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THE LAWS OF STRONG AND WEAK INTERACTIONS — THE LAWS OF ELECTROMAGNETISM IN MICROCOSM

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Законы сильного и слабого взаимодействий — законы электромагнетизма в микромире

В работе приведены массовые формулы для электрона, протона, мюона, нейтрона и дейтрона через фундаментальные константы без единого параметра, доказывающие однозначно электромагнитное содержание сильного и слабого взаимодействий в микромире.

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The Laws of Strong and Weak Interactions — the Laws of Electromagnetism in Microcosm

Mass formulas for the electron, proton, muon, neutron, and deuteron are given in terms of fundamental constants without a single parameter. They unambiguously prove the electromagnetic content of strong and weak interactions in the microcosm.

The investigation has been performed at the Dzhelepov Laboratory of Nuclear Problems, JINR.

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INTRODUCTION

Mass formulas for the electron (e), muon (μ), proton (p), neutron (n), and deuteron (d) in terms of fundamental constants without a single parameter, which unambiguously prove electromagnetic content of the strong and weak interactions are given in the paper. It is briefly explained how they were derived and what corollaries can be inferred from them (a comprehensive paper is being prepared for publication).

The mass formulas have been derived by generalizing the theory of relativity to the atomic structure of scales and clocks because of their participation in motion [1–7] in accordance with Einstein's opinion [8] about the necessity of this generalization, which he voiced after the known discussion with Bohr. Einstein pointed out that his construction of the special theory of relativity was illogical because the theory of scales and clocks did not follow from solutions of the basic equations despite the atomic structure of the scales and clocks themselves and their participation in motion. The latter results in the fact that the properties of kinematic scales and clocks in the special theory of relativity are separated from the entire world of physical phenomena. In addition, account was taken of Schwinger's well-grounded hypothesis [9] that strong interaction is due to the Dirac magnetic monopole [10], while weak interaction is an electromagnetic interaction.

1. RELATION OF GALILEAN AND LORENTZIAN COORDINATES IN INERTIAL SPACE–TIME

Generalization of the theory of relativity to the atomic structure of scales and clocks due to their participation in motion leads to the generalized Minkowski space–time with an added dimension that has an angular dimensional representation for fulfillment of the angular momentum conservation law, which always presented problems in the theory of relativity [1, 2]. For brevity, this generalized three-dimensional space was called an inertial space–time [6]. This inertial space–time has two isometry groups:

$$ds = dx - cdt, \tag{1}$$

$$ds^2 = dx^2 - c^2dt^2. \tag{2}$$

Space–time shifts (1) in this inertial space–time are invariant under the transformations

$$x' = \frac{x - vt}{1 + v/c}, \quad t' = \frac{t - (v/c^2)x}{1 + v/c}, \tag{3}$$

making up a subgroup of shifts of the Poincaré group with the same parametrization

$$v'' = \frac{v + v'}{1 + vv'/c^2}, \tag{4}$$

as the Lorentz transformation making the subgroup of turn (2) of the Poincaré group

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}}, \quad t' = \frac{t - (v/c^2)x}{\sqrt{1 - v^2/c^2}}, \tag{5}$$

turning half-declarative space–time unity into reality. Transformations (3) and (5) are in agreement with experiment in which physical laws are invariant under space–time shifts, turn in space–time, and transformations of motion themselves (meaning equivalence of frames of reference) which are the content of the Poincaré group [11]. In addition, the inertial space–time contains a transformation of coordinates of the dimension with the angular dimensional representation

$$\varkappa' = \frac{\varkappa - (v/c)\varkappa}{\sqrt{1 - v^2/c^2}} \tag{6}$$

with parametrization (4), which makes up an isomorphic rotation subgroup of the 15-parameter Bateman group. Maxwell electrodynamics is invariant under the Bateman group in the vacuum and contains the 10-parameter Poincaré group as a subgroup. The Bateman group was introduced in the quantum field theory by Dirac [12]. In addition, the inertial space–time contains a transformation of coordinates for the angular shift

$$\varkappa' = \frac{\varkappa - (v/c)\varkappa}{1 + v/c} \tag{7}$$

with parametrization (4) making up an isomorphic angle shift subgroup of the same Poincaré–Bateman group [12].

