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The Content of the Concept "Mass" and the Law of Mass Conservation in the Phenomena of the Macro and Microworld

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Abstract

The regularities of motion of physical bodies are formed by the addition of two components: the longitudinal, considered in traditional physics as the only form of manifestation of motion, and the transverse component - always with the closed curvilinear trajectory. It is with the characteristics of the transverse component of the motion that the content of the concept of "mass" is related. From the proposed definitions of mass and energy, it follows that their equivalence is caused by the unity of their dimensionless components. The doublets of particles are separated, which are the carriers of mass-energy, the invariance of the number and potential of which is caused by the law of conservation of mass-energy. The oscillation of the mass of neutrino formations is considered taking into account the degree of compression of the environment for their production and research. One of the reasons for the violation of the law of conservation of mass with a constant number of composite particles is a temporal change in the order of the internal organization of particles. This phenomenon is related to the cosmological redshift, mutual removal of cosmological objects; it is assumed the presence of relation with dark energy.

***Keywords:** Mass; Energy; Neutrino oscillations; Redshift*

Introduction

The concept of "mass" is one of the most discussed problems of modern physics, while the presence of uncertainty is frequently emphasized in the content of this fundamental characteristic of matter [1-7]. With penetration into the microcosm, the task arises

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not only of computing the mass of elementary particles but also of determining that hierarchical level, starting from which the mass becomes a characteristic property of matter [8-11].

In the approach, which is called “The structural theory of the physical world”, or simply the structural theory (ST), it is shown that the content of the "mass" notion is associated with such a hierarchical level of the structure of matter, which is also related to the mechanism of motion of physical bodies [12-15]. Based on the definition of mass given in ST, below we consider various options for mass effects depending on the nature and distance of interaction, determine the nature of mass and energy carriers, give a structural justification for the equivalence of mass and energy, discuss the problem of conservation and oscillation of energy.

In the ST, the hypothesis is put forward on the existence of some particles of conventionally minimum hierarchical level (ε-particles), the attribute of which is their ability to interact in pairs with each other. It is accepted that the elementary act of interaction between the ε-particles (ε-act) takes part with the strictly defined duration on the strictly defined distance; in addition, because of the ε-act, the particles pass same distance, creating new pairs. Hence, by counting the sequentially realized number of ε-act one can determine both path and time. By operating with the dimensional parameters, the ε-intervals of length and time are taken as ξ_d cm and ξ_l sec. Three types of Δ-elements are modeled with the use of ε-intervals: Δ_i, Δ_j and Δ_k oscillating along with three mutually perpendicular directions. Here and below, the indexes $\ll i \gg$, $\ll j \gg$, and $\ll k \gg$ denote the directions of motion. In each Δ-element, the content of ε-pairs and they mutual ordering are chosen in such a way, that Δ_i, Δ_j and Δ_k elements are mutually recognizable in the bound state. With the Δ-elements, the Δ-pairs are modeled both with the same ($2\Delta_i, 2\Delta_j, 2\Delta_k$) and the different directions of oscillations. The pair of identical Δ-elements is characterized by the α_0-fold repetition of oscillations with an amplitude H_c, that is, by the total number of ε-acts

$$H_{00} = \alpha_0 \cdot H_c \quad (1)$$

where $H_c = H_\Delta^2$, H_Δ is the oscillation amplitude of the Δ-element,

$$\alpha_0 = \sum_{n=1}^{7} n^2 = \sum_{n=1}^{7} \sum_{l=0}^{n-1} (2l+1) = 140 \quad (2)$$

is the number of sequentially realized states of Δ-pairs, *n* and *l* are analogs of the principal and azimuthal quantum numbers for the given hierarchical level.

From three Δ-pairs, the γ-particles of various destinations are modeled, which are the base of the known particles of micro and macro world, including γ_0-particles of the general Δ-composition 2j2i2k, the presence of which in all physical bodies explains the generality of the quantitative laws of their motion.

The bound state in γ-particles is caused by the self-consistent interaction and motion: the ε-particles in Δ-elements, the Δ-elements in the Δ-pairs, and Δ-elements themselves in the γ-formations. To provide the stability at the modeling of γ_{0i}-particles, the oscillations of $2\bar{i}$ and $2\bar{k}$ pairs are chosen with the phase difference equal to π/2; because of this, they are called the self-oscillations. At certain conditions, the $2\bar{k}$ and $2\bar{j}$ pairs switch the roles. In the case of self-interaction, the $2\bar{j}$ pair is selected relative to the oscillations of $2\bar{i}$ pair with the phase 3π/2, which also results in the closed trajectories; thereby, the base of the particle is always in the restricted part of the space.

The presence of the phase π/2 results in the formation of closed curvilinear trajectories as a result of which it is assumed that the computed amplitudes of oscillations H_c (1) are changing in χ_c times, that is, the Δ-pairs in the content of γ_{0i} - particles are characterized by the total number of ε-act

$$H_0 = \alpha_0 H_c / \chi_c = \alpha_c H_c \,, \tag{3}$$

where is denoted

$$\alpha_c = \alpha_0 / \chi_c \tag{4}$$

Equations of Motion of Physical Bodies

The final trajectory of motion of γ_{0i} -particles, determined by three parametric equations describing the behavior of each Δ-pair separately, is formed as a torus, the volume of which is called the trajectory and is computed by the integrals [13,14]:

$$\int_L Sdl = \int_{Sj} curlSdS_j \tag{5}$$

where $S = S_i + S_k$, and the axial vectors S_i, S_k and S_j are defined respectively by cross products $H_j \times H_k, H_i \times H_j$, and $H_k \times H_i$, $dl = dl_i + dl_k$ is the sum of elementary paths caused by the $2\bar{i}$ and $2\bar{k}$ pairs.

The interpretation of equation (5) differs from the interpretation of the analogous Stocks equation by the fact that in this case the motion of a single particle is described, and the volume formed from the traces of single γ_{oi} is calculated, and not the statistical system or medium with many particles. According to equations (5), the motion of physical bodies is the sum transversal component with the curvilinear closed trajectory (the circulation path) with the orthogonal surface S and the longitudinal component with the orthogonal surface S_j (the right-hand side of the equation of motion).

The limits and parameters of integration when calculating the trajectory volume according to (5) are selected depending on the conditions of interaction involving γ_{0i} -particles. Consider the calculation of integrals (5) using the example of the interaction of slow electrons (e^-) and positrons (e^+).

In the ST, e^- and e^+ are modeled by each of the two γ–particles: γ_{e0} and γ_{p0} - are the bases and γ_{eE} and γ_{pE} are particles of the Δ-content

$$\gamma_{e0} = 2\bar{i}2\bar{k}(\bar{i}\bar{k}), \gamma_{eE} = 4j(\bar{i}k); \gamma_{p0} = 2i2\bar{k}(i\bar{k}) \gamma_{pE} = 4\bar{j}(ik) \tag{6}$$

where the symbols of Δ_i, Δ_j and Δ_k -particles are replaced here and below by their corresponding indices, the vinculum over the symbol of Δ-elements denotes that they are moving in the backward direction, the indices $\ll e \gg$ and $\ll p \gg$ denote that the γ-particles belongs to e^- or e^+.

