Review Article

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On the specific features of dark matter and dark energy

Abstract

The latest experimental evidence that dark matter and dark energy together account for at least 95% of the mass of the visible universe shows that their inherent gravitational interaction was the basis of all other forms of energy in it. At the same time, this sheds new light on the essence of the darkest matter as a "forerunner", from which all other forms of the baryonic matter of the Universe were formed. This implies the need to consider the reproduction of the substance of the Universe as a process of buying and losing degrees of freedom different from the original.

An equally important addition to the theory of the evolution of the Universe is the derivation of the law of gravitational interaction, independent of Newtonian mechanics, from which follows the dependence of gravitational acceleration on the magnitude and sign of the density gradient of the Universe matter, the existence of "strong" and "weak" gravity, gravitational forces of "attraction" and "repulsion"; "stable" and "labile" gravitational equilibrium, etc. and the redundancy of dark energy as some kind of additional material entity responsible for its accelerated expansion.

All these phenomena are considered in the article from the standpoint of energodynamics, which generalizes thermodynamics to non-thermal forms of energy. Such consideration also leads to the conclusion that there are standing and traveling gravitational waves of dark matter, that it has energy equivalent to its mass, and that it plays a role as a source of stellar energy. The data of astronomical observations of recent years are presented, which directly confirm the developed concept.

Keywords: astrophysics, dark matter, and dark energy; forces of attraction and repulsion; standing and traveling waves; processes of evolution and involution, circulation of the Universe.

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Introduction

One of the most grandiose discoveries of the 20th century was the experimental discovery of the presence of "dark" matter in the Universe,[1] and then of "dark" energy.[2] According to the data of observations of the Planck space observatory published in March 2013, the total mass of the observable Universe consists of 4.9% of light (baryonic) matter and 95.1% of dark matter and dark energy, with a common property the property of which is non-participation in any other interactions, except for gravitational ones.[3]

This circumstance radically changes our understanding of the universe. Classical physics considered the ether and the electromagnetic field as the antipode of baryonic matter. Quantum theory considered the physical vacuum as such an antipode. With the discovery of two more directly unobservable entities (dark matter and dark energy), there is a need for significant adjustments in modern astrophysics.[4] In this article, the essence of "dark matter" and "dark energy" is considered from the standpoint of energodynamics,[5] which is a synthesis of thermostatic (classical thermodynamics[6]) and thermokinetics[7] (thermodynamics of irreversible processes[8,9]). This theory combines the methods of equilibrium and non-equilibrium thermodynamics and extends them to non-thermal forms of energy. At the same time, dark matter is considered as an indispensable part of any part of the Universe, which is a continuous medium that can be described by continuous analytical functions in terms of density, regardless of its corpuscular structure.

On this basis, the article derives a previously unknown relation between gravitational forces and substance density gradients, from which follows the existence of gravitational forces of attraction and repulsion, the existence of strong and weak gravitation, as well as zones of stable and unstable gravitational equilibrium. In addition, the theory predicts that dark matter has huge reserves of free gravitational energy and its ability to transfer radiant energy by traveling waves. At the same time, it is shown how, in an initially invisible medium with a single (gravitational) degree of freedom, spontaneous processes of formation and decay of visible ("baryonic") matter arise, causing the reproduction of dark matter and the opposite direction of the evolution of individual regions of the Universe.

Methodological features of energodynamics as applied to astrophysical processes

Energodynamics is based on two obvious principles of a general physical nature, which make it possible to preserve the phenomenological and deductive nature of the thermodynamic method. The first of them (the principle of distinguishability of processes) is based on the theorem on the number of degrees of freedom, according to which the number of independent arguments of energy as a function of the state of an arbitrary thermodynamic system is equal to the number of independent (qualitatively distinct and irreducible to others) processes occurring in object research. By this principle, which is proven "by contradiction", dark matter, which has a single (gravitational) degree of freedom, should be considered as the initial substance of the Universe, and additional extensive state parameters should be added as arguments for energy only as any new ones appear in the system. processes. Thus, this principle excludes both "underdetermination" and "overdefinition" of the systems under study, which is the main source of methodological errors in most theories[5] and allows you to "cut off" unnecessary entities.

The second principle (oppositeness of processes) asserts the inevitability of occurrence during non-equilibrium processes of changes in the state (thermodynamic properties) that are opposite in nature in its various parts (areas, phases, components) of the system. To prove its validity, it is enough to divide the object of study with volume V into subsystems V' and V'', within which the density $\rho_i(\mathbf{r},t) = d\Theta_i / dV$ of any extensive parameter of the system Θ_i (mass M, entropy S, numbers of moles k-th substances N_k, charge Q, momentum components $\boldsymbol{P}$, its momentum $\boldsymbol{L}$, etc.) is greater or less than its average value $\bar{\rho}_i(t) = V^{-1}\int \rho_i dV = \Theta_i / V$. Then, due to the obvious equality $\int \rho_i dV = \int \bar{\rho}_i dV = \Theta_i$ we have:[5]

$$\int [\rho_i'(\mathbf{r},t) - (t)]dV' + \int [\rho_i''(\mathbf{r},t) - \bar{\rho}_i(t)]dV'' = 0. \quad (1)$$