In the inertial space–time, a relation between the generalized Galilean (marked with asterisks) and Lorentzian (marked with hats) coordinates is established [1, 2]:

$$\overset{*}{x}{}^2 = \hat{x}\breve{x}, \quad \overset{*}{\varkappa}{}^2 = \hat{\varkappa}\breve{\varkappa}, \quad \overset{*}{t}{}^2 = \hat{t}\breve{t}. \tag{8}$$

From this relation it follows that

$$\begin{cases} \overset{*}{x} = \dfrac{\hat{x}+v\hat{t}}{\sqrt{1-v^2/c^2}}, & \overset{*}{\varkappa} = \dfrac{\hat{\varkappa}+\dfrac{v}{c}\hat{\varkappa}}{\sqrt{1-v^2/c^2}}, & \overset{*}{t} = \dfrac{\hat{t}+\dfrac{v}{c^2}\hat{x}}{\sqrt{1-v^2/c^2}}, \\ \overset{*}{x} = \dfrac{\check{x}-v\check{t}}{\sqrt{1-v^2/c^2}}, & \overset{*}{\varkappa} = \dfrac{\check{\varkappa}-\dfrac{v}{c}\check{\varkappa}}{\sqrt{1-v^2/c^2}}, & \overset{*}{t} = \dfrac{\check{t}-\dfrac{v}{c^2}\check{x}}{\sqrt{1-v^2/c^2}}. \end{cases} \tag{9}$$

The inertial space–time interval

$$d\,\overset{*}{s}{}^2 = d\,\overset{*}{x}{}^2 + c^2 d\,\overset{*}{t}{}^2 + d\,\overset{*}{\varkappa}{}^2 \tag{10}$$

is invariant under them. This interval with complex time [13] is also invariant under the shifts

$$\begin{cases} \overset{*}{x} = \dfrac{\hat{x}+v\hat{t}}{1-v/c}; & \overset{*}{\varkappa} = \dfrac{\hat{\varkappa}+\dfrac{v}{c}\hat{\varkappa}}{1-v/c}; & \overset{*}{t} = \dfrac{\hat{t}+\dfrac{v}{c^2}\hat{x}}{1-v/c}; \\ \overset{*}{x} = \dfrac{\check{x}-v\check{t}}{1+v/c}; & \overset{*}{\varkappa} = \dfrac{\check{\varkappa}-\dfrac{v}{c}\check{k}}{1+v/c}; & \overset{*}{t} = \dfrac{\check{t}-\dfrac{v}{c^2}\check{x}}{1+v/c}. \end{cases} \tag{11}$$

The linear intervals

$$\begin{cases} \sqrt{d\,\overset{*}{s}{}^2} = \sqrt{d\,\overset{*}{x}{}^2 + c^2 d\,\overset{*}{t}{}^2} + i\sqrt{\overset{*}{\varkappa}{}^2}; \\ \sqrt{d\,\overset{*}{s}{}^2} = \sqrt{d\,\overset{*}{x}{}^2 + c^2 d\,\overset{*}{t}{}^2} - i\sqrt{\overset{*}{\varkappa}{}^2}. \end{cases} \tag{12}$$

are also invariant under these shifts. This representation of linear intervals does not violate space–time unity, which is essential for the understanding of the World's structure.

The relation between the generalized Galilean and Lorentzian coordinates is established by requiring that relativity of the «approach» and «moving-apart» of the frame of reference should hold in the inertial space–time as in the real World [1, 2, 6]. As known, in the theory of relativity, Lorentz transformations make it impossible for a frame of reference to be distinguished with respect to one another because of the Doppler effect for it depends only upon their relative velocity. On the other hand, Lorentz transformations in principle do not forbid absoluteness of their approaching to or moving apart from each other. In this approach, the measured frequency is higher than the reference frequency, while on their moving apart, by contrast, the reference frequency is higher than the measured one if identical vibrators and frequency meters are placed in each system.

Though this conclusion is logical, it is in conflict with reality because, for example, when the frequency meter moves apart from the vibrator along the with the same velocity. Consequently, «approach» and »moving-apart» of the vibrator and the frequency meter are not absolute and are always relative contrary to the conclusion that may be drawn within the framework of the special theory of relativity.

The latter fully complies with the Doppler frequency ratio for a wave leaving its source and arriving from the opposite sides at the same real point in another frame of reference. The frequency-conserving invariance of the plane wave phase under (9) and (11) states the same equivalence of the directions of space–time shifts as does the Poincaré group in relativistic kinematics [11]. The difference is that the direction must also be oriented in the inertial space–time as, for example, inertial Coriolis forces in the northern and southern hemispheres of the Earth are oriented with respect to the river flow direction toward the corresponding Earth's poles. Therefore, Poincaré–Bateman group representations (9), (11) are split into two orientation subgroups.

