Review Article
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Elimination of incompatibility of mass defect with the law of its conservation

Abstract

The article shows that the so-called "mass defect" (a decrease in the total mass of nucleons when they merge in a nucleus) can be explained without violating the law of its conservation and proportionality of energy, if we exclude the postulates of the theory of relativity associated with the conversion of mass into energy. The need to consider the mass balance of by-products of the fusion reaction and the radiation accompanying it, in total equal to the "mass defect" is substantiated. The energy-consuming nature of the processes of cold and hot fusion, the cause of its occurrence and the source of fusion energy, which is the hidden mass of the Universe, are revealed. The reasons for the irreversibility of the nucleosynthesis process are named and the concept of its efficiency is introduced, the vanishing of which corresponds to the equality of the rates of synthesis and decay of chemical elements. On this basis, a conclusion is made about the inconsistency of the idea of using binding energy in hot and cold fusion power plants.

Keywords: primary and secondary nucleosynthesis, hidden mass, binding and fusion energy, mass balance, counter-direction of decay and fusion, irreversibility and efficiency.

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Introduction

"What we currently consider as particles are actually waves."

E. Schrödinger[1]

Currently, heat generation processes in nuclear fusion reactions are interpreted as a consequence of the transformation of the "mass defect" (the difference between the sum of the masses of particles in a free and bound state) into energy.[1,2] In this case, the source of heat is considered to be the internal energy of light elements present in nature. In this case, the fusion process appears as the burning of "nucleon fuel" stored by the Universe at an unknown time. The participation in this process of the medium, which was called "subtle matter" in ancient Indian philosophy four millennia before the introduction of the concept of "ether" by R. Descartes (17th century), is ignored. The situation did not change even after astronomers and astrophysicists of the twentieth century discovered the presence of "hidden mass" in the Universe, the share of which, judging by its influence on the movement of celestial bodies, is at least 95% of the amount of matter in it.[3] Not wanting to return the ether to physics, which was expelled from physics at the beginning of the 20th century, this subtle matter began to be called "physical vacuum", "physical field", "dark matter", "dark energy", etc. However, its participation in the balance of mass and energy of nucleosynthesis processes is still not considered, although there is no other medium in nature from which chemical elements would arise.

In this article, we will not touch upon the properties of this medium and the "mechanism" of this process, since these issues are devoted to our other articles.[4-8] We will not identify this medium with the substances mentioned above, calling it here abstractly "cosmic vacuum". The only thing we will do is discuss what the properties of this "cosmic vacuum" should be in order to avoid a contradiction with the laws of conservation of mass and energy.

Balance of mass and energy in nucleosynthesis processes

The concept of mass defect follows from the interpretation of the principle of equivalence of mass M and energy E, proposed by A. Einstein in 1905 and expressed by the relationship:[9]

$$E=Mc^2. \tag{1}$$

Einstein obtained this relationship by postulating the existence of a relativistic mass $M_{rel}(\upsilon)$, depending on the translational velocity υ, expanding this dependence in a series and limiting himself to its first two terms. Since this dependence was assumed to be universal, he extended expression (1) to all material objects, interpreting it as the possibility of converting a small mass M into a huge amount of energy E. This revolutionized the understanding of the behavior of matter at the atomic and subatomic levels, laying the foundation for nuclear physics. The development of technical means of the latter (in particular, mass spectrometers) made it possible to measure the mass of charged ions of matter with unusually high accuracy, which led to the discovery of the so-called "mass defect" ΔM − the difference between the total masses of the reactants and products of nuclear reactions:

$$\Delta M = (Zm_p + Nm_n - M_z), \tag{2}$$

where Z, N is the number of protons and neutrons with masses m_p and m_n, which are in an unbound state; M_z is the mass of the nucleus.

A kind of "missing mass" arose, which led to a violation of the law of its conservation (hence the concept of "mass defect"), as well as the principle of its equivalence (1). This incompatibility of the mass defect with the law of its conservation of mass was noticed by nuclear scientists, but was interpreted by them, following A. Einstein, as a consequence of the transformation of mass into energy. This made it possible to explain the release of energy in nuclear reactions and played a decisive role in understanding the processes of nuclear fusion and fission, as well as the stability of nuclei. Thus, the discovery of the defect led to the development of the theory of nuclear binding energy E_b, the value was taken to be equal to $c^2\Delta M$ regardless of the nature of the substance.