Doing the shuttle motion relative to bases, the γ_{eE} - and γ_{pE} - particles interact periodically with them according to the scheme

$$\begin{gathered} 4j(\bar{i}k) + 2\bar{i}2\bar{k}(\bar{i}\bar{k}) \rightleftarrows 2j2\bar{i}2\bar{k} + 2j2\bar{i}2\bar{k} \\ 4\bar{j}(ik) + 2i2\bar{k}(i\bar{k}) \rightleftarrows 2\bar{j}2i2\bar{k} + 2\bar{j}2i2\bar{k} \end{gathered} \tag{7}$$

Where the symbol ⇄ indicates that the interaction is reversible; with the participation of γ_E -particles, the electrostatic interaction between slow e$^-$ and e$^+$ is also realized, which is stressed by the index $\ll E \gg$ near γ . The initial stage of electrostatic interaction between slow e$^-$ and e$^+$ is reduced to the exchange *2j* and (*ik*) pairs between γ_E - particles and γ_0 -bases of partners according to a scheme

$$\frac{2\bar{i}2\bar{k}(\bar{i}\bar{k})}{4\bar{j}(ik)} \rightleftarrows \frac{2j_i 2\bar{i}2\bar{k}}{2\bar{j}_i 2i2k} \tag{8}$$

$$\frac{4j(\bar{i}k)}{2i2\bar{k}(i\bar{k})} \rightleftarrows \frac{2j2\bar{i}2k}{2\bar{j}_i 2i2\bar{k}}$$

where the γ-particles of e$^-$ are given in the numerator, and γ-particles of e$^+$ are given in the denominator. The indices $\ll i \gg$ near symbol $\ll j \gg$ denotes that the 2-pairs are introduced in the content of γ-particles as a result of interaction with the third-party partners. For Δ-elements, the change of nominator and denominator results in the change of direction of motion to the opposite. In the of interaction, the bases of e$^-$ and e$^+$ characterized by Δ-content: $\gamma_{ei} = 2j_i 2\bar{i}2\bar{k}$, $\gamma_{pi} = 2\bar{j}_i 2i2\bar{k}$, derivatives on γ_E - particles: $\gamma_{eM} = 2j2\bar{i}2k$ and $\gamma_{pM} = 2\bar{j}2i2k$.

For further approach, the positronium is formed from the right sides of (8), which later decays into the two photons with the opposite directions of motion:

$$\left[\frac{2j2\bar{i}2\bar{k},\ 2j_i 2\bar{i}2k}{2\bar{j}2i2k,\ 2\bar{j}2i2k}\right] = \frac{2j2\bar{i}2\bar{k}}{2\bar{j}2i2k\bar{k}} + \frac{2j2\bar{i}2k}{2\bar{j}2i2k} \tag{9}$$

where the direction of motion of a specific photon is defined by the presence in the nominator (the world of e$^-$) and in the denominator (the world of e$^+$) of the Δ-pairs with the same direction of motion ($2\bar{k}$ and $2k$ for given variant).

It follows from the above mechanism of photon production that after the expiration of the phase π, the leading Δ-pairs ($2\bar{k}$ and $2k$) mutually transition between the numerator and denominator takes place, which results in a change in the direction of motion to the opposite.

At the same time, the direction of oscillation of the leading Δ-pairs also changes to the opposite, as a result, because of the simultaneous double change, the direction of motion of the leading Δ-pairs remains unchanged, respectively, and the photon is in a state of constant translation in the direction of motion of the leading Δ-pairs.

In intrinsic interaction according to the scheme (6), only intrinsic γ -particles e$^-$ or e$^+$, are involved moduli of vibration amplitudes Δ-par are equal to $|\mathrm{H}_{ic}| = |H_{jc}| = |H_{kc}| = |H_c|$, where the additional index "i" indicates its interaction. Circulation path L, oriented surfaces $s = s_i + s_k$ and s_j are determined from parametric equations using curvilinear integrals [14]. The final trajectory of γ_{0i} - particles during their interaction is a torus with volume

$$\alpha_c 2\pi r_c \left[\alpha_c^2 \pi r_c^2\right] = \alpha_c \frac{\pi r_c}{2}\left[\alpha_c^2 \pi 4 r_c^2\right] = \alpha_c^3 2\pi^2 r_c^3 \tag{10}$$

where both torus radii are equal and defined by the formula $r_c = H_c\xi_d / 2$. Here and in what follows, the oriented surfaces will be included in square brackets.

The essence of interaction with its partner is the formation of a complex with the participation of shuttle particles γ_E - with the bases of partners (charges), while the result of interaction, respectively, and the trajectory of the motion of charges, is determined by the final Δ-composition of these complexes. As examples of interaction with its partner, we can consider the interaction of slow e^- and e^+ according to the scheme (8), e^- and a proton in an unexcited hydrogen atom, almost all variants of electrostatic interaction. In these cases, a certain part of the ε-acts is spent on the removal of γ_E -particles from their bases, and the interaction is realized with a smaller amplitude: $H_i = H_c / \chi$, where $\chi \geq 1$ indicates how many times the natural amplitude decreases H_c . In certain cases, χ takes only integer values [11,14]: $\chi = n = 1, 2, 3 \ldots$, respectively

$$H_i = \frac{H_c}{n} \tag{11}$$

The constants H_c , H_0 and the variable H_i are called the potentials of the γ_0i-particles.

From the equation (10), multiplying and dividing H_c by n, we obtain the trajectory volume of the γ_{0i} -particle as applied to the interaction with its partner

$$\alpha_c 2\pi R\left[\pi r^2\right] = \alpha_c \frac{\pi}{2} H_c\left[\pi\alpha_c^2 H_c^2\right] = 2\pi^2 R r^2, \tag{12}$$

where the following limits of integration are used

$$L = \alpha_c 2\pi n^2 \alpha_c^2 r_c, \;\; S_j = \pi\alpha_c^2 H_c^2 \xi_d^2, \tag{13}$$

the small and large radii of the torus are defined, respectively, by the formulas: $H_i\xi_d / 2, \;\; R = L / \alpha_c 2\pi$. Taking into account (3) and the above notation, it is often expedient to represent equation (12) in the form

$$\alpha_c 2\pi R\left[H_i^2\right] = \alpha_c H_c \xi_d\left[\pi H_0^2\right] = H_0\xi_d\left[\pi H_0^2\right] \tag{14}$$

The next variant of interaction occurs with the participation of physical bodies and externally introduced doublets of γ_{0i} -particles (β_ε -pairs), which in the free state appear as photons. Third-party β_ε -pairs can be introduced into the composition of physical bodies by external influences: irradiation, heat supply, mechanical shocks, etc. The mechanism of this interaction is as follows. As part of the body in question, β_ε -doublets are split into constituents γ_{0i} -particles that form complexes with their γ_{0i} −particles of a given body, sequentially exchanging with the leading Δ-pairs. As a result, the physical body in complex with third-part γ_{0i} -particles, by analogy with photons, goes into a state of motion in the direction of motion of the leading Δ-pairs of the β_ε -doublet. Because of the proposed mechanism of photon motion, its leading Δ-pairs are described by the equality $l = vt$, where *l* is the value of the longitudinal path that the photon travels at speed *v* in time *t* and not by the formulas of oscillatory motion. Hence, taking into account two more parametric equations describing the oscillatory motion of the remaining Δ-pairs, the γ_{0i} -photon particles are characterized by the relation

$$\lambda\left[H_i^2\xi_d^2\right]=H_i\xi_d\left[\pi H_0^2\xi_d^2\right]=l_i\left[\pi H_0^2\xi_d^2\right], \tag{15}$$

where λ is the value of transverse path corresponding to the passage of the longitudinal path

$$l_i=H_i\xi_d \tag{16}$$

In the case of interaction with third-party β_ε-doublets, all Δ-pairs in complexes of intrinsic and exterior γ_{0i}-particles are characterized by equal potentials H_i in all directions, respectively, and the perpendicular surfaces of the transverse motion are determined by the value $[H_i^2]$.. Taking into account that γ_{0i}-particles of the indicated complex constantly exchange leading Δ-pairs, the final trajectory volume is given by the sum of the volumes from the equations (14) and (15):

$$(\alpha 2\pi r+\lambda)[H_i^2\xi_d^2]=(H_0+H_i)[\pi H_0^2\xi_d^2], \tag{17}$$

that is, circulation path *L* by the transverse component of motion is determined by the sum $L=\alpha 2\pi r+\lambda$.

