Peertechz

Annals of Mathematics and Physics

MATHEMATICS AND PHYSICS GROUP

submitpaper@peertechz.com

ANNALS OF Mathematics and Physics OPEN ACCESS JOURNAL

ISSN: 2689-7636 DOI: https://dx.doi.org/10.17352/amp

Review Article

High temperature negative mass plasma

BG Golovkin*

Public Institute of Natural Sciences and Humanities, Yekaterinburg, 620795, Russia

Received: 12 April, 2024
Accepted: 27 April, 2024
Published: 29 April, 2024

***Corresponding author:** BG Golovkin, Public Institute of Natural Sciences and Humanities, Yekaterinburg, 620795, Russia, Email: gbg1940@mail.ru, gbg03.1940@mail.ru

Keywords: Negamatter; Negatons; Negaons; High-temperature plasma; Critical speed; Negative mass

https://www.mathematicsgroup.us

Abstract

A review of studies of matter with negative mass - negamatter, consisting of negaparticles - is given. Based on the assumption that Newton's laws are valid for negaparticles, their behavior in relation to other particles is described. It has been discovered that high-temperature plasma is a negasubstance, but only such a plasma whose temperature is above a certain critical temperature, depending on the chemical composition of the original substance, can be calculated using the appropriate formula. In addition, if anybody is in a state of motion with a speed above 235696.8871 km/s, then its substance undergoes a phase transition and becomes negamatter.

Introduction

Previous justifications for the existence, search, and possible application were based on the assumption that *negaparticles should obey the same physical laws as ordinary matter with positive mass* [1]. *The main indicator of the negative mass of a substance should have been its mechanical properties, which determined its mutual attraction or repulsion.* However, this did not give a clear answer that a substance with such properties must necessarily have a negative mass. Indeed, systems have been found in which only the effective (apparently negative) mass was negative [2–12]. A substance with such a mass would behave like a negative mass, although in reality, the mass of such a substance would most likely remain positive. Therefore, to detect non-matter, you need to use a different approach; you need to make sure, based on necessary and sufficient criteria, that as a result of some impact on the body, non-matter actually appears, and then study its properties. This is exactly the approach used in this work. If the discovered properties coincide with the hypothetical ones, then this will be an additional confirmation of the theory, otherwise, this will require correction of the relevant laws in relation to non-matter. As it turned out, a *necessary and sufficient criterion to guarantee the negative mass of a substance is its temperature and the speed of movement of the body.*

History of research into negamatter

Max Jammer (1915–2010) [13] describes the earliest studies of the possibility of the existence of matter with negative mass in the monograph. A world in which gravitational forces are only gravitational forces cannot be stable and, therefore, exist in time. The existence of negative gravitational masses was seriously considered as a solution to difficulties when Newton's law of gravity was applied to the Universe as a whole. The first person to draw attention to such difficulties back in 1874 was Carl Neumann (1832–1925) [14]. In 1895, the same problem was posed mathematically more rigorously by Hugo von Seeliger (1849–1924) [15]. He showed that the intensity of gravity increases in direct proportion to the radius of the sphere. Since, in relation to the scale of the Universe, this radius can take on arbitrarily large values, the intensity of the gravitational field can be infinite at any point in space. An attempt to overcome these difficulties was made by August Föppl (1854–1924) [16]. He introduced the concept of negative mass. Even earlier, Karl Pearson (1857–1936) spoke about repulsive gravitational forces in his hydrodynamic explanation of gravity and magnetism

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

[17]. Föppl developed a logically consistent theory of positive and negative masses by analogy with the positive and negative charges of James Maxwell's theory of the electromagnetic field. The fact that we do not observe mutual repulsion of masses can be explained by the plausible assumption that the negative masses, repelled by the positive masses prevailing in our region of space, moved away to distances inaccessible to our experience. Erwin Schrödinger (1887–1961) [18] and Léon Brillouin (1889–1969) [19] also assumed the possibility of the existence of bodies with negative gravitational mass.

In 1928, Paul Dirac (1902–1984) encountered the possibility of the existence of negative masses. He discovered that the wave equation for an electron has, along with desirable solutions for which the kinetic energy of the electron is positive, the same number of undesirable solutions with the negative kinetic energy of electrons, which, at that time, seemed to have no physical meaning [20–22]. If we reason purely formally, then according to the well-known formula of Albert Einstein (1879 - 1955), as well as similar formulas of the theory of relativity of Poincare, Lorentz [23], and F. Hasenöhrl [24], the energy E is related to the mass m (not only inertial but also gravitational [25]) and the speed of light with the relation:

$$E = mc^2, \tag{1}$$

so for negative energy values, the mass values are automatically negative. However, by modifying the theory, the electric charge of electrons with negative energy was made positive, and the resulting particles were interpreted as positrons with positive mass [26].

In theoretical physics, negative mass is a hypothetical type of exotic matter whose mass has the opposite sign with respect to the mass of ordinary matter [27,28] and is used in some hypothetical technologies, such as time travel to the past and future [29], construction traversable artificial wormholes that could also allow time travel, Krasnikov tubes, the Alcubierre drive, and possibly other types of FTL warps [30]. Currently, the closest known real representative of such exotic matter is the region of density with negative pressure created by the Casimir effect [31–35]. In December 2018, astrophysicist Jamie Farness proposed a "dark liquid" theory, partly related to ideas about gravitational repelling negative masses, that could help better understand, in a testable way, significant amounts of unknown dark matter and dark energy in the cosmos [36]. In the General Theory of Relativity (GTR), negative mass is any region of space in which the mass density is measured as negative to some observers. This may occur due to a region of space in which the sum of the three normal stress components (pressure on each of the three axes) of the Einstein stress-energy tensor is greater in magnitude than the mass density. All these are violations of one or another version of the positive energy condition of Einstein's general theory of relativity; however, the positive energy condition is not a necessary condition for the mathematical consistency of the theory. The first scientific work devoted to the description of the behavior of negative mass particles within the framework of general relativity was published by Hermann Bondi (1919 – 2005) in 1957 [37]. He suggested that mass could be either negative or positive, and this did not entail a logical contradiction as long as all three forms of mass were negative, but that the assumption of negative mass involved some counter-intuitive form of motion. For example, one would expect an object with negative inertial mass to accelerate in the direction opposite to that in which it was pushed. Several other analyzes of negative mass have been carried out, such as those carried out by R. M. Price [38], although none have addressed the question of what kind of energy and momentum would be needed to describe non-special negative mass. Indeed, the Schwarzschild solution for the negative mass parameter has a bare singularity at a fixed spatial position. The question immediately arises whether it will not be possible to smooth out the singularity using some kind of negative mass density. The answer is yes, but not with energy and momentum that satisfy the condition of dominant energy. This is because if the energy and momentum satisfy the condition of dominant energy in an asymptotically flat spacetime, as would be the case if a singular Schwarzschild solution with negative mass is smoothed, then it must satisfy the positive energy theorem [39,40]. However, it was observed by Bellettet and Paranjape that since the positive energy theorem does not apply to asymptotic de Sitter spacetime, it would, in fact, be possible to smooth out, with an energy-momentum that satisfies the dominant energy condition, the singularity of the corresponding exact solution of the Schwarzschild-de Sitter equation with negative mass [41].

Since then, theoretical works began to appear in which the behavior of negative masses in classical mechanics and general relativity was studied [42–44]. Thus, in the work of McIntosh [45], an interpretation is given to the cosmological models of Hoyle-Narlikar [46] and Dicke [47] from the point of view of relativistic cosmology within the framework of two- and three-fluid models, from which it follows that the presence of particles is required to explain these models with negative mass. In this model, it is possible to explain the phenomenon of interacting Vorontsov-Velyaminov galaxies [48] as a screening effect caused by the presence of negative masses.

Properties of negasubstance

When considering negative mass, it is important to consider which concept of mass is negative. Since Newton first formulated his theory of gravity, there have been three conceptually distinct quantities called mass:

- Inertial mass is the mass m_i, which appears in Newton's second law of motion, which determines the dependence of the acceleration of a body a on the force F of a non-gravitational nature acting on it:

$$F = ma \tag{2}$$

- "active" gravitational mass – mass m_a that creates a gravitational field to which other masses react
- "passive" gravitational mass – mass m_p, which reacts to the external gravitational field with acceleration.

The law of conservation of momentum requires that the

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

active and passive gravitational masses be identical. Einstein's Principle of Equivalence (EPE) [49–52] postulates that the inertial mass must be equal to the passive gravitational mass:

$$m_i = m_a = m_p, \quad (3)$$

and all experimental evidence to date shows that they are indeed always the same. Most analyzes of negative mass assume that the principle of equivalence and conservation of momentum continue to apply without using any matter in the process, and therefore all three forms of EPE mass, gravitational interactions between masses of arbitrary sign, can be studied based on the Newtonian approximation to the field equations Einstein [43,53,54]. The laws of interaction are then described in Figure 1:

The "ridiculous" unrestrained movement of positive and negative masses described by Bondi and Bonnor is highlighted in yellow (Figure 1).

- A positive mass attracts both other positive masses and negative masses.
- A negative mass repels other negative masses as well as positive masses.

For two positive masses, nothing changes and there is a gravitational attraction towards each other causing attraction. The two negative masses will repel each other due to their negative inertial masses. However, for different signs, there is a push, which pushes the positive mass away from the negative mass, and an attraction, which simultaneously attracts the negative mass towards the positive mass. The justification for these results is given in the author's works [1,50,51]. Consequently, Bondi pointed out that two objects of equal and opposite mass will cause a constant acceleration of the system towards the object with positive mass [37], an effect called "unrestrained (self-accelerating) motion" by Bonnor [44]. Such a pair of objects would accelerate indefinitely (with the exception of the relativistic object); however, the total mass, momentum, and energy of the system would remain zero. This behavior is completely contrary to common sense and the expected behavior of "normal" matter. But Forward showed that the phenomenon is mathematically consistent and does not lead to violation of conservation laws [54]. If the masses are equal in magnitude but opposite in sign, then the momentum of the system remains zero if they both move together and accelerate together, regardless of their speed, and equivalently for kinetic energy.

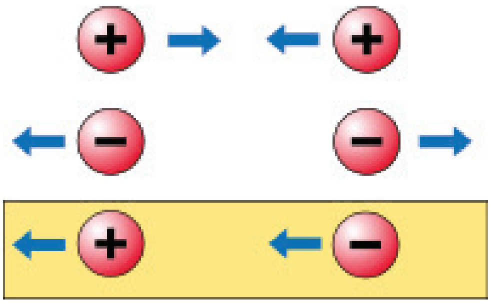

Figure 1: Interaction of bodies with positive and negative mass based on Einstein's principle of equivalence.

However, this may not be entirely true when the energy in the gravitational field is taken into account. Forward extended Bondi's analysis to additional cases and showed that even if the two masses $m^{(-)}$ и $m^{(+)}$ are not the same, the conservation laws remain the same. This is true even when taking into account relativistic effects, provided that the inertial mass, and not the rest mass, is equal to the gravitational mass.

This behavior can lead to strange results: for example, in a gas containing a mixture of positive and negative particles of a substance, the temperature of the positive part of the substance will increase without limit. However, some of the negative matter acquires a negative temperature [1,49,50] at the same rate, again equilibrating. D. A. Landis [55] pointed out other implications of Forward's analysis, including noting that although particles with negative mass will gravitationally repel each other, the electrostatic force will attract like charges and repel opposite charges. Forward used the properties of negative mass matter to create the concept of a diametric drive, a design for propelling a spacecraft using negative mass that requires no energy or reaction mass to achieve arbitrarily high acceleration.

Forward also coined the term "nullification" to describe what happens when normal matter and negative matter meet: they are expected to be able to neutralize or nullify each other's existence. The interaction between equal amounts of positive mass matter (hence with positive energy $E = mc^2$) and negative mass matter (with negative energy $-E = -mc^2$) would not result in the release of energy, but since the only configuration of such particles that has zero momentum (both particles moving at the same speed in the same direction) does not lead to a collision, such interactions would leave an excess of momentum.

The interaction of bodies with positive and negative mass based on other equivalence principles is described in [49–52]. Thus, the New Equivalence Principle (NEP) [49,50] assumes that

$$|m_i| = |m_a| = |m_p|, \quad (4)$$

from which it follows that the direction of acceleration of a particle, regardless of the sign of the gravitational charge of the mass of this particle, is always directed towards the action of the corresponding force. Therefore, the sign of particle acceleration is always positive. Bodies with negative mass should be attracted to each other in the same way as those with positive mass, and bodies with opposite mass charges, repelling from each other, will form huge colonies with positive and negative mass between which in the future there will be no connection.