From the act of positivity of the mass defect, a far-reaching conclusion was made about the release of binding energy both during the decay and synthesis of chemical elements. The violation of the dialectic of nature did not bother nuclear scientists. On the contrary, thermonuclear fusion began to be interpreted as the only source of energy of stars, "stored" by them at an unknown time and in an unknown way in the form of hydrogen-like atoms. Moreover, on this basis, grandiose and extremely expensive projects arose to create nuclear reactors for the synthesis of light elements, the practical implementation of which nuclear physicists have been unsuccessfully struggling for more than 60 years.

In this regard, questions of a paradigmatic nature are appropriate. In particular, why, despite the discoveries of recent decades, does the equation of the Moussa balance (2) not take into account the participation of the medium from which the nucleons appearing in it were formed? Is there another source of mass and energy of stars, other than the fictitious binding energy? How long will the concept of empty space separating nucleons in space dominate physics? The answers to these questions from the standpoint of energy dynamics as a unified theory of the processes of transfer and transformation of any forms of energy[10] will be the subject of the rest of the article.

The principle of the opposite direction of nonequilibrium processes as the basic law of dialectics

Energodynamics[8] adheres to the deductive method of research (from the general to the particular), considering as a system the complete set of interacting (mutually moving) material objects and the fields they create. All the energy of such a system U and all the processes occurring in it are internal, which requires the use of thermodynamic methods. Along with this, energy dynamics introduces parameters of spatial heterogeneity, allowing us to take into account the dependence of the system's energy U on the distribution of all its carriers Θ_i (mass M, numbers of moles of k-th substances N_k, charge 3, entropy S, momentum **P**, its momentum **L**, etc.) over the volume V it occupies.

If the value of Θ_i is represented by the integral of its local $\rho_i(\mathbf{r}, t) = d\Theta_i/dV$ and average density $\overline{\rho}_i(t) = \Theta_i/V$ by the integral $\Theta_i = \int\rho_i dV = \int\overline{\rho}_i dV$, then it is easy to obtain the identity:10

$$\int(\rho_i - \overline{\rho}_i)dV \equiv 0. \quad (3)$$

Expression (3) does not depend on whether it remains constant or changes due to the exchange of heat, matter, momentum or energy between the heterogeneous system and the environment. It does not depend on whether the conservation laws are valid for them, what the structure and physical and chemical properties of the system are, the speed of the processes occurring in it, the meaning of the parameters Θ_i, etc. In any case, it follows from identity (3) that in homogeneous systems, i.e., with the equality ρi - at all points of the system, no processes d(ρi -)/dt are possible in it. Consequently, the Universe as a whole and any of its regions in which any processes occur should be considered as spatially inhomogeneous (internally nonequilibrium). For ease of reference, we will call this general physical position the "principle of inhomogeneity". It implies the need to rely on the mathematical apparatus of nonequilibrium thermodynamics or continuum mechanics. Further, from the same identity (3) it follows that at least those occurring in any part of a heterogeneous system (including the Universe as a whole) would at least partially be counter-directed, i.e. $\rho_i - \overline{\rho}_i$, their speeds $d(\rho_i - \overline{\rho}_i)/dt$ would have the opposite sign. For ease of reference, we called this position the "principle of counter-directed processes". In essence, it corresponds to the well-known law of dialectics on the "unity and struggle of opposites" and can serve as its mathematical expression. In application to nucleosynthesis processes, this dialectical principle states that if nuclear decay reactions are accompanied by the release of energy (which has been confirmed experimentally), then the opposite reactions of nuclear synthesis should be accompanied by the absorption of energy (i.e. be energy-consuming).[9] This also applies to the mass balance equation, according to which the decrease in mass during nucleosynthesis should be accompanied by the formation of "by-products" of mass M_b and radiation that carries away the "missing" mass $M_k = \Delta M - M_n$, which corresponds to a mass balance equation of the form

$$Zm_p + Nm_n = M_z + M_b + M_r, \quad (4)$$

satisfying the law of conservation of mass. The presence of such by-products of the synthesis reaction, as well as radiation of unknown nature, has been reliably confirmed by experiments.[12]

