble vacuum, equal to the Hubble constant.

The spatial boundary of the vacuum is limited by the radius of the helical cylinder, which has a size of $R_{\text{ц}} = \phi \cdot ct_H$ Then the equation for the equality of accelerations in the helical line takes the form:

$$\Omega_V^2(\phi ct_H) = \frac{c^2}{(ct_H)^2}\phi ct_H = \frac{c^2}{\frac{(ct_H)^2}{\phi ct_H}} = \frac{c^2}{\frac{ct_H}{\phi}} = \frac{c^2}{\rho_{\text{кр}}} \qquad (6f)$$

Where: $\rho_{\text{кр}} = \frac{ct_H}{\phi}$ is the radius of curvature of the helical line;

c - absolute speed of motion along a helical line;

$\phi = 9/128\pi^2\alpha_e = 0{,}976264433$ - constant ϕ -field.

The square of the sine of the angle of inclination of the radius of curvature is equal to the square of the constant of the ϕ - field.

$$\sin^2\gamma = R_{\text{ц}} / \rho_{\text{кр}} = \phi \cdot ct_H / (ct_H/\phi) = \phi^2$$

Thus, the expansion of the Metagalaxy occurs inside a helical line directed along the axis of its own time duration.

Taking into account the found formula for angular velocity, we transform (6c) to the form:

$$\frac{1}{3}\Lambda_V c^2 = \Omega_V^2 = \frac{v_e^2}{2\pi \cdot l\alpha_e^2 l_{\text{я}}}\cdot(1-\frac{l^3}{l_{\text{я}1}^3}) = \frac{c^2\alpha_e^2 l_{\text{я}}}{2\pi l\alpha_e^2 \cdot l_{\text{я}}^2}\cdot(1-\frac{l^3}{l_{\text{я}}^3}) = \frac{c^2}{l_{\text{я}}^2}\frac{\alpha_e^2 l_{\text{я}}}{2\pi\cdot(\alpha_e^2 l)}\cdot(1-\frac{\alpha_e^6 l^3}{\alpha_e^6 l_{\text{я}}^3}) = \Omega_V^2\frac{\bar{l}_{\text{я}1}}{2\pi\bar{l}_1}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3})$$

Where: $\alpha_e^2 l_{\text{я}} = \alpha_e^2 ct_H = \bar{l}_{\text{я}1}$ gravitational radius of the first energy level:

$\alpha_e^2 l = \bar{l}_1$ - variable radius of 3-dimensional space.

From the obtained formula we move on to the equation of equality of accelerations

$$\Omega_V^2\bar{l}_1 = \Omega_V^2\frac{\bar{l}_{\text{я}1}}{2\pi_1}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) = \bar{\Omega}_{V1}^2\bar{l}_{\text{я}1}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) = \bar{\Omega}_{V1}^2\cdot(\bar{l}_{\text{я}1} - \bar{l}_{\text{я}1}\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) \qquad (7a)$$

Where: $\bar{\Omega}_{V1}^2 = \frac{\Omega_V^2}{2\pi}$ - the value of the square of the angular velocity

for the first vacuum energy level.

If we do not introduce a new angular velocity, we obtain the right-hand side in the form:

$$\Omega_V^2\frac{\bar{l}_{\text{я}1}}{2\pi}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) = \frac{c^2}{l_{\text{я}}^2}\frac{l_{\text{я}}\alpha_e^2}{2\pi}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) = \frac{c^2}{l_{\text{я}}}\frac{\alpha_e^2}{2\pi}\cdot(\frac{\bar{l}_{\text{я}1}^3 - \bar{l}^3}{\bar{l}_{\text{я}1}^3}) = \frac{c^2}{l_{\text{я}}\alpha_e^2}\frac{\alpha_e^4}{2\pi}\cdot(\frac{\bar{l}_{\text{я}1}^3 - \bar{l}^3}{\bar{l}_{\text{я}1}^3}) =$$

$$= \frac{c^2\alpha_e^4}{\bar{l}_{\text{я}1}}\frac{1}{2\pi}\cdot(\frac{\bar{l}_{\text{я}1}^3 - \bar{l}^3}{\bar{l}_{\text{я}1}^3}) = c^2\alpha_e^4\frac{1}{2\pi}\cdot\frac{\frac{4}{3}\pi}{\frac{4}{3}\pi}(\frac{\bar{l}_{\text{я}1}^3 - \bar{l}^3}{\bar{l}_{\text{я}1}^4}) = c^2\alpha_e^4\cdot(\frac{\frac{4}{3}\pi\bar{l}_{\text{я}1}^3 - \frac{4}{3}\pi\bar{l}^3}{\frac{8}{3}\pi^2\bar{l}_{\text{я}1}^4}) \qquad (7b)$$

Where: $\frac{4}{3}\pi\bar{l}_{\text{я}1}^3 = V_{1V}$- ball vacuum volume for the first vacuum level:

$\frac{4}{3}\pi\bar{l}^3 = V_{3\text{гр}}$- spherical volume of the expanding Metagalaxy to

the first energy level.