According to this expression, at $d(\rho_i - \bar{\rho}_i) \neq 0$ integral (1) vanishes only when the deviation of the parameters from their average value $d(\rho_i' - \bar{\rho}_i), d(\rho_i'' - \bar{\rho}_i)$, as well as the rate of these processes $d(\rho_i' - \bar{\rho}_i)/dt$, and $d(\rho_i'' - \bar{\rho}_i)/dt$ have the opposite sign in different parts (regions, phases, components) of the system and compensate each other. This is a feature of any non-equilibrium processes (in which $\rho_i \neq \bar{\rho}_i$), and not only for the Universe as a whole (i.e., for the entire set of interacting or mutually moving material objects), but also for any part of it. This principle makes it necessary to consider any object of thermodynamic research as a spatially inhomogeneous system and consider the non-static processes of redistribution of extensive parameters Θi between the individual parts of the system that occur in them. Such a redistribution is expressed in the displacement of the position in space of their center, given by the radius vector ri, by the value Δri and in the formation of a specific "distribution moment" Zi[5]:

$$\mathbf{Z}_i = \Theta_i \Delta\mathbf{r}_i = \int_V [\tilde{n}_i(\mathbf{r},t) - \bar{\tilde{n}}_i(t)]\mathbf{r}dV. \quad (2)$$

where $\Delta\mathbf{r}_i = \mathbf{r}_i(\mathbf{r},t) - \mathbf{r}_i(t)$ is the displacement of the center of quantity Θ_i from its equilibrium position $\mathbf{r}_i(t)$, which coincides with the volume center $\mathbf{r}_v$; $\rho_i(\mathbf{r},t)$ is the density of the quantity Θ_i as a function of the spatial (Eulerian) coordinate r and time t; $i = 1, 2, \ldots$, n is the number of energy forms of the system.

An example of such processes in astrophysics is the flow of matter from one star to another and its accretion onto the star from dust clouds. As a result of such processes, the energy of any part of the Universe E becomes dependent not only on the parameters Θ_i mentioned above, but also on the position of their center ri in space (in the case under consideration, on the position of the center of mass rm). In this case, the total energy of any (isolated or non-isolated) system as a function of its state takes the form $E = E(\Theta_i, \mathbf{r}_i)$, so that its total differential can be given the form of an identity[5]:

$$dE \equiv \Sigma_i \Psi_i d\Theta_i - \Sigma_i \mathbf{F}_i d\mathbf{r}_i. \quad (3)$$

Here $E = \Sigma_i E_i$ is the total energy of the system; $\Psi_i \equiv (\partial E / \partial\Theta_i)$ is the mass-averaged value of the generalized potential of the system ψ_g (its absolute temperature T, pressure p, chemical μ_k, electric φ, gravitational ψ_g, etc. potential); $\mathbf{F}_i \equiv -(\partial E / \partial\mathbf{r}_i)$ are forces in their general physical understanding, which differ from "thermodynamic forces"[8,9] in a single dimension and a single meaning of the gradient of the corresponding energy form of the system ∇E_i, taken with the opposite sign (which corresponds to positive direction of force to establish equilibrium). In this case, the terms of the 1st and 2nd sums of identity (3) describe, respectively, the processes of transfer and transformation of energy of any i-th form. In the absence of the latter, identity (3) turns into a generalized equation of equilibrium thermodynamics.[6,9]

These two principles and the basic identity of energodynamics (3) based on them turns out to be sufficient to derive by deductive means all the fundamentally important laws, equations, and consequences of not only equilibrium and nonequilibrium thermodynamics,[10] but also mechanics, the theory of heat and mass transfer, hydro - aerodynamics and electrodynamics, thereby carrying out the synthesis of their foundations.[11] It is even more interesting to apply the principles and equations described above to the problems associated with the existence of "dark matter".

Dark matter as the fundamental principle of the matter of the Universe

Since in the regions of the Universe, free from "light" (baryonic) matter, all 100% of their mass is matter, taking part only in gravitational interaction, this type of interaction should be considered the main one. At the same time, the emergence of baryon matter, consisting of protons, neutrons, electrons and other elementary particles, and the appearance of electromagnetic and other properties in it, can only be explained by the formation of these particles from dark matter. Let us consider the process of buying added degrees of freedom by baryon matter from the standpoint of energodynamics, which, like thermodynamics, is aliened to model concepts (especially at the stage of formation of its principles and equations). First, we note that from these positions it does not matter whether dark matter is a discrete or continuum medium, since energodynamics operates only with the concept of its density ρ, which is applicable in both cases. For it, as for a medium that fills the entire volume of the Universe and has a single degree of freedom, the cause of any processes can only be an inhomogeneous distribution of its density.

This inhomogeneity occurs with the slightest compaction of some and rarefaction of other areas of space, i. e. in the formation of longitudinal density waves like acoustic waves. To find the parameters of such waves, we consider a certain region of space in which the density of the medium ρ changes from its average (equilibrium) value in both directions (Figure 1). It follows from the figure that any density half-wave is formed by the transfer of some mass M of the medium in the direction of the wavy arrow. Such a transfer is accompanied by a displacement of the center of mass of the half-wave from the position with the radius vector $\mathbf{r}_{m0}$ to the position rm. As a result, a certain "distribution moment" of the mass $\mathbf{Z}_m$ is formed, which is decided by the expression:[5]

$$\mathbf{Z}_{m0} = M(\mathbf{r}_m - \mathbf{r}_m) = \int [\rho(\mathbf{r},t) - \bar{\rho}(t)]\mathbf{r}d\mathbf{V} \quad (4)$$