Similarly, if in some areas of the Universe processes of the "supernova explosion" type occur, then in others processes of substance synthesis should be observed. In other words, there should be an antipode of the material (baryonic) form of matter, which changes its state in the opposite way in the process of interaction with it. Such an antipode is the "hidden mass" discovered by astronomers and astrophysicists, no matter what model of it (ether, physical vacuum, electromagnetic field, dark matter, or dark energy) we adhere to. All forms of matter in the Universe were formed from it.

Processes of "reification" of hidden mass

The inhomogeneity of the cosmic vacuum inevitably leads to the emergence of density fluctuations in it. Indeed, since the local density ρk of any k-th type of matter depends on the radius vector of its field point r and time t, i.e. ρk = ρk(r, t), then the total change in time of this density includes convective $(\boldsymbol{\upsilon}_k\cdot\nabla)\rho_k$ and local $(\partial\rho_k/\partial t)_\mathbf{r}$ and the components:

$$d\rho_k/dt = (\partial\rho_k/\partial t)_\mathbf{r} + (\boldsymbol{\upsilon}_k\cdot\nabla)\rho_k, \quad (5)$$

From the standpoint of oscillation theory, this expression represents the so-called "kinematic" equation of a first-order wave, in which dρo/dt plays the role of the "damping function" of the wave. At $d\rho_o/dt = 0$, its right-hand side describes a standing wave of its density (∂ρo/∂t) r, arising due to the influx of the medium from adjacent regions of space at a speed of υ_o under the action of the gradient ∇ρ (Figure 1). A feature of these waves in the hidden mass is the limitation of their amplitude "from below" (in the region, $\rho_o < \overline{n}_i$),), since it cannot exceed the value of the average density ~ 10^{-29} g cm^{-3}, while the height of the wave "from above" ($\rho_o > \overline{n}_i$) is not limited by anything.[13] In nature, an example of such a wave is a tsunami arising at a shallow depth. Such "solitary," structurally stable and particle-like waves of "elevation" are called solitons. Becoming traveling, such waves transfer, like a tsunami, not only energy, but also mass. The creation of such waves requires a certain amount of work W, which in Newtonian mechanics is determined by the expression:

$$W = \int\boldsymbol{\upsilon}_o\cdot d\mathbf{P}_o, \quad (6)$$

where $\boldsymbol{\upsilon}_o$, $\mathbf{P}_o = M\boldsymbol{\upsilon}_o$ − the speed and momentum of the ordered motion of the object of study.

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The speed υ_o, of propagation of disturbances creating such a wave, is a property of the medium. If it is constant, integration (6) yields a value known as the "living force" of G. Leibniz:

$$U_o = M\upsilon_o^2. \quad (7)$$

It is characteristic that it was in this form that the energy of the ether was expressed even before A. Einstein by H. Schramm (1871); N. Umov (1873); J. Thomson (1881); O. Heaviside (1890), A. Poincaré (1898) and F. Hasenohrl (1904). It was this quantity that, at the suggestion of T. Young, began to be called energy in the 19th century, and after the introduction of the concept of external potential energy – internal energy.

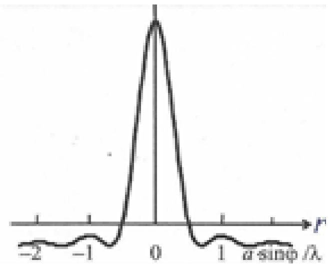

Figure 1 Standing soliton.

