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Connection of the Theory of Time with the Friedmann Equation

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ABSTRACT

The proposed work shows a new approach to deriving the Friedmann equation. The approach is based on the fact that the primary medium from which the universe could arise is a time substance consisting of primary tiny particles. This medium is described by a scalar field. The mathematical apparatus used for its study allowed obtaining dual equations, which were interpreted by the author as waves of direct and reverse time directed towards each other. When the waves contacted, an inversion of the reverse wave occurred. It took the direction of the direct wave. As a result of the inversion, dynamic processes arose that led to the appearance of acceleration in 4-dimensional space. Analysis of the formulas for velocity and acceleration led to the derivation of Friedmann equations for a flat universe, obtained by him from Einstein's gravitational equation. Introduction. The concept of a continuous space-time continuum has become firmly established in modern physics. It was introduced by A. Einstein in the special and then General Theory of Relativity (GTR). By tacit agreement, it is generally accepted that the continuum is filled with matter that is in continuous motion, moving at speeds not exceeding the speed of light. Matter has mass, which leads to the curvature of space-time. GTR interprets this curvature as the presence of a gravitational field in the continuum. To describe it, A. Einstein's tensor gravitational equation is used. It is used to analyze curved 4-dimensional space-time. With this approach, the dimension consists of three spatial and one time coordinate. The result is a mathematically complex theory, lacking clarity and poorly understood. In 1922, A.A. Friedman solved the equations of GTR after modifying the second cosmological postulate. This led to a result that meant a change in the size of the Metagalaxy over time, i.e. to its non-stationarity. The solutions obtained formed the basis of the theoretical basis of cosmology. No other approaches to deriving Friedman's equations, except on the basis of GTR, were undertaken. But there is another approach. And the author talks about it in this article. It is based on the theory of time developed by him.

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Time as a Scalar Field

The theory of time is based on the premise that before the universe, which we will call the Metagalaxy, the World existed in the form of primary particles forming a temporary substance. This means that the temporary substance is primary in relation to matter, i.e. it is the cause of its generation. The theoretical approach determining the parameters of primary particles has been developed by the author, but is not presented in this paper. For further description, it is sufficient to consider the temporal substance as an object consisting of a set of points. Each point exists simultaneously in the spatial and temporal parts. The existence of a point in the spatial part will be characterized by its proper spatial time $\hat{t}$, and in the temporal part –by its proper time ψ. Then, for each point in a given region, a certain number can be associated $\hat{t}$. In this case, we say that a scalar field is given in the region, which is a scalar function of a point M, belonging to the temporal substance. Mathematically, a point can be defined using a vector or a set of two temporal coordinates. Let us introduce the definition of a directional derivative. Let a scalar field be given $\hat{t} = \hat{t}(\hat{\tau},\psi)$. Let us choose an arbitrary point in this field and draw a certain straight line through. We will define a straight line in the scalar field by a point and a direction vector θ. The derivative of $\hat{t}$ with respect to direction θ is called the rate of change of the field in this direction, related to the unit length (in this case, duration) [1]:

$$d\hat{t} / d\theta = \lim_{N \to M}\left[\hat{t}(N) - \hat{t}(M)\right] / MN$$

The total differential of a function of two variables is calculated using a formula known from a course in mathematical analysis:

$$d\hat{t}(\hat{\tau},\psi) = \frac{\partial \hat{t}}{\partial \hat{\tau}} d\hat{\tau} + \frac{\partial \hat{t}}{\partial \psi} d\psi \qquad (1)$$

Then the directional differential is:

$$\frac{d\hat{t}(\hat{\tau},\psi)}{d\theta} = \frac{\partial \hat{t}}{\partial \hat{\tau}}\frac{d\hat{\tau}}{d\theta} + \frac{\partial \hat{t}}{\partial \psi}\frac{d\psi}{d\theta}$$

It is convenient to represent the right side as a scalar product of two vectors:

$$\frac{d\hat{t}}{d\theta} = \left\{(\frac{\partial \hat{t}}{\partial \hat{\tau}})i + (\frac{\partial \hat{t}}{\partial \psi})j\right\}\left\{(\frac{d\hat{\tau}}{d\theta})i + (\frac{d\psi}{d\theta})j\right\}$$