As a result, the Lorentzian coordinates themselves in the inertial space-time are coordinates of the center-of-inertia system [1]:

$$\hat{x} = \frac{\check{x} - \dfrac{2v}{1+v^2/c^2}\check{t}}{\sqrt{1-(4v^2/(1+v^2/c^2)^2c^2)}};$$
$$\hat{\varkappa} = \frac{\check{\varkappa} - \dfrac{2v}{(1+v^2/c^2)c}\check{\varkappa}}{\sqrt{1-(4v^2/(1+v^2/c^2)^2c^2)}}; \qquad (13)$$
$$\hat{t} = \frac{\check{t} - \dfrac{2v}{(1+v^2/c^2)c^2}\check{x}}{\sqrt{1-(4v^2/(1+v^2/c^2)^2c^2)}}.$$

Actually, the relation between the Galilean and Lorentzian coordinates has always existed since Galilei's time. Why?! Let us consider motion of a train relative to an observer at the railway terminal. For a passenger sitting in the railway car, the Galilean transformations will be written as follows:

$$\begin{cases} \Delta x' = \Delta x - v\Delta t, \\ \Delta t' = \Delta t. \end{cases} \qquad (14)$$

For a passenger moving along the car in the direction of the train's motion at a velocity v' relative to the sitting passenger, the Galilean transformations will be as follows:

$$\begin{cases} \Delta x'' = \Delta x - (v+v')\Delta t, \\ \Delta t'' = \Delta t, \end{cases} \qquad (15)$$

where $(v+v')$ is the velocity of the passenger in motion relative to the observer at rest at the terminal according to the Galilean velocity addition rule. Then the distance covered by the passenger in motion in the frame of reference of the observer at rest at the terminal will be

$$\Delta t''(v+v') = \Delta t(v+v'), \tag{16}$$

and the distance covered at the same time by the passenger at rest in the car in the same frame of reference is

$$\Delta t'' \left(\frac{v+v'}{1+vv'/v^2}\right) = \Delta t v, \tag{17}$$

where $\left(\frac{v+v'}{1+vv'/v^2}\right)$ is the velocity relative to the laboratory frame of reference (in our case it is the terminal with its railway), which can be obtained by the Lobachevsky velocity addition rule (as known, it is only planimetry that dictates the velocity addition rule). This rule involves the velocity of the passenger at rest instead of the fundamental boundary velocity for the propagation of the light front in free space in terms of the Fock representation as well [14]. This is physically justified by existence of a family of boundary velocities of sound in various media such that motion of a body in a medium with a velocity in excess of the corresponding boundary velocity results in formation of a wave front in the form of a Mach cone. This velocity addition rule (17) is also justified by the fact that for each particular medium there is its own velocity of the electromagnetic wave front propagation such that motion of a charged particle with a velocity in excess of it results in the Cherenkov effect. Obviously, it is impossible to generalize the theory of relativity to condensed matter without knowing this velocity addition rule (17) and without understanding that the Galilean space–time includes the Lobachevsky planimetry in the form of chronogeometry. It must be said in fairness that as far back as the beginning of the past century Klein pointed out that the relative velocity plays the same role in the Galilean transformation as the velocity of light in the special theory of relativity [15]. This fact is in itself another weighty argument in favor of existence of the anthropic principle in the Universe.

Thus, a limitation should obviously be imposed on the velocity of the laboratory frame of reference rather than on the velocity of propagation of a wave front in free space. Then the boundary velocity will be automatically present in the Lorentz transformation (13). That is why Poincaré [11], when presenting the principle of relativity as generalization of the Galilean principle, did it by forbidding Newton's absolute frame of reference from existing in Nature. Yet, in the Minkowski space–time, the space–time and the world line are absolute and his principle of the «absolute world» (world postulate) states that in phenomena we only have a projection of the World four-dimensional in space and time and that this projection on space and time may be taken with some arbitrariness.

Therefore, what is used in our case to fuse the concepts of the theory or relativity and the concepts of quantum mechanics is the generalization of the theory of relativity to the atomic scales and clocks [1–6]: physical laws are not affected by switching to another frame of reference because of the universal limitation imposed on the relative velocity of these frames of reference by finiteness of microscales of rulers, angle gauges, and clocks so that only their total set in frames of reference makes up physical reality in the World. By the boundary velocity is naturally meant the velocity of time flowing from the «past» to the «future» equal to the velocity of propagation of the light front in free space. The direction of time from the «past» to the «future» in the three-dimensional space, unlike its direction from the «past» to the «future» in the two-dimensional Minkowski space, does not violate equivalence of Poincaré directions.

It follows from the aforesaid that the frame of reference by itself may be represented only by the laboratory frame of reference in the form of a bound substance making up a macroscopic body with rulers, angle gauges, and clocks arranged on it in a certain order and their ordered collection constitutes a space–time grid, together with measuring instruments, in contrast to Einstein's frames of references having no mass, as Brillouin pointed out [5]. This definition of the frame of reference requires adjustment of space–time intervals in inertial frames of reference, i. e., matching of the origins of space–time coordinate grids during preparation for the experiment before studying a microphenomenon, which totally agrees with the Bohr principle of complementarity [5].

This relation (9), (11) between the Galilean and Lorentzian coordinates is physically not only justified but also necessary for the description of the microcosm because measurements describing microobjects can be made only with a macroscopic instrument as said above (physical grounds for the Bohr principle of complementarity in quantum mechanics).