Until 1981, particles with negative mass were called "minus-particles" [53]. In 1981, Ya. P. Terletsky [53,56–58] proposed calling them negatons, and particles of positive mass – positons. In [49,50], particles of negative and positive

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

mass, subject to NPE, in contrast to negatons and positons, Ya.P. Terletsky, subject to EPE, it is proposed to call *negaons* and *posions*, and accordingly add the prefix "nega" to the terms of objects having a negative mass: *negaparticles*, *negamatter*, *negasubstance*.

Arguments in favor of the existence of negasubstance

In the theory of quasicrystalline vacuum Golubeva S.M. [59], a necessary condition for the existence of neutral and charged vector bosons turned out to be the presence of negative masses in their cores. Attractive forces can arise only during the exchange of particles whose velocity and momentum vectors are directed in opposite directions. With formal inevitability, the mass of such particles should be considered negative. The exchange of particles with positive mass can only provide the appearance of repulsive forces. In the literature, a conditional model of the appearance of the force of attraction during exchange interaction is often used: two interacting people throw each other not a ball, but a boomerang. The boomerang returns due to aerodynamic forces. The boomerang effect exists only in air; it is impossible in a vacuum, therefore, in order for the force of attraction to appear, you need to throw an object with negative mass, not a boomerang, to each other. If for now only a speculative generator of particles with a negative mass is mounted on the ceiling, and the emitted beam is directed downward, then when particles with a negative mass are reflected from the floor, the impulse transmitted to the floor will be directed upward. As a result, an attractive force will arise between the floor and ceiling.

Such a generator, while still fantastic, could capture material objects with its "beam", lift them, and move them to another place. It seems obvious that the carriers of gravitational attraction have not yet been experimentally discovered, the relativistic equivalent of mass can only be negative. This changes the combinatorics of quantum numbers on the basis of which the standard model predicts the spin of these hypothetical particles. Similarly, the relativistic equivalent of the mass of those virtual photons, the exchange of which provides electromagnetic attraction, can only be negative. It is possible that from the point of view of symmetry, it is advisable to consider such virtual unobservable photons with a negative mass equivalent as antiparticles in relation to ordinary photons. In standard theory, the photon is considered a truly neutral particle, identical to its antiparticle. As in the case of heavy leptons, the standard model's ideas about the true fundamental nature of vector bosons do not correspond to reality - these are composite particles. Moreover, the cores of gauge bosons are analogues of fermions. For a neutral boson, this is an analogue of a neutron, and for charged bosons, it is an analogue of muons (or pions, but both muons and pions are fermions) [59]. The existence of substances with negative mass is not contradicted by any fundamental physical laws. It is easy to see that the law of conservation of mass, the law of conservation of momentum, and the law of conservation of energy are fulfilled [1]. Therefore, there are no logical prohibitions on their existence. Moreover, the mechanism for the emergence of mass in fundamental particles has now been developed. It is based on their interaction with the homogeneous *Higgs field* filling the space, in accordance with which fermions acquire masses [60]

$$m_f = \frac{\xi \cdot \varphi_0}{c^2}, \tag{5}$$

Where φ_0 is the Higgs field strength, ξ is the coupling constant of the corresponding fermion with this field. In the case of a real Higgs field, only two points of minimum energy are possible: $\varphi_0 = +a$ and $\varphi_0 = -a$ [61]. Together with (5), these values of ϕ_0 give us reason to assume the existence of matter with negative mass.

Search for negasubstance

In general relativity, the universe is described as a Riemannian manifold associated with a metric tensor solution of the Einstein field equations. In such a structure, "unrestrained motion" prohibits the existence of negative matter [37,44]. Some bimetric theories of the Universe suggest that instead of one, there may be two parallel universes with the opposite direction of the arrow of time, bound together by the Big Bang and interacting only through gravity [62,63]. The universe is then described as a manifold associated with two Riemannian metrics (one with positive matter mass and the other with negative matter mass). According to group theory, the matter of the conjugate metric will appear to be the matter of the other metric to have the opposite mass and arrow of time (although its own time would remain positive). The coupled metrics have their own geodesics and are solutions of two coupled field equations [64]. Negative matter of a bound metric interacting with the matter of another metric via gravity may be an alternative candidate to explain dark matter, dark energy, cosmic inflation, and an accelerating Universe [64]. The overwhelming consensus among physicists is that antimatter has a positive mass and should be subject to gravitational influences in the same way as ordinary matter. Direct experiments with neutral antihydrogen were not sensitive enough to detect any difference between the gravitational interaction of antimatter and ordinary matter [65]. Bubble chamber experiments provide further evidence that antiparticles have the same inert mass as their conventional counterparts. In these experiments, a chamber is exposed to a constant magnetic field, which causes charged particles to move along spiral trajectories whose radius and direction correspond to the ratio of electric charge to inert mass. Particle-antiparticle pairs are seen to move in spirals with opposite directions but equal radii, implying that the relationships differ only in sign; but this does not indicate whether the charge or inert mass is inverted. However, an electrical attraction of particle-antiparticle pairs to each other is observed. This behavior implies that both particles have positive inertial mass and opposite charges; if the opposite were true, then a particle with positive inertial mass would be repelled from its antiparticle partner.

Physicist Peter Engels and a team of colleagues at Washington State University reported observing negative mass behavior in rubidium atoms. On April 10, 2017, Engels' team

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

created a negative effective mass by reducing the temperature of rubidium atoms to almost absolute zero, creating a Bose-Einstein condensate. Using a laser trap, the team was able to reverse the rotation of some rubidium atoms in this state and observed that upon release from the trap, the atoms expanded and exhibited negative mass properties, specifically accelerating toward the force of the push rather than away from it [2,3]. This type of negative effective mass is similar to the well-known apparent negative effective mass of electrons at the top of dispersion bands in solids [4]. However, in neither case is mass negative for the purposes of the stress-energy tensor.

Some recent work on metamaterials suggests that some as-yet-undiscovered compounds of superconductors, metamaterials, and ordinary matter may exhibit signs of negative effective mass in much the same way that low-temperature alloys melt below the melting point of their components or some semiconductors have negative differential resistance [5,6].

In 1928, the Dirac Field theory of elementary particles, which is part of the standard model, already included negative solutions [23–25]. The Standard Model is a generalization of quantum electrodynamics (QED), and negative mass is already built into the theory.

M.S. Morris, K. S. Thorne, U. Yurtsever [66] indicated that the quantum mechanics of the Casimir effect can be used to create locally. Subsequent work by others showed that negative matter could be used to stabilize a wormhole. [67] reported that such wormholes could have been created in the early Universe, stabilized by cosmic string loops with negative mass. Stephen Hawking argued that negative energy is a necessary condition for creating a closed timelike curve by manipulating gravitational fields within a finite region of space [68]; this implies, for example, that Tipler's finite cylinder cannot be used as a time machine.

For the energy eigenstates of the Schrödinger equation, the wave function is wave-like wherever the particle energy is greater than the local potential, and exponential (decaying) wherever it is less. One could, in order to cancel the local potential, assume that the kinetic energy is negative in the damped regions. (to cancel the local potential). However, kinetic energy is an operator in quantum mechanics, and its mathematical expectation is always positive; when summed with the mathematical expectation of potential energy, the eigenvalue of energy is obtained.

Newton's second law

As will be seen below, the conclusion about the possibility of the existence of non-matter follows from Newton's second law [69,70]. This law initially did not take into account the effects of the Special Theory of Relativity (SRT) and was written in the form (2), but later, if force is defined as the rate of increase in momentum, then equation (2) allows for changes in both mass and speed [71]:

$$\mathrm{F} = \frac{d}{dt}\left(m\mathrm{v}\right) = m\frac{d\mathrm{v}}{dt} + \frac{dm}{dt}\mathrm{v}. \quad (6)$$

Since the mass m of a moving body depends on its speed and rest mass m_o, then

$$m = m\left(v\right) = m_v = \frac{m_0}{\sqrt{1 - v^2/c^2}} \quad (7)$$

after substituting (7) into (6) we get

$$\begin{aligned}\mathrm{F} &= \frac{m_0}{\sqrt{1-v^2/c^2}}\frac{d\mathrm{v}}{dt} + \frac{d}{dt}\left(\frac{m_0}{\sqrt{1-v^2/c^2}}\right)\mathrm{v} \\ &= \frac{m_0}{\sqrt{1-v^2/c^2}}\frac{d\mathrm{v}}{dt} + \frac{\mathrm{v}}{c^2}\frac{d}{dt}\frac{m_0 c^2}{\sqrt{1-v^2/c^2}}\end{aligned} \quad (8)$$

From consideration of equations (6) and (8) it is clear that the force acting on the body is equal to the sum of two vectors, one of which is directed in the direction of acceleration $\frac{d\mathrm{v}}{dt}$ and the other in the direction of the existing speed v, so, in general, the force and the acceleration it produces do not act in the same direction and the other in the direction of the existing speed v, so, in general, the force and the acceleration it produces do not act in the same direction.

In the case that is important for further analysis, when acceleration, velocity, and its change have the same direction, equality (8) can be written in the form

$$F = F_v + F_m = \frac{m_0}{\sqrt{1-v^2/c^2}}\frac{dv}{dt} + \frac{v}{c^2}\frac{d}{dt}\frac{m_0 c^2}{\sqrt{1-v^2/c^2}} \quad (9)$$

The terms of equality (9) can be represented as

$$F_v = m_v \cdot \frac{dv}{dt} = m_v a = \frac{m_0 a}{\sqrt{1-v^2/c^2}} \quad (10)$$

$$\begin{aligned}F_m &= v\frac{dm}{dt} = v\frac{d\frac{m_0}{\sqrt{1-v^2/c^2}}}{dt} = \frac{m_0 v^2/c^2}{\left(1-v^2/c^2\right)^{1.5}} \cdot \\ \frac{dv}{dt} &= m_0 a\frac{v^2/c^2}{\left(1-v^2/c^2\right)^{1.5}} = m_v a\frac{v^2}{c^2 - v^2},\end{aligned} \quad (11)$$

where

$$a = a_0 f(v), \quad (12)$$

$f(v)$ is a normalization function. Since the value a in equalities (10 – 12) plays the role of acceleration of the body both at the initial moment of action of the force (the moment of breaking out), and at any other moment when the speed

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

of the body is already equal to v, and the breaking off relates already to this moment, then the acceleration a is essentially a constant. Therefore, the normalization function can be defined equal to:

$$f\left(v\right)=1, \tag{13}$$

then:

$$a=a_0. \tag{14}$$

Substituting (7, 10 – 14) into (9), we obtain a convenient version of Newton's second law, taking into account changes in mass and speed

$$F=m_v a_0\left(1+\frac{v^2}{c^2-v^2}\right)=m_v a_v, \tag{15}$$

where

$$a_v=a_0\left(1+\frac{v^2}{c^2-v^2}\right)=\frac{a_0}{1-v^2/c^2} \tag{16}$$

From equalities (15, 16) it is clear that with an increase in the speed of a body, its acceleration under the influence of the same force takes on even greater values, and when the speed of the body reaches equal to the speed of light, it becomes infinite. If this conclusion were correct, then the speed of the body, under the influence of appropriate forces, would become greater than the speed of light, which contradicts the postulates of Einstein [72] and the fact that, in accordance with formula (7), the mass of the body becomes imaginary. Thus, taking into account only the relativistic change in body mass in Newton's second law leads to obviously false results. However, formulas (6 – 9, 15, 16) do not take into account other relativistic effects – time dilation and changes in body size. In the work of E.L. Feinberg [73], the position was substantiated that with a change in the speed of a body, relativistic changes in the length scale in the direction of motion of the body, the rate of time, the mass and acceleration of a moving body are the result of the action of certain forces. Naturally, these forces are part of the force F that acts on the body. Based on this idea, proof of the possibility of the existence of negasubstance was given in [74].