The equations (5), (10), (14), (15), and (17) are called the basic equations of motion. In these equations, the smallest intervals of the longitudinal path associated with the manifestation of the integrity of γ_{0i}- particles of the considered interaction options are represented by the formulas

$$l_i=H_i\xi_d, l_0=H_0\xi_d, l_{0i}=(H_0+H_i)\xi_d\ , \tag{18}$$

to which correspond the least transversal paths defined by equations

$$\lambda=\frac{H_i\pi H_0^2\xi_d}{H_i^2}=\frac{\pi H_0^2\xi_d}{H_i}, \lambda_0=\frac{\pi H_0^2\xi_d}{H_0^2}=\pi H_0\xi_d, \lambda_{0i}=\frac{\left(H_0+H_i\right)\pi H_0^2\xi_d}{H_{is}^2}, \tag{19}$$

As a generalizing parameter of longitudinal and transversal motions, the path λ_Σ is introduced in the form of

$$\lambda_\Sigma=\frac{\left(H_0+H_i\right)\pi H_{0s}^2\xi_d}{H_0^2+H_i^2}=\frac{\left(H_0+H_i\right)\pi H_{0s}^2\xi_d}{(H_0+H_i)^2}=\frac{\pi H_{0s}^2\xi_d}{(H_0+H_i)} \tag{20}$$

where, with the allowance of the condition $H_i\perp H_0$, it is assumed that $H_i\cdot H_0=0$.

Because the longitudinal component of motion is realized by the «netting» of perpendicular surface πH_{0s}^2, the paths (18) are overcome at the time intervals

$$\tau_i=H_i\xi_\tau,\ \ \tau_0=H_0\xi_\tau,\ \ \tau_{0i}=\left(H_0+H_i\right)\xi_\tau \tag{21}$$

where the new coefficient of time dimension is introduced

$$\xi_\tau=\pi H_0^2\xi_t \tag{22}$$

Taking into account that the trajectory of displacement caused by the oscillations of intrinsic Δ-pairs is always closed, the total displacement of γ_{0i}- particles will be caused only by the exterior interaction and their velocity of longitudinal motion is represented by the relationship of path l_i and time τ_{0i}:

$$\upsilon=\frac{H_i\xi_d}{\left(H_0+H_i\right)\xi_\tau}=\frac{H_i}{H_0+H_i}c \tag{23}$$

where *c* is denoted as

$$c = \xi_d / \xi_\tau \tag{24}$$

Because of its Δ-content (6), the longitudinal motion of photon is realized only by one direction with the orthogonal surface πH_{0s}^2, thereby the path $H_i \xi_d$ (18) is overcome in time τ_i (21), correspondingly, the velocity of motion of photon will be given by the relation $H_i \xi_d / H_i \xi_\tau = \xi_d / \xi_\tau = c$, that is, by the formula (24). Thus, the velocity of photons is always constant because of the constant ξ_d and ξ_τ. Multiplying the dimensionless components of transversal paths (19) for time, we obtain one more series that is characteristic:

$$\tau_i^{'} = \frac{H_i \pi H_0^2 \xi_\tau}{H_i^2} = \frac{\pi H_0^2 \xi_\tau}{H_i}; \tau_0^{'} = \pi H_0 \xi_\tau; \tau_{0i}^{'} = \frac{\left(H_0 + H_i\right) \pi H_0^2 \xi_\tau}{H_i^2} \tag{25}$$

It is obvious that with the use of the reciprocal quantities of temporal intervals (25) the frequencies of manifestation of paths (19) can be determined:

$$\upsilon_i = \frac{H_i \xi_\upsilon}{\pi H_0^2}; \; \upsilon_0 = \frac{\xi_\upsilon}{\pi H_0}; \; \upsilon_{0i} = \frac{H_i^2 \xi_\upsilon}{\left(H_0 + H_i\right) \pi H_0^2} \tag{26}$$

Where the coefficient with the dimension frequency is denoted by ξ_υ

$$\xi_\upsilon = \xi_\tau^{-1}. \tag{27}$$

Mass Energy and their Equivalence

We represent equations (10), (15), and (17) in the form

$$\frac{\alpha_c^2 H_c^2}{\pi H_0^3} = \frac{\xi_d}{\alpha_c 2\pi r_0}; \frac{H_i^2}{H_i \pi H_0^2} = \frac{\xi_d}{\lambda}; \frac{H_i^2}{\left(H_0 + H_i\right) \pi H_0^2} = \frac{\xi_d}{\alpha_c 2\pi r + \lambda} \tag{28}$$

where axial vectors are replaced by their modules. From the left-hand sides of the above formulas, we compose the identities

$$\frac{\alpha_c^2 H_c^2}{\pi H_0^3} = \frac{\alpha_c^2 H_c^2}{\pi H_0^3}; \frac{H_i^2}{H_i \pi H_0^2} = \frac{H_i^2}{H_i \pi H_0^2}; \frac{H_i^2}{\left(H_0 + H_i\right) \pi H_0^2} = \frac{H_i^2}{\left(H_0 + H_i\right) \pi H_0^2} \tag{29}$$

Multiplying both parts of the above identities by ξ_d^2 / ξ_τ, further multiplying and dividing the right-hand sides by a strictly constant value with the dimension of the mass ξ_m, taking into account formulas (19), (23), and (24), we obtain

$$m_0 c \lambda_0 = h; m_i c \lambda = h, m_{0i} c \lambda_{0i} = h, m v \lambda = h \tag{30}$$

where the rest mass m_0, the interaction mass m_i, the mass of general interaction m_{0i} and total mass m computed by the sum

$$m = m_0 + m_i \tag{31}$$

are defined by the formulas

$$m_0 = \frac{\xi_m H_0^2}{H_0 \pi H_0^2} = \frac{\xi_m}{\pi H_0}; \; m_i = \frac{\xi_m H_i^2}{H_i \pi H_0^2} = \frac{\xi_m H_i}{\pi H_0^2}; \; m_{0i} = \frac{\xi_m H_i^2}{(H_0 + H_i) \pi H_0^2}; \; m = \frac{\xi_m \left(H_0 + H_i\right)}{\pi H_0^2} \tag{32}$$

It is easy to see that the total mass m (31) can be derived from the transverse path (20).

Just as by multiplying the number of ε-acts by ξ_d and ξ_t, we obtain the dimensional values of length and time, so by multiplying the dimensionless parts of equations (32) by ξ_m, we obtain quantities with the dimension of mass. Hence, constants ξ_d, ξ_t (or ξ_τ) and ξ_m are called coefficients or operators of the dimensions of length, time, and mass.

In formula (30), the constant *h* is a combination of the coefficients of dimensions

$$h = \frac{\xi_m \xi_d^2}{\xi_\tau} \qquad (33)$$

and coincides with Planck's constant [13,14].

Formula (30) is mathematically identical to the de Broglie equations, but it has a completely different interpretation, these equations do not at all imply the duality of the nature of physical bodies, in this case, the quantities λ_0, λ_{0i}, and λ are not the wavelengths at all, they are real transverse paths localized in a limited part of the particle space.

According to the definition (30), the mass is a result of unifying of transversal and longitudinal motions characteristics; from definition (32) one is represented by the relations of orthogonal surfaces to the trajectorial volume or, by the corresponding potentials of interaction to the orthogonal surface of the longitudinal motion.

The final trajectory of γ_0-particles taking part only in their proper interaction (7) is always closed. Thereby, if to observe the particle during τ_0 -interval or multiple to τ_0 - intervals and one fixes the particle in the state of rest, therefore, m_0 is called the rest mass.

Depending on the nature of revealing, in Physics we operate with the gravitational and inertial masses. The gravitational mass is the quantitative criterion of the force of interaction of the physical body with external gravitational fields, and the gravitation field created by the body itself. In the variant set, one considers the different variants of manifestations just the inertial mass.