2. SYMMETRY OF HEISENBERG UNCERTAINTY RELATIONS ABOUT DIMENSIONS OF PHYSICAL MEASUREMENTS

According to Gauss [16], in a three-dimensional space, like the inertial space–time,

$$(d\overset{*}{s})^2/d\overset{*}{t}=\overset{*}{L}\,d\overset{*}{t}, \tag{18}$$

where $\overset{*}{L}$ is the Lagrangian function,

$$\frac{(d\overset{*}{s})^2}{d\overset{*}{t}}=\frac{d\overset{*}{\rho}}{d\overset{*}{t}}d\overset{*}{\rho}+\frac{4r_0^2}{\pi^2}\frac{d\overset{*}{\varkappa}}{d\overset{*}{t}}d\overset{*}{\varkappa}+c^2d\overset{*}{t}, \tag{19}$$

where

$$\overset{*}{\rho}^2=\overset{*}{x}^2+\overset{*}{y}^2+\overset{*}{z}^2, \tag{20}$$

and the factor $(4r_0^2/\pi^2)$ is related to dimensions and a particular circumference. If the material point is in a potential field, its dimension of action in interaction is

$$d\overset{*}{S}=\frac{(d\overset{*}{s})^2}{d\overset{*}{t}}=\frac{\partial\overset{*}{S}}{\partial\overset{*}{\rho}}d\overset{*}{\rho}+\frac{\partial\overset{*}{S}}{\partial\overset{*}{\varkappa}}d\overset{*}{\varkappa}+\frac{\partial\overset{*}{S}}{\partial\overset{*}{t}}d\overset{*}{t}, \tag{21}$$

while a comparison of (19) and (21) yields a system of equations

$$\frac{\partial\overset{*}{S}}{\partial\overset{*}{\rho}}=\frac{d\overset{*}{\rho}}{d\overset{*}{t}},\quad \frac{\partial\overset{*}{S}}{\partial\overset{*}{\varkappa}}=\frac{4r_0^2}{\pi^2}\frac{d\overset{*}{\varkappa}}{d\overset{*}{t}},\quad \frac{\partial\overset{*}{S}}{\partial\overset{*}{t}}=c^2 \tag{22}$$

describing variation in the momentum, moment, and energy of the material point in the interaction.

It is evident that this variation in the action of the material point should be invariant under turning and rotational transformations

$$\left\{\begin{array}{llllll} \overset{*}{\rho} = \dfrac{\hat{\rho}+v\hat{t}}{\sqrt{1-v^2/c^2}}, & \overset{*}{\varkappa} = \dfrac{\hat{\varkappa}+\dfrac{v}{c}\hat{\varkappa}}{\sqrt{1-v^2/c^2}}, & \overset{*}{t} = \dfrac{\hat{t}+\dfrac{v}{c^2}\hat{\rho}}{\sqrt{1-v^2/c^2}}, \\ \overset{*}{p} = \dfrac{\check{p}-\dfrac{v}{c^2}\check{E}}{\sqrt{1-v^2/c^2}}, & \overset{*}{I} = \dfrac{\check{I}-\dfrac{v}{c}\check{I}}{\sqrt{1-v^2/c^2}}, & \overset{*}{E} = \dfrac{\check{E}-v\check{p}}{\sqrt{1-v^2/c^2}}, \end{array}\right. \tag{23}$$

and under shifts

$$\left\{\begin{array}{lll} \overset{*}{\rho} = \dfrac{\hat{\rho}+v\hat{t}}{1-v/c}, & \overset{*}{\varkappa} = \dfrac{\hat{\varkappa}+\dfrac{v}{c}\hat{\varkappa}}{1-v/c}, & \overset{*}{t} = \dfrac{\hat{t}+\dfrac{v}{c^2}\hat{\rho}}{1-v/c}, \\ \overset{*}{p} = \dfrac{\check{p}-\dfrac{v}{c^2}\check{E}}{1+v/c}, & \overset{*}{I} = \dfrac{\check{I}-\dfrac{v}{c}\check{I}}{1+v/c}, & \overset{*}{E} = \dfrac{\check{E}-v\check{p}}{1+v/c}. \end{array}\right. \tag{24}$$

This invariance corresponds to three conservation laws for momentum, moment, and energy.

For the sake of certainty in interpretation of the results obtained, we define matter as objective reality representing the World by quantitative manifestation of its properties in various forms and observed by variation in this manifestation [2, 6].

According to this definition, solutions to the system of equations (22) will be observable because they are variation in quantitative manifestation of matter. This means that such momentum, moment, and energy variations are respective measures of length, angle, and time intervals because of their belonging to different frames of reference (left and right). In this sense the special theory of relativity is reduced in the Minkowski space-time to two-dimensional dimensions projected onto a 4-orthogonal basis [2, 6].