$\frac{8}{3}\pi^2\bar{l}_{\text{я}1}^4 = S_{5\text{сф}}$- surface of a 5-dimensional sphere with the

radius of the first vacuum level.

Thus, the formula for the equality of accelerations describes a single process of expansion of the Metagalaxy's radius in a 5-dimensional sphere. To move from this formula to accelerations arising in 3-dimensional space, it is necessary to equate (7a) to the second derivative, taken with a minus sign for the forward flow of time:

$$\Omega_V^2\bar{l}_1 = \Omega_V^2\frac{\bar{l}_{\text{я}1}}{2\pi}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) = -\frac{vdv}{d\bar{l}_1} \qquad (8a)$$

With this approach, we have a system of two differential equations:

$$\Omega_V^2\frac{\bar{l}_{\text{я}1}}{2\pi}\cdot(1-\frac{\bar{l}_1^3}{\bar{l}_{\text{я}1}^3}) = -\frac{vdv}{d\bar{l}_1} \quad (8b) \qquad \text{and} \qquad \Omega_V^2\bar{l}_1 = -\frac{vdv}{d\bar{l}_1} \quad (8c)$$

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Let us reduce them to specific energies by finding in each of them half the square of the velocity.

We solve equation (8b) by separating the variables:

$$-vdv = \Omega_V^2 \frac{\overline{l}_{я1}}{2\pi}\cdot(1-\frac{\overline{l}_1^3}{\overline{l}_{я1}^3})d\overline{l}_1 = \frac{c^2}{l_я{}^2}\frac{\overline{l}_{я1}}{2\pi}\cdot(1-\frac{\overline{l}_1^3}{\overline{l}_{я1}^3})d\overline{l} = \frac{c^2}{l_я{}^2}\frac{\alpha_e^2 l_я}{2\pi}\cdot(1-\frac{\overline{l}_1^3}{\overline{l}_{я1}^3})d\overline{l}$$

$$= \frac{v_e^2}{2\pi l_я}\cdot(1-\frac{\overline{l}_1^3}{\overline{l}_{я1}^3})d\overline{l}_1$$

We integrate under the initial conditions: $v(0)=v_0$ and $l(0)=l_0$:

$$-\int_{v_0}^{v} vdv = \frac{v_e^2}{2\pi\cdot l_я}\cdot(\int_{l_0}^{\overline{l}_1} d\overline{l}_1 - \int_{l_0}^{\overline{l}_1}\frac{\overline{l}_1^3}{\overline{l}_{я1}^3}d\overline{l}_1)$$

We get:

$$\frac{v^2}{2}-\frac{v_0^2}{2} = -\frac{v_e^2}{2\pi\cdot l_я}[(\overline{l}_1-l_0)-(\frac{\overline{l}_1^4}{4\overline{l}_{я1}^3}-\frac{l_0^4}{4\overline{l}_{я1}^3})] = \frac{v_e^2}{2\pi\cdot l_я}[(\frac{\overline{l}_1^4}{4\overline{l}_{я1}^3}-\frac{l_0^4}{4\overline{l}_{я1}^3})-(\overline{l}_1-l_0)] \quad (9a)$$

We assume that the initial conditions in both parts cancel each other out. As a result, we obtain two equations. The first is related to the initial velocity and has the form:

$$\frac{v_0^2}{2} = \frac{v_e^2}{2\pi l_я}(\frac{l_0^4}{4\overline{l}_{я1}^3}-l_0) = \frac{v_e^2\alpha^2}{2\pi l_я\alpha^2}(\frac{l_0^4}{4\overline{l}_{я1}^3}-l_0) = \frac{v_e^2\alpha^2}{2\pi\overline{l}_{я1}}(\frac{l_0^4}{4\overline{l}_{я1}^3}-l_0) = \frac{v_e^2\alpha^2}{2\pi}(\frac{l_0^4}{4\overline{l}_{я1}^4}-\frac{l_0}{\overline{l}_{я1}}) \quad (9b)$$

The second equation describes the square of the velocity in general

$$\frac{v^2}{2} = \frac{v_e^2\alpha^2}{2\pi}\cdot(\frac{\overline{l}_1^4}{4\overline{l}_{я1}^4}-\frac{\overline{l}_1}{\overline{l}_{я1}}) \quad (9c)$$

From equation (9b) with a known value of velocity, the value is found, which is the initial value for the second differential equation (8c) with $l(0)=l_0$.and $v(0)=0$.