If one assumes that some physical body consists of $N_m \gamma_{0i}$ - particles, its mass can be represented by the equation

$$M = \frac{\xi_m N_m \left(H_0 + H_i\right)}{\pi H_0^2}, \qquad (34)$$

However, such an estimate is purely an averaged one; for proper calculation of the mass of particles, there is a need for more information about their structure. Nevertheless, one can always choose some average potential H_1 for simplified calculations (for example, starting from the atomic unit of mass)

$$M_1 = \frac{\xi_m N_{m1} H_1}{\pi H_0^2}\ , \qquad (35)$$

Where N_{m1} is the number of structural units with the potential H_1. It follows from the mechanisms of synthesis of elementary particles [9] that the protons are the sources generating the gravitational interaction (the particles of the gravitational field), correspondingly, the gravitational mass M_G will be defined for this case as

$$M_G = \frac{\xi_m N_{mp} H_p}{\pi H_{0S}^2} \ , \tag{36}$$

Where N_{mp} is the number of protons, H_p the number of ε-acts characterizing the integrity of protons.

We define the inertial mass M_{in} by the formula

$$M_{in} = \frac{\xi_m N_{mp} (H_{p+} \sum H_i)}{\pi H_0^2}, \tag{37}$$

Where $\sum H_i$ includes potential difference $H_1 - H_p$ and potentials of third-party β_ε- pairs. In the absence of special acceleration conditions, always $H_p \gg \sum H_i$, respectively equal are the gravitational and inertial masses: $M_G \approx M_{in}$.

According to ST, such particles as e^-, e^+, muons, π-mesons, photons although they participate in gravitational interaction, they are not sources of particles of the gravitational field.

Compiling from ξ_d , ξ_τ and ξ_m the coefficient of energy dimension

$$\xi_\varepsilon = \frac{\xi_m \xi_d^2}{\xi_\tau^2} \tag{38}$$

and multiplying it by the dimensionless components of formulas (32), we obtain definitions (23) and (31),

$$\varepsilon_0 = m_0 c^2, \varepsilon_i = m_i c^2, \varepsilon_{0i} = m_{0i} c^2 = mv^2, \varepsilon = mc^2, \tag{39}$$

where taking into account the class of interaction, the corresponding energies are denoted as

$$\varepsilon_0 = \frac{\xi_\varepsilon H_0}{\pi H_0^2}, \varepsilon_i = \frac{\xi_\varepsilon H_i}{\pi H_0^2}, \varepsilon_{0i} = \frac{\xi_\varepsilon H_{is}^2}{\left(H_0 + H_i\right) \pi H_0^2} \ , \varepsilon = \frac{\xi_\varepsilon (H_0 + H_{i)}}{\pi H_0^2} \tag{40}$$

Multiplying Planck's constant (33) by the frequency dimension factor ξ_υ (27), we obtain the energy dimension coefficient

$$h\xi_\nu = \frac{\xi_m \xi_d^2}{\xi_\tau \cdot \xi_\tau} = \xi_\varepsilon, \tag{41}$$

Accordingly, multiplying formulas (26) by h, we obtain:

$$hv_0 = m_0 c^2, hv_i = m_i c^2, hv_{0i} = m_{0i} c^2 = mv^2 \tag{42}$$

Comparing equations (32), (40), (42), whence, taking into account the sum (31), it also follows $hv = mc^2$ and we can conclude that the equivalence of the mass, energy, and frequency of manifestation of the integrity of particles lies in the unity of their dimensionless components. Accordingly, both the law of conservation of mass and the law of conservation of energy become unified. It follows from that the relativistic quantities of mass and energy are also unified [14].

Numerical Values of ST- Constants

Based on formulas (10), (24), (33), and (34), the self-interaction energy e^2, we define the equality

$$m_e c^2 = \frac{c\hbar}{\alpha_c r_{ec}}, \tag{43}$$

Where are indicated $\xi_\varepsilon \xi_d = ch, \hbar = h/2\pi$, and it is taken into account that e$^-$ in the state of intrinsic interaction (7) consists of two γ_{0i} - particles $(N_m = 2, H_i = 0)$, the mass m_e and the classical radius r_{ec} of an electron are defined by the formulas :

$$m_e = \frac{2\xi_m H_0}{\pi H_0^2} = \frac{2\xi_m}{H_0}, \tag{44}$$

$$r_{ec} = \frac{H_{ec}\xi_d}{2} = \frac{H_c \xi_d}{4}, \tag{45}$$

Using the notation $H_{e0} = H_0/2$ and $H_{ec} = H_c/2$.

Comparing formulas (43) and (44) with the known one, $m_e c^2 = e^2/r_{ec}$ and $\alpha c\hbar = e^2$, we can conclude that the constant α_c, defined by formulas (2) and (4), is equal to the inverse value of the fine structure constant α [16-18]

$$\alpha_c = \alpha^{-1} \text{ or } \alpha_c e^2 = c\hbar \tag{46}$$

In [13] it is shown that the numerical value of Newton's gravitational constant G is also a combination of the coefficients of dimensions

$$G = \frac{\xi_d^3}{2\pi \xi_m \xi_\tau^2} \tag{47}$$

Respectively, taking into account the notation (24) and (33), we determine the numerical values of ξ_d, ξ_τ and ξ_m :

$$\xi_d = \left(\frac{2\pi G h}{c^3}\right)^{1/2} \approx 1,015\cdot 10^{-34} m, \xi_\tau = \left(\frac{2\pi G h}{c^3}\right)^{1/2} \approx 3,38\cdot 10^{-43} s, \xi_m = \left(\frac{ch}{G}\right)^{1/2} \approx 2,176\cdot 10^{-8} kg \tag{48}$$

whence, it follows that $\xi_m = m_p, \xi_d = 2\pi l_p, \xi_\tau = 2\pi t_p$, where m_p, l_p, t_p are Planck`s units of mass, length, and time [19].

Starting from the formulas of calculation of m_e (44) and ξ_m (48), the numerical values of the constants are the following

$$H_0 = 1,521\cdot 10^{22}\ , H_c = H_0 / a_c = 1,11\cdot 10^{20}, \tag{49}$$

Where the value of $a_c = 137,03599$ has been used [19].

To the Law Mass-Energy Conservation

Now, based on the content of the definition of mass, energy, and their equivalence, we will reveal the content of one of the basic laws of nature: the law of conservation of mass-energy. As soon as the property of matter "energy" is associated with the characteristics of γ_{oi} - particles, then the content of the law of conservation of energy should be considered at the hierarchical level of γ_{oi} - particles. The smallest formations from γ_{oi} - particles in the free state are photons (9), doublets from γ_{oi} - particles (γ_{ef} and γ_{pf}), derivatives of e$^-$ and e$^+$, which in the state of interaction are called the β_ε - pairs. In the same β_ε - pairs γ_{ef} and γ_{pf}

-particles are characterized by equal potentials, identical phases, and directions of motion. The total energy of an isolated system, when there are no external influences and mass-energy exchange with the environment, can be determined by the sum of the energies of its own and third-party interactions. When considering phenomena within the framework of classical physics, the final rest mass of the participants, as a rule, remains unchanged, therefore, any change in the mass-energy of the participants will be uniquely determined by a change in the interaction mass. Hence, any changes in energy in an isolated system are reduced to the transition of β_ε - pairs from one participant to another or the exchange of β_ε - pairs with different potentials, or a combination of transitions and mutual exchanges of β_ε - pairs, while the potentials of each β_ε - pair remains unchanged. Thus, the law of conservation of energy within the framework of classical physics is quantitatively represented by the formula

$$\sum_n N_{\beta n} H_{in} = const, \tag{50}$$

Where the index "n" underlines the number β_ε -pairs N_β with the interaction potential H_{in}.