Thus, the generalization made is just the generalization of the special theory of relativity to the microcosm, where simultaneous measurement of canonically conjugate dynamic variables is forbidden. While in quantum mechanics, simultaneous measurement of ΔE and Δt is not forbidden because of the absence of the time operator (there is only awareness of the necessity of this forbidding); in the inertial space–time (23), (24), there are simply no other options because of relativity of approach and moving-apart of the frames of reference.

In this three-dimensional space (23), (24) Heisenberg uncertainty relations are symmetrized about dimensional physical dimensions:

$$(25)\ \Delta p\,(2\pi\Delta\rho) \geq \frac{1}{2}\hbar\left(\frac{2\pi}{\lambda_0}\right)\lambda_0, \longrightarrow 2\pi\frac{1}{\lambda_0} = 2\pi k_0,\ (26)$$

$$(27)\ \Delta I_\rho\,(2\pi\Delta\theta) \geq \frac{1}{2}\hbar\left(\frac{2\pi}{2\pi}\right)2\pi, \longrightarrow 2\pi\frac{1}{2\pi} = 2\pi\varkappa_0,\ (28)$$

$$(29)\ \Delta E\,(2\pi\Delta t) \geq \frac{1}{2}\hbar\left(\frac{2\pi}{t_0}\right)t_0, \longrightarrow 2\pi\frac{1}{t_0} = 2\pi\nu_0.\ (30)$$

Because of equivalence of uncertainty relations (25), (27), and (29), one should admit both the angular number (28) as are admitted the wave number (26) and the frequency (30), the physical dimension of the angle in relation (27) similarly to dimensions of length and time in uncertainty relations (25) and (29) respectively.

If we pass to the rigorous equality in uncertainty relations (25), (27) and (29)

$$(31)\ 2\pi\Delta\rho_0 = \hat{\rho}_0, \longleftarrow \check{p}_0\hat{\rho}_0 = \frac{1}{2}(hk_0)\lambda_0 \longrightarrow \overset{*}{p}_0 = hk_0,\ (32)$$

$$(33)\ 2\pi\Delta\theta_0 = \hat{\theta}_0, \longleftarrow \check{I}_0\hat{\theta}_0 = \frac{1}{2}(h\varkappa_0)2\pi \longrightarrow \overset{*}{I}_0 = h\varkappa_0,\ (34)$$

$$(35)\ 2\pi\Delta t_0 = \hat{t}_0, \longleftarrow \check{E}_0\hat{t}_0 = \frac{1}{2}(h\nu_0)t_0 \longrightarrow \overset{*}{E}_0 = h\nu_0,\ (36)$$

formulas (32) and (36) with the constant h in the Planck representation are the physical content of the corpuscular-wave nature of the electron in quantum mechanics. Then (34) is nothing but a quantum-mechanical top (generalized Kovalevskaya top [13]), the very physical object which manifests itself in a corpuscular or wave form in the interaction with a classical instrument in full compliance with the Bohr principle of complementarity.

Consequently, relations (32), (34), (36) define inertial space–time dimensions of this quantum-mechanical top, while the uncertainty relations are the physical content of the atomic scales of rulers, angle gauges, and clocks in quantum mechanics and establish the boundary region relative to which classical phenomena may exist.

For the non-commuting canonically conjugate variables (31), (33), (35) to comply with quantum mechanics, they must necessarily be written in the form of vector products, which is natural in this case:

$$[\hat{\vec{\rho}}_0, \check{\vec{p}}_0] = \frac{1}{2}h\vec{\sigma}_\lambda; \qquad [\hat{\vec{\theta}}_0, \check{\vec{I}}_0] = \frac{1}{2}h\vec{\sigma}_\varkappa; \qquad [\hat{\vec{t}}_0, \check{\vec{E}}_0] = \frac{1}{2}h\vec{\sigma}_t. \tag{37}$$

The vector representation of the relation for $\hat{\vec{t}}_0$ and $\check{\vec{E}}_0$ is justified by existence of the Umov vector for the density of mechanical energy and the Poynting vector for the density of electromagnetic energy in nature as well as by the presence of the «time arrow» from the «past» to the «future» in the three-dimensional space, which forbids realization of the perpetuum mobile of the second kind in the microcosm requiring that physical processes in the microcosm should be considered in the generalized Fock space. In this case equivalence of Poincaré directions in the *three-dimensional* space is not violated. The dynamic variable $\hat{\vec{\theta}}_0$ is related to «left» and «right» rotation.