We integrate equation (8c):

$$\int_0^v vdv = -\Omega_V^2\int_{l_0}^{\overline{l}_1}\overline{l}_1 d\overline{l}_1$$

We get:

$$\frac{v^2}{2} = \frac{\Omega_V^2}{2}(l_0^2-\overline{l}_1^2) = \frac{c^2}{2l_я^2}(l_0^2-\overline{l}_1^2) = \frac{c^2\alpha_e^4}{2l_{я1}^2\alpha_e^4}(l_0^2-\overline{l}_1^2) = \frac{v_e{}^2\alpha_e^2}{2}(\frac{l_0^2-\overline{l}_1^2}{\overline{l}_{я1}^2}) \quad (10)$$

The squares of the velocities (9c) and (10) found are specific energies equal to each other.

Equating them, we obtain the equation for the equality of specific energies:

$$\frac{v^2}{2} = \frac{v_e^2\alpha^2}{2\pi}\cdot(\frac{\overline{l}_1^4}{4\overline{l}_{я1}^4}-\frac{\overline{l}_1}{\overline{l}_{я1}}) = \frac{v_e{}^2\alpha_e^2}{2}(\frac{l_0^2-\overline{l}_1^2}{\overline{l}_{я1}^2}) \quad (11a)$$

Let's transform it into an equation to the 4th degree:

$$0 = (\frac{\overline{l}_1^4}{4\overline{l}_{я1}^4}-\frac{\overline{l}_1}{\overline{l}_{я1}}) - \pi(\frac{l_0^2}{\overline{l}_{я1}^2}-\frac{\overline{l}_1^2}{\overline{l}_{я1}^2}) = \frac{\overline{l}_1^4}{4\overline{l}_{я1}^4}-\frac{\overline{l}_1}{\overline{l}_{я1}}-\pi\frac{l_0^2}{\overline{l}_{я1}^2}+\pi\frac{\overline{l}_1^2}{\overline{l}_{я1}^2} \quad (11b)$$

We introduce the designation: $x = \frac{\overline{l}_1}{\overline{l}_{я1}} = \frac{\alpha_e^2 l}{\alpha_e^2 l_я} = \frac{l}{l_я} = \frac{l}{ct_H}$.

Then we obtain an equation in the form:

$$0 = \frac{\overline{l}_1^4}{4l_{я1}^4}-\frac{\overline{l}_1}{l_{я1}}+\pi\frac{\overline{l}_1^2}{l_{я1}^2}-\pi(\frac{l_0^2}{l_{я1}^2}) = \frac{x^4}{4}-x-\pi x_0^2+\pi x^2 \quad (11c)$$

We express it through x :

$$0 = x^4+4\pi x^2-4x-4\pi x_0^2 \quad (11d)$$

As we can see, the solution of the equation depends on the initial condition $x_0 = \frac{l_0}{l_{я1}} = \frac{l_0}{ct_H}$. To find it, we solve equation (9b), composed of the initial conditions. We take the initial velocity $v_0 = 0$

$$\frac{v_0^2}{2} = 0 = \frac{c^2}{2\pi}(\frac{l_0}{l_{я1}}-\frac{l_0^4}{4l_{я1}^4}) \text{ или } 0 = (\frac{l_0}{l_{я1}}-\frac{l_0^4}{4l_{я1}^4}) \quad (12a)$$

We introduce the designation: $\frac{l_0}{l_{я1}} = x_0$. We obtain an equation of the 4th degree:

$$0 = \frac{l_0}{l_{я1}}-\frac{l_0^4}{4l_{я1}^4} = x_0-\frac{x_0^4}{4} = \frac{4x_0-x_0^4}{4} \quad (12b)$$

We express it through x_0

$$x_0^4-4x_0 = 0 \quad (12c)$$

The graphical solution of the equation gives two roots:

$$x_{01} = 0 = \frac{l_{01}}{l_{я1}} \quad \text{and} \quad x_{02} = 1{,}5874 = \frac{l_{02}}{l_{я1}}$$

For the initial value, we select the first root x_{01}= 0 and substitute it into equation (11d):

$$0 = x^4+4\pi x^2-4x-4\pi x_0^2 = x^4+4\pi x^2-4x \quad (13a)$$

The graphical solution gives two roots:

$$x_{01} = 0 \quad \text{и} \quad x_{02} = 0{,}3158 = \frac{l_{02}}{ct_H}$$

We'll assign the first zero root to the origin of the first vacuum level.