Let's take this shift $\mathbf{r}_{m0} - \mathbf{r}_m$ wave amplitude A_v (m). Since this process of wave formation goes ahead in time with a frequency ν, it is accompanied by the transformation of the potential energy of the medium E^p into kinetic energy E^k. During the half-cycle of oscillations $\tau/2 = 1/2\nu$, the average rate of its transfer in this oscillatory process $|\mathbf{v}| = 2A_v\nu$, and the kinetic energy $E^k = M\mathbf{v}^2/2 = 2A_v^2\nu^2$. At the nodes of the wave, this kinetic energy reaches its maximum and again turns into potential energy in the antinode zone of the wave, so that their sum stays unchanged and decides at any time the variable part of the gravitational energy of dark matter E^T. In terms of the wave mass, this makes the average wave energy density ε_v equal to

$$\varepsilon_v = \bar{\rho}A_v^2\nu^2/2, \ (J\ m^3) \quad (5)$$

This expression corresponds to the known one from the theory of oscillations.[12] Thus, due to instability in dark matter, longitudinal density waves arise. Encountering obstacles (for example, with particles of baryonic matter) or other inhomogeneities, they form a system of standing waves. Such waves, as is known, do not transfer energy through their nodes, which leaves the oscillating dark matter invisible.

Figure 1 also clearly demonstrates the fact that any half-wave is a spatially inhomogeneous object with a non-uniform distribution of the density ρ (**r**, *t*) in it along the wavelength λ. The resulting gradient $(\partial\varepsilon_\nu / \partial\mathbf{r})$ of the wave energy density $\varepsilon_\nu = \varepsilon_\nu(\mathbf{r},t)$ generates, according to (3), a pair of mechanical forces proportional to the steepness of its leading and trailing fronts and acting in the direction indicated arrow in Fig.1. Thus, the waves of dark matter appear as a set of dipoles that give rise to its desire to fill all the space provided to them due to the presence of their repulsive forces. The emergence of such forces determines the ability of dark matter to perform work, which is accompanied by the transformation of its gravitational energy into other forms and the formation of baryonic matter from it. The first of such processes was the process of wave formation considered above. The next step is the formation of baryonic matter. It is accompanied by a sharp increase in the density of dark matter. This process in relation to the ether A. Einstein called it "condensation".[13] It is easier to imagine it if one adheres to the wave theory of the structure of matter, according to which "what we currently consider to be particles are actually waves".[14]

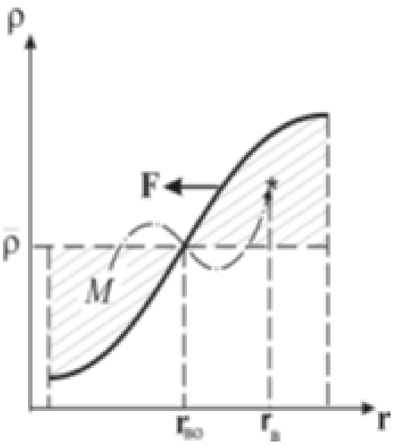

Figure 1 Half wave as a dipole.

In this case, this process can be represented as the formation of "pieces" of standing waves of a suitable length of closed (ring-shaped or torus-shaped) waves, differing in amplitude, frequency and phase of oscillations, the nature and direction of rotation of the ring and the plane of polarization of the wave, the step of its "twist" etc. Such waves can be imagined by connecting the beginnings and ends of the wave packets that describe photons in the wave theory of light. Since there are no inhomogeneities in the ring waves that cause reflection and the formation of standing waves, the latter become traveling. A characteristic feature of such waves is that the transfer of energy in them is not accompanied by the rotation of its material carrier - dark matter. This cuts the contradiction of any vortex theories with the fact that dark matter does not have a perceptible "ethereal wind" (more precisely, the dark matter wind), which is inevitable in the case of the movement of ordinary matter in it and the presence of viscosity in it. In the absence of viscosity, vortex structures, by the Helmholtz theorem, cannot arise. According to energy dynamics, viscosity and dissipation appear only with the appearance of a chaotic (thermal) form of motion in baryonic matter, which makes it possible to transform ordered forms of energy into chaotic.[5]

The number of parameters characterizing wave structures is so diverse that it can reflect any properties of baryonic matter. All these properties are due to the above-mentioned feature of non-equilibrium processes to cause opposite in nature changes in properties in different parts (regions, phases, components) of ordinary matter: their relative motion, dielectric and magnetic polarization, dissociation, ionization, dialysis, photochemical and photonuclear reactions, etc. These changes, which give rise to the spatial inhomogeneity of the object of study, we usually give some name (momentum, charge, spin, etc.), attributing the opposite sign to them. Discussion of these issues is beyond the scope of this article. It is enough for her to admit that the interaction between dark and light matter is of a force nature and is accompanied by their mutual transformation. "Dark energy" should also be considered a product of such a transformation, since in order to fulfill its role as a medium that causes an accelerated expansion of the Universe, it must have negative pressure and a corresponding energy density.[15]

These new properties are due to the appearance in it of such forms of energy as thermal, electrical, chemical (molecular), atomic, intranuclear, etc. With the emergence of these forms, naturally, the mechanical energy of dark matter decreases, which follows from the law of conservation of energy. With the appearance of the internal thermal form of energy, thermal radiation also arises, making baryon matter "light" (visible). In order to understand the reason for the "visibility" of baryonic matter, let us show the possibility of the emergence of traveling waves in dark matter, without resorting to the ethereal, electromagnetic, or any other theory of light for this. To this end, we take into account that any impact on oscillating dark matter leads to a change in its energy and modulates it with frequencies characteristic of oscillations of any particles of baryonic matter. At the same time, energy dynamics represents the radiation process as the transformation of any (including electromagnetic) vibrations in baryonic matter into vibrations of dark matter, followed by the restoration of their original form in the radiation receiver. This makes it possible to avoid the contradiction associated with the absence of electrical and magnetic properties of photons, ether and dark matter as carriers of radiant energy.[16]