Then

$$[\hat{\vec{\rho}}_0, \check{\vec{p}}_0] - [\check{\vec{p}}_0, \hat{\vec{\rho}}_0] = h\vec{\sigma}_\lambda; \tag{38}$$

$$[\hat{\vec{\theta}}_0, \check{\vec{I}}_0] - [\check{\vec{I}}_0, \hat{\vec{\theta}}_0] = h\vec{\sigma}_\varkappa; \tag{39}$$

$$[\hat{\vec{t}}_0, \check{\vec{E}}_0] - [\check{\vec{E}}_0, \hat{\vec{t}}_0] = h\vec{\sigma}_t. \tag{40}$$

Thus, we may use a generalization of the Heisenberg equation to (38), (39), (40) to graduate rulers, angle gauges, and clocks in the microcosm:

$$i\hbar\frac{d\hat{\vec{\rho}}}{dt} = [\hat{\vec{\rho}}, \check{\vec{p}}_0] - [\check{\vec{p}}_0, \hat{\vec{\rho}}] = h\vec{\sigma}_\rho \longrightarrow \frac{d\hat{\vec{\rho}}}{dt} = -2\pi i\vec{\sigma}_\rho; \tag{41}$$

$$i\hbar\frac{d\hat{\vec{\theta}}}{dt} = [\hat{\vec{\theta}}, \check{\vec{I}}_0] - [\check{\vec{I}}_0, \hat{\vec{\theta}}] = h\vec{\sigma}_\varkappa \longrightarrow \frac{d\hat{\vec{\theta}}}{dt} = -2\pi i\vec{\sigma}_\varkappa; \tag{42}$$

$$i\hbar\frac{d\hat{\vec{t}}}{dt} = [\hat{\vec{t}}, \check{\vec{E}}_0] - [\check{\vec{E}}_0, \hat{\vec{t}}] = h\vec{\sigma}_t \longrightarrow \frac{d\hat{\vec{t}}}{dt} = -2\pi i\vec{\sigma}_t; \tag{43}$$

Nonunified clock and scale graduation, for example, in the special theory of relativity [1, 5, 6, 14] causes the «relativistic clock paradox».

3. NECESSITY OF FORMULATING FIELD MECHANICS OF THE PROTOVOLCHOK

In [1–6] the key points of mechanics of the protovolchok (generalization of the Kovalevskaya top [13]) in the gravitating field of the Universe are formulated for the three-dimensional space (23), (24). The protovolchok field mechanics itself was formulated with allowance for Dirac's comments on the current concept of the microcosm and for its prophetic opinion about the future of the microcosm theory [6].

According to Dirac [17], the current quantum theory is very similar to the pre-Heisenberg quantum theory when Dirac himself was stubbornly sticking to Bohr orbits. Dirac believes that physicists *are mistaken* continuously trying to develop physics ideas to which they got accustomed: these ideas, usually expressed in Feynman's terms, and attempts to introduce artificial renormalization procedures in order to bypass difficulties result in the fact that *infinitely larger* quantities have to be rejected. It is just *mathematically senseless.* In mathematics a quantity is rejected only if it turns out to be *very small.* In his opinion, it is necessary to have *mathematics of a new type, new equations* which would express *interaction between the main physics quantities.* In addition, Dirac [18] thinks it is *very probable* that the future will once see the advent of *improved quantum mechanics* in agreement with Einstein's opinion, where *return to causality* occurs. Yet, this return to causality, in his opinion, may be possible *at the cost of rejection of any other fundamental idea* which is now unreservedly supported. And he thinks that one may only guess which idea should be sacrificed.

The three-dimensional space (23), (24) turned out to be a generalization of the Friedmann–Lobachevsky space [14, P. 11, 12]. This space, unlike the Galilean one, allows existence of the gravitating field that *in places* is nonuniform, according to Fock. While in the Galilean space, ordinary Cartesian coordinates and time are dominating, (which all together are called Galilean coordinates according to Fock [14, P. 12]), the dominating coordinates of the generalized Friedmann–Lobachevsky space are generalized Galilean coordinates (8). Domination of the Cartesian coordinates in the Galilean space–time is due to the fact that Lorentz transformations expressing uniformity of space will be linear in these coordinates. Domination of the generalized Galilean coordinates (8) in the Friedmann–Lobachevsky space is due to splitting of the Poincaré–Bateman group representation into two orientation subgroups (9), (11) turning transformations (8) into the linear ones (9), (11) as well. The protovolchok itself is an object with a corpuscular-wave structure and a generalization of Newton's material point in the form of a generalized Euler solution of the equation of motion of a heavy point for the shortest time in the gravitating field in this three-dimensional space [2]. As a result of obtaining a relation between the electromagnetic interaction and the gravitating one in [2], it is established that the protovolchok has electromagnetic characteristics of the Schwinger dion [9], namely, the Coulomb charge and the bipole with opposite magnetic poles each equal in value to the Dirac monopole [10]. The term «bipole» it taken for the reason that Dirac uses the Latin prefix «bi» in his works, e. g. bispinor. It is revealed that the physical content of the Coulomb and gravitation charges is the mechanical moment of the generalized Umov–Poynting vector for the energy density [2, 6], with which, according to Fock [19], one can associate a quantum-mechanical operator, thus solving the problem of the Coulomb charge conservation in quantum mechanics formulated by Wigner [20]. It is demonstrated that the quantum-mechanical top (34) is present in this generalized Euler solution [2, 6].