The first of these is called the field gradient and is denoted by

$$grad\hat{t} = (\frac{\partial \hat{t}}{\partial \hat{\tau}})i + (\frac{\partial \hat{t}}{\partial \psi})j$$

The second vector is the unit direction vector θ :

$$(\frac{d}{d\theta})\{\hat{\tau}i+\psi j\}=\frac{dn}{d\theta}=\bar{k}$$

Thus, we can write

$$\frac{d\hat{t}}{d\theta}=(grad\hat{t})\cdot(\bar{k})$$

The first factor on the right-hand side, for a given field $\hat{t}$, depends only on the choice of point *M*. The second factor depends only on the direction *θ*. Since the scalar product of any vector by a unit vector is simply the projection of the first vector onto the second, the previous formula can be rewritten as a projection of the gradient in the direction *θ*:

$$\frac{d\hat{t}}{d\theta}=grad_\theta\hat{t}$$

From the analysis of the formula, the question arises: in which direction θ is the projection of the vector $grad_\theta\hat{t}$ the largest? Obviously, any vector when projected onto different directions gives the largest projection equal to its length when projected onto its own direction. Thus, the vector under consideration at the point points in the direction of the fastest increase of the –field. Since we are talking about time, it is logical to assume that the vector points in the direction of the time coordinate of proper time $\hat{\tau}$. Moreover, this fastest speed, related to a unit of length, is equal to $|grad_\theta\hat{t}|$; the faster the field changes, the longer the gradient. The gradient is closely related to the level surfaces of the field, i.e. the surfaces on which it has a constant value $\hat{t}(\hat{\tau},\psi)=const$ At each point *M* the gradient is normal to the level surface passing through *M*.

The idea of time as a scalar field allows us to formulate the following postulate of the theory of time (TT): *the gradient of a scalar field points towards its own time, being a constant value and equal to plus or minus one:*

$$grad_\tau\hat{t}=\frac{d\hat{t}}{d\hat{\tau}}=\pm 1 \qquad (2)$$

Using the introduced postulate, one can imagine the propagation of time in the form of a chrono wave described by the wave equation following from (1):

$$\pm 1=grad_\tau\hat{t}=\frac{d\hat{t}}{d\hat{\tau}}=\frac{\partial\hat{t}}{\partial\hat{\tau}}+\frac{\partial\hat{t}}{\partial\psi}\frac{d\psi}{d\hat{\tau}} \qquad (3)$$

We express the derivatives on the right side through the following functions:

$$\dot{\psi}=\frac{d\psi}{d\hat{\tau}};\ \frac{\partial\hat{t}}{\partial\hat{\tau}}=\frac{\hat{\tau}}{\hat{t}}=\cos\varphi;\ \frac{\partial\hat{t}}{\partial\psi}=\frac{\psi}{\hat{t}}=\sin\varphi \qquad (4)$$

Substituting them into (3) leads to the wave equation of time:

$$\pm\hat{t}=\hat{\tau}+\psi\dot{\psi} \qquad (5)$$

The condition follows from the postulate: $\pm d\hat{\tau}=d\hat{t}$. Making a substitution in the first term and integrating under zero initial conditions, we arrive at the equation:

$$\hat{t}^2=\hat{\tau}^2+\psi^2 \qquad (6)$$

It describes a central circle in scalar field coordinates, with a variable radius equal to time $\hat{t}$.
is the level surface passing through the point of the scalar field. The resulting formula can also be interpreted as the modulus of the radius vector drawn from the origin of the coordinate system to the point *M* of the scalar field. Thus, for time there are two simultaneously fulfilled equations (3) and (6). Equating them, we obtain the dual equation of time:

$$\pm\hat{t}=\sqrt{\hat{\tau}^2+\psi^2}=\hat{\tau}+\psi\dot{\psi} \qquad (7)$$

It is called dual because the left part contains the expression of the radius vector modulus associated with a point of a scalar field. Such a description is typical for the mechanical movement of a point. The right part contains an equation describing the wave properties of a point of a scalar field. The simultaneous manifestation of mechanical and wave properties of a point is called wave-particle dualism in physics. This is where its name comes from. Using the introduced notations (4), it is convenient to write the gradient (3) as

$$grad\hat{t}=\cos\varphi+\dot{\psi}\sin\varphi=\pm 1 \qquad (8)$$

It follows from this that the derivative has two values:
is the tangent of a half angle:

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$$\dot{\psi}_{пр}=\frac{d\psi}{d\hat{\tau}}=tg\frac{\varphi}{2} \qquad (9)$$

is the cotangent of a half angle with a minus sign:

$$\dot{\psi}_{обр}=\frac{d\psi}{d\hat{\tau}}=-ctg\frac{\varphi}{2} \qquad (10)$$

In the future, we will call these derivatives the direct and inverse rates. We will establish the connection between the rates by solving the dual equation (7) together and applying the connection formula (4). As a result, we arrive at a quadratic equation of rates:

$$\dot{\psi}^2+2ctg\varphi\cdot\dot{\psi}-1=0 \qquad (11)$$

Its solutions are two roots:

$$\dot{\psi}_1=-ctg\varphi+\sqrt{ctg^2\varphi+1}=tg\frac{\varphi}{2}=tg\alpha \qquad (12)$$

$$\dot{\psi}_2=-ctg\varphi-\sqrt{ctg^2\varphi+1}=-ctg\frac{\varphi}{2}=-ctg\alpha \qquad (13)$$

As we see, the first root, according to (9), is the direct tempo; the second root, according to (10), is the inverse tempo. The roots of a quadratic equation have two properties:

$$\dot{\psi}_1+\dot{\psi}_2=-2ctg\varphi=-2\frac{\hat{\tau}}{\psi}\ \text{и}\ \dot{\psi}_1\cdot\dot{\psi}_2=-1 \qquad (14)$$

Thus, the connection between the direct and reverse tempo is obvious. This means that the direct and reverse flows of time are mutually connected. After replacing the trigonometric functions with their relations in (4), we obtain for (12) and (13), respectively: the equation of direct time with direct tempo.

$$\hat{t}=\sqrt{\hat{\tau}^2+\psi^2}=\hat{\tau}+\psi\dot{\psi}_{пр} \qquad (15)$$

inverse time equation with inverse tempo

$$\breve{t} = -\hat{t} = \sqrt{\hat{\tau}^2 + \psi^2} = \hat{\tau} + \psi\dot{\psi}_{\text{обр}} \qquad (16)$$

Thus, the presence of a scalar field leads to the conclusion that both direct and reverse time flows exist in it simultaneously. Since they differ only in sign, they should be perceived as flows directed towards each other. What can happen when they meet? One of the options is that the reverse flow inverts when meeting the direct flow, i.e. changes the negative sign to positive. As a result of the difference in flows, a resulting flow arises in which the direct and reverse rates become positive. In the resulting flow with an inverted reverse rate, a non-Euclidean time-like interval arises, coinciding with the interval of the special theory of relativity (STR). To prove this, we take the difference between the wave parts of direct and reverse time:

$$\hat{t} - (-\hat{t}) = 2\hat{t} = (\hat{\tau} + \psi\dot{\psi}_{\text{пр}}) - (\hat{\tau} + \psi\dot{\psi}_{\text{обр}}) = \psi(\dot{\psi}_{\text{пр}} - \dot{\psi}_{\text{обр}}) = \psi(\dot{\psi}_{\text{пр}} - (-\frac{1}{\dot{\psi}_{\text{пр}}})) = \psi(\dot{\psi}_{\text{пр}} + \frac{1}{\dot{\psi}_{\text{пр}}}) = \psi(\frac{\dot{\psi}_{\text{пр}}^2 + 1}{\dot{\psi}_{\text{пр}}})$$

Where

$$\frac{2\hat{t}}{\psi} = \frac{2}{\sin\varphi} = \frac{\dot{\psi}_{\text{пр}}^2 + 1}{\dot{\psi}_{\text{пр}}} = \dot{\psi}_{\text{пр}} + \frac{1}{\dot{\psi}_{\text{пр}}} = \dot{\psi}_{\text{пр}} + \dot{\psi}_{\text{ин}} \qquad (18)$$

where $\dot{\psi}_{\text{ин}} = \frac{1}{\dot{\psi}_{\text{пр}}}$ is the inverted tempo.