Expression (7) allows us to find the law of gravity in the latent mass as a field medium, where in principle it is impossible to distinguish either "field-forming" or "test" masses. Since for field quantities it is more convenient to relate all extensive quantities to a unit of volume, we will operate with the concept of the energy density of the gravitational field $\rho_g = dU/dV = \rho c^2$ (J m^{-3}). The gradient of this energy has the meaning of the gravitational field strength $\mathbf{X}_g = \rho\mathbf{g}$, which at c = const becomes a function of the density gradient of the substance $\nabla\rho$:[14]

$$\mathbf{X}_g = c^2\nabla\rho, \text{ или } \mathbf{g} = c^2\nabla\rho/\rho. \quad (8)$$

This intensity can have a different sign depending on the sign of the density gradient $\nabla\rho$. Therefore, we called expression (4) the bipolar law of gravitation. Newton's law of gravitation follows from it as a special case for the pairwise interaction of two bodies.[14] This makes the bipolar law of gravitation (8) universal, and Coulomb's law, which has the same structure, a special case (8) $_{Ee} = \varphi^2\nabla\rho_e$, where φ, ρ_e are the electric potential and the density of the electric charge. Due to $\varphi^2 < c^2$, the electrostatic forces of interaction of charges in matter, caused by the non-uniform charge density, are weaker than gravitational forces and do not depend on the sign of the charge. In the hidden mass, which is not observed precisely because of its non-participation in electromagnetic interactions, these forces are completely absent. This makes the gravitational forces in the hidden mass the only ones, and the interaction itself the strongest of its known forms at equal relative density gradients $\nabla\rho/\rho$. According to (8), these forces in the region ρo > have the character of attractive forces (towards the region of increased density), and in the region ρo < − the character of forces of "repulsion" of antinodes (Fig. 2), which is observed in the Universe during the expansion of voids and the "dispersion" of galaxies. In this case, the main feature of the bipolar law is the absence of gravitational forces in the antinode of the wave (where $\nabla\rho=0$), i.e., the presence of gravitational equilibrium between them. This explains the stability of the group soliton as a discrete wave packet, previously attributed to the photon, as well as the atom formed during the compaction of the group soliton to the state of matter. In this case, the atom can be represented as a group soliton consisting of a central core (nucleus) surrounded by spherical waves – shells (Figure 2). In such a (wave) model of the atom there is no dualism, no quarks, gluons, protons, electrons, neutrons, etc. - there are oppositely twisted solitons of different frequencies, which are true quanta,[15] It is distinguished by its stability in the absence of any other forces, including the "Coulomb barrier". Its absence removes the "prohibition" of nuclear physics on the implementation of "cold" nuclear fusion, which is observed in living and nonliving nature at all levels of the universe during the "condensation" of hidden mass but is not recorded by existing technical means due to its low speed and intensity. It is necessary to show that this process is also associated with the release of energy, however, not the above-mentioned binding energy, but the energy of the hidden mass released during its condensation.

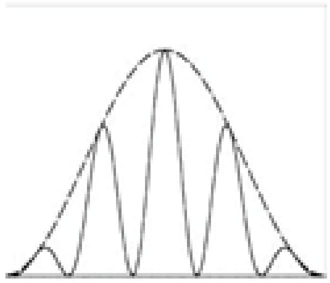

Figure 2 Cross-section of an atom as a group soliton.

Energy-consuming nature of nucleosynthesis

Energodynamics, which generalizes the thermodynamic method of research to non-thermal processes, considers nucleosynthesis as an internal process of local structuring of the "reification" of hidden mass as a field form of matter, i.e., as a phase transition of a non-baryonic medium into a baryonic one. This process is associated with an increase in the heterogeneity of the hidden mass and therefore requires work to be done "against equilibrium" in it. This work is done at the expense of the "living force" of the hidden mass, the condensation of which releases energy equal to 931.5 MeV/a. m. This energy is two orders of magnitude higher than the binding energy, which does not exceed 8.8 MeV/a. m. The driving force of this process is the potential difference between the hidden mass $\psi_g = c^2$ and the substance $\psi_k = \upsilon^2$. This difference is always different from zero, which causes the continuous process of condensation of the hidden mass and, ultimately, the circulation of matter in the Universe. The evolutionary branch of this process includes the formation of nuclei and atoms, molecules and their compounds, the formation of gaseous, liquid, and solid bodies, nebulae and planets, stars, and galaxies - in a word, everything that is classified as ordinary (baryonic) matter.[16] From the standpoint of the wave concept of the universe, this looks like a compaction of group solitons with different frequencies and configurations of wave packets to a poorly defined state of matter, and from the corpuscular position - like the creation of elementary (without internal structure) particles with certain "innate" properties, the combination of which subsequently forms distinguishable substances. In this case, the "primary" nucleosynthesis assumes the presence of protons, electrons, neutrons, and quarks that appeared out of nowhere, ready to merge even in the absence of binding energy, as is the case with protium ^1H. However, in both cases, one part of the condensed hidden mass of M_o forms the target product, another part forms by-products with a mass of Mn, and the third part is carried away with α, β and γ radiation, as well as with other, even less studied, energy flows. Some of these flows are still considered, like photons, to be massless, although in reality the transfer of radiant energy is carried out by solitons, which, due to their asymmetric form, transfer not only energy and momentum, but also mass in the cosmic vacuum. This is confirmed by unusual mechanical damage (traces) on detectors.[17]