The second root describes the "jump" from the first vacuum radius to the size $l_2 = 0{,}3158ct_H$.

This size is the initial condition for the second "jump". We determine the roots of the equation for x_{02}.

$$0 = x^4+4\pi x^2-4x-4\pi x_0^2 = x^4+4\pi x^2-4x-4\pi(0{,}3158)^2$$

$$x_{03} = -0{,}19432 \qquad x_{04} = 0{,}50538 \quad (13b)$$

The root x_{04} is the initial condition for the third "leap":

$$0 = x^4 + 4\pi x^2 - 4x - 4\pi x_0^2 = x^4 + 4\pi x^2 - 4x - 4\pi(0,50538)^2 \quad (13c)$$

$$x_{05} = -0,3693 \quad x_{06} = 0,67334$$

The root x_{06} is the initial condition for the fourth "leap":

$$0 = x^4 + 4\pi x^2 - 4x - 4\pi x_0^2 = x^4 + 4\pi x^2 - 4x - 4\pi(0,67334)^2 \quad (13d)$$

$$x_{07} = -0,52825 \qquad x_{08} = 0,82401$$

The root x_{08} is the initial condition for the fifth "leap":

$$0 = x^4 + 4\pi x^2 - 4x - 4\pi x_0^2 = x^4 + 4\pi x^2 - 4x - 4\pi(0,82401)^2$$

$$x_{09} = -0,67045 \qquad \frac{l}{ct_H} = x_{10} = 0,95754 \approx \phi^2 = (0,976264433)^2 = 0,953092243$$

In this case, the radius of the Metagalaxy reaches a value $l = \phi^2 ct_H$ that becomes slightly less than the radius of the helical line cylinder (6f), equal to $R_ц = \phi ct_H$.

If the found value x_{10} is substituted into the equation as an initial condition, then the “sixth” jump can be obtained:

$$0 = x^4 + 4\pi x^2 - 4x - 4\pi x_0^2 = x^4 + 4\pi x^2 - 4x - 4\pi(0,95754)^2$$

$$x_{11} = -0,79501 \qquad \frac{l}{ct_H} = x_{12} = 1,07373 \approx \frac{1}{\phi^2} = 1,074725607 \quad (13f)$$

However, this jump already exceeds the value ct_H. This means that the expansion of the Metagalaxy in the Hubble vacuum ceases. Since $l > l_я$, the Metagalaxy absorbs the Hubble vacuum, and gravity arises within it. On the other hand, the expansion of the Metagalaxy does not cease. This can be explained by the fact that its surface is already transitioning to a different type of vacuum, different from the Hubble vacuum. This is the vacuum of dark energy. But that's another story. Proving it is beyond the scope of this article.

In the initial description of the Hubble vacuum model in Section 2, it was established that this vacuum must contain seven energy levels. The presented calculation of vacuum jumps involves precisely seven energy levels. The first energy level corresponds to a radius of $ct_H \alpha_e^2$. The seventh, upper energy level corresponds to a radius of ct_H. Between them, there are six "jumps," meaning there are five more levels, the radius of each of which is determined by the quantities found.

Thus, the above-described model of the expansion of the Universe within the Hubble vacuum is fully confirmed by the presented calculations. The calculation scheme is shown in Fig. 1

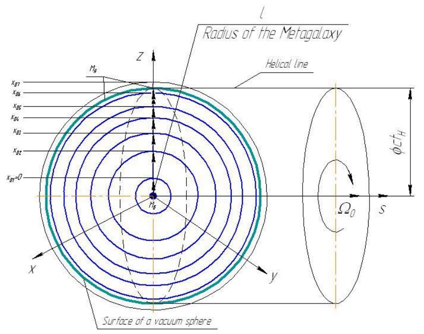

Figure 1: Diagram of the expansion of the Metagalaxy in the Hubble vacuum

Conclusion

In closing, I'd like to add the following. The presented method for calculating the expansion of the Metagalaxy describes only its initial stage. Further investigation of the resulting equations leads to the establishment of a connection between the Hubble vacuum and the hydrogen atoms created during expansion. Furthermore, a calculation related to the dark energy vacuum can be performed. The Metagalaxy transitions into this vacuum after the Hubble vacuum. If this proposed topic is of interest to readers, the author will be happy to write a continuation of the article.

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