Based on equations (30), (34), and (35), the basic equation of mechanics can be represented in the integral form

$$(m_0 + m_i)v = mv = m_i c \text{ или } Mv = M_i c \ , \tag{51}$$

Hence it follows that the momentum is the mass of the interaction and at $m_0 = const$ (or $M_0 = const$) the change in momentum is uniquely determined by the change in the number and potential of external β_ε - pairs along the direction of the interaction. Hence, the momentum conservation law is also determined by the formula (50) taking into account the directions of interaction.

To the law of mass-energy conservation in the phenomena of microworld

Drawing up an energy balance based on the number and potential of β_ε - pairs do not depend on the form of manifestation of energy: mechanical, thermal, electrical, etc. The fact is that the specific form of manifestation of energy is determined by the specifics of the interaction of β_ε -pairs with particles of the medium [12, 13], while the ray form of energy is the energy of photons, that is, β_ε - pairs in the free state. It was when considering the balance between the ray and thermal forms of energy manifestation that Planck put forward the idea of energy quantization, having determined the energy by the number and potential of individual β_ε -pairs. The introduction of the idea of quantization meant penetration into the depths of the structure of matter, operating (though not explicitly) with individual structural units of the hierarchical level β_ε -particles, determinants, and carriers of the very concept of "energy". Already at this hierarchical level, new features of energy exchange and the conservation law are revealed. In this case, in particular, separate events with the participation of only a few particles often become objects of study, that is, to determine the energy balance, it becomes important to take into account the change in the energy of each participant separately. Let us consider the scattering of a photon by e^-. Taking into account formulas (30) and (42) for a photon before and after scattering, we can write $\varepsilon_1 \lambda_1 = \varepsilon_2 \lambda_2$, accordingly, the change in energy Δε due to scattering is given by the equation

$$\Delta\varepsilon = \varepsilon_1 - \varepsilon_2 = \varepsilon_1 \left(1 - \frac{\lambda_1}{\lambda_2}\right), \tag{52}$$

where indices "1" and "2" indicate the values of ε and λ before and after scattering.

It follows from formula (52) that at $\lambda_2 > \lambda_1$ photon energy decreases (the Compton effect), and when $\lambda_2 < \lambda_1$ and $\Delta\varepsilon < 0$ the photon energy increases (the inverse Compton effect), that is, in the case under consideration, the potentials H_i of the participants change, while the total energy of the pair e$^-$ -photon remains unchanged.

Another important feature of energy conservation at the considered hierarchical level is related to mutual transitions between rest and interaction masses. When slow e^-and e^+ collide according to schemes (6) to (9), two γ-quanta are born; in Schwinger fields, e$^-$ e$^+$ -pairs are born from γ-quanta. As a result, because of the change in the phase relations between Δ-pairs of γ_{oi} -elements, particles with a rest mass turn into particles with an interaction mass and v.v., the number and final potential of γ_{oi} -particles remain unchanged.

The transition from the interaction mass to the rest mass is also observed during the collision of accelerated charges. The very process of acceleration in ST is reduced to the formation of complexes with the participation of accelerated charges and β_ε - pairs formed with the participation of particles of the accelerating medium [12, 13], that is, already indicated complexes participate in collisions. The ST does not operate with the ideas of physical vacuum and second quantization [3, 20], by analogy with chemistry, any transformations involving particles of the microworld are reduced to reactions of addition, exchange of constituent parts, and decomposition. Note that the use of the term “birth of particles” in this work does not at all imply transitions between various forms of manifestation of matter, it simply means the formation of a new particle.

Let the leading Δ-pairs of β-particles of colliding charges be $2j/2j$ and $2\bar{j}/2\bar{j}$ quartets. At the initial stage of the collision, as a result of permutations of type $2j/2j+2\bar{j}/2\bar{j} \rightarrow 2\bar{j}/2j+2j/2\bar{j}\,\gamma_{oi}$ -inclusions are formed with $2j$-pairs (or $2\bar{j}$) oscillating, that is, these γ_{oi} -inclusions are already characterized by three periodic parametric equations, which is a criterion for the presence of a rest mass. Thus, as a result of the collision of accelerated charges, the β_ε-particles, characterized by the mass of interaction become participants in the formation of γ_{oi} -inclusions with a rest mass. At the same time, the presence in the composition of newly born particles of leading Δ-pairs with opposite directions of motion results in the decay of these same particles. As an example, let us consider the production and subsequent decay of $\pi^{\pm}$-mesons through the channels:

$$e^+ + e^- \rightarrow \pi^+ + \pi^- \qquad (53)$$

$$\pi^+ \rightarrow \mu^+ + \nu_\mu; \;\; \pi^- \rightarrow \mu^- + \tilde{\nu}_\mu \qquad (54)$$

$$\mu^+ \rightarrow e^+ + \tilde{\nu}_\mu + \nu_e; \;\; \mu^- \rightarrow e^- + \nu_\mu + \tilde{\nu}_e \qquad (55)$$

It follows from the balance of the above transformations that two pairs of muon and electron neutrinos and antineutrinos are additionally produced: $2\nu_\mu$, $2\tilde{\nu}_\mu$, ν_e and $\tilde{\nu}_e$; which, according to the interpretation apparatus used, are the result of subsequent transformations that accelerate the charges of β_ε-pairs. The mechanism of transformations through channels (53)-(55) is as follows. At the initial stage of the collision of accelerated e$^-$ and e$^+$, a complex of general composition is formed $\left[\left(e^-(\beta_1\right)2\beta_2\beta_3\left(\beta_1 e^+\right)\right]$, which further decays, respectively, into π^- and π^+ mesons, characterized by the following formulas:

$$\pi^- = \left[\left(e^-\beta_1\right)\beta_2\tilde{\gamma}_{ev}\right]; \quad \pi^+ = \left[\left(e^+\beta_1\right)\beta_2\gamma_{ev}\right] \qquad (56)$$

Further, $\pi^{\pm}$ - mesons decay according to the schemes:

$$\left(e^{-}\beta_1\right)\beta_2\tilde{\gamma}_{ev} \to \left(e^{-}\beta_1\right)\gamma_{\mu v}\tilde{\gamma}_{ev} + \tilde{\nu}_{\mu};\ \left(e^{+}\beta_1\right)\tilde{\gamma}_{\mu v}\gamma_{ev} \to \left(e^{+}\beta_1\right)\tilde{\gamma}_{\mu v}\gamma_{ev} + \nu_{\mu} \quad (57)$$

$$\left(e^{-}\beta_1\right)\gamma_{\mu v}\tilde{\gamma}_{ev} \to e^{-}\beta_1\tilde{\gamma}_{ev} + \nu_{\mu};\ \left(e^{+}\beta_1\right)\tilde{\gamma}_{\mu v}\gamma_{ev} \to \left(e^{+}\beta_1\right)\gamma_{ev} + \tilde{\nu}_{\mu} \quad (58)$$

$$e^{-}\beta_1\tilde{\gamma}_{ev} \to e^{-}\beta_1 + \tilde{\nu}_e\ ;\ \left(e^{+}\beta_1\right)\gamma_{ev} \to e^{+}\beta_1 + \nu_e\,\mathrm{e} \quad (59)$$

where μ^{-} and μ^{+} muons are represented respectively by the compositions $\left(e^{-}\beta_1\right)\gamma_{\mu v}\tilde{\gamma}_{ev}$ and $\left(e^{+}\beta_1\right)\tilde{\gamma}_{\mu v}\gamma_{ev}$; β_{e1}, β_2 and β_3 are particles of the medium with different potentials included in the accelerated charges; $\gamma_{ev}, \tilde{\gamma}_{ev}, \gamma_{\mu v}\, u\, \tilde{\gamma}_{\mu v}$ inclusions obtained as a result of transformations of β_{ε}-pairs according to schemes: $\beta_2 \to \gamma_{\mu v} + \tilde{\gamma}_{\mu v}$; $\beta_3 \to \gamma_{ev} + \tilde{\gamma}_{ev}$ and turning during subsequent decays into neutrino particles: respectively into muon $\left(\nu_{\mu}\ and\ \tilde{\nu}_{\mu}\right)$ and electron $\left(\nu_e and\ \tilde{\nu}_e\right)$ neutrinos, respectively. The potential β_1-pair determines the kinetic energy of the resulting particles with a rest mass.

