Review Article

The Nature of the Physics of Matter with Negative Mass

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Abstract

The formation of a substance with negative mass (negamatter) at very high temperatures or body speeds above 235696.8871 km/s is theoretically justified. The reason for this is the reversal of the direction of time inside the substance. The law of dependence of body weight on the rate of time passing in the physical body has been derived. Based on the weakness of gravitational forces, the stability of negamatter is justified, under appropriate conditions.

Introduction

Calculations have shown [1-3] that all bodies, upon reaching critical speed [4].

$$\omega = \frac{c}{\sqrt{\Phi}} = c\sqrt{\frac{\sqrt{5}-1}{2}} \approx 235696.8871 \ km/s \qquad (1)$$

Where c = 299792458 km/s – speed of light [5], $\Phi \cong 1,618033989$ – the value of the golden section [6,7], undergo a phase transition, consisting of an inversion of body mass, accompanied by a change in the sign of body mass. The mass changes abruptly from positive values to the same absolute value, but negative values. This gives reason to assume that, directly, at this very speed of movement of the body, mass zeroing occurs. A similar phase transition occurs with substances at corresponding high temperatures, but different for different chemical compositions of the substance [2,3]. The results obtained, although they give an idea of the behavior of particles with a negative mass under various conditions, do not yet

allow us to understand the essence of a negative mass of a substance and its differences from ordinary matter with a positive mass. The purpose of this work is to find an answer to this question.

The very name "negative mass", as well as the name of particles with negative mass "negatons" was given by Ya.P. Terletsky [8,9]. The idea of the mechanism for the transition of matter into a state with a negative mass lies in the assumption of the existence of *chronons*, consisting of two spherical elementary particles - *chrons*, which are responsible for the pace of time in the part of space in which the body is located, depending on the speed of its movement. Pairs of chrons, touching each other, rotate around each other. But to simplify the calculations, we will assume that one of the chrons, called non, rotates, and the other chron is at rest. The concepts of *chronons, chrons,* and *nones* are introduced in this article. The direction of time - the arrow of time depends on the direction of rotation of the non around the chron. The orbital speed of rotation of the noon ω (1) does not depend on the speed of the body within

which the chronon is located. As long as the linear speed of a moving body, and with it the speed of movement of the chron located at that moment at the location of the body, is less than the speed of non ω, the mass of the substance that makes up the moving body remains positive. At the moment when the speed of the body, as well as the speed of the chron, becomes equal to the critical speed ω, the non-stops rotate around the chron. With a further increase in the speed of the body, when the speed of the body and, accordingly, the speed of the chron become greater than ω, the non will begin to rotate in the opposite direction. From this moment on, body weight becomes negative.

Determination of chronnons parameters

It is currently assumed that the minimum length of space is the Planck length l_p, composed of fundamental constants [5]:

$$l_p = \sqrt{\left(hG / 2\pi c^3\right)} = 161605(10) \cdot 10^{(-35)} \, M, \qquad (2)$$

Where $h = 6.6260755 \cdot 10^{-34}$ J·s – Planck's constant;

$G = 6.67259 \cdot 10^{-11} \, M^3 \cdot kg^{-1} s^{-2}$ – gravitational constant. Under this, we will assume that the three-dimensional space of the Universe can be packed with cubic Planck cells with a side length equal to l_p, the cells themselves are filled with chrons, and the mass of a Planck cell will be equal to the Planck mass m_p:

$$m_p = \sqrt{\left(hc / 2\pi G\right)} = 2.17671(14) \cdot 10^{-8} \, kg \qquad (3)$$