The resulting equation is reduced to a square sinusoidal equation of tempos.

$$\dot{\psi}_{\text{пр}}^2 - \frac{2}{\sin\varphi}\dot{\psi}_{\text{пр}} + 1 = 0 \qquad (19)$$

Its roots are:

$$\dot{\psi}_1 = \frac{1}{\sin\varphi} - \sqrt{\frac{1}{\sin^2\varphi} - 1} = \frac{1}{\sin\varphi} - ctg\varphi = tg\frac{\varphi}{2} = tg\alpha \qquad (20)$$

$$\dot{\psi}_2 = \frac{1}{\sin\varphi} + \sqrt{\frac{1}{\sin^2\varphi} - 1} = \frac{1}{\sin\varphi} + ctg\varphi = ctg\frac{\varphi}{2} = ctg\alpha \qquad (21)$$

Here: $\dot{\psi}_1 = \dot{\psi}_{\text{пр}}$ there is a direct tempo; $\dot{\psi}_2 = \dot{\psi}_{\text{ин}}$ there is an inverted tempo.

Expressing trigonometric functions through projection ratios, we arrive at two types of equations:

$$\hat{\tau} = \sqrt{\hat{t}^2 - \psi^2} = \hat{t} - \dot{\psi}_{\text{пр}}\psi \qquad (22)$$

$$\bar{\bar{\tau}} = -\sqrt{\hat{t}^2 - \psi^2} = \hat{t} - \dot{\psi}_{\text{ин}}\psi \qquad (23)$$

As we can see, the left parts of the equations are intervals that easily transform into STR intervals after multiplying them by the speed of light:

$$c\hat{\tau} = \hat{s} = \sqrt{(c\hat{t})^2 - l^2} = c\hat{t} - \dot{\psi}_{\text{пр}} l$$

$$c\bar{\bar{\tau}} = \bar{\bar{s}} = \sqrt{(c\hat{t})^2 - l^2} = c\hat{t} - \dot{\psi}_{\text{ин}} l$$

where $l = c\psi$ is a spatial interval.

As shown in the work [2], all formulas of STR follow from them, but with some amendments.

The aim of our work is to prove that these equations also lead to the Friedman equations. For this we will need the tempo functions in metric form. To find them, we will show the derivation of the sinusoidal equation of the dual equation from the interval formula by differentiating it.

$$\frac{d\hat{s}}{d(c\hat{t})} = 1 = \frac{(c\hat{t}) - l\frac{dl}{d(c\hat{t})}}{\sqrt{(c\hat{t})^2 - l^2}} = \frac{(c\hat{t}) - l\dot{\psi}_{\text{пр}}}{\sqrt{(c\hat{t})^2 - l^2}}$$

where the unit derivative indicates that the speed of light is constant when moving along the axis $\hat{s}$.

We transform to the dual equation:

$$\hat{s} = \sqrt{(c\hat{t})^2 - l^2} = (c\hat{t}) - l\dot{\psi}_{\text{пр}} \qquad (24)$$

To establish the rate function, we integrate the equation with a unit derivative under the initial conditions: $\hat{s}(0) = 0$; $c\hat{t}(0) = ct_0 = l_0$ . . As a result, we obtain a solution in the form:

$$\hat{s} = \sqrt{(c\hat{t})^2 - l^2} = (c\hat{t}) - l_0 \qquad (25)$$

Comparing with the right side of the dual equation, we see that it is satisfied provided that the second term is equal to: $l\dot{\psi}_{\text{пр}} = l_0 = m_{0l}G/c^2$ From this equality follows the direct tempo function:

$$\dot{\psi}_{\text{пр}} = \frac{l_0}{l} \qquad (26)$$

Then the inverted tempo is:

$$\dot{\psi}_{\text{ин}} = \frac{1}{\dot{\psi}_{\text{пр}}} = \frac{l}{l_0} \qquad (27)$$

We will need the found rate functions to derive the Friedman equation.