If the angular dimension is set to zero, the protovolchok with a finite number of degrees of freedom will turn into a quantum point of Dirac's relativistic theory [6]. But then the protovolchok equation becomes adequate to the relativistic Dirac equation, which eliminates the Lamb shift problem [2]. For example, in the case of a positronium consisting of the protovolchok and antiprotovolchok the solution of the equation of the protovolchok in the three-dimensional space involves a correction to the seventh decimal place for the ground state of the positronium while, in contrast, the solution of the Dirac equation in the two-dimensional Minkowski space involves a correction to the tenth decimal place in a similar situation. As established [2, 6], in the three-dimensional space the electron is an extended dynamic system comprising one protovolchok. Neglect of this has led to the Lamb problem.

The latter agrees with Fock's comment [19, P. 291, 373] on the free electron in Dirac's relativistic theory where this electron is treated as a *point* object: a second intrinsic degree of freedom of the electron appearing in addition to the spin cannot be interpreted within the framework of the one-body problem. This interpretation would be in conflict with the fundamentals of quantum mechanics despite a formal possibility of formulating a problem for one body (electron) in the given external electromagnetic field in agreement with the requirement of the theory of relativity.

Therefore solutions of the Dirac equation involve two-fold degeneracy in angular momenta $\ell_{1,2} = j \pm 1/2$ for the $2S_{1/2}$ and $2P_{1/2}$ levels in the hydrogen atom. In the case of the electron in the three-dimensional space, the degeneracy could be eliminated within the framework of protovolchok field mechanics by allowing for two additional intrinsic angular momenta for the protovolchok in the electron arising from the extension of the electron, namely, the angular momentum of the heavy point relative to the center of inertia of the protovolchok, which is formed in a cycle of time, and the angular momentum of the center of inertia of the protovolchok relative to the center of inertia of the electron, which is formed as a whole in two cycles. Within the framework of protovolchok field mechanics, the protovolchok cycle is in its physical essence a unit time scale which is invariant (43) in the three-dimensional space.

Presence of the protovolchok in the electron is confirmed by existence of the anomalous magnetic moment of the electron. The anomalous magnetic moment of the electron turned out to be a sum of known quantum effects making a contribution up to the ninth decimal place due to the quantum character of the dynamics of the protovolchok in the electron. This moment can be calculated by the known quantum-mechanical formulas derived from (38), (39), (40) [see the comprehensive paper].

4. DYNAMIC MECHANISM OF THE BOHR PRINCIPLE OF COMPLEMENTARITY IN THE THREE-DIMENSIONAL SPACE

With this knowledge [1–6] it is possible to get a mass formula of the free electron in the gravitating field ignoring obligatory precession and nutation of the protovolchok in this field within the framework of protovolchok field mechanics with a zero length dimension (in the time-angle space):

$$m_{0e}c^2 = 2m_0c^2 - (e/2\alpha)(e/r_0), \tag{44}$$

where m_0 is the protovolchok mass [2]; c is the boundary fundamental velocity in the three-dimensional space equal to the propagation velocity of the light front in free space in terms of Fock [14]; e is the Coulomb charge of the protovolchok equal to the Coulomb charge of the electron; α is the fine-structure electromagnetic constant; r_0 is the radius of the electron in the three-dimensional space; (e/r_0) is the Coulomb potential at the center of inertia of the electron with its extension in the three-dimensional space (23), (24) taken into account;

$$e/2\alpha = \mu_D \tag{45}$$

is the value of the Dirac monopole $\hbar c/(2e) = e/(2\alpha)$. A factor of 2 preceding m_0c^2 in (44) results from the protovolchok having two degrees of freedom, translational and rotational (cycloidal Euler solution [2, 6]), which determines its corpuscular-wave structure (32), (36) [6] in space–time (23), (24). As established [3, 6], to the translational degree of freedom there corresponds the Minkowski energy-momentum tensor and to the rotational degree of freedom there corresponds the Abraham energy-momentum tensor. Interaction between the Coulomb charge of the protovolchok and the magnetic field of the Dirac bipole (45) in the electron ($(e/2\alpha)(e/r_0)$), which results from motion of the protovolchok inside the electron, is similar to the spin–orbit interaction in quantum mechanics.