The number of chrons in a cell coincides with the number of vertices of a cubic cell and is equal to 8. Accordingly, the mass of chron M_0 will be 8 times less than the Planck mass:

$$M_0 = \frac{m_p}{8} = 2.720889 \cdot 10^{-9} \, kg \qquad (4)$$

The side of a cubic cell of Planck of length l_p is limited by two vertices of the cube, so that a straight line parallel to the side of a cell of Planck of length l_p can pass, within the cell, through 2 chrons. And since a non-rotates near each of them, which at rest can be the size of a chron, then on the side of the cell, there can be up to 4 chrons at some time intervals. Therefore, the diameter of the chron will be 4 times less than l_p and the radius of the chron ι_0, accordingly, will be 8 times less:

$$l_0 = \frac{l_p}{8} = l_0 = 2.04006(32) \cdot 10^{-36} \, m \qquad (5)$$

If the chron is at rest, then the non rotates around it in a circular orbit with the first cosmic speed W, then the radius of the non, ι_w, following the Special Theory of Relativity (STR) is equal to:

$$l_w = l_0 \sqrt{1 - \frac{w^2}{\tilde{n}^2}}, \qquad (6)$$

Assuming that the masses of chron and non are concentrated at their centers, the radius R of non's orbit will be equal to the distance between the centers of chron and non, equal to the sum of the radii of chron and non:

$$R = l_0 + l_0 \sqrt{1 - \frac{w^2}{\tilde{n}^2}} \qquad (7)$$

The time τ_w, during which the non makes a full revolution around the chron is taken to be equal to the minimum Planck time τ_p [5]:

$$\tau_p = l_p / c = \sqrt{\left(hG / 2\pi c^5\right)} = 5.39056(34) \cdot 10^{-44} \, s, \qquad (8)$$

and taking into account STR:

$$\tau_w = \frac{\tau_p}{\sqrt{1 - \frac{w^2}{\tilde{n}^2}}} \qquad (9)$$

Then for the orbital speed of non one can write the equality

$$w = \frac{2\pi R}{\tau_w} \qquad (10)$$

Substituting (7) and (9) into (10) we get:

$$w = \frac{2\pi l_0}{\tau_p} \left(1 - \frac{w^2}{\tilde{n}^2} + \sqrt{1 - \frac{w^2}{\tilde{n}^2}}\right) \qquad (11)$$

Solving this equation, we find

$$w = \omega \cong 235696.8871 \, km / s \qquad (12)$$

The correctness of solution (12) can be easily verified by simply substituting (12) into formula (11). The obtained value of the non's orbital velocity (12) coincides with the value (1) found for the critical velocity of a body at which an inversion of its mass occurs [1–4,7,10]. Substituting (12) into the right side of (11), we find that the expression in parentheses is equal to 1, so the formula for calculating the orbital speed of non (11) is significantly simplified:

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$$w = \omega = \frac{2\pi l_0}{\tau_p} \qquad (13)$$

An important conclusion follows from (13): the critical speed ω is the speed of movement of nones around the chrons in a circular orbit.

From equality (7) we find the radius of the orbit of non

$$R \cong 3.301 \cdot 10^{-36} \, m \qquad (14)$$

Considering that the chron has a spherical shape, let us estimate its density ρ:

$$\rho = M_0 \, / \, \frac{4}{3}\pi l_0^3 \cong 7.654 \cdot 10^{106} \, kg \, / \, m^3 \qquad (15)$$

To calculate the speed of non, another formula can be used, obtained from the equation of Newton's second law for a body taken as a material point moving in an orbit around a planet with a radial density distribution [10]:

$$mg = G\frac{Mm}{R_\text{Ç}^2}, \qquad (16)$$

where m — object mass, g — acceleration of free fall of an object, G = 6,674 30(15)·10^{-11}M^3·kg·s^{-2} = 6.67·10^{-8} $dyne \cdot cm^2 \cdot g^{-2}$ — gravitational constant, M — Earth mass, R — radius of the orbit of a body moving around the Earth. In our case, the role of the planet Earth is played by the chron, and the moving body is played by the non. Therefore, formula (16) (after reduction by m) for the chronon can be written

$$a = G\frac{M_0}{R^2}, \qquad (17)$$

where a – acceleration of free fall non, R – non's orbital radius (5). Из (17) находим

