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SHORT COMMUNICATION

New Particle Mechanics with Negative Mass

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ABSTRACT

A new mechanics of physical objects with negative mass is proposed. Their properties are explained by the positive inertia of any body with a mass of any sign. Accordingly, the principle of equivalence of inert and gravitational masses has been adjusted. Particles of negative mass repel each other from bodies with a positive mass and attract each other, forming huge islands of negative matter. Such particles are called negaons. The energy and temperature of the negaons are negative.

Keywords: negative mass, negatons, negaons, positons, equivalence principle, inertial mass, gravitational mass

1. INTRODUCTION

The first report on negative masses was made back in 1897 [1]. Further, it was developed in many papers [2-8]. Until 1981, particles with negative mass were called "minus particles". In 1981, Ya. P. Terletsky [6], it was proposed to call them negatons, and particles of positive mass – positons. A review of the literature on the theory, synthesis, properties and possible applications of particles with negative mass is given in the work [3].

No law of physics contradicts the existence of negative masses, in particular, the laws of conservation of energy and momentum are satisfied for them. At present, according to the proposal of G. Bondi [2], in any theory of gravity, in accordance with the method of measurement, it is customary to distinguish three types of mass: inert m_i, passive gravitational m_p, and active gravitational mass m_a. Inertial mass is the mass that characterizes the body's ability to acquire a given acceleration under the action of non-gravitational forces applied to it. It enters Newton's second law, acquires a certain acceleration under the action of an applied force

$$\boldsymbol{F} = F^\alpha = m_{\mathbf{i}} a^\alpha \tag{1}$$

$$\mathbf{a} = \mathbf{F}/m_i, \tag{2}$$

from where

$$\boldsymbol{F} = m_i \boldsymbol{a}. \tag{3}$$

The passive gravitational mass of the body characterizes the effect of the gravitational field U on it and is determined by the expression

$$F_\alpha = -m_p \frac{\partial U}{\partial x^\alpha} \tag{4}$$

Active gravitational mass m_a of the body characterizes its ability to create a gravitational field. Both gravitational masses are included in the formula of Newton's law of the world:

$$\boldsymbol{F}_g = -G \frac{m_p \cdot m_a \mathbf{r}}{r^3}, \tag{5}$$

where $\mathbf{F}_g$ − the attractive force of two bodies with masses m_p and m_a, G − the gravitational constant, $\mathbf{r}$ − the radius-vector connecting the centers of these masses.

The equivalence principle [9] postulates the equality of these types of mass:

$$m_i = m_a = m_p. \tag{6}$$

It was on the basis of this principle that the mechanics of the interaction of particles with negative mass between themselves and particles of positive mass was derived. Additionally, it was assumed that all known laws of physics for bodies of positive mass are also valid for bodies of negative mass. This principle allows you to write an expression of equality of inertial forces and forces of gravitational interaction:
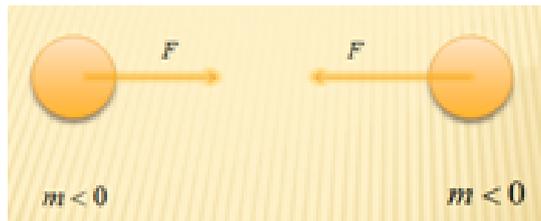
$$F = m_i a = -G \frac{m_p m_a}{r^2} \tag{7}$$

Consider on the basis of equality (7) the interaction of two bodies of positive mass:
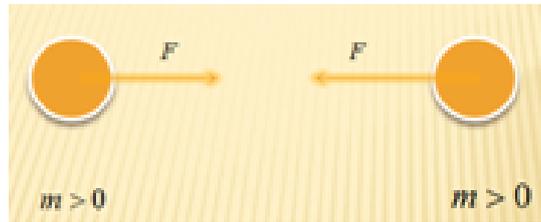
(Fig. 1)

As can be seen from Figure 1, if the mass of both bodies is positive, the bodies are attracted. We observe this phenomenon every day when bodies fall to the ground. Now consider the case when the mass of both bodies is negative (negatons) (Fig. 2):


(Fig. 2)

Substituting the values of the masses in the formula (5), we obtain a positive value of the force. Consequently, negative mass bodies should also be attracted. Consider the case when two bodies have a mass of different sign (Fig. 3).