Let us now represent, as usual, the total derivative with respect to time t of the wave energy density ε_ν (**r**, *t*) in expression (5) as the sum of its local $(\partial\varepsilon_\nu / \partial t)$ and spatial components $(\tilde{\mathbf{o}}_\nu.\nabla)\ \varepsilon_\nu$. The last component, due to the transfer of the wave form of energy in space, can be easily represented as the product of the flux density of the radiant energy carrier $\mathbf{j}_\nu = \rho_\nu \grave{A}_\nu \nu \tilde{n}(at\ \upsilon_\nu = \tilde{n})$ and its driving (thermodynamic) force $\tilde{O}_\nu = -\nabla\psi_\nu = -\nabla A_\nu \nu$), as is customary in nonequilibrium thermodynamics:[8,9]

$$(\tilde{\mathbf{o}}_\nu.\nabla)\varepsilon_\nu = \rho A_\nu \nu \tilde{\mathbf{o}}.\nabla(A_\nu \nu) = -\mathbf{j}_\nu \times \ _{\nu,}\left(W\ m^{-3}\right). \qquad (6)$$

Here $\psi_\nu = A_\nu \nu\left(m\ s^{-1}\right)$ is some wave potential, which we called amplitude-frequency;[16] $\mathbf{j}_\nu = \rho\psi_\nu \tilde{n}(J\ m^{-3})$ is a quantity known as the spectral density of radiation.

Thus, the modulation of standing waves of dark matter by the radiation of baryonic matter leads to the appearance of traveling waves in dark matter, due to which it plays the role of a carrier of radiant energy, previously attributed to the ether or photons. For this reason, dark matter is a more universal medium than the "light-bearing" ether or its quantum counterpart - the physical vacuum, which makes it appropriate to rethink the content of these concepts.

The presence of free energy in dark matter

The potential energy of the gravitational field, based on Newton's law, is usually referred to the category of "external" energy, due to the position of the test body in the gravitational field created by other, "field-forming" masses. However, for an isolated Universe, which is understood as the totality of material objects, the concept of "external" energy, independent of internal processes, loses all meaning. Therefore, in energy dynamics it is simply called "ordered". For an ordinary (baryon) substance arbitrarily distributed in space, it can be found by the well-known formula:

$$\mathring{A}^{\hat{a}} = -\tfrac{1}{2}\int \rho\psi dV, \qquad (7)$$

where ρ, ψ are the density and gravitational potential of the medium. In Newtonian mechanics, this potential is decided by the Poisson equation $\nabla^2\psi = -4\pi G\rho$, the general solution of which for a field point located outside a body with mass M_s has the form

$$\psi = -G\int(\rho / R)dV, \qquad (8)$$

where G is the gravitational constant; ρ is the density of the "field-forming" (tacitly assumed baryon) medium; R is the distance from the field point to the volume element dV.

According to (7), the gravitational energy is negative, while the gravitational force $\mathbf{F}_g = \grave{I}\ \mathbf{g}$ and the free fall acceleration $g = -\nabla\psi$ are positive. Such "calibration" is usually justified by considerations of convenience in solving individual problems. It corresponds to the expression of Newton's law of gravitation

$$\psi = -\grave{G}\quad R_{\tilde{n}}, \qquad (9)$$

where R_c is the distance to the center of mass of the "field-forming" body M.

According to this expression, the gravitational potential is negative and decreases to the rudder when the test mass is removed to an infinite distance $(R_c = \infty)$. However, negative values of gravitational energy are not acceptable for the Universe, since before the appearance of baryonic matter in it, gravitational energy was the only form of energy, and, moreover, not "external", but "internal", like all other forms of energy of an isolated system. Internal energy, as is known from thermodynamics, cannot be negative. Following this, all the potentials ψ_i in it, defined by identity (3), are also purely positive. Therefore, in energy dynamics as a unified theory of the processes of transfer and transformation of any form of energy, the gravitational potential of visible matter $\psi_{\tilde{n}}$ is decided by the expression:[5]

$$\psi_{\tilde{n}} = \grave{G}_{\tilde{n}}(1R_o - 1R), \qquad (10)$$

where R_o is the minimum distance to which the "trial" and "field-forming" bodies can be brought together. In this case, the gravitational potential ψ_c becomes positive, increasing as the test body moves away and vanishing at $R = R_o$. Such a "calibration" ($R_o > 0$) is more in line with the conditions of the Cavendish experiment, which, as is well known, was carried out with lead balls of finite dimensions. According to it, gravitational energy vanishes when the further work done by the forces of gravity becomes impossible, which is completely natural. In addition, with such a calibration, the divergence of the energy E^n and the forces F_g also disappears, which creates added difficulties due to the inability of mathematics to run with infinities.

However, this does not cut other shortcomings of the Newtonian law of gravitation, which, as is known, describes only the pair interaction of fixed point masses M_1 and M_2, neglecting the influence of other (non-baryonic) bodies, and does not recognize the existence of a gravitational equilibrium characterized by the vanishing of the force gravity at a finite value $R < \infty$. Meanwhile, in astrophysics, the phenomenon of libration is well known, when the position or trajectory of a celestial body fluctuates compared to the position of stable equilibrium. Finally, the gravitational energy, defined by expressions (7) or (10), is so small that the gravitational interaction is the weakest of all its known types. All this makes Newton's law unsuitable for its further generalization to non-baryonic matter in search of a more general law of dark matter interaction.