It follows from the above transformations that neutrinos of different generations are single γ-particles, characterized by the same Δ-compositions of the type $j(\bar{i}k)$ / $j(i\bar{k})$ or $\bar{j}(\bar{i}\bar{k})$ / $\bar{j}\left(ik\right)$ [12]. It follows from the Δ-compositions of neutrinos that their perpendicular surfaces are weaved by a pair of Δ-elements, while γ_{oi}-particles are woven by quartets of Δ-elements. It is this circumstance that is responsible for the high penetrability of neutrino particles.

Based on the proposed Δ-composition and the previously given definition of the mass of γ_{oi} -particles, the question arises of the validity of applying the concept of "mass" to neutrino particles. Rather, inclusions of the type $(\gamma_{ev}\,\tilde{\gamma}_{\mu v})$, $(\tilde{\gamma}_{ev}\gamma_{\mu v})$, $(e^{-}\tilde{\gamma}_{ev})$ and $(e^{+}\gamma_{ev})$ with leading Δ-pairs with opposite directions of motion become the causes for the appearance of both the rest mass and the decay of these particles.

When strongly accelerated charges collide, the exchange by Δ-elements occurs at distances smaller than the oscillation amplitude of Δ-pairs. This results in the appearance of new weaving centers and the growth of perpendicular surfaces of transverse motion and, as follows from equations (14) and (17), to a significant reduction in the circulation radius along the transverse path. As a result, systems are formed with compressed γ_{oi} -inclusions with a larger mass than before acceleration. Hence, we can conclude that as a quantitative criterion for the degree of compression of γ_{oi} inclusions, we can use the value of the transverse path of manifestation of λ integrity (15). Formulas (30) and (39) imply the equality

$$\varepsilon\lambda = ch\ or\ m_i\lambda = \xi_m\xi_a, \quad (60)$$

that is, an increase or decrease in the energy or mass of interaction is associated with a decrease or increase in the transverse path λ, respectively, and the degree of compression of the particles.

Because of the collision of accelerated charges, unstable particles are created in most cases. However, if leading Δ-pairs with opposite directions of motion are removed from the composition of the initial complex formed after the collision of accelerated charges, particles with higher viability can be obtained. In [12], the production of a proton and an antiproton from accelerated e^{+} and e^{-} according to such a mechanism is considered, where γ_{oi} -particles are bound at small distances, that is, the part of the space occupied p^+ can be considered as a compressed medium. The very formation of deuterons and subsequently nuclei from deuterons and p^+ occurs according to the principle of generalization at small distances of interaction, thus, nuclei are anisotropic media with different degrees of compression [12].

Because of the high permeability, free neutrino particles can only interact with particles of highly compressed media, for example, with particles of atomic nuclei, which is currently used in the study of neutrinos of various generations [21, 22]. Penetrating the nuclear medium, neutrinos of a particular generation, depending on the degree of compression of the medium, form γ_v - inclusions: γ_{ve}, $\gamma_{v\mu}$ or $\gamma_{v\tau}$ with different rest masses. The mechanism of interaction of the absorbed neutrino with the particles of the nucleus is reduced to the exchange of the Δ-elements. The greater the degree of compression of the medium, the smaller the distance of interaction between the particles of the medium, therefore, foreign particles introduced into this medium from the outside participate in interactions at shorter distances, and new γ_v-formations are characterized by a larger mass. Thus, the greater the degree of compression of the medium, the greater the mass of new formations. If due to any interactions the γ_{ve} inclusion sequentially passes into media with a higher density, then, with the same sequence γ_{ve} passes into $\gamma_{v\mu}$ - and $\gamma_{v\tau}$-states, as well as during subsequent transitions to less dense media, $\gamma_{v\tau}$ is the inclusion passes in the $\gamma_{v\mu}$ - and γ_{ve} - states. The above description practically coincides with the Mikheyev–Smirnov–Wolfenstein effect [23].

We especially note that transitions between γ_v -states, or energy oscillations of γ_v-inclusions occur with the participation of particles of a compressed medium. Each of the inclusions γ_{ve}, $\gamma_{v\mu}$ or $\gamma_{v\tau}$ can become a source of production of neutrinos of the corresponding generation: γ_{ve}, $\gamma_{v\mu}$ or $\gamma_{v\tau}$, as well as any of these neutrinos, can become a participant in the production of γ_v -inclusions of the corresponding types.

Thus, neutrinos of different generations differ in the degree of compression, respectively, and neutrino oscillations are the result of a change in the degree of compression with a constant Δ-composition [24,25].

Because experimental studies of neutrinos of different generations are carried out using detectors - nuclei, it can be assumed that the experimentally observed results often characterize exactly the corresponding γ_v-inclusions.

If the computation of the energy balance of a certain process to carry out with allowance of γ_v-inclusions, to which the mass is attributed, then, the energy conservation law will be quite reasonable. However, if the energy balance is computed for processes involving free neutrinos, then, taking into account their Δ-composition and the accepted definition of mass, the energy conservation law will be violated because free neutrino particles are most likely massless. Moreover, based on the proposed Δ-composition, one can explain the high neutrino penetrability, because the perpendicular surface, which is woven by (*ik*)-pair, is almost 1020 times smaller than that which is woven by *2i2k*-quartet.

Relaxation Expansion Effect And Hubble´s Law

When compressed structures are formed, for example, by a collision of accelerated charges, the approach of particles results in the oscillations of Δ- pairs with smaller amplitudes, because their Δ-elements, including those from different γ_{oi} -particles, participate in the formation of new weaving centers of perpendicular surfaces, which, according to (28), increases the mass of compressed particles. The weaving of new perpendicular centers is realized according to the rules (2), where the azimuthal quantum number l according to the interpretation given in is the number of third-party or additional partners participating in the weaving of new centers within a given energy family [15]. With further compression, each previously formed center becomes the basis for weaving a new energy family, thus, the total number of centers N_c and the interaction potential H_{i0} can be determined by the following formulas

$$N_c = n^p \lambda^q \tag{61}$$

$$H_{i0} = N_c H_0 = n^p \lambda_c^q H_0\,, \tag{62}$$

Where $q = 0, \pm 1, \pm 2, \pm 3\ldots$ is the basis for classifying interactions according to energy families, n is the principal quantum number of a given energy family, $p = \pm 1$, indicates further contraction $(p = +1)$ or expansion $(p == -1)$ within the given family.

In, positive values of q in formula (62) are used to classify elementary particles by mass, negative values of q correspond to lower interaction energies, in particular, the condition $q = -1$ corresponds to the interaction energy of e^- with atomic nuclei [15].

The more the number of surface weaving centers becomes, the smaller the oscillation amplitude of the leading Δ-pair, in fact, according to (61), the oscillation amplitude of the normal state H_c is divided between $n^p \lambda_c^q$ centers, that is, $H_i = H_c / n^p ?^q$. Dividing both sides of equation (10) by π and taking $N_c = H_0$, with the allowance of formulas (28) and (32), for the transverse path and mass per one γ_{0i} -particle, we obtain

$$\lambda = \frac{H_0^3 \xi_d}{H_0^3} = \xi_d\,,\;\; m = \frac{\xi_m H_0^3}{H_0^3} = \xi_m \tag{63}$$

As noted, the value ξ_m is equal to the Planck mass m_p, which is the characteristic mass of matter in the singularity state [26]. Recall that ξ_d and ξ_m are dimensional coefficients; they were introduced to give the structural parameters the dimensional content [13, 15], that is, according to formulas (63), at $N_c = H_0$, the dimensionless values of the mass and the transverse path are equal to unity. This means that at the singularity point we have the theoretically most possible dense state of matter with the distance between ε-particles in one ε-interval. In this state, there are no hetero formations in the system.