(Fig. 3)

When substituting masses in formula (5), the result will be negative. Consequently, the body must repel. However, upon a deeper examination, we will come across "pitfalls". If the mass is negative, then the acceleration is negative, which follows from Newton's second law (3) (Fig. 4):
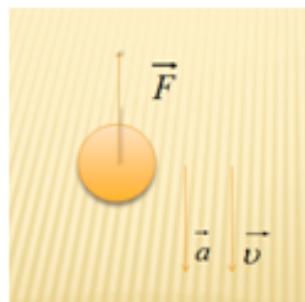
(Fig. 4)

From this it follows that the body will move in the opposite direction of force. Let's reconsider the previous examples taking into account this conclusion. As can be seen from Fig.

5, bodies with a negative mass will repel, and bodies with different masses will move in the same direction.
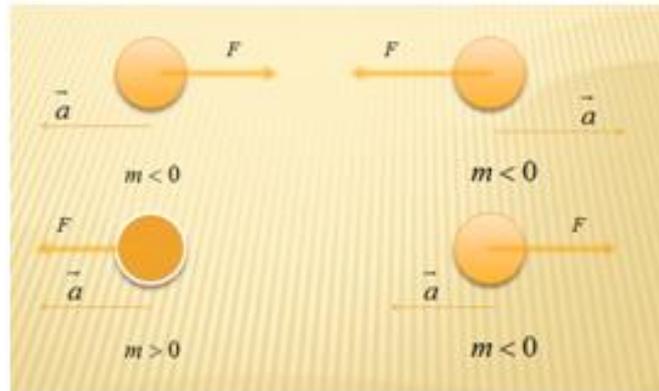
(Fig. 5)

At first glance, the latter phenomenon violates the law of conservation of momentum: two bodies cannot just fly in one direction. But since the mass of one of the bodies is negative, then its impulse is negative, therefore, it is quite possible. This circumstance can create a big problem for the study of negative mass: even if we can get it, we will not be able to move it, because when it tries to move in the way we are used to, it will tend to move in the opposite direction. We move it straight, and it goes backwards.

Despite the seemingly logical prerequisites for constructing the mechanics of particles with negative mass, such a formal method to solve the problem of their interactions with positons and with each other, led, however, to unreliable results. This primarily refers to the fact that when trying to move the body in the usual way for us, the body will tend to move in the opposite direction. The purpose of this work is to eliminate the drawbacks of the formalism of the method previously used [1-8] and to propose a corresponding updated mechanics of the interaction of particles with a negative mass.

2. NEW PRINCIPLE OF EQUIVALENCE

In many theories, mass is perceived as the amount of substance in the body. Just as particles can have an electric charge, they can have a positive or negative gravitational charge. However, unlike electric charges, of which the body can have different quantities, gravitational charges in substances known to us are always contained in quantities proportional to body mass, from which it follows that body mass is always saturated with a gravitational charge. This circumstance does not exclude the possibility of the existence of bodies with the same inertial masses, but different quantities of gravitational charges of the same, although such are not known to us yet. In Newton's second law (3), the inertial mass acts as a quantity of substance. It plays the role of resistance to the movement of the body, regardless of whether it has a gravitational charge: positive or negative, since the inertia of the body is determined by the movement of the body relative to the entire Universe. Therefore, in order to take into account the behavior of negative masses, the generalized second law of Newton must be of the form:

$$\mathbf{F} = |m_i|\mathbf{a} \qquad (8)$$

From the expression (8) it follows that for the inertial force is important the amount of substance in the body, and not the amount and sign of the gravitational charge contained in the mass of this body. Naturally, when: $m_a \geq 0$; $m_p \geq 0$:

$$|m_i| = +m_a = |m_a| \tag{9}$$

$$|m_i| = +m_p = |m_p| . \tag{10}$$

For negative values $m_a < 0$; $m_p < 0$:

$$|m_i| \neq -m_a, \quad \text{но} \quad |m_i| = |m_a| \tag{11}$$

$$|m_i| \neq -m_p, \quad \text{но} \quad |m_i| = |m_p| . \tag{12}$$

Thus, the new equivalence principle, taking into account the possibility of the existence of particles of negative mass, can be written in the form:

$$|m_i| = |m_a| = |m_p| \tag{13}$$

It follows from formulas (8) and (13) 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, and the equality of the inertial force to the force of gravitational interaction (7), in accordance with the new equivalence principle (13), will look like:

$$F = |m_i|a = -G\frac{m_p m_a}{r^2} . \tag{14}$$

Particles of negative mass, subject to the new equivalence principle (13), in contrast to negatons. Terletsky [6], we will call negaons and to the terms of objects with negative mass, we will add the prefix "nega": negaparticles, negaelectron, negapositron, negaantiproton, negasubstance, negamaterial, negastar, negaplanet, negagalaxy, Negauniverse, etc.