$$a \cong 1.683 \cdot 10^{52} \, m \, / \, s^2 \qquad (18)$$

On the other hand, the first escape velocity $v_{1.Earth}$ for a body rotating around the Earth in a circular orbit equal to the radius of the Earth R_{Earth} is determined by the formula [10,12]:

$$v_{1.Earth} = \sqrt{R_{Earth}^2 g} \qquad (19)$$

For a chronon, this formula allows one to independently calculate the orbital speed of the non

$$v_1 = \omega = \sqrt{aR} \cong 235696.8871 \, km \, / \, s \qquad (20)$$

The emergence of negamatter

From the thermodynamic hypotheses of V.A. Atsyukovsky [13] and S.A. Nikolaev [14] it follows that with each oscillation of the wave, the photon emits a subquantum in the direction of its movement, which is either absorbed by the environment [13] or decays to form ether particles, named in the monograph by S.A. Nikolaev – photonics [14]. The frequency of light decreases accordingly. In the proposed version of the theory of photon involution, the photon does not decay, but the expansion of the space of the Universe takes place, as a result of which the wavelength of the photon increases, and because the speed of light during this expansion remains the same, the frequency of the photon decreases accordingly. This process continues until the photon degrades into a photonic, so that eventually from each photon, over time, as a result of the expansion of the Universe, only one photonic will arise. The mass of such subquanta

$$m_f = \frac{hH}{c^2} \approx 1.7 \cdot 10^{-68} \, kg \qquad (21)$$

where H - the Hubble constant does not depend either on the frequency of the primary radiation or the speed of its source, then such subquantum, naturally, should be considered limiting particles - photonics. Photonics are inert particles and will therefore fill the space of the Universe.

If in ether-dynamic theories [13,14] during the aging process the decay of photons into subquanta is assumed, and therefore formally this contradicts the works of M.P. Bronstein [15-17], then in the discussed theory of photon involution no decay occurs, but instead the expansion of the Universe occurs, which leads to a decrease in the frequency of photons and their degeneration to photonics.

As shown in [18], photonics have zero speed and non-zero frequency $v_f = \frac{m_f c^2}{h} = 2.2989 \cdot 10^{-18} c^{-1} v_f$. *The well-known formula for the dependence of the speed of light on its wavelength λ and frequency ν*

$$c = \lambda v \qquad (22)$$

for photonics that are at rest, the wavelength turns out to be zero. For this reason, the expansion of space in the Universe does not have any effect on photonics. Their sizes remain zero. A set of photonics at rest represents "standing" light, which can serve as an Absolute Reference Frame (AFR) [18].

The mass density of photonics ρ_m in the Universe is equal to [18]:

$$\rho_m \approx 1.36 \cdot 10^{-65}\, kg\,/\,m^3 \tag{23}$$

Such an insignificant mass density of photonics at the current level of science and technology practically does not allow us to detect the influence on the movement of bodies and processes occurring in the Universe. This makes it possible to ignore the existence of AFR, which makes it valid within the accuracy of measuring the parameters of the observed phenomena and confirms the truth of Einstein's first postulate, which states that in any IFR all processes occur according to the same laws.

An exceptional feature of photonics, as the limit of photon involution, is that they are at Absolute rest in absolutely all reference systems! This allows us to assert that photonics form the basis of the Absolute Reference Frame (AFR).

In our case, the relative velocities of chron and non can be correlated to the third body or the AFR using SRT formulas, the validity of which has been confirmed by experiment.