Therefore, it is advisable to rely on more general provisions, for example, on the principle of equivalence of the rest mass of the system (in this case, the mass of dark matter) $M_т$ and its energy $\mathring{A}_T$, extended by A. Einstein to all types of matter:

$$\mathring{A}_{\eth} = \grave{I}_{\eth}\tilde{n}^2, \qquad (11)$$

where c is the speed of light in "empty" space.

Before A. Einstein, this expression (with a proportionality coefficient ranging from 0.5 to 4/3) was attributed to the ether as a carrier of radiation, assuming it was capable of transforming into ordinary matter (N. Umov, 1873; J. Thomson, 1881; O. Heavyside, 1990; A. Poincaré, 1900; F. Hazenorl, 1904, etc.[17] However, with the same reason, this ratio can also be attributed to the energy of dark matter $E_т$, which is also capable of transforming into baryonic matter.

From the standpoint of energy dynamics, the non-equilibrium part of the gravitational energy of dark matter $\mathring{A}_T$ is "free" (available for transformation), as showed not only by the occurrence in it of the above-described oscillatory process with a nonzero kinetic energy E^k, but also by the very fact of its transformation into baryonic matter. It is this energy, apparently, that is the main source of stellar energy. The basis for this statement is the fact that the energy released during thermonuclear reactions, decided by the baryon mass defect ΔM, is much less than this mass M itself, while the mass of dark matter $M_т$ coming from the surrounding space and participating in the process of its transformation into baryonic substance, is not limited by anything. The fact that such a "recharge" is real and carried out under terrestrial conditions is showed by the result of tests of a hydrogen bomb over Novaya Zemlya in 1961, when the fireball of the explosion rose into the stratosphere and continued to burn there for half an hour, exceeding the calculated energy release of a thermonuclear reaction by 105 times.[18] The same source of free energy should also explain the appearance of ball lightning, "living" up to 15 minutes, and the existence of a number of "over unity" machines, the output power of which is several times higher than the input,[19] as well as the phenomenon of the so-called " "cold" nuclear fusion, when excess heat release is not accompanied by radiation required for nuclear transformations.[20]

Existence of "strong" gravity and gravitational forces of "repulsion"

Let us now apply the basic identity of energy dynamics (3) to that part of the Universe in which there is still no baryon matter. In this case, the energy of the system $\mathring{A} = \mathring{A}_T$ as a function of its state has the form $\mathring{A}_T = \mathring{A}_T(M_T, \mathbf{r}_T)$ and the thermodynamic identity for it is correspondingly simplified:

$$d\mathring{A}_T \equiv \psi_T dM_T - \mathbf{F}_T d\mathbf{r}_T, \qquad (12)$$

where $\psi_T \equiv (\partial \mathring{A}_T / \partial M_T)$ is the gravitational potential of dark matter; $\mathbf{F}_T \equiv -(\partial \mathring{A} / \partial \mathbf{r}_T)$ is the gravitational force generated by the inhomogeneous distribution of dark matter. Comparing $(\partial \mathring{A}_T / \partial M_T)$ with the equivalence principle (11), we find that the gravitational potential of dark matter is equal to the square of the speed of light:

$$\psi_T = (\partial \mathring{A} / \partial M_T) = d\mathring{A}_T / dM_T = \tilde{n}^2. \qquad (13)$$

It is of interest to compare the value $\psi_T = \tilde{n}^2 \approx 9.10^{16}$ J kg^{-1} with the Newtonian gravitational potential on the Earth's surface $\psi_{\tilde{n}} = \dot{G}\ {}_{\tilde{n}}R \approx 1{,}7.10^9$ (G= 6,672·10^{-11} N m^2 kg^{-2}; M_c = 5,976 ·10^{24} kg; R = 6,36·10^6 m), considering it positive. As you can see, the potential of dark matter exceeds the Newtonian one by many orders of magnitude. This gives a good reason to talk about the presence of "strong" and "weak" gravity, since it belongs to various material carriers. Their incompatibility forces us to reconsider the established views on the role of gravity in structure formation in the Universe. Another equally important consequence is the discovery of gravitational repulsive forces in dark matter itself. According to (13), $\mathring{A}_T = \tilde{n}^2 \int \rho_T dV$, i.e. is a function of the dark matter density ρ_T. Accordingly, the size of the gravitational force as an energy gradient $\mathbf{F}_T = -(\partial \mathring{A}_T / \partial \mathbf{r}_T)$ is also proportional to the gradient of this density:

$$\mathbf{F}_T = -\tilde{n}^2 \int \nabla \rho_T dV. \qquad (14)$$

This force is always directed against the density gradient of the dark matter $\nabla \rho_T$ and in different regions of the Universe it can have a different value and sign depending on the value and sign of this gradient. This position in no way followed from Newton's law of gravitation. Nevertheless, it does not contradict this law, if the conditions for its application are changed. Indeed, Newton's law in the form (8) expresses the gravitational potential $\psi_{\tilde{n}}$ as a function of coordinates (radius vector r) of a field point for a given distribution of matter density ρ over the volume of the system V outside this point, i. e. $\psi_{\tilde{n}} = \psi_{\tilde{n}}(\mathbf{r})$. Let us now pose another problem: to find the dependence of the gravitational potential $\psi_{\tilde{n}}$ on the density of baryonic matter $\rho_{\tilde{n}}$ in some region of space with volume V for a fixed value of $\Delta \mathbf{r}_c$, i. e. with a constant distribution of matter in it, as required by the partial derivative $\mathbf{F}_{\tilde{n}} \equiv -(\partial \mathring{A} / \partial \mathbf{r}_{\tilde{n}})$. Let us denote this potential by $\psi_{\tilde{n}}(\rho_{\tilde{n}})$ to avoid confusion. In this case, we are talking about finding the gravitational potential of baryonic matter $\psi_{\tilde{n}}$ in different regions of the Universe as a function of its density $\rho_{\tilde{n}}$ with its constant distribution in it ($\Delta \mathbf{r}_{\tilde{n}} = \mathbf{r}_{\tilde{n}} - \mathbf{r}_v = const$), i. e. at the same distance $R = |\Delta \mathbf{r}_{\tilde{n}}|$ from the center of its mass $M_{\tilde{n}} = \int \rho_{\tilde{n}} dV$. Under these conditions, the gravitational energy of ordinary matter will depend only on the density of the medium $\rho_{\tilde{n}}$, as well as the value of its gravitational potential $\psi_{\tilde{n}} = \mathring{A}_{\tilde{n}} / M_{\tilde{n}}$. On this basis, taking R in expression (8) out of the integral sign, we find for the gravitational acceleration $\mathbf{g}_{\tilde{n}} = -\nabla \psi_{\tilde{n}}$ the dependence:

$$\mathbf{g}_{\tilde{n}} = (G / R) \int \rho dV, \qquad (15)$$

which corresponds to Newton's law, which does not take into account the presence of dark matter.

To emphasize the difference between the law of gravity (14) and (13), we represent the latter in the form $\mathbf{F}_T = -\tilde{n}^2 \int (\nabla \rho_T / \rho_T) d\grave{I}_T$. Then the expression for acceleration $\mathbf{g}_T \equiv (\partial \mathbf{F}_T / \partial \grave{I}_T)$ in the gravitational field of dark matter can be given a more elegant form:

$$\mathbf{g}_T = \psi_T \nabla \rho_T / \rho_T. \qquad (16)$$

According to this expression, the acceleration $\mathbf{g}_T$ is always directed towards the matter density gradient. If, for example, dark matter formed the core of a galaxy, in which its density decreases towards the periphery, then the acceleration in it acts towards the center, causing further contraction. For the same reasons, the fluctuation of density, which randomly arose due to instability, is further enhanced by completely deterministic forces, generating an increase in density from the first state, estimated at 10^{-27} kg m^{-3}, to a value of 10^{18} kg m^{-3}, characteristic of white dwarfs. This makes the processes of structure formation in the Universe stochastic, and the state of spatial homogeneity in the distribution of dark matter is unlikely.

Further, the value of acceleration in the field of dark matter according to (16) is proportional to the relative value of its density gradient $\nabla \rho / \rho$ with a proportionality coefficient equal to the gravitational potential (the square of the speed of light). This means that where this one is smaller, the acceleration also weakens. The latter explains the anomalous acceleration of space probes like the Pioneer and Voyager 1.2 spacecraft. If their movement slows down, then this shows more likely the transition of the devices to the region of the Universe with a more uniform distribution of dark matter, and not the resistance of the environment.

Finally, according to (16), the direction of gravitational forces in dark matter can be different depending on the sign of the density gradient. The action of these forces can be observed indirectly by the concentration of baryonic matter, which is produced more actively in the zone of increased density of dark matter. Therefore, if we observe an accumulation of baryonic matter in any region of space, then the total density of the matter of the Universe, which is made up of the density of dark and light matter, is also higher in it. This favorable circumstance makes it possible to judge the behavior of dark matter from the behavior of light matter.

If, when moving in any direction from a cluster of stars, we observe a decrease in its density, therefore, in this region of space, gravitational forces predominate, continuing to condense dark matter and accelerate the process of the emergence of baryonic matter in it. If, with further distance from the cluster under study, an increase in the density of another cluster ($\nabla \rho / \rho > 0$) is observed, then this indicates the appearance in this region of space of dark matter repulsive forces, which reduce the attraction to the cluster under study. Since this attraction weakens with distance, at a certain distance from it, the repulsive forces can exceed the attractive forces. Then the removal of these objects begins, which we perceive as an expansion of galaxies. It is easy to establish that this expansion prevails in the peripheral regions of galaxy clusters, where gravitational forces are relatively small.

However, the heuristic value of the gravitational equation (16) does not end there. It is important that it predicts the existence of a gravitational equilibrium in dark matter, characterized by the absence of Ft forces. This state corresponds to the general criteria for the equilibrium of thermodynamics, which in this case takes the form:[5]

$$(\partial \psi_T / \partial \mathbf{r}_T) = 0. \qquad (17)$$

According to (17), the condition of strong gravitational equilibrium corresponds to a uniform density distribution of dark matter $(\nabla \rho_T = 0)$. This equilibrium is stable when the condition