Derivation of the General Differential Equation of Rates

Let us derive the general differential equation of rates based on the sinusoidal equation (18). Let us write it in the form $d\hat{t}$

$$2\hat{t} = \psi(\dot{\psi}_{\text{пр}} + \dot{\psi}_{\text{инв}})$$

Let's differentiate with respect to:

$$\frac{2d\hat{t}}{d\hat{t}}=\frac{d[\psi(\dot{\psi}_{пр}+\dot{\psi}_{инв})]}{d\hat{t}}=\frac{(\dot{\psi}_{пр}+\dot{\psi}_{инв})d\psi+\psi d(\dot{\psi}_{пр}+\dot{\psi}_{инв})}{d\hat{t}}=\frac{(\dot{\psi}_{пр}+\dot{\psi}_{инв})d\psi}{d\hat{t}}+\frac{\psi d\dot{\psi}_{пр}}{d\hat{t}}+\frac{\psi d\dot{\psi}_{инв}}{d\hat{t}}=$$

$$\frac{(\dot{\psi}_{пр}+\dot{\psi}_{инв})d\psi}{d\hat{t}}+\frac{\psi d\dot{\psi}_{пр}}{d\hat{t}}+\frac{\psi d\dot{\psi}_{инв}}{d\hat{t}}=(\dot{\psi}_{пр}+\dot{\psi}_{инв})\dot{\psi}_{пр}+\psi\ddot{\psi}_{пр}+\psi\ddot{\psi}_{инв}=\dot{\psi}_{пр}^2+\dot{\psi}_{инв}\cdot\dot{\psi}_{пр}+\psi\ddot{\psi}_{пр}+\psi\ddot{\psi}_{инв}$$

Where:

$$2=(\dot{\psi}_{пр}^2+\psi\ddot{\psi}_{пр})+(\dot{\psi}_{инв}\cdot\dot{\psi}_{пр}+\psi\ddot{\psi}_{инв})$$

Since $\dot{\psi}_{инв}\cdot\dot{\psi}_{пр}=1$, the equation can be written as:

$$2=(\dot{\psi}_{пр}^2+\psi\ddot{\psi}_{пр})+1+\psi\ddot{\psi}_{инв}=(\dot{\psi}_{пр}^2+1)+\psi(\ddot{\psi}_{пр}+\ddot{\psi}_{инв})$$

We find the sum of accelerations:

$$\frac{1-\dot{\psi}_{пр}^2}{\psi}=\ddot{\psi}_{инв}+\ddot{\psi}_{пр}$$

As we can see, it is expressed through the parameters of the direct time flow. Let us express the inverted acceleration through the direct tempo and the acceleration from it.

$$\ddot{\psi}_{инв}=\frac{d\dot{\psi}_{инв}}{d\hat{t}}=\frac{d}{d\hat{t}}\left(\frac{1}{\dot{\psi}_{пр}}\right)=\frac{d}{d\hat{t}}(\dot{\psi}_{пр}{}^{-1})=-\dot{\psi}_{пр}{}^{-2}\frac{d\dot{\psi}_{пр}}{d\hat{t}}=-\frac{\ddot{\psi}_{пр}}{\dot{\psi}_{пр}{}^2} \quad (29)$$

Substituting, we get:

$$\frac{1-\dot{\psi}_{пр}^2}{\psi}=\ddot{\psi}_{инв}+\ddot{\psi}_{пр}=-\frac{\ddot{\psi}_{пр}}{\dot{\psi}_{пр}{}^2}+\ddot{\psi}_{пр}=\ddot{\psi}_{пр}\left(-\frac{1}{\dot{\psi}_{пр}{}^2}+1\right)=\ddot{\psi}_{пр}\left(\frac{\dot{\psi}_{пр}{}^2-1}{\dot{\psi}_{пр}{}^2}\right)$$

We find the acceleration from the direct tempo:

$$\ddot{\psi}_{пр}=\frac{1-\dot{\psi}_{пр}^2}{\psi\left(\frac{\dot{\psi}_{пр}{}^2-1}{\dot{\psi}_{пр}{}^2}\right)}=-\frac{\dot{\psi}_{пр}{}^2}{\psi} \quad (30)$$

We bring it to metric form:

$$c\ddot{\psi}_{пр}=-c^2\frac{\dot{\psi}_{пр}{}^2}{c\psi}=-c^2\frac{\dot{\psi}_{пр}{}^2}{l}$$

Let's apply the direct tempo function (26). We get:

$$c\ddot{\psi}_{пр}=-c^2\frac{\dot{\psi}_{пр}{}^2}{l}=-c^2\frac{l_0^2}{l^3}=-c^2\frac{m_{0l}^2G^2}{c^4l^3}=-c^2\frac{m_{0l}^2G}{\frac{c^4}{G}l^3}=-c^2\frac{m_{0l}^2G}{F_0l^3} \quad (31)$$

where $F_0=\frac{c^4}{G}$ there is Planck force.