So, we have determined that the space of the Universe can be packed with primitive cubic Planck cells, in the 8 vertices of which there is one chronon, around which the non rotates with a speed ω, independent of the speed of the body v in which the chronon finds itself:

$$w = \omega = \omega(v) \tag{24}$$

However, such packing with Planck cells is not realized everywhere and not always. Since physical bodies can move in space, the chronons are not rigidly fixed at the tops of the cells but can shift under the influence of moving bodies and generally move chaotically. Chrons are part of elementary particles and any physical bodies. The concentration of chrons in bodies differs from their concentration in space, so it may well be that all physical bodies can consist only of chrons packaged in various ways. Particles whose sizes are smaller than the chrons are included in the composition of the chrons, and the mass of such particles will constitute a corresponding fraction of the mass of the chron. It follows from this that the mass of a physical body is no less than the sum of the masses of the chronons that are part of the substance of this body. The properties of the physical body and, in particular, the sign of the body mass are determined by the properties and signs of the mass of the chrons.

The orbital speed ω of the non at each point of its orbit can be decomposed into two components perpendicular to each other: the speed of the non's fall ζ on to the chron and the displacement speed ξ of the non in the direction perpendicular to the speed of the non's fall onto the chron. If a body moves with speed v, then the speed of displacement

of the non is parallel to v. If the body is at rest $v = 0$, then the non-moves are in a circular orbit, so that the squares of the velocities of the fall and the displacement of the non are equal to each other

$$\zeta^2 = \xi^2, \tag{25}$$

and the final orbital speed ω non is equal to

$$w = \omega = \sqrt{\zeta^2 + \xi^2} = \zeta\sqrt{2} \tag{26}$$

If the body moves with speed $\vec{v}$, then the speed of displacement of non $\vec{\zeta}_v$ in the direction of the speed of movement of the body will be equal to

$$\vec{\zeta}_v = \vec{v} + \vec{\xi} = \vec{v} + \vec{\zeta} \tag{27}$$

From the orbital speed of none $\vec{w}$:

$$\vec{w} = \sqrt{\vec{\zeta}^2 + \left(\vec{v} + \vec{\zeta}\right)^2} \tag{28}$$

find the speed of the non's fall

$$\vec{\zeta} = \frac{1}{2}\left(-\vec{v} \pm \sqrt{2\vec{w}^2 - \vec{v}^2}\right) \tag{29}$$

And since the orbital speed of non, under (24), is equal to the critical speed ω, then, substituting (24) into equality (29) we obtain:

$$\vec{\zeta} = \frac{1}{2}\left(-\vec{v} \pm \sqrt{2\vec{\omega}^2 - \vec{v}^2}\right) \tag{30}$$

If the non rotates in the opposite direction, then the corresponding equality (27) will look like:

$$\overleftarrow{\zeta}_v = \overleftarrow{v} - \overleftarrow{\xi} = \overleftarrow{v} - \overleftarrow{\zeta} \tag{31}$$

$$\overleftarrow{w} = \sqrt{\overleftarrow{\zeta}^2 + \left(\overleftarrow{v} - \overleftarrow{\zeta}\right)^2}, \tag{32}$$

and the rate of fall of the non, obtained from (32), will be equal to:

$$\overleftarrow{\zeta} = \frac{1}{2}\left(\overleftarrow{v} \mp \sqrt{2\overleftarrow{\omega}^2 - \overleftarrow{v}^2}\right) \tag{33}$$

Table 1 shows the velocities of nonfall per chron $\zeta_{1,2}$) calculated using formulas (30) and (33) depending on the body speed v.

Table 1: Dependence of the rate of fall ζ_1, ζ_2 non per chron on the body speed v.

V m/s	$\vec{\zeta}_1$ m / s (30)	$\vec{\zeta}_1$ m / s (33)	$\vec{\zeta}_2$ m / s (30)	$\vec{\zeta}_2$ m / s (33)
1	2	3	4	5
0	$1.661 \cdot 10^8$	$-1.661 \cdot 10^8$	$-1.661 \cdot 10^8$	$1.661 \cdot 10^8$
10^8	$1.085 \cdot 10^8$	$-1.085 \cdot 10^8$	$-2.085 \cdot 10^8$	$2.085 \cdot 10^8$
$2 \cdot 10^8$	$0.327 \cdot 10^8$	$-0.327 \cdot 10^8$	$-2.327 \cdot 10^8$	$2.327 \cdot 10^8$
	0	0	$-\omega$	ω
$2.5 \cdot 10^8$	$-0.155 \cdot 10^8$	$0.155 \cdot 10^8$	$-2.345 \cdot 10^8$	$2.345 10^8$
$2.8 \cdot 10^8$	$-0.505 \cdot 10^8$	$0.505 \cdot 10^8$	$-2.295 \cdot 10^8$	$2.295 \cdot 10^8$
c	$-0.793 \cdot 10^8$	$0.793 \cdot 10^8$	$-2.207 \cdot 10^8$	$2.207 \cdot 10^8$