$$(\partial^2 \psi_T / \partial \mathbf{r}_T{}^2) < 0. \qquad (18)$$

The presence of zones of stable equilibrium is showed by the phenomenon of libration. By expression (16), this phenomenon is observed when, when a massive body deviates from the equilibrium state, it enters an area with an increasing density ρ_T (with a positive gradient $\nabla\rho_T > 0$). Then there is a "returning" force, due to which the trajectory resembles the movement of a river between the banks. According to (17) and (18), the libration zone depends on the length of the equilibrium region $(\partial\psi_\delta / \partial\mathbf{r}_T) = 0$. Where the gradient $\nabla\rho_T$ is small, and the density of the substance ρ_T, on the contrary, is significant, the libration zones, like flat rivers, can occupy a significant part of the space of the Universe. However, as the inhomogeneity increases, the libration zone narrows and may disappear altogether. Such a situation is seen in the so-called "close systems" of paired stars or galaxies, where the instability of equilibrium is manifested in the flow of matter from one celestial body to another. The same is seen with a decrease in the density of the medium ρ. Such is the situation with Newton's law, in which bodies are assumed to be separated by empty space. Thus, the equation of gravitation (16) makes it possible to explain in a consistent way several phenomena in front of which the Newtonian theory of gravitation turned out to be powerless.

Dark energy as a superfluous entity

Let us now touch on those consequences of identity (3) that relate to dark energy as its special form introduced into the mathematical model of the Universe to explain its expansion with acceleration. In cosmology, which accepts this hypothesis as a standard one, it is considered as a kind of constant energy density of the physical vacuum that evenly fills the space of the Universe and has a negative pressure equal in absolute value to the energy density.[15] It is usually believed that the latter requirement follows from thermodynamics, in which the gas pressure p (J m^{-3}) is often interpreted as the potential energy density of elastic deformation $p = \varepsilon^p$. In such a case, an increase in the volume of the Universe ($dV > 0$) means an increase in its internal energy. This is tantamount to it performing the negative work of expansion $pdV < 0$, from which it follows that $p < 0$. The absurdity of such an "explanation" is obvious and consists in the fact that in classical (equilibrium) thermodynamics, the work of expansion pdV is under the assumption of equality of pressures in the system p and in the environment p_o, when, by the legal conservation of energy, this work is equal to the work of compression of the environment $p_o dV$. For the Universe as a whole, $p = 0$, even if we consider it to have boundaries, since there is nothing outside of it. It is equally illogical to attribute negative pressure to a physical vacuum having only "virtual", (non-material) particles, at least until its understanding as a material medium has become generally accepted. Moreover, it makes no sense to attribute dark energy to the physical vacuum, since the energy of vacuum zero-point oscillations is positive and exceeds by many tens of orders of magnitude the allowable value for cosmological reasons.

All these contradictions can be avoided if we consider the existence of repulsive forces in the dark matter itself at $\nabla\rho_T / \rho_T$. It is the existence of gravitational equilibrium in dark matter that supplies a delicate balance of attractive and repulsive forces, which supporters of numerous hypotheses are trying to find. No hypothetical "dark energy" is needed to explain this fact, which makes dark energy a redundant entity.

Discussion of the results and experimental confirmation of the consequences of energodynamics

Convincing confirmation of the consequences described above from the equation of gravitation (16) can be found in recent data obtained at the Lawrence Berkeley Laboratory (USA) on the distribution of galaxies in the visible part of the Universe.[21] The main goal of the research of this laboratory within the framework of the global project of the Digital Sky Survey (SDSS) was the most correct (forming today 1%) calculation of the coordinates of star clusters and the compilation of a three-dimensional map of the starry sky. Analyzing their distribution at a fixed distance from the observer,[22] scientists discovered recurring ring structures in the distribution of galaxies (Fig. 2), which they interpreted as baryon acoustic oscillations of the primary plasma of the Universe. These rings have approximately the same diameter of about half a billion light years, in which galaxies are concentrated mainly either in its center or on its periphery.

This character of the distribution of baryonic matter in the Universe is in good agreement with the equation of gravity (16). According to him, the gravitational forces $F_g = m\mathbf{g}$ is always directed in the direction opposite to the density gradient $\nabla\rho$. This is what we see in Figure 2, in each of the ring structures of which the density of star clusters in their central part decreases with distance from their center. In this case, the gravitational forces are directed inside the cluster, accelerating its contraction. The same is seen in the peripheral part of the ring, where the density of star clusters decreases with deviation from the center line in both directions, like a half-wave of "elevation". The fact that a vast space is observed between them, practically free of galaxies, indicates the existence of a gravitational equilibrium in it $(\nabla\rho = 0)$, when there are no conditions for the formation of baryonic matter.

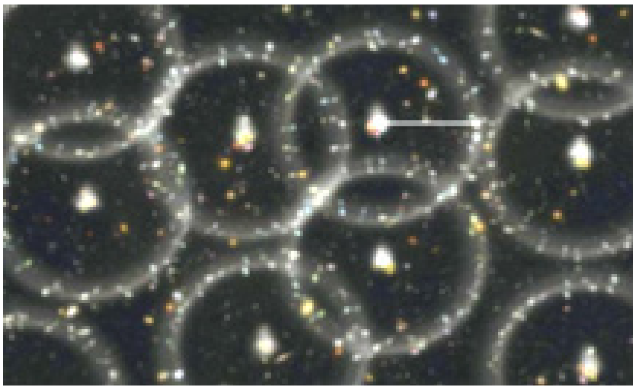

Figure 2 Map of the Universe depicting ring structures (Berkeley National Laboratory).