The resulting acceleration is gravitational, acting in a 4-dimensional space Thus, we have arrived at the Ehrenfest formula [3]. This acceleration formula is the initial formula from which follows the Einstein-Friedmann-Lemaitre equation without a term, obtained by Friedmann by modifying the second cosmological postulate, which can be briefly formulated as follows [4]: The metagalaxy is isotropic. To arrive at the form of acceleration obtained by Friedmann, it is necessary to know the energy density contained in a space with four dimensions. There are two ways to determine the function of change in time of the radius of this space. The first is to jointly solve the sinusoidal equation of rates (25). As a result, we arrive at the function:

$$\hat{s}=\frac{l^2}{2l_0}-\frac{l_0}{2} \quad (32)$$

The second method involves solving the differential equation of direct tempo:

$$\dot{\psi}_{пр}=\frac{dl}{cd\hat{t}}=\frac{dl}{d\hat{s}}=\frac{l_0}{l} \quad (33)$$

under initial conditions: $l(0)=l_0$ and $\hat{s}(0)=0$. As a result, we arrive at the same function. Function (32) can be transformed to the form of radiation time $t_{5и}$.

$$c\hat{t}_{5и}=\hat{s}+\frac{l_0}{2}=\frac{l^2}{2l_0} \quad (34)$$

In it l is the radius of a 5-dimensional sphere. To prove it, we square it and multiply both parts by 8 . As a result, we obtain the surface of a 5-dimensional sphere:

$$\frac{32\pi^2}{3}l_0^2\cdot(c\hat{t}_{5и})^2=\frac{32\pi}{3}\cdot\frac{\pi m_{0l}{}^2G^2}{c^4}(c\hat{t}_{5и})^2=\frac{8\pi^2}{3}l^4=S_5 \quad (35)$$

We transform the resulting formula into the form of energy density contained in a 5-dimensional sphere:

$$\varepsilon_5=\frac{\pi m_{0l}{}^2G}{\frac{8\pi^2}{3}l^4}=\frac{3c^4}{32\pi G(c\hat{t}_{5и})^2}=\frac{3c^2}{32\pi G\hat{t}_{5и}^2} \quad (36)$$

Let us express the radius of the sphere through the obtained energy density. Let us introduce the notation:

$$\kappa=\frac{\pi m_{0l}{}^2G}{\frac{8\pi^2}{3}} \quad (37)$$

Then (36) can be written as:

$$\varepsilon_5=\frac{\pi m_{0l}{}^2G}{\frac{8\pi^2}{3}l^4}=\frac{\kappa}{l^4}=\frac{3c^4}{32\pi G(c\hat{t}_{5и})^2}=\frac{3c^2}{32\pi G\hat{t}_{5и}^2}$$

Find the radius:

$$l=\sqrt[4]{\frac{32\pi G\hat{t}_{5и}^2\kappa}{3c^2}}=\sqrt[4]{\frac{32\pi G\kappa}{3c^2}}\hat{t}_{5и}^{\frac{1}{2}} \quad (38)$$

From the function we determine the function of the velocity in time of radiation. We square (38) and after differentiation and transformation we find the velocity:

$$\dot{l}=\frac{dl}{d\hat{t}_{5и}}=\frac{1}{2l}\sqrt{\frac{32\pi G\kappa}{3c^2}}=\sqrt{\frac{32\pi G\kappa}{3c^2\cdot4l^2}}=\sqrt{\frac{8\pi G\kappa}{3c^2l^2}}$$

We square:

$$\dot{l}^2=\frac{8\pi G\kappa}{3c^2l^2}=\frac{8\pi G\kappa}{3c^2l^4}l^2=\frac{8\pi G}{3c^2}\varepsilon_5l^2 \quad (39)$$

Thus, we arrive at the first Friedmann equation for k = 0, which corresponds to a flat universe [4].