Newton's second law, taking into account relativistic changes in mass, speed, object size and pace of time

The composition of the force F acting on the body, which is spent on changing the scale of the dimensions of a physical object, according to the idea of E.L. Feinberg [69,73], can be represented in the form

$$\mathrm{F}=\mathrm{F}_v+\mathrm{F}_m+\mathrm{F}_i+\mathrm{F}_\tau, \tag{17}$$

where the cost of force F_v directly to change the speed v of an object in the direction of force F, F_m is the cost of force F to change the mass m of the object, F_l is the cost of force F to change the length l of the object in the direction of force F, F_τ is the cost of force F_τ to change the tempo time $\tau = \Delta t$. There is no change in the length of an object in directions perpendicular to the speed of the object in accordance with SRT. In the future, since all components of the acting force F, as well as the length, speed, and acceleration of the object, are estimated only in the direction of the force F, then in subsequent formulas, for the sake of convenience of recording and perceiving information, their vector nature will not be fixed, and equality (17) can be written:

$$F=F_v+F_m+F_i+F_\tau, \tag{18}$$

Considering that in SRT

$$l=l_0\sqrt{1-v^2/c^2} \tag{19}$$

we can write the equality:

$$F_l=-v\frac{m_0}{l_0}\cdot\frac{dl}{dt}=-v\frac{m_0}{l_0}\cdot\frac{dl_0\sqrt{1-v^2/c^2}}{dt}$$
$$=-\frac{m_0 d\sqrt{1-v^2/c^2}}{dv}\cdot\frac{dv}{dt}=-m_0 a\cdot\frac{v^2}{c^2\sqrt{1-v^2/c^2}}. \tag{20}$$

The coefficient $-v\frac{m_0}{l_0}$ is selected so that the entire expression for F_l has the dimension of force, and the minus sign indicates that the length of the body decreases rather than increases as its speed increases.

Reasoning similarly, taking into account that the rate of time $\tau=\Delta t$ in SRT slows down in a moving body

$$\tau=\frac{\tau_0}{\sqrt{1-v^2/c^2}}, \tag{21}$$

we find

$$F_\tau=-\frac{m_0 v}{\tau_0}\cdot\frac{d\tau}{dt}=-m_0 a\cdot\frac{v^2/c^2}{\left(1-v^2/c^2\right)^{1.5}}. \tag{22}$$

The minus sign in formula (22) is explained by the fact that the rate of time of a moving body slows down and does not accelerate, i.e. the amount of time, as it were, "accumulated by the body" during movement becomes smaller, in contrast to mass, the amount of which increases with increasing speed of the body.

Substituting (7, 10 – 14, 20, 22) into equality (18), we obtain the formula for Newton's second law in the form

$$F=m_0 a_0\sqrt{1-v^2/c^2}=$$
$$\frac{m_0}{\sqrt{1-v^2/c^2}}a_0\left(1-\frac{v^2}{c^2}\right)=m_v a_v, \tag{23}$$

where

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

$$a_v = a_0\left(1-\frac{v^2}{c^2}\right) \tag{24}$$

In appearance, formula (23) for Newton's second law looks the same as formula (15), which does not take into account the forces causing relativistic effects, but the dependence of acceleration on the speed of the body turns out to be completely different. Formula (24) says that the greater the speed of the body, the smaller the acceleration that the body receives from the influence of force F becomes, and when the body reaches a speed equal to the speed of light, the acceleration of the body generally becomes zero so that the influence of force F does not allow you to increase the speed of a body above the speed of light. This solution explains the impossibility of moving at a speed greater than the speed of light by the reason that, regardless of the magnitude of the force applied to a body moving at the speed of light, the acceleration of the body turns out to be zero, i.e. the speed of a body cannot exceed the speed of light.

Newton's second law taking into account the delay of relativistic effects

According to the works of S.I. Syrovatsky [75,76], relativistic effects are delayed, i.e. first, some change in the speed of the object occurs, and then the corresponding consequences appear: changes in the mass, length, and rate of time of the moving object. According to the principle of relativity of A. Einstein, among inertial reference systems there is no privileged reference system and it is impossible to detect a state of absolute motion. Therefore, anybody can be chosen as at rest, so that at the initial moment of interaction of the body with an object exerting a force on the body, its speed is $v = 0$, mass $m_v = m_o$ and acceleration $a = a_0$. Substituting these values of the parameters of a body at rest into (10), we obtain

$$F_v = m_v \cdot \frac{dv}{dt} = m_v a = m_0 a_0 = F_0. \tag{25}$$

Then equation (18) taking into account (25) and the conclusion of S.I. Syrovatsky can be written:

$$F = F_0 + F_m + F_l + F_\tau . \tag{26}$$

Indeed, an object, as a source of force, begins to influence the body even when it is at rest, and changes in the mass, length, and rate of time of the body occur somewhat later, namely when the body has already acquired a certain minimum speed and began to move. Therefore, the forces expended on changing the mass, length, and rate of time of the body are already related to this minimum speed, and therefore formulas (11), (20), and (22) should remain the same.

Substituting equalities (11 – 14, 20, 22, 25) into (26), we obtain the desired expression for Newton's second law:

$$F = m_0 a_0\left(1-\frac{v^2}{+c^2\sqrt{1-v^2/c^2}}\right) = \frac{m_0}{+\sqrt{1-v^2/c^2}} \cdot a_0\left(+\sqrt{1-v^2/c^2} - v^2/c^2\right) = m_v a_v , \tag{27}$$

where

$$a_v = a_0\left(+\sqrt{1-v^2/c^2} - v^2/c^2\right). \tag{28}$$

The "+" sign in formulas (26, 27) indicates that the mass of the body and its acceleration are positive quantities.

Proof of the existence of negasubstance

From formula (28) it is clear that the acceleration of the body will decrease with increasing speed of the body, and at a certain critical speed ω will be equal to zero. To find, solve the equation

$$\sqrt{1-v^2/c^2} - v^2/c^2 = 0 \tag{29}$$

$$v^4 + c^2 v^2 - c^4 = 0, \tag{30}$$

from this we get

$$v = \omega = c\sqrt{\frac{\sqrt{5}-1}{2}} \approx 0,7862c \approx 235696.8871\ km/s. \tag{31}$$

The square of the critical speed ω is the golden ratio of the squares of velocities not exceeding the speed of light, i.e. he divides the range of squares of these velocities in extreme and mean ratios into two parts such that the boundary of this section is the geometric mean between these parts. However, in most literary sources, the reciprocal value Φ = 1.618034 [77], which is usually denoted by the first letter of the name of the ancient Greek architect Phidias, is taken as the value of the golden ratio.

Table 1 presents the characteristics of a body moving with acceleration: mass and acceleration calculated using formulas (7, 28) - columns 2 and 5, mass defect $\Delta m_r = m_r - m_o$ (column 4), mass m_r and acceleration a_r, which the body should have as a result of applying the principle of reinterpretation [78] - columns 3 and 6. The action of the principle of reinterpretation is that the sign of negative acceleration changes to a positive value with compensation for the change of the positive sign of mass to negative.

As can be seen from Table. 1 at the critical speed of the body, the mass of the body experiences an inversion: it simultaneously becomes equal to $\pm\Phi m_0$. This gives reason to believe that the mass is "zeroed", its transition to a massless state, and a further increase in the speed of the body leads to the emergence of non-matter.

Negative acceleration can be understood in three senses:

1. As a decrease in the absolute value of the acceleration of a body's movement relative to the acceleration that was recorded at a certain point in time. If the acceleration of the body a_2 became less than a_1, which was up to this moment, then the difference between these accelerations $a_2 - a_1 = -a_{21}$ could be considered a negative acceleration.

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

Table 1: Characteristics of a body moving under the influence of force F (26).

1	2	3	4	5	6
v	m_v(7)	m_r	Δm_r	a_v (28)	a_r
0	m_0	m_0	0	a_0	a_0
0.5c	1.155m_0	1.155m_0	0,155a_0	0,616a_0	0,616a_0
0.75c	1.512m_0	1.512m_0	0,512a_0	0,099a_0	0,099a_0
ω	Φm_0	$\pm\Phi m_0$	+0.718m_0	0	0
0.8c	1.666m_0	-1.666m_0	-2.666m_0	-0.040a_0	0.040a_0
0.9c	2.294m_0	-2.294m_0	-3.294m_0	-0.374a_0	0.374a_0
$\sqrt{2(\sqrt{2}-1)}c$	2.385m_0	-2.385m_0	-3.385m_0	$-\left(\sqrt{2}-1\right)a_0$	$\left(\sqrt{2}-1\right)a_0$
c	∞	-∞	-∞	-a_0	a_0

2. As a deceleration, a decrease in the absolute value of the speed of movement of a body, when the speed of the body begins to decrease relative to the speed that was recorded at a certain point in time.

3. Like a change in the sign of the direction of movement of a body, when the body from a certain moment begins to suddenly move in the opposite direction.

In our case, the absolute value of both the acceleration a_v and the body velocity at $v>\omega$ (Table 1) increase rather than decrease. Therefore, the first two options for interpreting negative acceleration are not acceptable. There remains a third option when the sign of the direction of movement of the body changes. However, in this case, formula (26) is violated, namely, the right side of the formula becomes negative, and the left remains positive since the direction of the acting force does not change. This is only possible if the body weight also becomes negative.

Alternative proof of the existence of nega-substance

From dimensional considerations, we determine the cost of force for changing the speed of the mass, the length of the moving body in the direction of movement, and the rate of time involved in equality (18), by the formulas:

$$F_v = m_0 \cdot \frac{dv}{dt} = m_0 \cdot a, \qquad (32)$$

$$F_m = v \cdot \frac{dm}{dt}, \qquad (33)$$

$$F_l = \frac{m_0 v}{l_0} \cdot \frac{dl}{dt}, \qquad (34)$$

$$F_\tau = -\frac{m_0 v}{\tau_0} \cdot \frac{d\tau}{dt}, \qquad (35)$$

where the quantities m, l, τ are determined by formulas (7, 19, 21), and m_o, t_o, τ_o are the mass, length, and time tempo of a physical object at rest, c is the speed of light, v and a is the speed and acceleration of the body, respectively. The minus sign in formula (35) is explained by the fact that the rate of time of a moving body slows down and does not accelerate, i.e. the amount of time, as it were, "accumulated by the body" during movement becomes smaller, in contrast to mass, the amount of which increases with increasing speed of the body. The quantities m_o, l_o, τ_o and v in formulas (7, 19 – 22), in this case, play the role of proportionality coefficients, i.e. such that the dimensions of the right-hand sides of these equalities together have the dimension of force. The coefficient v is a variable independent of the corresponding arguments, therefore it is not included in the differential sign in formulas (33 – 35).

Substituting formulas (7, 19, 21) into equalities (33 – 35), and carrying out differentiation, we obtain:

$$F_m = m_0 a \cdot \frac{v^2/c^2}{\left(1 - v^2/c^2\right)^{1.5}}, \qquad (36)$$

$$F_l = -m_0 a \cdot \frac{v^2}{c^2\sqrt{1 - v^2/c^2}}, \qquad (37)$$

$$F_\tau = -m_0 a \cdot \frac{v^2/c^2}{\left(1 - v^2/c^2\right)^{1.5}} \qquad (38)$$

Substituting expressions (32, 36 – 38) into equality (18), we obtain

$$F = m_0 a \left(1 - \frac{v^2}{c^2\sqrt{1 - v^2/c^2}}\right). \qquad (39)$$

Formula (39) shows that the expenditure of the acting force on increasing body mass and slowing down time were mutually compensated. This indirectly indicates the dependence of the pace of time on an object on body mass.

Since the mass depends on the speed of the body according to formula (7), to note this circumstance, we write formula (39) in the form:

$$F = \frac{m_0}{\sqrt{1 - v^2/c^2}} \cdot a\left(\sqrt{1 - v^2/c^2} - v^2/c^2\right). \qquad (40)$$

On the other hand, the force defined by equality (40), acting on a body of mass (7) and causing acceleration a, is the same force that acted at the moment the movement began and caused acceleration a_o, therefore:

$$F = m_0 a_0. \qquad (41)$$

where

$$a_0 = a = \frac{F}{m_0}. \qquad (42)$$

Substituting (42) into (40), we obtain the already known formulas (27, 28). The further proof proceeds in the same way as in the previous section.

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

Proof of the existence of negasubstance by the analytical method

The method is described in [74]. The acceleration of a physical body is determined by differentiating its speed

$$v = \frac{dx}{dt} \tag{43}$$

where dx is the distance traveled by the body in time dt. Any movement of the body is caused by the force interactions of this body with the surrounding matter and its characteristics. Thus, the interval dx and the time interval dt included in equality (43), are external parameters, depending on the speed of the body, by which, in this case, the speed is found. During the movement, the quantities dx and dt do not change the speed of movement of the point, but, on the contrary, they themselves change depending on the change in speed, so

$$dx = df\left(v,\tau\right), \tag{44}$$

$$dt = df\left(\tau\right), \tag{45}$$

where τ is the proper time of a moving body.