The fact that the cluster of galaxies has a cross-sectional shape of rings around the central cluster, and is located at a considerable distance from it, indicates the presence of both attractive and repulsive forces in space. The latter, as expected, appear at a considerable distance from the central cluster. The repeating (fractal) nature of such ring structures and their close sizes throughout the entire observable part of the Universe is considered in[22] as evidence of the applicability of the Euclidean geometry to it. This also corresponds to the conclusions of energy dynamics, which continues the classical line of development of physics. The difference with[22] here is only that the ring structures in Figure 2, resembling receding waves in stagnant water, are, in the light of the above, not acoustic, but gravitational waves of giant length, since other waves arise in dark matter cannot.

The countermovement of these waves clearly visible in the figure up to their mutual penetration confirms the principle of the opposite direction of non-equilibrium processes[5] and deprives the assertion of a unilateral expansion of the boundaries of the Universe that are not detectable in principle throughout their entire length. At the same time, the stated theory of gravitation testifies that the properties of

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dark matter are more diverse than those that were reflected by Newton in his law of gravitation, and more universal than the properties of the luminiferous ether. In this respect, equations (16) are closer to reality.

In conclusion, it is of interest to briefly describe the evolution of the Universe from the standpoint of the proposed theory. According to it, dark matter is the main (and in some areas of space - the only) component of its matter. In this matter, due to the instability of a homogeneous state, spontaneous processes of wave formation arise, leading to the "thickening" of some and the "rarefaction" of other areas. Once having arisen, this inhomogeneity is then intensified by the action of not random but ordered gravitational forces. Some areas, which have reached sufficient compaction due to this, form the "cores" of future stars and galaxies. The action of strong gravity in dark matter is enhanced by the accretion of matter from the surrounding space, which supplements the work of compression with a convective influx of internal energy. In this process, the dark matter gradually forms the structural elements of baryonic matter, which have a number of new properties (additional degrees of freedom). There is also a chaotic motion, accompanied by an increase in temperature and the appearance of thermal radiation, which makes baryonic matter visible. The maximum of this radiation corresponds to a "supernova" explosion. When the radiation begins to prevail over the energy input, the "supernova" cools down. Nevertheless, the process of increasing mass and contraction, which continues, leads to the formation of "black holes" in the nuclei of galaxies, which exclude the loss of energy by radiation and therefore become invisible. Further compression (collapse) is accompanied by the degeneration of chaotic motion (the formation of "white dwarfs") and the loss of other previously acquired degrees of freedom (involution). With an increase in their density, the value of $\nabla\rho / \rho$ decreases, and the compression forces weaken. When they become weaker than the internal forces caused by the residual pressure in them, the process of decay of white dwarfs and the return of dark matter to its original state, invisible to astrophysical instruments, begins. Such cycles chaotically arise and repeat in one or another region of space. The non-stationarity of internal processes caused by this opens up the possibility of the processes of its "reproduction" unlimited in time in the Universe. Such a "scenario" differs significantly from that predicted by the Standard Model in its realism.

Conclusion

1. The predominance of the "hidden" (unobservable) mass in the Universe, which makes up at least 95% of its substance and does not participate in electromagnetic radiation, indicates that it is precisely this mass that is the primary form of matter from which all types of baryon (observable) substance.
2. The application of energy dynamics to hidden (non-baryonic) matter as to a continuous medium with an inhomogeneous density reveals the inevitability of the emergence of self-oscillations in it, the energy of which corresponds to the Einstein equivalence principle. This energy forces us to recognize gravitational energy as the original form of all types of energy of baryonic matter and the true "fuel" of stars and the source of energy for the processes of synthesis of baryonic matter and many "over-unit" devices.
3. The principle of equivalence of mass and energy of hidden matter makes it possible to find a field-left (short-range) form of the law of gravitation, which sets up the proportionality of its strength to the local density gradient of matter. This form predicts the existence of gravitational forces of attraction and repulsion depending on the sign of this gradient and the existence of gravitational equilibrium in its absence. Such a "bipolar" form of the law of gravity makes gravity and repulsion a consequence of the non-uniform distribution of the matter of the Universe.
4. The bipolar law of gravity reveals the existence of "supergravity" with a potential exceeding the Newtonian one by several tens of orders. This makes gravity the "strongest" type of interaction, not inferior to nuclear forces, and all force fields are special cases of the gravitational field, weakened due to the limited range of oscillations or proximity to equilibrium.
5. The presence of repulsive forces in the field (short-range) form of the law of gravity makes the concept of a hypothetical "dark energy" redundant, allowing us to consider the hidden mass, ether, physical vacuum, dark matter, etc. as a single entity - non-baryonic matter.
6. The emergence of density self-oscillations in non-baryonic matter gives rise to gravitational waves of its density, which are not observable due to their "background" nature. These waves are detected only because of their modulation by frequencies generated by electromagnetic and non-electromagnetic radiation of baryonic matter, which makes non-baryonic matter a "light-bearing medium".
7. The ability of latent matter to condense into baryonic (structured) matter opens the possibility of judging the processes in it by the behavior of baryonic matter, which significantly expands the possibilities of observational astronomy.
8. Lack of isolation from gravitational forces makes it necessary to consider latent matter as an indispensable component of any material system and take into account its participation in all processes occurring on our planet.
9. The properties of hidden matter, following from the bipolar law of gravitation, make it possible to clarify a number of ideas about the nature and sequence of evolutionary and involutionary processes in the Universe, which allow it to function indefinitely, bypassing the state of equilibrium.

The validity of a number of consequences of energy dynamics in relation to the properties of non-baryonic matter is confirmed by the existence of stable structures at all levels of the universe in the absence of a balance of centrifugal and gravitational forces.

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