The relationship between the rate and irreversibility of nucleosynthesis and its efficiency

Since the mass defect, like the binding energy, is purely positive, modern nuclear physics considers the process of synthesis of transuranic elements to have no limit in principle. However, it has not yet been possible to find or artificially obtain chemical elements with an atomic number greater than 118. This indicates the incompleteness and even erroneousness of the modern theory of nucleosynthesis. Based on the concept of the mass defect. A criterion is needed that could predict the conditions for the onset of a balance of the rates of synthesis and decay of chemical elements. Such a criterion is proposed by energy dynamics in the form of the "power" efficiency η_N, expressed as the ratio of the power N_j at the output and input N_i in some converting device.[18] Unlike all other efficiency indicators, this efficiency considers the kinetics and operating mode of the installation, and its reduction to zero means the termination of the process. With regard to the processes of primary and secondary nucleosynthesis, this ratio can be expressed simply as the ratio of the energy of the target product U_k, $M_k\upsilon^2$, obtained per unit time, to the energy supplied from the energy source during the same time $U_o = M_o c^2$

$$\eta_N = U_k/U_o < 1. \quad (15)$$

Here, it should be taken into account, firstly, that in the process of "primary" nucleosynthesis of the k-th substance M_k from the "hidden mass" M_o, some part of its M_b is transformed into "by-products" of the synthesis M_b, and the other part M_r – is carried away with all the above-mentioned types of radiation. Therefore $M_k = M_z = M_o – M_b – M_r = (1 – \sigma)M_o$, where $\sigma = (M_b + M_r)/M_o$ is the loss fraction. In general, as is known, the mass of by-products of the reaction decreases with an increase in the charge number of the element being synthesized, but the probability of β-decay and emission of γ-radiation increases. Therefore, its value cannot be neglected. Secondly, it should be considered that the specific energy of the substance $\varepsilon_k = \upsilon_k^2$ is less than the specific energy of the source $\varepsilon_o = c^2$, which is not considered in any way when calculating the binding energy. Therefore, the efficiency value η_N at any stage of the nucleosynthesis process can (15) be expressed by the ratio:

$$\eta_N = (1 - \sigma) /n_k^2. \quad (16)$$

This indicator belongs to the category of relative efficiencies, which ideally (in this case, at $M_k = M_o$ and $n_k = 1$) reach unity. Its difference from this value characterizes the degree of irreversibility of the process. In this case, it is the irreversibility of a special pod, associated not with the transformation of the source energy into heat, It characterizes a special category of irreversible processes, in which the dissipation of the initial energy is caused not so much by its transformation into heat, but by the "branching" of the trajectory of the synthesis process in the space of variables along many "trajectories" (the formation of many "by-product" substances, massive and massless particles, neutrino flows, etc.). According to (16), the process of synthesis of new elements at $n_k > 1$ ends long before the share of losses due to radiation, nuclear decay, etc. reaches 100%. That is why no elements with numbers higher than 118 have been found in the depths of the Earth or in meteorites. This circumstance should be considered by nuclear physicists who spend enormous amounts of money to achieve unrealistic goals.

Conclusion

As we can see, the rejection of hypotheses and postulates in the foundations of the theory of nucleosynthesis leads to the conclusion about the inviolability of the laws of conservation of mass and energy, eliminates the contradiction of the mass defect with the law of its conservation and allows us to obtain results consistent with experience.

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