From the data in the second column of Table. 1 it follows that the rate of fall of non-on-chron $\vec{\zeta}_1$ is maximum if the physical object (body) is at rest. With an increase in the speed of movement of the body in the direction of the orbital speed of the non (conventionally, to the right), the speed of the fall of the non-decreases, so that when the critical speed ω is reached, the speed of the fall becomes equal to zero, and with a further increase in the speed of the body, up to the speed of light, the speed of the fall of the non becomes negative. The change in sign of the rate of fall $\vec{\zeta}_1$ can be considered as an inversion of the direction of the passage of time in the opposite direction. This is justified by the fact that the calculation of the falling speed of a non $\vec{\zeta}_1$, rotating in the opposite direction (conditionally, to the left), leads to formula (33), and the values of falling speeds are presented in column 3 of Table. 1, calculated using formula (33) turns out to be the same, but with the opposite sign. Thus, we can conclude that if the speed of the body is above ω, the passage of time in the body will go in the opposite direction. The direction of rotation of the none determines the arrow of time not only in the none and chron but also in the body itself. This conclusion follows from the dependence of body mass on the rate of time in it, obtained from the following considerations.

From SRT there are known formulas for the dependence of mass m and rate of time τ on body speed v:

$$m = \frac{m_0}{\sqrt{1 - \dfrac{v^2}{c^2}}}, \tag{34}$$

$$\tau = \tau_0 \sqrt{1 - \frac{v^2}{c^2}}, \tag{35}$$

where m_0 is the mass of the body at rest, and τ_0 is the rate of time in the body at rest. From formula (35) we have:

$$\sqrt{1 - \frac{v^2}{c^2}} = \frac{\tau}{\tau_0} \tag{36}$$

Substituting (36) into formula (34), we obtain the law of dependence of body mass on the passage of time in the body:

$$m = \frac{m_0 \tau_0}{\tau} \tag{37}$$

From the resulting formula (37) it is immediately clear that with time inversion, which consists in changing the direction of the arrow of time to the opposite, the sign of the passage of time changes, and the sign of the body mass becomes negative.

Per the Table. 1, an inversion of the direction of rotation of the non, and therefore a change in the sign of the tempo of time, occurs when the body reaches a critical speed ω, which is consistent with the phase transition to negative values of body mass that occurs at this speed [1-4].

The second solutions of equations (30) and (33), are presented in the fourth and fifth columns of Table 1 does not currently have any satisfactory interpretation.

From Table 1 also shows that the negative mass of a body when its speed exceeds ω is consistent with the change in sign of the speed of the fall of the non $\vec{\zeta}_1$, the speed of the fall of the non becomes negative, which is naturally perceived as the speed of "take-off", or the speed of removal from the chron due to formally appearing in non the force of repulsion from the chron.

Following Einstein's Principle of Equivalence of inertial and gravitational masses, two particles of negative mass (non-particles) must repel each other [19]. Indeed, Newton's law of universal gravitation says that such particles should be attracted, but because they have negative masses, their accelerations should also be negative. For this reason, particles with negative mass repel each other. Under the New Principle of Equivalence (NPE) of the absolute values of the inertial and gravitational masses, non-particles would be attracted to each other [19], but, unfortunately, this principle was not realized in the described behavior of negamatter. This, however, does not yet exclude the possibility of the existence of non-matter of the second type, subject to NPE.