We transform the square of the velocity by replacing

$$\dot{l}^2 = \frac{8\pi G\kappa}{3c^2 l^2} = \frac{8\pi G}{3c^2 l^2}\cdot\frac{\pi m_{0l}^2 G}{\frac{8\pi^2}{3}} = \frac{m_{0l}^2 G^2}{c^2 l^2} = \frac{m_{0l}^2 G^2}{c^4 l^2}c^2 = \frac{l_0^2}{l^2}c^2 \qquad (40)$$

From here we arrive at the formula for speed proportional to direct tempo:

$$\dot{l} = \frac{dl}{d\hat{t}_{5u}} = \frac{l_0}{l}c = \dot{\psi}_{np}c$$

Thus, in the time of radiation in the 5-dimensional sphere, a direct tempo arises. This confirms the thesis that the reverse and direct tempos are interconnected.

Next, we continue to study acceleration. We find it from the square of the obtained velocity (40), by differentiating with respect to the time of radiation:

$$d\dot{l}^2 = 2\dot{l}d\dot{l} = \frac{8\pi G}{3c^2}d(\varepsilon_5 l^2) = \frac{8\pi G}{3c^2}(\varepsilon_5 dl^2 + l^2 d\varepsilon_5)$$

$$= \frac{8\pi G}{3c^2}(2l\varepsilon_5 dl + l^2 d\varepsilon_5)$$

Divide by $d\hat{t}_{5è}$:

$$2\dot{l}\frac{d\dot{l}}{d\hat{t}_{5u}} = \frac{8\pi G}{3c^2}(2l\varepsilon_5\frac{dl}{d\hat{t}_{5u}} + l^2\frac{d\varepsilon_5}{d\hat{t}_{5u}})$$

Where

$$\ddot{l} = \frac{d\dot{l}}{d\hat{t}_{5u}} = \frac{8\pi G}{3c^2}(\frac{2l\varepsilon_{\chi g}}{2\dot{l}}\frac{dl}{d\hat{t}_{5u}} + \frac{l^2}{2\dot{l}}\frac{d\varepsilon_{\chi g}}{d\hat{t}_{5u}}) = \frac{8\pi G}{3c^2}(\frac{2l\varepsilon_5}{2\dot{l}}\cdot\dot{l} + \frac{l^2}{2\dot{l}}\frac{d\varepsilon_5}{d\hat{t}_{5u}})$$

$$= \frac{8\pi G}{3c^2}(l\varepsilon_5 + \frac{l^2}{2\dot{l}}\frac{d\varepsilon_5}{d\hat{t}_{5u}}) = \frac{8\pi Gl}{3c^2}(\varepsilon_5 + \frac{l}{2\dot{l}}\frac{d\varepsilon_5}{d\hat{t}_{5u}}) \qquad (41)$$

Here:

$$\frac{l}{2\dot{l}}\frac{d\varepsilon_5}{d\hat{t}_{5u}} = \frac{l}{2\dot{l}}\frac{d\frac{\kappa}{l^4}}{d\hat{t}_{5u}} = \frac{l\kappa}{2\dot{l}}\frac{dl^{-4}}{d\hat{t}_{5u}} = \frac{-4l\kappa}{2\dot{l}}\frac{l^{-5}dl}{d\hat{t}_{5u}} = \frac{-4l\kappa}{2\dot{l}}l^{-5}\dot{l} =$$

$$-2l\kappa l^{-5} = -2\kappa l^{-4} = -2\frac{\kappa}{l^4} = -2\varepsilon_5$$

Substituting, we get:

$$\ddot{l} = \frac{d\dot{l}}{d\hat{t}_{5u}} = \frac{8\pi Gl}{3c^2}(\varepsilon_{\chi g} + \frac{l}{2\dot{l}}\frac{d\varepsilon_{\chi g}}{d\hat{t}_{5u}}) = \frac{8\pi Gl}{3c^2}(\varepsilon_5 - 2\varepsilon_5) = -\frac{8\pi Gl}{3c^2}\varepsilon_5$$

$$= -\frac{4\pi Gl}{3c^2}2\varepsilon_5 = -\frac{4\pi Gl}{3c^2}(\varepsilon_5 + 3p) \qquad (42)$$