Relations (44, 45) show that in formula (43) the differential dt of the argument t in this case does not depend on t. In this regard, the second differential of the function $f(\tau)$ is equal to the differential of its first differential:

$$d\left[df\left(\tau\right)\right] = d^2 f\left(\tau\right) \tag{46}$$

Using the well-known formula for the second derivative through differentials [79]:

$$\frac{d^2 y}{dx^2} = \frac{dx \cdot d^2 y - dy \cdot d^2 x}{dx^3}, \tag{47}$$

the acceleration of the body can be defined as

$$\frac{dv}{dt} = \frac{d^2 x}{dt^2} - \frac{dx}{dt} \cdot \frac{d^2 f\left(\tau\right)}{dt^2} \tag{48}$$

When $df(\tau) = d\tau$ equality (48) will look like

$$\frac{dv}{dt} = \frac{d^2 x}{dt^2} - \frac{dx}{dt} \cdot \frac{d^2 \tau}{dt^2} \tag{49}$$

or, taking (43) into account, we obtain

$$\frac{dv}{dt} = \frac{d^2 x}{dt^2} - v \cdot \frac{d^2 \tau}{dt^2} \tag{50}$$

On the right side of equation (50), both terms are, in essence, partial derivatives of the path and proper time, so equality (50) can be written as:

$$a = \frac{dv}{dt} = \frac{\partial^2 x}{\partial t^2} - v\frac{\partial^2 \tau}{\partial t^2}. \tag{51}$$

Based on the dependence of the length of a body on its speed (19), the change in its length will be equal to

$$dl = dl_0 \sqrt{1 - v^2 / c^2} \tag{52}$$

To determine the reduction in the object's own time (acceleration of the rate of time), we assume that a signal moving at the speed of light will travel a distance dl in time $d\tau$:

$$\frac{dl}{c} = d\tau = \frac{dl_0 \sqrt{1 - v^2 / c^2}}{c} = dt\sqrt{1 - v^2 / c^2}, \tag{53}$$

where

$$\frac{\partial \tau}{\partial t} = \frac{d\tau}{dt} = \sqrt{1 - v^2 / c^2}, \tag{54}$$

$$\frac{\partial^2 \tau}{\partial t^2} = \frac{\partial\sqrt{1 - v^2 / c^2}}{\partial t} = \frac{\partial\sqrt{1 - v^2 / c^2}}{\partial v} \cdot \frac{\partial v}{\partial t} \tag{55}$$

$$\frac{\partial^2 \tau}{\partial t^2} = -\frac{v}{c^2\sqrt{1 - v^2 / c^2}} \cdot \frac{\partial v}{\partial t} \tag{56}$$

The second derivative of the path with respect to time at the moment of starting is equal to

$$\frac{d^2 x}{dt^2} = \frac{\partial v}{\partial t} = a_0. \tag{57}$$

where a_0 is determined by formula (42). Substituting formulas (56, 57) into (51), we obtain

$$a_v = \frac{dv}{dt} = \frac{\partial v}{\partial t}\left(1 - \frac{v^2}{c^2\sqrt{1 - v^2 / c^2}}\right) = a_0\left(1 - \frac{v^2}{c^2\sqrt{1 - v^2 / c^2}}\right) \tag{58}$$

Newton's second law in accordance with (58) will have the form

$$F = m_0 a = m_0 a_0\left(1 - \frac{v^2}{c^2\sqrt{1 - v^2 / c^2}}\right). \tag{59}$$

And since the mass of a body depends on its speed according to formula (7), then formula (59) can be rationally represented in the form:

$$F = m_v a_v = \frac{m_0}{+\sqrt{1 - v^2 / c^2}} \cdot a_0\left(+\sqrt{1 - v^2 / c^2} - v^2 / c^2\right). \tag{60}$$

Formula (60) coincides with formulas (27, 40), and the dependence of acceleration a_v on body speed (58) is determined by the formula (28). The further proof proceeds in the same way as in the previous sections. Thus, we obtained the same

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

results as in [69], but without using the idea of E.L. Feinberg on the admissibility of decomposing the action of force into changes in the dynamic characteristics of the body, which confirms his hypothesis

Proof by M.G. Lobanovsky

One of the main consequences of Newtonian physics is the conclusion about the existence of an infinite number of inertial frames of reference. M.G. Lobanovsky [80] noted that since there are material gravitating objects in the Universe, ideal inertial systems do not exist in nature. In a gravitational field, all bodies are in relative motion, so we do not have a single set of bodies that are motionless relative to each other. From this follows the assumption that any collection of objects must-have features that would allow it to be used as a frame of reference. This indicates that any one body from a given set can be chosen as a reference system. Consequently, in order to construct a universal physical theory, it is necessary that when choosing a reference system there are no restrictions on the issue of its combination with a physical object, i.e. the coordinate system we accept as the calculated one must be more universal than the Cartesian one, in the sense that it must allow the possibility of combining it with any, one and only one physical object arbitrarily moving in space. The Cartesian coordinate system does not satisfy this position, since it requires the presence of at least three objects that are motionless relative to each other and is not applicable due to the fact that in nature all objects are in relative motion. Based on the above, for the purpose of studying the interactions of moving bodies, Lobanovsky chose the method of hinged coordinates, invented by him [80].

Derivation of the equation for the change in mass from the speed of movement of the body

In his theory, M.G. Lobanovsky uses finite differences of values $dx \neq dx$ instead of differentials, for example,

$$\mathrm{d}x = x_2 - x_1, \tag{61}$$

and instead of the speed of light c, it uses the speed of propagation of interactions C. The beginning of the proof, taking these differences into account, essentially coincides with the previous method. Thus, equalities (51) and (56) will look like:

$$a = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2 x}{\mathrm{d}t^2} - v \cdot \frac{\mathrm{d}^2 \tau}{\mathrm{d}t^2}, \tag{62}$$

$$\frac{\mathrm{d}^2 \tau}{\mathrm{d}t^2} = -\frac{v}{C^2\sqrt{1 - v^2/C^2}} \cdot \frac{\mathrm{d}v}{\mathrm{d}t} \tag{63}$$

Considering the instantaneous state of a material point at the moment of the beginning of its motion and taking m_0 for the instantaneous value of the moving mass m corresponding to the instantaneous state of motion, we obtain equation (64), valid for any cases of motion:

$$F = m_0 \frac{dv}{dt} = m \frac{d^2 x}{dt^2}, \tag{64}$$

Substituting (62) into (64) we obtain the equation for the force causing the acceleration of the object:

$$F = m_0 \frac{d^2 x}{dt^2} - m_0 v \cdot \frac{d^2 \tau}{dt^2}, \tag{65}$$

Let us substitute (63) in (62):

$$\frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2 x}{\mathrm{d}t^2} + \frac{v}{C^2\sqrt{1 - v^2/C^2}} \cdot \frac{\mathrm{d}v}{\mathrm{d}t} \tag{66}$$

From (66) we determine the relationship between $\frac{\mathrm{d}v}{\mathrm{d}t}$ and $\frac{\mathrm{d}^2 x}{\mathrm{d}t^2}$:

$$\frac{\mathrm{d}v}{\mathrm{d}t} = \frac{C^2\sqrt{1 - v^2/C^2}}{C^2\sqrt{1 - v^2/C^2} - v^2} \cdot \frac{\mathrm{d}^2 x}{\mathrm{d}t^2} \tag{67}$$

Substituting (67) into (64) and reducing the resulting expression by $\frac{\mathrm{d}^2 x}{\mathrm{d}t^2}$ we find the law of change in the mass of a moving physical object depending on the speed of its movement in the form

$$m = m_v = \frac{m_0 C^2\sqrt{1 - v^2/C^2}}{C^2\sqrt{1 - v^2/C^2} - v^2} = m_0 + \frac{m_0 v^2}{C^2\sqrt{1 - v^2/C^2} - v^2} \tag{68}$$

From equation (68) it follows that at the point

$$v^2 = C^2\sqrt{1 - v^2/C^2} \tag{69}$$

there is a critical transition, which consists of changing the sign of the mass from positive to negative, or vice versa, at the speed of the object

$$v \approx 0,7862C\ km/c. \tag{70}$$

Estimating the speed of interaction propagation

The work [72] concluded that the speed of propagation of interactions coincides with the speed of light at an infinite frequency of its wave c_∞, which is only slightly higher than the speed of visible light c_v:

$$C = c_\infty = c_v / \left(1 - 10^{-66}\right)\ km/s \tag{71}$$

After substituting (71) into (70), we obtain the expected

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

value of the critical speed ω = 235696,8871 *km/s* However, M.G. Lobanovsky believes that there is movement with speed *w* inside the object ("internal movement"), and the speed of propagation of interactions is $\sqrt{2}$ times higher than the speed of light:

$$C = c\sqrt{2} \approx 1,4142c = 423970.560\ km / s \tag{72}$$

If we substitute the interaction speed (69) into (72), then the value of the critical speed according to Lobanovsky will be equal to 333325.654 *km/s.*

The speed *w* is associated with changes in the size and rate of time of the object. From the fact that the velocity vector *w* does not coincide with the velocity vector of the relative motion of the object ("external motion"), we can conclude that the numerical axis on which this vector can be depicted is imaginary, and the value of the velocity *w*, accordingly, is imaginary number *wj* (with multiplication table ($j^2 = +1$; $j1 = 1j = 1/j = j/1 = j$). In this representation, the law of conservation of motion will be determined by the speed of propagation of interactions equal to the sum of vectors and *w*, which follows:

$$v^2 + wj^2 = v^2 + w^2 = C^2 \tag{73}$$

$$C = \sqrt{v^2 + w^2} \tag{74}$$

If ν = *w* = *c*, i.e. if the speed of internal motion is equal to the speed of light, and the object also moves at the speed of light, then the speed of propagation of interactions in this case will be maximum and equal to (72). But if *w* = c, and ν<*c*, then

$$C = \sqrt{v^2 + c^2} \tag{75}$$

From (75) it is clear that if the delay of relativistic effects is small so that the speed of their onset is determined by the speed of light, then the speed of propagation of interactions will depend on the relative speed of the object ν, and in a stationary object (ν*v*=0) the speed of propagation of interactions is equal to the speed of light *C* = c. With. However, any body, relative to its own frame of reference, is always at rest. Therefore, equality (71) is satisfied for any body. As shown in [72], photons, decay into photonics (the final product of photon decay [81]) with a frequency of $2{,}2989 \cdot 10^{-18} S^{-1}$ form "standing light", the speed of movement which is equal to zero, which could be, in essence, an Absolute frame of reference. If this is confirmed, then the speed of the object will be considered an absolute value, and the maximum speed of propagation of interactions may turn out to be greater than the speed of light by the amount *wj*, i.e. be a complex quantity. Naturally, in this version, the values of *C*≠*c* cannot serve as a signal in the SRT formulas.

Obtaining negasubstance

Despite the fact that the possibility of the existence of negasubstance has been proven in many works, no one has yet been able to obtain negasubstance or detect it in nature. At the same time, an analysis of the methodology and results of a number of experiments conducted by different authors gives reason to believe that they were dealing with negaparticles.

Experiments to determine electron mass

The first determinations of the specific charge of electrons were carried out by three methods in 1897 - 1899 by D.D. Thomson [76], but with low accuracy. Greater accuracy was achieved in 1900 - 1906. V. Kaufman [82–88]. In his experiments, he used a longitudinal electric and transverse magnetic field: a beam of cathode rays exited the lower open end of the chamber and fell on a fluorescent screen. A metal thread was stretched at the top of the anode, giving a narrow shadow on the light spot of the fluorescent screen. Large coils created a uniform magnetic field. The beam deflection was measured by the displacement of the shadow from the thread. The speed v_0 with which the particle entered the magnetic field was determined from the equation

$$\frac{mv_0^2}{2} = eU, \tag{76}$$

and the electron mass *m* was calculated using the formula [85]:

$$m = eH^2b^4 / 8z_b^2Uc^2, \tag{77}$$

where *U* is the difference between the cathode and the anode, *H* is the magnetic field strength, z_b is the total deflection of the particle along its entire path in the magnetic field acting on the path section *b*, e=$-1{,}60217733 \cdot 10^{-19}$ coulomb (charge electron), *c* is the speed of light. At electron velocities from $2{,}36 \cdot 10^8$ to $2{,}83 \cdot 10^8$ *m/s*, the electron mass increases from $1{,}23 \cdot 10^{-30}$ to $2{,}54 \cdot 10^{-30}$ *kg*, respectively [89,90].