Particles with a smaller number of γ_{0i} -elements and greater compression can have very similar masses with particles with less compression and a larger number of γ_{0i} -elements, while they may differ in other properties. Thus, $\pi^\pm$- and π^0- mesons have practically the same masses and are considered as an isotopic triplet with isospin 1 and isospin projections 0, ±1. However, $\pi^\pm$- mesons consist of six γ_{0i} -particles (56), π^0-mesons mainly decompose into two photons, that is, consist of four γ_{0i} -particles. It follows that π^0-mesons are in a more compressed state, which causes their significantly lower viability (≈7.3·10-17sec) as compared to $\pi^\pm$ mesons (≈2.6·10-8sec). The energy of each photon, obtained as a result of the decay of π^0-mesons, is approximately equal to 67 MeV. Photons with a mass from several to several tens of MeV are also born as a result of nuclear transformations and cosmic phenomena, while photons with such high energy must have a very high penetrability. However, practically no photons with such high energy and penetrability have been detected experimentally. Most of the particles found in cosmic rays do not have particularly high masses either. It is assumed that in the absence of conditions for fixing the compressed state, the relaxation processes occur in newly born particles: the forcedly formed weaving centers of perpendicular surfaces are dismantled, the oscillation amplitude Δ-pairs increases, which is accompanied by a decrease in the mass of particles. In this case, it should be expected that the greater the degree of initial compression, the greater the rate of mass reduction.

The indicated decrease in mass due to relaxation processes occurs without changing the Δ-composition of the initial particles, without the exchange of energy carriers, without external influences or participation in any interactions. In this case, the decrease in mass is caused by a change in the internal order of an organization at the level of Δ- pairs, while their number is strictly preserved. Thus, the mass of elementary particles depends not only on the number of composites of γ_{0i} -particles, but also on the order of their internal organization.

The phenomenon, as a result of which a decrease in the mass of particles occurs with a constant Δ-composition in time, will be called relaxation expansion. It follows from the foregoing, that due to the relaxation expansion in time, the mass-energy conservation law is violated.

The idea of relaxation expansion can be useful when considering phenomena not only in elementary particle physics but also in astrophysical and cosmological processes. At the point of singularity, the Universe was in a state of greatest contraction in all directions, as a result of which the newly born cosmological objects after the Big Bang had opposite directions of motion, which in turn is characterized as their mutual removal or expansion of the Universe [26]. One of the main questions that arise when considering the expansion of the Universe is the following: what is the reason for finding cosmological objects in a state of motion, are there any forces that repel cosmological objects from each other?

Let some physical body be in a state of motion, and it does not matter how the motion was initiated. Let no forces act on this body. According to Newton's first law, the body in question will be in a state of motion with a constant speed. The body will go into a state of acceleration in the presence of an acting force - Newton's second law. According to, the body is in a state of motion due to the presence of complexes formed with the participation of β_ε-energy pairs, the momentum of the body $m_i c = mv$ (51) is determined by the interaction mass m_i, the force F is the change in momentum by external influences: $F = cdm_i / dt$. Thus, the presence of a physical body in a state of motion is caused by the presence of externally introduced β_ε-pairs [27]. The result of external influences the force is a change in the number and potential of β_ε-pair. In the case of cosmological objects, the appearance of β_ε-particles in the compositions of the corresponding complexes are caused not by interactions with third-party partners, but by the specifics of the birth of cosmological objects, while the transition to the state of accelerated motion is mainly caused by the change in the rest mass because of the relaxation expansion. It is assumed that after the Big Bang a large number of complexes with the participation of β_ε-particles were formed in cosmological objects, the leading Δ-pairs of which had opposite directions of motion because in the singularity state matter was compressed in all directions. It is the presence of β_ε-particles with leading Δ-pairs having opposite directions of motion that explain the mutual removal of newly born cosmological objects, which is perceived as an expansion of the Universe.

Consider some compressed complex averaged over the entire cosmological object involving p^+ with the potential H_{p1} for some initial time t_1, and the potential H_{p2} for the measurement time t_2. Let the complex under consideration in the time interval from

t_1 to t_2 be characterized by averaged rest potentials H_{pt} and interactions H_i. Let the cosmological object under consideration traverse the path r relative to the observer, which is related to the change in the potential p of the complex by the equality

$$(H_{p1} - H_{p2})\chi_r \xi_d = r = N_p \cdot H_i \xi_d \tag{64}$$

where χ_r is the proportionality factor, N_p is the number of γ_{pi}-intervals of the path *r* with averaged intervals $H_i \xi_d$.

Taking into account the time-averaged potential H_{pt}, we represent the duration of the path *r* as the product

$$t = N_p (H_{pt} + H_i)\xi_\tau \; or \; t = N_p H_{pt} \tag{65}$$

at $H_{pt} \gg H_i$.

Dividing all parts of equation (64) by the time *t* (65), we obtain the Hubble law, the rate of mutual removal of cosmological objects

$$V = \frac{r}{t} = \frac{\left(H_{p1} - H_{p2}\right)\chi_r \xi_d}{N_p H_{pt} \xi_\tau} = Hr = \frac{H_i}{H_{pt}} c, \tag{66}$$

where the Hubble constant *H* is defined by the relation

$$H = \frac{1}{N_p H_{pt} \xi_\tau} \tag{67}$$

Based on equation (66), the Hubble law can also be represented by the relations

$$cz' = Hr \; and \; V = \frac{\Delta \underline{H}_{p1} \chi_r}{H_{pt}} c \tag{68}$$

where indicated $c = \xi_d / \xi_\tau$ (24),

$$z' = \frac{z\chi_r}{N_p}, z = \frac{H_{p1} - H_{p2}}{H_{p2}} \quad , \tag{69}$$

the change in the potential H_p over one p-interval $\Delta \underline{H}_{p1}$ is given by the relation

$$\Delta \underline{H}_{p1} = \frac{H_{p1} - H_{p2}}{N_p} \tag{70}$$

Equations (66) and (68) imply a relationship between two averaged quantities

$$\chi_r \Delta \underline{H}_{p1} = H_i \;\; u \;\; \chi_r V_{\Delta p} = V , \tag{71}$$

where $V_{\Delta p}$ is the average rate of potential change H_p for one p-interval.

Equations (66) and (68) use averaged and practically constant values of H_i and H_{pt}. The approximate constancy of H_i and H_{pt} to the greatest extent is performed relatively late, that is, the longest stages of the formation of the Universe. Hence, for the evaluation calculations, we can take $H_{pt} \approx H_{p2} \approx H_{p0}$. The value of H_{p0} can be determined using formula (36), assuming $N_{pm} = 1$:

$$H_{p0} = \frac{\pi H_0^2 m_p}{\xi_m} \approx 5,585 \cdot 10^{25} \tag{72}$$

Where the mass p^+ is taken from [19], the quantities ξ_m and H_0 are represented in (48) and (49).

Using the results obtained at the Max Planck Observatory and taking $H_{pt} = H_{p0}$ (72), we obtain from equations (64), (66), and (72) [28]

$$H_i = \frac{vH_{p0}}{c} = 1,266 \cdot 10^{22}; \;\; N_p = \frac{r}{H_i \xi_d} = 2,4 \cdot 10^{34}, \tag{73}$$

Accordingly, taking into account (72), we obtain for the Hubble constant from formula (67)

$$H = \frac{1}{N_p \cdot H_{p0} \cdot \xi_\tau} = 2,2 \cdot 10^{-18} c^{-1}, \tag{74}$$

where the numerical values of ξ_d and ξ_τ are given in the series (48).