Stability of negamatter

The fact revealed above that particles of negamatter at high temperatures or when a body reaches a speed above ω will repel each other suggests that non-matter, according to M.G. Lobanovsky [12], fragment into the smallest non-

particles and scatter in different directions. However, in non-matter, not only gravitational repulsive forces act, but also others, in particular, chemical and electrical forces. Let us compare the effect of these forces with the example of a molecule of sodium chloride Na^+Cl^-, located in space, far from strong gravitating masses (melting and boiling points are 800 and 1440^0C, respectively). We find the gravitational force F^- of repulsion of sodium and chlorine ions with negative masses from each other according to Newton's law of universal gravitation:

$$F^- = G\frac{M_{Na} \cdot M_{Cl}}{\left(R_{NaCl}\right)^2} = 1,9 \cdot 10^{-37} \, dyne, \tag{38}$$

where $G = 6.6726 \cdot 10^{-8} \frac{dn \cdot cm^2}{g^2}$ – gravitational constant, M_{Na} = 38.165·10^{-24}g – molecular weight of a sodium atom, M_{Cl} = 58.85·10^{-24}g – molecular weight of chlorine atom, R_{NaCl} = 2.815·10^{-8}cm – molecular radius $NaCl$, taken equal to the crystal lattice constant $NaCl$.

The chemical force of attraction F^+ of sodium and chlorine ions, which, in our case, is equal to the electrical force of their attraction, is found according to Coulomb's law:

$$F^+ = \frac{Q_{Na} \cdot Q_{Cl}}{\left(R_{NaCl}\right)^2} = -2,9 \cdot 10^{-4} \, dyne, \tag{39}$$

Where Q_{Na} = 4.8·10^{-10}CGSE – cation charge, Na^+, Q_{Cl} = -4.8·10^{-10}CGSE – anion charge Cl^-.

From equalities (38) and (39) it is clear that the chemical force of attraction, as well as the electrical force of attraction, is 1.5·10^{33} times stronger than the gravitational repulsive forces:

$$\frac{F^+}{F^-} = \left|\frac{2.9 \cdot 10^{-4}}{1.9 \cdot 10^{-37}}\right| = 1.5 \cdot 10^{33} \tag{40}$$

Thus, a body moving at a speed above 235696.8871 km/s will have a negative mass will not disintegrate, and will be stable. If you use the technology for producing non-matter by increasing its temperature [3], then it can dissociate due to the high temperature, and non-matter cannot always be formed.

The temperature of a substance usually characterizes the state of a large number of molecules. However, in [20] it was possible to relate the concept of temperature T to an individual molecule (particle):

$$T = \frac{l}{kR} \cdot \frac{mv^2}{2} = \frac{l}{kR} \cdot \frac{m_0 v^2}{2\sqrt{1 - v^2/c^2}}, \tag{41}$$

where m – particle mass, v – particle speed, R – particle radius, l – particle free path, k=1.38·10^{-16} erg/k – Boltzmann constant. This made it possible to construct a distribution of molecules by their temperatures at the corresponding general gas temperature [21], which allows us to quantitatively estimate the concentration of non-particles. The temperature T_0, above which the particle mass becomes negative, is determined by the formula [3]:

$$T_0 = \Phi\frac{m_0 \omega^2}{3k} \tag{42}$$

The temperature of such a phase transition for a NaCl molecule, calculated using formula (42), is equal to. T_0 = 2·10^{14}k. This is a very high temperature at which the molecules of already evaporated sodium chloride if heated thermally, will most likely dissociate into sodium and chlorine atoms. However, as formula (41) shows, it is theoretically possible to increase the temperature of particles by increasing their free path. Indeed, at particle speed $v \geq \omega$ from formula (41) we obtain that for

$$\iota \geq \frac{2kRT\sqrt{1 - \omega^2/c^2}}{m_0 \omega^2} \tag{43}$$

From (43) we find that the critical free path of $Nacl$ molecules with a speed ω is equal to l 2Å. From formula (41) it is clear that to increase the temperature of a molecule it is necessary either to increase its speed or the mean free path. The increase in particle speed is limited by the speed of light. However, the free path length can formally be as large as desired. We will assume that the mean free path of a particle is the same in all directions. Then the volume v of a space cell that satisfies this condition will be a sphere of radius R:

$$V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi\left(\frac{l}{2}\right)^3 = \frac{\pi l^3}{12} = \frac{4}{3}\pi \cdot 10^{-24} \, cm^3 \tag{44}$$