From equality (77) it is clear that due to the fact that the charge of the electron is negative, the mass of the electron under the conditions of this experiment should also be negative. From work [79], if we assume that the speed of interaction is equal to the speed of light, as well as works [69,70,74,91], it follows that the mass of anybody when it reaches a speed greater than the critical one ω = 235696.8871*km*/s becomes negative. And since the velocities of the electrons, the masses of which were measured by V. Kaufman, were greater than ω, they were indeed negative.

To quantitatively establish the type of dependence of mass on speed, the accuracy of V. Kaufman's experiments was insufficient. Following Kaufman, the law of dependence of mass on speed was subjected to experimental verification by A.G. Bucherer, K. Volz, G. Neumann (compensation method of crossed electric and magnetic fields, source of electrons - radium preparation, 1909 – 1914); E. Gupka (constancy of deviations in the magnetic field of electrons of various speeds in high vacuum, the source of electrons is the photoelectric effect, 1910); F. Paschen (magnetron method and two-capacitor method, thermionic emission, 1916); C.E. Guye, S. Ratnowsky et C. Lavanchy (method of similar trajectories, source of electrons - induction machine, 1911 - 1921) [79,85–87,92–94]; H. Busch (focusing by a longitudinal magnetic field, thermionic emission, 1922); P.L. Kapitsa and R.A. Tricker (method using a focal monochromator, electron source – radioactive drug, 1925) [87,88]. Method of C. T. Zahn and A. H. Spees, source

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

of electrons - radioactive drug, 1938 [86,88,89,95]; method M. M. Rogers, A.W. McReynolds, F.T. Rogers using radium preparation, 1940 [96], etc.

In the experiments of R.A. Tricker used a focal monochromator scheme for electrons proposed by P.L. Kapitsa [88] for the analysis of electron velocities. A diverging beam of rays passes through a control diaphragm D, a lens, and a movable diaphragm C. Beams with different wavelengths are focused at different points on the optical axis $S_1, S_2, S_3 ...$. Short-wave rays are focused closer to the lens; long-wave rays are focused further from it. By moving the diaphragm, rays of any wavelength can be released from its opening. In this method, the role of a lens is played by a longitudinal magnetic field with axial symmetry, i.e. solenoid. Electrons are focused by such a lens at a distance

$$l = 2\pi mv\cos\alpha / eH, \tag{78}$$

Where α is the angle of inclination of the direction of flight of the electron to the axis of the longitudinal magnetic field. The D diaphragm could be charged up to ±5000V and thereby speed up or slow down the electrons. Changing the electron speed by Δv shifts the focus to

$$\Delta l = 2\pi m\Delta v\cos\alpha / eH \tag{79}$$

Tricker's measurements showed that at electron speeds up to 240,000 *km/s*, the change in mass follows the Lorentz-Einstein formula with an accuracy of 1–2%. However, no change in the sign of the mass upon transition to velocities greater than ω was noted. A possible reason for this was that the speed of 240,000 *km/s* was only slightly higher than the critical speed. For this reason, the speed of the electrons during their flight through the installation became less than ω and the non-matter returned to the state with a positive mass, or, conversely, due to kinetic difficulties, the mass of the electrons did not have time to transition to the state of negasubstance.

In the experiments of C.E. Guye, S. Ratnowsky et C. Lavanchy [79,85,92–94] electrons were subjected to the action of a longitudinal electric field, running through a potential difference *U*. After leaving this field, they entered a space in which they were exposed to the action of a transverse electric field of a flat capacitor with a potential difference on the plates *V* or the action of a transverse magnetic field *H* and then fell on the photographic plate. Their directions were chosen so that each of the fields caused the electron beam to deflect in the same direction. The novelty of the method consisted of a special way of taking into account edge effects. The final formulas used to determine the masses of electrons m_1 and m_2, moving with velocities v_1 and v_2, respectively:

$$\frac{m_1}{m_0} = \frac{V_0 i_1^2}{V_1 i_0^2}, \tag{80}$$

$$\frac{m_2}{m_0} = \frac{V_0 i_2^2}{V_2 i_0^2}, \tag{81}$$

$$\frac{v_1}{v_0} = \frac{V_1 i_0}{V_0 i_1}, \tag{82}$$

$$\frac{v_2}{v_0} = \frac{V_2 i_0}{V_0 i_2}, \tag{83}$$

where m_0 is the rest mass of the electron; v_0 is determined from an equation similar to (1). The values of V and the electron current *i* were selected such that the observed deviations from their main direction were the same. The velocities v_1 and v_2 were calculated from equations (82, 83), and the electron masses m_1 and m_2 from (80, 81) [86]. More than 25 measurements were made at speeds from 69,000 to 144,900 *km/s* and a curve was constructed for the dependence of the electron mass on its speed, which completely coincided with the corresponding Lorentz-Einstein function [79,86,94]. As can be seen from equations (84, 86), the mass values were found through the ratio of the determined mass of the corresponding electron to the mass of the electron at rest, which was considered positive, then the masses of moving electrons also turned out to be positive. However, since the speeds of the electrons under study were less than the critical speed ω, they should be positive. At the same time, if the electron velocities were greater than ω, then the electron masses, in accordance with [79,69,74], should be negative, although it follows from formulas (84, 86) that they are positive.

Experiment by C. T. Zahn and A. H. Spees

The best results confirming the Lorentz-Einstein formula for the dependence of the electron mass on its speed and, importantly, over the entire speed range, with an accuracy of 1%, were obtained in 1938 by C. T. Zahn and A. H. and Spees [85,86,89,95]. This deserves special consideration. The device they developed consists of an electron source and two diaphragms with narrow slits S_1 and S_2.

The source of the electrons was a radioactive drug that emits electrons in all directions at different speeds, from zero to close to the speed of light. Diaphragms S_1 and S_2 allow only a narrow beam of these particles to pass into the condenser. Electrical voltage is applied to the capacitor plates. There are magnet poles on both sides of the capacitor. Thus, an electric field of intensity *E* and a magnetic field of intensity *H*. are created in this capacitor. Having flown through the capacitor, electrons fall on another diaphragm S_3, and those that manage to fly through it reach a counter that registers these electrons. The whole device works in such a way that the source emits electrons, the capacitor and magnet sort them and pass on those that satisfy certain conditions, and the counter counts them.

All this happens as follows: an electron flying along the axis of a capacitor with a speed *v* is acted upon by a magnetic field directed perpendicular to the trajectory of the electron moving horizontally! This field acts on the electron with the Lorentz force.

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

All this happens as follows: an electron flying along the axis of a capacitor with a speed v is acted upon by a magnetic field directed perpendicular to the trajectory of the electron moving horizontally! This field acts on the electron with a Lorentz force directed vertically:

$$F_1 = evH, \tag{84}$$

The Lorentz force bends the trajectory of the electron, forcing it to move in a circle of radius R, relative to the direction of its horizontal speed, it is centripetal and, thereby, is attracted to the center of this circle. Force (84) has a negative sign due to the fact that the electron charge included in the formula (84) is negative. At the same time, the same electron is acted upon by an electric field, also directed vertically, but in the opposite direction. The electric field acts with force

$$F_2 = eE. \tag{85}$$

If any of these forces is greater than the other, then the electron is deflected up or down, collides with the capacitor plate, and leaves further play. Only those electrons pass through the gap of the capacitor for which both of these forces are equal in magnitude and opposite in direction $F_1 = F_2$, i.e.

$$evH = -eE \tag{86}$$

Meanwhile, this condition is satisfied only for those electrons whose speed, as follows from (86), is exactly equal to

$$v = -\frac{E}{H} \tag{87}$$

This means that the capacitor works as a *speed filter*, and by setting certain values of the electric and magnetic field strengths, you can pass through it electrons that have only a certain speed, and, consequently, a very certain mass.

The same device allows you to determine the mass of electrons. As already mentioned, the magnetic field creates a force (84) acting on the electron and is directed perpendicular to the trajectory of the electron, which bends this trajectory and forces the electron to move along a circular arc of radius R. This force is counteracted by the quasi-elastic force F_3 [97] of the moving electron against Lorentz force (sometimes mistakenly called centrifugal force):

$$F_3 = mv^2 / R \tag{88}$$

Since this force is directed against force (84), then $F_1 = -F_3$. Thus, from the equality of these forces we have:

$$\frac{mv^2}{R} = -evH, \tag{89}$$

and taking (87) into account we obtain

$$m = +eRH^2 / E \tag{90}$$

The mass m used in equalities (88–90) is the inertial mass m_i. Since e = -1.60217733·10⁻¹⁹, the value of the electron mass under the experimental conditions turns out to be negative. This means that electrons with negative mass were emitted from the radioactive drug, regardless of their speed.

The principle of non-equivalence of inertial and gravitational masses

Mass is included in Newton's gravitational dynamics as inertial mass m_i, which determines the resistance to the movement of a body, and as gravitational mass m_g, which determines the force of influence of bodies between themselves, which manifests itself in the active m_a or passive m_p form. Einstein's Principle of Equivalence (EPE) asserts the equality of these masses [1,49–51,98]:

$$m_i = m_g = m_a = mp \tag{91}$$

This principle is local in nature. In [1], the results of works where small differences in the absolute values of these masses are substantiated are discussed.

H.E. Repchenko [99] proposed the Field Principle of Equivalence (FPE):

1. Inertial and gravitational masses are fundamentally different physical characteristics of objects. m_i characterizes the magnitude of the change in the speed of an object under the influence of external forces, and m_g is the intensity of the object's participation in gravitational interaction.
2. The main contribution to m_i comes from the interaction with the gravitational field of the Universe - global interaction. In places where other interactions are small in comparison with it, an effect is observed that the inertial mass of a body is proportional to its gravitational charge.
3. The proportionality coefficient k increases when approaching strongly gravitating objects.
4. $k = 1$ in the surrounding space is ensured by introducing a gravitational constant. This creates the appearance of equality (91).
5. The presence of fields of a non-gravitational nature leads to a violation of proportionality between two types of masses and provides the possibility of independent measurement of these properties of objects, as well as experimental detection of deviations from equality (91).

When trying, as a first approximation, to apply PES in practice, we are forced to be guided by the same equality (91). What EPE and PES have in common is that they do not notice the possibility of mass having a negative sign. Therefore, the formal application of these principles to determine the nature of the interaction of non-matter gives the same results, namely, non-particles repel each other, and particles of different signs move in the same direction one after another [1,49–52,74].

Now, let's ask ourselves, how can we explain the results of experiments to determine the dependence of the mass

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

of an electron on its speed from the point of view of these equivalence principles? If electrons of positive mass were emitted from the source, this means that their speed was less than ω; in the process of flying through the capacitor, their speed could not increase, since there was no accelerating field in the device. And since the electron mass, in accordance with (90), turned out to be negative, it follows that their speed was, in fact, greater than ω. If we assume that the electrons escaping from the source had a negative mass. In this case, formula (90) shows that the mass of the filtered electrons was positive, not negative. The revealed paradox within the framework of EPE and PPE cannot be explained.

In [41–44], a New Equivalence Principle (NEP) was proposed, which allows for the existence of non-matter and determines a more plausible nature of the interaction of non-matter:

$$|m_i| = |m_a| = |m_p| \tag{92}$$

In accordance with the NPE, non-particles are attracted to each other and repelled from particles with positive mass. An absurd conclusion is obtained if we apply NPE to the results of the experiments of C. T. Zahn and A. H. Spees. Simple substitution $|m_i|$ instead of m_i in equality (90) shows that the body mass module can take negative values:

$$|m_i| \neq eRH^2 / E \tag{93}$$

which contradicts the concept of a module.

The results of these experiments can be explained if, instead of the principles of equivalence, the *Principle of Nonequivalence* (PN) is applied:

1. The material body has an inertial mass *mi* and gravitational mass $m_g = m_a = m_p$.
2. m_i determines the amount of matter in the body, and m_g determines the amount of gravitational charge of the body of the corresponding sign. The concepts of "amount of matter" and "amount of gravitational charge" are currently insufficiently defined and require clarification of their physical essence.
3. Since the amount of matter in a body can be either zero or positive, then the inertial mass can also be either zero or positive $m_i \geq 0$.
4. The gravitational charge can be either positive or negative $0 \geq m_g \geq 0$.
5. From characteristics 3 and 4 follows PN: $m_i \neq m_g$.
6. In quantitative terms, there is a proportionality between inertial and gravitational masses

$$m_i = k\left|m_g\right|, \tag{94}$$

and in the adopted system of measures k=1.