3. PROPERTIES OF NEGAONS

The kinetic energy E of the particle and its temperature τ can be represented by the formulas [10]:

$$E = mv^2/2 \tag{15}$$

$$\tau = \frac{l}{kr} \cdot \frac{mv^2}{2} = \frac{l}{kr}E, \tag{16}$$

where $k-$ Boltzmann constant; $m,\ r,\ v,\ l-$ respectively, the mass, radius, speed and length of the particle free path (the formula for the distribution of the free paths of gas molecules

depending on their size, temperature and gas pressure is given in [11]). If we substitute in the formulas (15, 16) negative mass values corresponding to negaons, then we obtain that the energy and temperatures of negaons will be negative.

Consider, on the basis of the equivalence principle (13) and equality (14), the interaction of two bodies of positive mass. As can be seen from Figure 1, if the mass of both bodies is positive, then the bodies are attracted. Now consider the case when the mass of both bodies is negative (negaons) (Fig. 2). Substituting the values of the masses in the formula (14), we obtain a positive value of force. Consequently, negative mass bodies should also be attracted. Consider the case when two bodies have a mass of different sign (Fig. 3). When substituting the masses in formula (14), the result will be negative. Consequently, the body must repel. In the above reasoning, there are no "pitfalls". If the mass is negative, then the acceleration is positive, which follows from Newton's second law (8). From this it follows that the body will move in the direction of the acting force.

Considering the above properties of negaons, it is easy to make sure that they, pushing away from ordinary matter of positive mass, and attracting each other, will accelerate away from positive mass bunches, galaxies and metagalaxies, and form huge colonies of negative masses, negagalacxies and negametagalaxies. When negaelectrons collide with negapositrons, they will be annihilated with the formation of negaphotons. The photons from our positon Universe will deviate from the negagalaxies, just as the negaphotons will, in their motion, repel from the positon objects. However, if in some artificial way to arrange a meeting of negaons with positons, for example, a frontal collision, then, having come close to a certain critical distance, they should begin to scatter in the opposite directions. If the collision is not strictly frontal, then before flying apart, they will first rotate around each other for a while with a decrease in oncoming speed. If the sizes of the particles encountered are in some integer relation with the sizes of the orbits of their rotation, then these orbits can become stationary. In this way, it is possible that the formation of "mixed atoms" from negaons and positons is possible.

The existence of negasubstance confirms the dark matter hypothesis [12, 13] and explains the following facts:

- Stars and galaxies move "too fast" at a given distribution of visible matter. They would not have stable orbits, if they were not kept in their orbits something else massive and invisible. Such massive objects could be negaobjects that are located nearby, which push stars and galaxies from all sides towards their center of mass, which is equivalent to the additional attraction of stars and galaxies among themselves.
- Rays of light deflected in gravitational fields too much. Visible matter is not able to provide the effect of the observed magnitude. The explanation is simple: light, like other matter, is pushed off by nonmaterial into the side of stars and galaxies and thereby increases the usual force of attraction of light to material objects.
- Dark matter is concentrated in "bunches", like ordinary matter and does not experience collisions with ordinary matter. The properties of the negaons described above correspond to these conclusions.
- Places of clusters of ordinary and dark matter mostly coincide. This conclusion only says that there are places of clusters of negamatter near the stars and galaxies. As for remote clusters of negamatter, since they do not emit photons, and negaphotons are pushed back by the matter of stars and galaxies towards negaobjects, there is no reason to deny their existence.

4. CONCLUSIONS

The existence of substances with negative mass does not contradict 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. Consequently, there are no logical restrictions on its existence.

In addition, its existence closes a big gap in the Big Bang theory, according to which the Universe appeared "out of nothing", which is impossible, according to classical mechanics, since the law of conservation of mass is violated. But if we assume the existence of negative mass, then we can make an important conclusion: the total mass of the Universe has always been and still remains zero!

For the manufacture of a pair of bodies with equal in magnitude and of different sign masses, zero energy is necessary. Therefore, a contradiction in the big bang theory is eliminated, and the existence of a negative mass is very likely.

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