Let us assume that with the help of thermal heating, we can heat sodium chloride to 2000 K, but to obtain a non-substance, a temperature of T_0 = 2·10^{14}k is required. This means that, following the directly proportional relationship between T_0 and the travel speed (41), it is necessary to increase the travel speed by $\frac{2 \cdot 10^{14}}{2000} = 10^{11}$ times. But if you increase the travel speed, then, accordingly, the volume of the reservoir in which the increased travel speed is realized will increase:

$$V^+ = \frac{\pi \left(l \cdot 10^{11} \right)^3}{12} = \frac{\pi}{12} \cdot 10^9 \; cm^3 \approx 260 \, m^3 \qquad (45)$$

If the tank has a spherical shape, then using formula (44) we find that its radius will be only 3.95 m. Thus, an increase in the path length of a molecule, and at the same time a significant increase in the temperature of the molecule due to an increase in the volume of the reservoir in which only one molecule is located, seems to be one of the possible ways to obtain negamatter.

Conclusion

Extrapolation of the above-described mechanism of the passage of time in matter to the one operating in nature makes it possible to predict the properties and behavior of physical bodies under extreme conditions when the substance of which these bodies are composed is reconstructed into non-matter. Such a restructuring occurs only when the body begins to move at a speed above ω = 235696.8871 km/s, regardless of its chemical composition and other characteristics of the substance, and also when the body temperature becomes above a certain critical temperature, individual for each substance. The temperature of a particle can be increased both due to various methods of thermal heating, and by increasing its free path, by increasing the volume of the reservoir in which the particle is located. In the work, using the example of $NaCl$ molecules, it is shown that gravitational repulsive forces are many orders of magnitude weaker than chemical and electrical forces. This indicates the relative stability of negamatter, in particular, the spacecraft and the astronauts on it, after overcoming the critical speed ω and the transition of the substance of which they are composed into negamatter, will remain alive and unharmed.

From the law of dependence of body mass on the passage of time in the body (37) it follows that with time inversion, which consists in changing the direction of the passage of time to the opposite, the sign of body mass becomes negative. This does not mean that astronauts will begin to look younger. The change in the sign of the passage of time is only relative! Absolute time will only move into the future [22]. This must be understood in such a way that all bodies with a positive mass will evolve and develop as usual, and bodies whose mass has become negative will also change, but in a slightly different way than if the sign of their mass had not changed. But what the differences are, it's impossible to say anything yet.

The substantial theory of time considered in the work determines the nature of the physics of matter with negative mass. The existence of chrons and nones is allowed, revolving around chrons responsible for the pace of time

in matter. Based on the fact that the space of the Universe can be packed with cubic Planck cells, their sizes and mass were calculated, and the orbital speed of the nones, found by fundamentally different methods, coincided with the critical speed ω.

It is essential that the negamatter obtained by the described methods turned out to obey Einstein's Principle of Equivalence. This was expressed in the fact that the resulting particles of non-matter repel each other. However, this does not exclude the possibility that in nature there may exist a substance with a negative mass of the second type, subject to another principle of equivalence, the particles of which are attracted to each other and repel from a substance with a positive mass. Such matter could form huge colonies, very distant from our part of the Universe.

This work is a logical result of previous works by the author and other researchers, which theoretically explains not only the possibility of existence but also their reality. But, unfortunately, substances from negative mass have not only not yet been obtained, but even attempts to obtain them have not yet been made.

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