Taking $H_{p1} = 2H_{p2}$, that is, $z = 1$ from (69), we obtain from formulas (70) and (71)

$$\Delta \underline{H}_{p1} = \frac{H_{p2}}{N_p} \simeq 2,32 \cdot 10^{-9}, \;\; \chi_r = \frac{H_i}{\Delta H_{p1}} = 5,46 \cdot 10^{30} \tag{75}$$

that is, the rate of change of rest mass $\mathrm{V}_{\Delta p}(71)$, $5.46 \cdot 10^{30}$ times less than the removal rate of the corresponding cosmological object, that is, at this stage of the evolution of the Universe, the relaxation expansion rate is very small.

One of the main questions that arise when considering the Hubble law is the following: why does the rate of mutual removal of cosmological objects increase with the increasing distance *r*? It follows from equation (66) that at $H_i \approx const$, with increasing *r*, H_{pt} decreases due to relaxation expansion, and the speed V increases accordingly.

Because over time the number of p-intervals N_p grows, and H_{pt} decreases owing to the relaxation expansion, the product can be taken as $N_p H_{pt} \approx const$, thus the change in H according to formula (74) should not be very significant. The rate of relaxation expansion depends on the duration of the evolution of the Universe. At the initial stage of the evolution of the Universe, the rate of relaxational expansion should be much higher; at later stages of evolution, the rate of relaxational expansion decreases significantly, and a better agreement between the Hubble law and the observed results should be expected because $N_p H_{pt} \approx const$. Thus, the expansion of the Universe is not explained by the expansion of space itself, but an alternative option is proposed: the mutual removal of cosmological objects is caused by the presence of β_ε-pairs (interaction mass), the genesis of which is associated with the specifics of the birth of these objects, while the increase in the removal rate from the distance is associated with the relaxation expansion of compressed systems.

Conclusion

It is assumed that all physical bodies contain the same structural elements the γ_{0i}-particles start from a certain hierarchical level, and the laws of motion of these particles determine the generality of the quantitative laws of all physical bodies. The trajectory of motion of γ_{0i}-particles consist of two components: transverse, always closed curvilinear with the weaving of a perpendicular surface, and longitudinal, which is considered in conventional physics. Just with the characteristics of the transverse motion, the content of the fundamental property of matter, "mass" is related. The mass can also be represented as the result of combining the characteristics of longitudinal motion: the momentum mv and the transverse path λ associated with the manifestation of the integrity of the γ_{0i}- particles, which in conventional physics is considered as the length of the wave coupled to the particles: $mv = h\lambda^{-1}$, where h is the Plank constant.

Depending on the nature of the participants, three types of mass are classified in interactions:

- The rest mass m_0, with the participation of only own compound particles;
- The mass of the general interaction m_{0i}, with the participation of only the own constituent particles of the partners;
- The mass of interaction m_i, with the participation of third-party partners.

Additionally, the concept of the total mass is introduced, which is determined by the sum of the rest and interaction masses: $m = m_0 + m_i$.

Energy is classified similarly, while the equivalence of mass and energy for each interaction option is caused by the unity of their dimensionless components.

Structurally, the manifestation of mass (energy) is related to the presence of binaries of γ_{0i}-particles, called β_ε-energy pairs or β_ε β_ε-pairs. In the case of intrinsic interaction and interaction with its partner, the creation of β_ε-pairs is the result of interactions with the participation of its constituent particles, interaction with third-party partners (mechanical effects, heat transfer, etc.) is reduced to the exchange of β_ε-pairs. It is β_ε-pairs that are carriers and quantitative determinants of mass-energy.

The total mass of any classical system is determined by the sum of the rest and interaction masses, while, as a result of any processes, the rest mass of each of the participants remains unchanged. The potential of each β_ε-energy pair also remains unchanged, thus, the total energy of an isolated system remains constant, while the change in the energy of each participant is caused by the mutual exchanges of β_ε-energy pairs. When considering the phenomena of the microcosm, the objects of study are often separate acts of interactions involving a very limited number of particles. In such phenomena as the direct and inverse Compton effect, the potential of a single β_ε-pair changes, in the phenomena of annihilation and the birth of an $e^{\pm}$-pair, mutual transitions between the rest and interaction masses are observed, while, in these phenomena, the total mass remains unchanged.

The transition of the interaction mass to the rest mass occurs in almost all cases of collision of accelerated charges. The acceleration process itself is the formation of complexes with the participation of particles of the accelerating medium, which is accompanied by an increase in the interaction mass. As a result of the collision of accelerated charges, new particles are born, often with a significantly larger rest mass than the rest mass of the accelerated charges. This is caused by the fact that the mass of the interaction of accelerated charges as a result of the collision is transformed into inclusions with the rest mass. Newly born particles decay into separate particles, including single formations - neutrinos of different generations of the same composition. The rest mass of neutrino inclusions formed in newly born particles or as a result of neutrino absorption depends on the density or the degree of compression of the medium; the smaller the distance between the constituent particles of the medium, the greater the mass of the neutrino inclusion, respectively, and the mass of neutrinos produced during the subsequent decay of the systems under consideration. Thus, an electron neutrino (ν_e), interacting with particles of a high degree of density, able to form neutrino inclusions that emit muon (ν_μ) or tau neutrinos (ν_τ) in subsequent transformations. As well as in the opposite direction, ν_μ and ν ν_τ, forming neutrino inclusions with particles of a less dense medium, subsequently emitted as ν_e.

Thus, the neutrinos of different generations differ in the degree of compression for the same Δ-composition. Neutrino oscillations, that is, mutual transitions between neutrinos of different generations are rather realized through the stage of interaction with particles of media characterized by different degrees of density. Oscillation without the participation of external particles is possible only in one direction - from more compressed to less compressed, that is, transitions like $\nu_\tau \rightarrow \nu_\mu, \nu_\tau \rightarrow \nu_e$ e and $\nu_\mu \rightarrow \nu_e$ are possible.

In the collision of accelerated charges, nuclear and cosmological processes, particles are often born in a forcedly compressed state, characterized by very small distances between the constituent elements. This results in the emergence of new centers of weaving perpendicular surfaces, respectively, and to an increase in mass. In the future, as a result of relaxation processes, the indicated centers of weaving are dismantled and the mass of particles is reduced, while the number of composite particles remains unchanged. In this case, the decrease in mass is due not to the processes of mass or energy exchange, but a change in the order of the internal organization of the object under consideration. This phenomenon of mass reduction, accompanied by an increase in the transverse path of manifestation of the integrity of particles is called relaxation expansion.

The decrease in mass due to relaxation expansion is irreversible, that is, there is an irreversible loss of mass, while the value of the irreversibly lost mass can be significantly greater than the mass of the objects under consideration at the time of measurements.

It is with the help of relaxation expansion that the increase in the speed of cosmological objects with their mutual removal (Hubble's law) is explained, as well as the cosmological redshift. The very mutual removal of cosmological objects is explained not by the expansion of space, but by the presence of an interaction mass, the genesis of which is caused by the specifics of the birth of the cosmological objects themselves.

The phenomenon of relaxation expansion is noteworthy in that with a decrease in mass, the number of constituent particles of the objects under consideration, that is, the amount of matter remains unchanged, so the concepts of "amount of matter" and "value of mass" is not always equivalent.

Two cases of violation of the law of constancy of mass-energy follow from the foregoing:

- in the case of reorganization of γ_{0i} -particles into such forms of existence, to which the definition of mass (energy) is not applicable,
- due to relaxation expansion: a decrease in mass caused by the change in the order of internal organization.

In both cases, the amount of matter remains unchanged, the number of composite particles - participants in these processes.

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