Here:

$$\varepsilon_5 = \frac{\pi m_{0l}^2 G}{\frac{8\pi^2}{3}l^4} = \frac{m_{0l}^2 G}{\frac{4\pi}{3}2l^4} = \frac{3}{4\pi l^2}\frac{m_{0l}^2 G}{2l^2} = 3p;$$

$$\ddot{l} = -\frac{8\pi Gl}{3c^2}\varepsilon_5 = -c^2\frac{l_0^2}{l^3}$$

where $\eth$ is the pressure created by the gravitational force on the cross-section of space Then the acceleration will take the form:

$$\ddot{l} = \frac{d\dot{l}}{d\hat{t}_{5u}} = -\frac{4\pi Gl}{3c^2}(\varepsilon_5 + 3p) = -\frac{4\pi Gl}{3}(\frac{\varepsilon_5}{c^2} + \frac{3p}{c^2}) = -\frac{4\pi Gl}{3}(\rho_5 + \frac{3p}{c^2}) \qquad (43)$$

where

$$\rho_5 = \frac{\varepsilon_5}{c^2} = \frac{\pi m_{0l}^2 G}{\frac{8\pi^2}{3}l^4 c^2} = \frac{m_{0l}}{\frac{8\pi}{3}l^4}\frac{m_{0V}G}{c^2} = \frac{m_{0l}}{\frac{8\pi}{3}l^4}l_0 = \frac{0,5m_{0l}}{\frac{4\pi}{3}l^3}\cdot\frac{l_0}{l} = \frac{0,5m_{0L}}{\frac{4\pi}{3}l^3}\cdot\dot{\psi}_{np}$$

(44)

there is a variable density in the 5-dimensional sphere, proportional to the direct tempo.

The Einstein–Friedmann–Lemaitre equations in general have the form [4]:

$$\ddot{a} = -\frac{4\pi G}{3}a(\varepsilon + 3p)\ ; \quad \dot{a}^2 = \frac{8\pi G}{3}\varepsilon a^2 - k \qquad (45)$$

where $\dot{a}$ is the scale factor; $k = 0, (+1), (-1)$ coefficient taking three values that determine the types of geometry of the Metagalaxy.

k = 0 - flat Metagalaxy; k = 1- closed; k = -1- open.

In the obtained equations (39) and (43) the scale factor is denoted by l. All other designations correspond to the specified equations for k = 0, describing a flat Metagalaxy. The equations were obtained from the Einstein tensor equation without the Λ - term [4], which in the simplest case has the following form:

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = (\frac{8\pi G}{c^4})T_{\mu\nu} \qquad (45)$$

where $g_{\mu\nu}$ is the metric tensor, $R_{\mu\nu}$ is the Ricci tensor, R is the scalar curvature, G is the gravitational constant, $T_{\mu\nu}$ is the energy-momentum tensor.

The dynamics of development in (45) can be described by a model of an ideal fluid with density $\varepsilon(t)$ and pressure $\eth(t)$ under the condition of isotropy and homogeneity of 3-dimensional space. Then the energy-momentum tensor takes the form [4]:

$$T_{\mu\nu} = diag(\varepsilon, -p, -p. -p)$$

and the gravitational equation turns into the Einstein-Friedmann-Lemaitre equations (39) and (43). As we can see, the path to deriving these equations was difficult and thorny. To do this, it was necessary to introduce two basic cosmological postulates that the Metagalaxy is a homogeneous and isotropic medium throughout all stages of its evolution.

It should be noted that the obtained dependences of velocity and acceleration refer to a 5-dimensional sphere, which is a space whose dimension is one unit greater than the dimensions of a 3-dimensional ball. This difference in dimensions determines the different expansion laws of these objects.

The transition from 4-dimensional to 3-dimensional space in modern cosmology is explained by the fact that the pressure in the acceleration formula (43) becomes equal to zero. The reason is supposedly that the scale factor expands to enormous sizes, at which the pressure tends to zero. Allegedly, the remaining density determines the change in the law of gravity in a 3-dimensional ball. But as can be seen from the formulas. energy density and pressure are related to each other by a proportional dependence. A decrease in one of them equally leads to a decrease in the other. Therefore, the given explanation loses its meaning. The author explains the transition using the theory of multidimensional vacuum, which is not considered in this paper [5].

The given derivation of formulas is based on the idea of two chrono waves arising in a scalar field formed by a time substance and moving towards each other. The result of their meeting is an interaction manifested in the inversion of the reverse chrono wave. The dynamic processes occurring in this case cause the appearance of the specified acceleration in the 5-dimensional sphere.

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Conflict of Interest: This work was carried out by the author alone, at the request of the editors of the journal, based on personal scientific works: [6-9]. It uses literary sources from open databases, so permission for their publication is not required.

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