It is easy to see that the behavior of non-particles when interacting with each other and particles of positive mass will be the same as in the case of the action of NPE. The fundamental difference between PN and NPE is that in the case of NPE, the inertial mass can be either positive or negative, and the rules of NPE are such that when determining the behavior of non-particles, their characteristics are taken modulo so that the absolute values turn out to be equal to negative numbers (93). It is precisely this circumstance that makes NPE unsuitable for explaining the experiments under discussion. In the case of PN, the inertial mass cannot in principle be negative, from which it follows that on the right side of equality (90) there is a gravitational mass

$$m_g = +eRH^2 / E, \tag{95}$$

and the device of C. T. Zahn and A. H. Spees responded not to the inertial mass, but to the gravitational mass of the body, which quantitatively, by virtue of (19), is equal in absolute value to the inertial mass. As a result, equality (15) should be written:

$$m_i = |m_g| = |eRH^2 / E|. \tag{96}$$

Equality (96) also says that regardless of the sign of the mass of the electrons emitted from the source, the sign of the mass of the electrons passing through the device is determined by their speed: if the speed of the electrons was greater than the critical one, then they had a negative mass, and if less, then positive mass. From the above, it follows that the inertial mass, apparently, only determines the quantitative content of matter in the body and therefore can only be positive, and the gravitational mass characterizes the amount of gravitational charge in the body and therefore can be both positive and negative. Therefore, they cannot be equivalent. And since radioactive substances can emit electrons with negative mass at velocities higher than ω, such substances can be used to produce non-particles.

Object temperature criterion

If the research system is a set of particles in free motion and experiencing collisions with each other, then it can be considered as a gas consisting of these particles, for which the average kinetic energy of the translational motion of the particles is written in the form

$$\frac{m\bar{v}^2}{2} = \frac{3}{2} KT, \tag{97}$$

Where k = 1,3807·10^-16^ *erg/K* is Boltzmann's constant, and T is the absolute temperature K [60]. From formula (97) it is clear that the particle speed and gas temperature are interrelated. Therefore, since a criterion for the speed of a particle for its transition into a non-particle has been identified, such a criterion should also exist for temperature. As shown in [100], the functional equations of Maxwell and Boltzmann have not one, but two solutions: one solution corresponds to

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

the Maxwell distribution, and the other corresponds to the equal-velocity distribution. In a real gas in an isolated system, due to dissipation of the first kind, associated with a change in the angular momentum of molecules during a collision, evolution moves towards a universal distribution of velocities and angular momentum, and due to dissipation of the second kind (overcoming the resistance of the medium) it leads to equalization of the velocities of gas molecules and reducing these speeds to zero values, i.e. to gas degradation. Equal-velocity distribution is thus one of the states of a gas, which can also be characterized by the corresponding temperature. Specifically, for the critical speed ω equality (97) taking into account (7) can be written

$$\frac{m_0 \omega^2}{\sqrt{1-\omega^2/c^2}} = 3kT \tag{98}$$

Noticing that

$$\sqrt{1-\omega^2/c^2} = \frac{1}{\Phi}, \tag{99}$$

we find

$$m_0 = \frac{3kT}{\omega^2 \Phi} \tag{100}$$

$$T = \frac{m_0 \omega^2 \Phi}{3k} \tag{101}$$

$$\omega = \sqrt{\frac{3kT}{m_0 \Phi}} \tag{102}$$

From Table 1 it can be seen that the dependence of the mass of a body on its speed at the critical speed of the body ω undergoes a transition from positive to negative values. This indicates that at this speed the value of the body mass is essentially zero, which means that formula (100) allows one to find the rest mass of a particle if the temperature at which the particle is known, in accordance with the Higgs theory [60,101], loses mass, and formula (101) makes it possible to determine the temperature of transition to a massless state if the mass of the particle is known. Formula (102) allows one to find the critical speed ω if the mass of the particle and the temperature of its transition to a massless state are known.

At $T \approx 10^{28}$K, the end of the Grand Unification of fundamental interactions occurs [60,101], the strong interaction is separated from the electroweak interaction, and the carriers of the Grand Unification, the X- and Y-bosons, acquire masses of ≈ 10^{15}–10^{16} GeV/c^2 [61] (according to [101] ≈ 10^{14} GeV/c^2). Choosing the average of these values to be equal to 10^{15} GeV /c^2 using formula (81), we find the value of the critical speed to be equal to ~232453 *km/s*, which is quite close to the exact value of the critical speed ω. The mass of these bosons, calculated using formula (100), turned out to be equal to 1.781·10g.

The carriers of the Superunification forces of all four fundamental interactions, including gravity, are Planck particles with a mass of $1.222 \cdot 10^{19}$ GeV/c^2, and the temperature of their transition to a massless state is approximately considered equal to 10^{31}–10^{32}K [60]. Choosing the average temperature value equal to $5 \cdot 10^{31}$ K according to formula (102) for the critical speed, we obtain ~242419 *km/s*. The obtained value is less satisfactory, but this is due to the fact that the temperature of the Superunion taken for the calculation is also not accurate enough. The revealed fact of the existence of a critical speed is important. Substituting the exact value of the critical speed of 235696.8871 *km/s* into formula (101), we obtain that Planck particles should become massless at a temperature of $4.723 \cdot 10^{31}$K.

Table 2 shows, calculated using formulas (100, 101), the values of the rest mass m_0 and the temperature of transition to a massless state (mass zeroing temperature) $_0$ for a number of elementary particles and chemical elements.

Table 2 shows that in order for a substance to transition to a state with zero or negative mass, it is necessary to heat it to very high temperatures (for chemical elements up to 10^{13}–10^{15}K), which is the third condition for the existence of non-matter.

Density criterion

From Table 2 it can be seen that the transition temperatures of chemical elements into a massless state, and even more so into a state with a negative mass, exceed 10^{13}K. At such temperatures, all ordinary substances transform into a state of high-temperature plasma, which, naturally, is called "negagas". The temperature I of an individual particle of such a gas [96,102,103], naturally, can be represented by the same formula as for an ordinary gas:

Table 2: Temperatures at which particles transition to a massless state.

Particle name	m_{0g}	$m_0 c^2$	I_0 K
Particle, conditionally minimal mass	$1.375 \cdot 10^{-34}$	0.078 eV	300
Electron neutrino	$3.56 \cdot 10^{-32}$	< 2eV	77185
Muon neutrino	$3.38 \cdot 10^{-28}$	<0.19 MeV	7328246
Electron	$9.109 \cdot 10^{-28}$	0.511 MeV	197396000
τ - neutrino	$< 3.24 \cdot 10^{-26}$	<18.2 MeV	$7.02 \cdot 10^{10}$
Muon	$1.8807 \cdot 10^{-25}$	105.66 MeV	$4.08 \cdot 10^{11}$
Proton	$1.6726 \cdot 10^{-24}$	938.272 MeV	$3.62 \cdot 10^{12}$
τ - lepton	$3.163 \cdot 10^{-24}$	1.777 GeV	$6.86 \cdot 10^{12}$
w^+, w^- - bosons	$1.4278 \cdot 10^{-22}$	80,15 GeV	$3.09 \cdot 10^{14}$
z^0 -boson	$1.623 \cdot 10^{-22}$	91.188 GeV	$3.51 \cdot 10^{14}$
Higgs boson	$2.228 \cdot 10^{-22}$	125.18 GeV	$4.84 \cdot 10^{14}$
X,Y- bosons	$1.781 \cdot 10^{-9}$	GeV ≈10^{15} GeV	≈10^{28}
Planck particle	$2.1767 \cdot 10^{-5}$	$1.222 \cdot 10^{19}$ GeV	$4.726 \cdot 10^{31}$
He, helium	$6.6420 \cdot 10^{-24}$		$1.441 \cdot 10^{13}$
Fe, iron	$9.2988 \cdot 10^{-23}$		$2.018 \cdot 10^{14}$
Pb, lead	$3.4372 \cdot 10^{-22}$		$7.450 \cdot 10^{14}$

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

$$\Im = \frac{l}{kr} \cdot \frac{mv^2}{2}, \quad (103)$$

Where m,v,r,l are, respectively, the mass, speed, radius and mean free path of the *particle*, the temperature dependence of the distribution of which is given in [104]. From the distribution of gas molecules by their temperatures [105] it *follows* that the fraction of molecules satisfying the condition $I_{\geq}I_0$, is relatively small and may not be sufficient to detect with the available means the presence of substances with negative mass in the volume of the test gas under study. From formula (103) it is clear that the temperatures τ of gas molecules, and at the same time the overall gas temperature T, can be increased if their path length is increased, which can be achieved by reducing the concentration of the substance under study in the gas flow or in the corresponding container. From formula (103) we find the free path

$$l = \frac{2kr\Im}{mv^2} \quad (104)$$

For example, for iron from the data in Table. 2, using its ionic radius $r = 1.26\AA$ as the radius of the particle according to formula (83) at v = ω we find:

$$l \approx 0.134 \cdot 10^{-7} \tilde{n}\hat{\imath} \quad , \quad (105)$$

which corresponds to the density of such negagas:

$$\rho = 1/l^3 \approx 0.4 \cdot 10^{24} \ particles / cm^3 \quad (106)$$

If the installation for the production of non-gas iron operated at a temperature of 10^8 K, then in order to increase the temperature of iron to the temperature of zeroing its mass, it is necessary to heat it to $2.018 \cdot 10^{14}$K (Table 2). From (104), the free path of iron atoms at 10^8 K is found to be equal to ~$0{,}67 \cdot 10^{-13}$ *cm*, and the density, accordingly, is equal to ~$3.3 \cdot 10^{39}$ *Particles/cm*^{3}, which exceeds approximately 10^{16} times the required value for zeroing the mass of the substance under study and its subsequent transition to the state of non-matter.

From formulas (104, 106) we obtain the dependence of the gas density on the particle velocity and its temperature:

$$\rho = \left(\frac{m}{2kr}\right)^3 \cdot \left(\frac{v^2}{\Im}\right)^3 \quad (107)$$

From the above, it follows that the temperature of a particle can be increased by reducing its density, i.e. decreasing the concentration of the test substance. The very condition for the necessary density of non-matter is determined by the equality:

$$\rho \leq \left(\frac{m}{2kr}\right)^3 \cdot \left(\frac{\omega^2}{\Im_0}\right)^3 \quad (108)$$

From the criteria described above that define a particle with negative mass, a speed greater than the critical speed ω is a necessary and sufficient condition for the particle to have negative mass. The gas temperature T, due to the existence of a temperature distribution of gas particles [105], only indicates that the gas under study contains a certain number of particles having a temperature $\Im_0$ and higher temperatures corresponding to the existence of non-gas. At the same time, the gas temperature T, due to the Maxwell distribution of gas particles according to their velocities, indicates that the gas always contains particles moving at various velocities, including very high ones, in particular, exceeding the critical velocity ω. But if any particular particle has a temperature $I_i \geq I_0$, then this is a necessary and sufficient sign that it is a non-particle. However, due to the fact that this non-particle participates in interactions with other particles and gas non-particles, the time of its existence in the non-particle state is limited, although it is periodically renewed.

A necessary condition for the existence of non-particles is the presence of the mechanical properties described above, subject to the corresponding equivalence principle.

High temperature plasma

As is known, plasma is understood as an ionized gas, which is a mixture of electrons, ions, and neutral atoms. Taking into account the special physical properties of plasma, it is generally accepted to consider it the *fourth state of matter*.

One of the most important characteristics of plasma is the *degree of ionization*. The fewer neutral atoms in its composition, the more ion-electron pairs and high density. The ideal case is the fully ionized plasma that stars are made of. The lower the degree of ionization, the shorter the time it "lives". What happens to her then? It does not disappear anywhere but only turns into neutral elements and molecules due to recharging processes. So a charged ion can become a neutral atom, and a neutral atom can become a charged ion. Depending on the temperature, plasma is divided into low-temperature (up to one million Kelvin) and high-temperature (more than a million Kelvin). The higher the temperature, the greater the degree of ionization and luminosity of the plasma. This division of plasma into two types is formal and does not have any essential reasons for such a division. However, such reasons were revealed immediately as soon as we discovered that the above temperatures presented in Table. 2 plasma consists of non-particles, i.e. becomes neggas. Therefore, high-temperature plasma should only be considered a plasma whose temperature is higher than the zeroing temperature of the mass of the corresponding particles, which are indicated in Table. 2. It is precisely such plasma and only it that is the fourth state of aggregation of matter since such plasma consists of matter with negative mass. Low-temperature plasma, the temperature of which is below the mass zeroing temperature, although it is a partially ionized gas, is not a fundamentally new type of state of matter.

The findings are consistent with the mass generation model of S.N. Golubev [59], who defines a "quasicrystal" as a

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

non-periodic structure of virtual particles filling space, which determines the structure of the vacuum. Real particles are a complex consisting of a central particle, called a "*kern*", and a shell surrounding it, consisting of virtual particles with the appropriate structure, which form the mass of elementary particles and the mass of atomic nuclei. The mass of particles is generated by the number of pairwise interactions that occur between the virtual particles of the complex that are part of the particle. The essence of mass, its carrier, thus turns out to be not virtual particles, but paired interactions between them! Such paired interactions are very similar in meaning to strings. S.N. Golubev found an algorithm that allows a simple calculation of the number $n(n+1)/2$ of combinatorially possible pair interactions in a system of $(n+1)$ particles to calculate with high accuracy the masses of chemical elements and elementary particles. It turned out that the masses of the vector boson cores have a negative mass. This gives reason to assume that the cores located in the center of elementary particles may contain a substance with a negative mass, i.e. a high-temperature plasma, and the temperature at the center of the particles can be extremely high.

What is the evolution of high-temperature plasma found in stars and particle cores? Obviously, the answer to this question should be sought in the theories of the corresponding objects. But in general terms, taking into account the relative stability of stars and elementary particles, it should be noted that in accordance with the NPE, non-particles are attracted to each other and form colonies of negasubstance, which can be cores of elementary particles and stars. And since the shells of these cores, consisting of a substance with a positive mass should be repelled by such cores. This repulsion should lead to the disintegration of both stars and elementary particles. Freed from the shells of positive mass matter, the cores will be attracted to other released cores and form huge colonies of negasubstance.

If EPE is valid in our world, then the cores of stars and elementary particles should immediately fall apart, because the non-particles of the cores will repel each other. But for some time the repulsion will be restrained by a shell of positons. Obviously, an increase in temperature, or some other reason, should lead to the victory of repulsion. Then the core negatons will fly apart and be scattered throughout the Universe. The remaining free positons, attracting each other, will form colonies of a substance with a positive mass.

It is possible that two types of matter with negative mass can exist simultaneously, both negaons and negatons. In this case, both mechanisms described above will operate, determining their evolution.

On October 26, 2023, the JT-60SA thermonuclear reactor was launched in Japan, which made it possible to obtain the first plasma with a temperature of 2 000 000 000 C, which was maintained for 100 seconds. Achieving such temperatures makes it possible in principle to transfer electrons and neutrinos to a state with a negative mass, but this has not yet been done.

Chemical negaelements and negaparticles

In [106], by extrapolating properties in the Periodic Table of Elements (PSE), D.I. Mendeleev, it was suggested that negasubstance consists of chemical negaelements, which continue the PSE into the region of negative atomic numbers. Hydrogen and helium are located in the eighth and seventh groups, respectively. Non-elements with negative serial numbers -1, -2, etc. are located in the fifth, fourth, etc. groups. The element with zero serial number is the photon, which is located in the sixth group. However, the properties of the photon do not at all correspond to the properties of the elements of the sixth group. The photon does not form any chemical compounds with other elements but is an elementary particle with zero rest mass. Therefore, it is more natural to consider the zero element to be simply a certain volume of empty space; in the case of crystal lattices of various compounds, or even amorphous bodies, this is a vacancy, i.e. the absence of a corresponding chemical compound at some position of a chemical compound. It follows from this that in the PSE extended to the region of chemical negaelements, each chemical element must be associated with a corresponding negaelement. This new hypothesis is easily consistent with the relevance criteria described above. Indeed, non-matter is formed only at temperatures above $\Im_0$, and at such temperatures, the substance is in the form of a high-temperature plasma of fully ionized gas (negagas). However, such a gas will be different for different non-gas elements, and, naturally, it is expected that periodicity will be observed in the properties of such non-gases in accordance with the PSE. The negagas itself will be a stable formation since due to the NPE of the neganucleus, the substances will be attracted to each other. And if the EPE is true, then although non-nuclei will have a tendency to decay and fly apart, due to the fact that non-nuclei are surrounded by electron gas, the entire system as a whole will be a relatively stable formation. An increase in temperature will lead to the separation of electrons from the electron shells of atoms and the exposure of their nuclei. This is explained by the fact that the same force on electrons and the nucleus leads to different changes in their speed:

$$\frac{m_e v_e^2}{2} = \frac{MV^2}{2}, \tag{109}$$

Where m_e and v_e are the mass and speed of the electron; M and V are the mass and velocity of the nucleus, from which:

$$v_e = \sqrt{\frac{m}{me}}\mathrm{V}. \tag{110}$$

If initially the velocities of the electrons and the nucleus were equal ($v_e = V$), then after the force action, since $M > m_e$ the speed of the electrons will be greater than the speed of the nucleus. After this difference exceeds a certain limit, electrons will be separated from the nucleus.

Free negaparticles can be formed as a result of natural disasters or artificially in the appropriate installations for the production of non-matter. If a non-particle was formed in

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

a medium with a relatively high density of matter, then the biography of the non-particle can be easily determined by the properties of this medium and the non-particle itself. If a non-particle turns out to be flying in a very large volume of empty space, then taking into account that in front, outside of this space, there will be particles with a positive mass, then they will repel (in accordance with both NPE and EPE) the non-particles from themselves, i.e. slow them down, and as soon as the speed of the latter becomes less than ω, the non-particles will acquire a positive mass. If there are negative particles ahead, then, in the case of NPE action, the flying negative particle will accelerate towards the oncoming negative particles, as a result of which huge colonies of non-matter will be formed, which will move away from the substance with positive mass. And in the case of EPE, the non-particles will move away from each other, and thereby dissipate.

Conclusion

The main conclusion: anybody whose movement speed reaches the critical speed ω= 235696.8871 *km/s*, the value of its mass experiences an inversion, consisting of an abrupt change from positive values to negative values. A further increase in the speed of the body leads to even greater negative values so that when the body reaches the speed of light, its mass formally becomes equal to -∞.

As a result of the analysis of well-known experiments to determine the dependence of the electron mass on their speed, performed back in the last century, errors were discovered in determining the sign of the electron mass. It is concluded that inertial mass determines the quantitative content of matter in the body and therefore can only be positive, and gravitational mass characterizes the amount of gravitational charge in the body and therefore can be both positive and negative. Therefore, they cannot be equivalent. The Principle of Non-Equivalence of Inertial and Gravitational Masses is proposed, which explains the results of these experiments. Since radioactive substances can emit electrons with negative mass at velocities higher than ω, such substances can be used to produce non-particles.

High-temperature plasma with a temperature above the critical mass zeroing temperature I_0 depends on its chemical composition and has a negative mass. This circumstance could serve as the basis for a method for obtaining non-matter.

It has been suggested that chemical elements in the state of high-temperature plasma could be assigned corresponding negative atomic numbers in the Periodic Table of Elements by D.I. Mendeleev.

References

1. Golovkin BG. Negative mass is a component of the Universe. Noosphere. Society. Human. 2019;(1):40. Available from: http://noocivil.esrae.ru/259-1903
2. Physicists observe 'negative mass' [Internet]. BBC News. 2017 Apr 19 [cited 2017 Apr 20]. Available from: https://www.bbc.com/news/science-environment-39642992
3. Khamehchi MA, Hossain MK, Mossman ME, Zhang Y, Busch T, Forbes MM, Engels P. Negative-Mass Hydrodynamics in a Spin-Orbit–coupled Bose-Einstein Condensate. Phys Rev Lett. 2017 Apr 14;118(15):155301. doi: 10.1103/PhysRevLett.118.155301. PMID: 28452531.
4. Ashcroft NW, Mermin ND. Solid State Physics. Philadelphia: Saunders College; 1976. pp. 227–2N.
5. Cselyuszka M, Sečujski M, Crnojević-Bengin V. Novel negative mass density resonant metamaterial unit cell. Phys Lett A. 2015 Jan 19;379(1–2):33. doi: 10.1016/j.physleta.2014.10.036.
6. Smolyaninov II, Smolyaninova VN. Is There a Metamaterial Route to High Temperature Superconductivity? Adv Condens Matter Phys. 2014;2014:479635. doi: 10.1155/2014/479635.
7. Milton GW, Willis JR. On modifications of Newton's second law and linear continuum elastodynamics. Proc R Soc A. 2007 Mar 8;463(2079):855–880. doi: 10.1098/rspa.2006.1795.
8. Chan CT, Li J, Fung KH. On extending the concept of double negativity to acoustic waves. J Zhejiang Univ Sci A. 2006 Jan;7(1):24–28. doi: 10.1631/jzus.2006.A0024.
9. Huang HH, Sun CT, Huang GL. On the negative effective mass density in acoustic metamaterials. Int J Eng Sci. 2009 Apr 1;47(4):610–617. doi: 10.1016/j.ijengsci.2008.12.007.
10. Yao Sh, Zhou X, Hu G. Experimental study on negative effective mass in a 1D mass-spring system. New J Phys. 2008 Apr 14;10(4):043020. doi: 10.1088/1367-2630/10/4/043020.
11. Bormashenko E, Legchenkova I. Negative Effective Mass in Plasmonic Systems. Materials. 2020 Apr;13(8):1890. doi: 10.3390/ma13081890.
12. Bormashenko E, Legchenkova I, Frenkel M. Negative Effective Mass in Plasmonic Systems II: Elucidating the Optical and Acoustical Branches of Vibrations and the Possibility of Anti-Resonance Propagation. Materials. 2020 Aug;13(16):3512. doi: 10.3390/ma13163512.
13. Jammer M. The concept of mass is in classical and modern physics. M. Book House; 2003. 255 p. ISBN: 5-354-00353-6.
14. Neumann CG. (On the elementary laws attributable to the forces of electrodynamic origin. Treatises of the mathematical-physical class of the Royal Saxon Society of Sciences. 1874; 10(6):417–524.
15. Seeliger H. (About Newton's law of gravitation. Astronomical News) Über das Newton'sche Gravitations-Gesetz. Astronomische Nachrichten. 1895; 137:129–136.
16. Föppl A. About a possible extension of Newton's law of gravitation. Meeting reports of the math.-phys. Class of the K. B. Academy of Sciences in Munich. 1897; 27:93–99.
17. Pearson K. On the Motion of spherical and ellipsoidal bodies in fluids. Philosophical Transactions of the Royal Society of London. 1893 Jan 1;184:157–234. doi: 10.1098/rsta.1893.0005.
18. Schrödinger E. The wave theory of matter. Annalen der Physik. 1926; 79(4):361–376. doi: 10.1002/andp.19263870402.
19. Brillouin L. Relativiti Reexamined. Academic Press. New York and London. 1970. 144.
20. Dirac P. The Quantum Theory of the Electron. Proceedings of the Royal Society. A. 1928; 117: 610–624.
21. Dirac P. The Quantum Theory of the Electron. Part II. Proceedings of the Royal Society. A 1928; 118: 351-361.
22. Dirac P. A Theory of Electrons and Protons. Proceedings of the Royal Society. A. 1930; 126: 360–365.
23. Whittaker EA. History of the Theories of Aether and Electricity. The modern Theories. 1900 – 1926. London. Thomas Nelson. 1953; 27–43.

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

24. Schmutzer E. (Relativity theory – current. A contribution to the unity of physics. BSB B.G. Teubner. Publishing company). 1981; 69: 99-212.

25. Wizgin VP. Relativistic theory of gravity. Origins and formation 1900 – 1915. Ed. "The science". 1981; 112: 352.

26. Dirac P. The Principles of Quantum Mechanics. Oxford. At the clarendon press. 1958. 1979; 357–360.

27. Griffin A. Scientists observe liquid with 'negative mass', which turns physics completely backwards. The Independent. Archived from the original on 18 June 2022. Retrieved 11 December 2020.

28. N. Mortillaro. / Scientists create fluid that seems to defy physics:'Negative mass' reacts opposite to any known physical property we know. 2017.

29. Khanna G. Time travel is possible – but only if you have an object with infinite mass. The Conversation. 2019.

30. Krasnikov SV. Some questions of causality in general relativity: "time machines" and "superluminal travel". Main ideas and most important results over the past decades. M. Lennand. 2021; 103–108: 336.

31. Dzyaloshinskii IE, Lifshitz EM, Pitaevskii LP. The general theory of van der Waals forces. Advances in Physics. 1961; 10(38): 165.

32. Munday JN, Capasso F, Parsegian VA. Measured long-range repulsive Casimir–Lifshitz forces. Nature. 2009; 457(7226):170–3.

33. Milton KA, Abalo EK, Parashar P, Pourtolami N, Brevik I, Ellingsen SA. Repulsive Casimir and Casimir–Polder Forces. J Phys. 2012; A. 45(37):4006.

34. Everett A, Roman T. Time Travel and Warp Drives. 2012. University of Chicago Press. 167.

35. Golovkin BG. Dark matter and the Casimir effect are possible reasons for the existence of the Maxwell distribution. East European Scientific Journal. 2015; 2: 45–49.

36. Farnes JS. A Unifying Theory of Dark Energy and Dark Matter: Negative Masses and Matter Creation within a Modified ΛCDM Framework. Astronomy & Astrophysics. 2018; 620: A92. arXiv:1712.07962. Bibcode:2018A&A...620A..92F. doi:10.1051/0004-6361/201832898. S2CID 53600834.

37. Bondi H. Negative Mass in General Relativity. Reviews of Modern Physics. 1957; 29: 423-428.

38. Price RM. Negative mass can be positively amusing. Am J Phys. 1993; 61(3): 216.

39. Shoen R, Yao ST. On the proof of the positive mass conjecture in general relativity. Commun Math Phys. 1979; 65(1): 45–76.

40. Witten E. A new proof of the positive energy theorem. Comm Math Phys. 1981; 80(3): 381–402.

41. Belletête J. Paranjape M. On Negative Mass. Int J Mod Phys. 2013; D. 22(12):1341017.

42. Forward R. Rocket engine on the substance of negative mass. J of Propulsion and Power. 1989; 28–37.

43. Bonnor WB, Swaminarayan NS. An Exact Solution for Uniformly Accelerated Particles in General Relativity. Zeitschrift für Physik. 1964; 177: 246–256.

44. Bonnor WB. Negative Mass in General Relativity. General Relativity and Gravitation. 1989; 24: 1143–1157.

45. McIntosh CBG. Relativistic Analogs of Scalar-Tensor Cosmologies // Journal of Mathematical Physics. 1970; 11. 250–253.

46. Hoyle F, Narlikar JV. Mach's principle and the creation of matter. Proceedings of the Royal Society A. 1963; 273. 1–11.

47. Dicke RH. Mach's Principle and Invariance under Transformation of Units. Physical Review. 1962; 125: 2163–2167.

48. Vorontsov-Velyaminov BA. Interactions of galaxies and the nature of their branches, bars and tails. Morphology of galaxies V. Astronomical Journal. 1958; 35:858–869.

49. Golovkin BG. New particle mechanics with negative mass. World Scientific News. 2019; 126: 283–290.

50. Golovkin BG. New principle of equivalence of inertial and gravitational masses. Noosphere Society Human. 2019; 5; http://noocivil.esrae.ru/263-2044

51. Golovkin BG. Mechanics of particles with negative and imaginary mass. Part I. Noosphere Society Human. 2020; noocivil.esrae.ru/265-2054

52. Golovkin BG. Gravitational interactions of bodes from the point of view of different principles of equivalence. World Scientific News. 2020; 141: 48–65.

53. Terletsky YaP. Paradoxes of the theory of relativity. Electronic edition: Almanac "Thoughts About Truth". 2015.11.07.

54. Forward RL. Negative matter propulsion. Journal of Propulsion and Power. 1990; 6: 28–37. doi:10.2514/3.23219.

55. Landis G. Comments on Negative Mass Propulsion. J Propulsion and Power. 1991; 7(2): 304. doi:10.2514/3.23327.

56. Terletsky YaP. Paradoxes of the theory of relativity. M. Science. 1966.

57. Terletsky YaP. Negative Masses and the Energy-Sources of the Universe. Experimentelle Technic der Physik. 1981; B.29:331 – 332.

58. Terletsky YaP. Materials of the VII All-Union Conference "Modern theoretical and experimental problems of the theory of relativity and gravitation. Yerevan. 1988; 457.

59. Golubev SM. Quasicrystalline structure of vacuum. The key to unraveling the mystery of living cells and quantum particles. M. Book House. "LIBROCOM". 2014; 262. ISBN 978-5-397-04422-6.

60. Ishkhanov BS, Kapitonov IM, Yudin NP. Particles and atomic nuclei. M.: LENAND. 2019; 548:672.

61. Bogush AA. Introduction to gauge field theory of electroweak interactions. Minsk. Science and Technology. 1987; 185; 359.

62. Sakharov AD. Cosmological model of the Universe with a time vector inversion. JETP Lett. 1980; 52: 349–351.

63. Barbour J, Koslowski T, Mercati F. Identification of a Gravitational Arrow of Time. Physical Review Letters. 2014. 113 (18): 181101.

64. Hossenfelder S. A Bi-Metric Theory with Exchange Symmetry. Physical Review. 2008; D. 78(4): 044015. arXiv:0807.2838. Bibcode:2008PhRvD..78d4015H doi:10.1103/PhysRevD.78.044015. S2CID 119152509.

65. ALPHA Collaboration; Charman AE, Amole C, Ashkezari MD, Baquero-Ruiz M, Bertsche W, Butler E, Capra A, Cesar CL, Charlton M, Eriksson S, Fajans J, Friesen T, Fujiwara MC, Gill DR, Gutierrez A, Hangst JS, Hardy WN, Hayden ME, Isaac CA, Jonsell S, Kurchaninov L, Little A, Madsen N, McKenna JT, Menary S, Napoli SC, Nolan P, Olin A, Pusa P, Rasmussen CØ, Robicheaux F, Sarid E, Silveira DM, So C, Thompson RI, van der Werf DP, Wurtele JS, Zhmoginov AI. Description and first application of a new technique to measure the gravitational mass of antihydrogen. Nat Commun. 2013;4:1785. doi: 10.1038/ncomms2787. PMID: 23653197; PMCID: PMC3644108.

66. Morris MS, Thorne KS, Yurtsever U. Wormholes, time machines, and the weak energy condition. Phys Rev Lett. 1988 Sep 26;61(13):1446-1449. doi: 10.1103/PhysRevLett.61.1446. PMID: 10038800.

67. Cramer JG, Forward RL, Morris MS, Visser M, Benford G, Landis GA. Natural wormholes as gravitational lenses. Phys Rev D Part Fields. 1995 Mar 15;51(6):3117-3120. doi: 10.1103/physrevd.51.3117. PMID: 10018782.

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115

68. Hawking S, Norton WW. The Future of Spacetime. 2002; 96.

69. Golovkin BG. Newton's Second Law in Special Theory of Relativity. Journal of Physics & Optics Sciences. 2022. SRC/JPSOS/199. DOI: doi.org/10.47363/JPSOS/2022(4)173

70. Golovkin BG. Phase transition of matter to a massless state. Conference materials: “Gravity 2023”. https://disk.Yandex.ru/d/s5-zv3VLNII08g

71. Tolman RC. XLIV. Non-Newtonian mechanics:—The direction of force and acceleration. The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science. 22: 129; 458–463.

72. Golovkin BG. Proof of Einstein`s postulates. Ann Math Phis. 2022; 13-20.

73. Feinberg EL. Is it possible to consider the relativistic change in the scales of length and time as a result of the action of some forces? Einstein collection (1975-1976). M. Science. 1978;. 43-77.

74. Golovkin BG. A substance with negative mass. Ann Math Phys 2023; 6(2): 119-125. DOI: https://dx.doi.org/10.17352/amp.000091

75. Syrovatsky SI. On the question of the "delay" of the relativistic contraction of moving bodies. Einstein collection (1975-1976). M. Science. 1978; 78-81.

76. Thomson JJ. The corpuscular Theory of Mutter. London. 1907.

77. Deagostini M. Fernando Corbalan. The Golden Ratio. The Beautiful Language of Mathematics. Deagostini. 2010. 2013.

78. Bilaniuk OM. Sudarshan ECG. Particles Beyond the Light Barrier. Physics Today. 1969; 22: 43.

79. Vygodsky MYa. Handbook of higher mathematics. M. FIZMATLIT. 1973; 425-872.

80. Lobanovsky MG. Foundations of natural physics. M. "Higher School". 1990; 264. ISBN 5-06-000535-6.

81. Golovkin BG. Theory of photon aging. Noosphere. Society. Human. 2017. No. 8. URL: http://noocivil.esrae.ru/253-175988. J.J. Thomson. / The corpuscular Theory of Mutter. // London. 1907.

82. Golovkin BG. Generation of a substance with negative mass. Ann Math Phys. 2024; 067-071. DOI: https://dx.doi.org/10.17352/amp.000108.

83. Kaufmann W. The electromagnetic mass of the electron. Physical Journal. 1902; 54-57.

84. Kaufmann W. About the constitution of the electron. Annals of Physics. 1906; 19: 487-553.

85. Malkovsky GP. On mass and energy in modern physics. Ed. Kazan University. 1961; 180.

86. Kovner MA. Electronic theory and theory of relativity. Ed. Saratov University. 1967; 296.

87. Zavelsky FS. Mass and its measurement. M. Atomizdat. 1974; 240.

88. Shpolsky EV. Atomic physics. T. 1. Ed. "Science" Ch. ed. PHYSMATLIT. M. 1974; 576.

89. Zahn CT, Spees AH. Specific charge of decaying radium electrons. E. Physical Review. 1938; 53: 365-372. DOI:https://doi.org/10.1103/PhysRev.53.365

90. Rogers MM, McReynolds AW, Rogers FT. A Determination of the Masses and Velocities of Three Radium B Beta-Particles. Physical Review. 1940; 57: 379-383. http://ivanik3.narod.ru/Vacuum/p379_1Rogers.pdf

91. Golovkin BG. The speed of the body at the moment of transition to a massless state is a new world constant. Ann Math Phys. 2023; 6(2): 114-118. DOI: https://dx.doi.org/10.17352/amp.000090

92. Guye CE, Lavanchy C. Experimental verification of the Lorentz-Einstein formula using high-speed cathode rays. Archives of Physical and Natural Sciences of Geneva. 1916; 42: 286-299 & 353-373 & 441-448.

93. Guye CE, Ratnowsky S. Experimental determination of the variation in inertia of cathode corpuscles as a function of Speed. Archives of Physical and Natural Sciences of Geneva. 1911; 31: 293-321.

94. Karim Y. Towards an experimental verification of the theory of special relativity: replication of the experiments of Charles-Eugène Guye (1907-1921). Other [q-bio.OT]. Claude Bernard University - Lyon I; University of Geneva, 2011. French) .

95. Zahn CT, Spees AH. An improved method for the determination of the specific charge of beta-particles. Physical Review. 1938; 53: 357-365.

96. Golovkin BG. Temperature of the molecule. Distribution of gas molecules by their temperatures. East European Scientific Journal. 2015; 4: 103-105.

97. Buchholz NN. Basic course of theoretical mechanics. Part I. Ed. The science. Ch. Ed. PHYSMATLIT. M. 1972; 345: 468.

98. Treder HJ. Gravitational theory and equivalence principle. Academy Publishing Berlin. 1971.

99. Repchenko ON. Field physics or how the World works? M.: Gallery. 2008; 320.

100. Golovkin BG. Realization of Equilibrium Distributions of Molecules in Gases. To Physics Journal. 2019; 4. ISSN: 2581-7396 http://www.purkh.com/index.php/tophy 61

101. Okun LB. Leptons and quarks. M. “Science”. Main editorial office of physical and mathematical literature. 1990; 346. ISBN 5-02-014027-9.

102. Golovkin BG. Temperature of the molecule. Engineering Physics. 2016; 11: 22-24.

103. Golovkin BG. Physical meaning temperature of gas and separate molecule. World Scientific News. 2018; 94: 313–320.

104. BG. Golovkin. Distribution of the lengths of free paths of gas molecules. // World Scientific

105. Golovkin BG. Distribution of gas molecules by their temperatures. World Scientific News. 2020; 144: 89-102.

106. Serov NV. Information model of quantization in the periodic system of elements. Information Processes and Systems. 2022; 11: 31-34.

Citation: Golovkin BG (2024) High temperature negative mass plasma. Ann Math Phys 7(1): 118-137. DOI: https://dx.doi.org/10.17352/amp.000115