Now let us find the electron mass ($m_{0e}c^2$) in terms of the unit mass of the protovolchok (m_0c^2). To this end we introduce designations

$$m_0c^2 \equiv \xi; \quad m_{0e}c^2 \equiv \eta; \quad (e/2\alpha)(e/r_0) \equiv f(r_0), \tag{46}$$

where r_0 is a parameter because e and α are the experimentally known fundamental constants Let us write (44) in terms of (46):

$$\eta = 2\xi - f(r_0). \tag{47}$$

This equation (47) with two unknowns and a parameter belongs to the class of Diophantine equations*, when the number of unknowns is larger than the number of equations in the system. Therefore, we find one more equation for finding a solution to equation (47). As is usually done, we impose a boundary condition on the parameter r_0 which follows from the obligatory physical requirement that the quantum-mechanical relation (32):

$$2r_0 = (\hbar/m_{0e}c), \tag{48}$$

be valid for (47) as well. In the above relation $(\hbar/m_{0e}c)$ is the Compton length of the electron wave $\lambda\!\!\!^{-}_0$ but not the classical radius of the electron, as would seem *a priori* without symmetrization of the Heisenberg relations. Why so?! We shall find it out later when we derive the mass formula for the muon. Within the framework of modern concepts, fundamentality of $\lambda\!\!\!^{-}_0$ as a parameter, but not a constant, determining the minimum error with which the coordinate of the particle can be measured in its rest frame of reference, consists in the fact that at distance smaller than $\lambda\!\!\!^{-}_0$ the elementary particle appears as a system with an infinite number of degrees of freedom and its interactions should be described by the quantum field theory. This all results from the fact that, according to Heisenberg uncertainty relations, an elementary particle localized in a region with linear dimensions $\leq\lambda\!\!\!^{-}_0$ has a quantum-mechanical uncertainty in the momentum $\geq mc$ and an uncertainty in energy $\geq mc^2$. The value of $\lambda\!\!\!^{-}_0$ is calculated by the wavelength shift from experimental measurements of the X-ray photon scattering from electrons in accordance with the energy and momentum conservation laws $\Delta\lambda = \lambda' - \lambda = h/m_e c(1 - \cos\theta)$ (where λ and λ' are the wavelength before and after scattering, θ is the scattering angle, m_e is the electron mass) at $\theta = \pi/2$ on the assumption that the photon and the electron do not interact. As a result of (48), the function $f(r_0)$ from (44)

$$(e/2\alpha)(e/r_0)\Big|_{r_0=(\lambda\!\!\!^{-}_0/2)} = m_{0e}c^2 \equiv \eta, \tag{49}$$

because $\alpha = e^2/\hbar c$. Thus, formula (49) confirms the main postulate of modern quantum field theory that the mass of a particle results from its participation in interactions. If we insert (49) into the right-hand side of (47), we shall obtain

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*Diophantine equations are equations with integer coefficients for which integer solutions are sought.

$m_{0e}c^2 = m_0c^2$. Thus, in the field mechanics of the protovolchok the protovolchok itself is a unit scale of the mass scale.

In this way, the protovolchok field mechanics legitimates existence of unit charges according to Dirac [10]: Coulomb one and Dirac monopole (45) multiplicity of magnetic poles. The quantized structure of the magnetic charge was obtained by Dirac as a condition for consistency of the equation of motion for a charged particle in a magnetic and *vice versa*. Why? Unlike the case in classical electrodynamics, in quantum mechanics the particle can be treated as a wave, which inevitably results in interference effects. And multiplicity of a magnetic charge is only possible if the Coulomb charge is also multiple.

In addition, it is evident that the term $((e/2\alpha)(e/(\lambda\!\!\!^{-}_0/2)))$ in (44) plays the role of the mass defect (binding energy) in the known semiempirical mass formula for nuclei because of interaction between nucleons in the nucleus. The minus sign of the mass defect in (44) means, as in the case of nuclei, that the electron is «stationary» and not simply dynamically stable. Dynamic stability itself also allows a finite lifetime of the dynamic system, e. g. a radioactive nucleus, if the mass defect is positive.

To compare mass formulas with the experimental values, let us calculate the unit-scale mass of the protovolchok in terms of the unit mass of the Gaussian system. Let us substitute the left-hand side of (49) into the left-hand side of (47) instead of η, then

$$m_0c^2 = (e/2\alpha)(e/(\lambda\!\!\!^{-}_0/2)) = 0.5110042 \text{ MeV}. \tag{50}$$

A difference of 0.8 eV at the level of a half-MeV (50) from the experimental electron mass 0.5110034 (14) MeV [21] (the figure in parentheses is the error), used in modern particle physics and obtained from annihilation measurements, can be taken into account if the obligatory precession and nutation of the protovolchok when the electron is in the gravitating field are taken into account. But in electrodynamics one used the electron mass 0.51099906 (15) MeV [22] found by the magnetospectrometric method from the (e/m) measurement. Then it seems that $((e/2\alpha)(e/(\lambda\!\!\!^{-}_0/2))) \neq m_0c^2$. This can be easily checked by substituting the «rest mass» of the electron in grammes into the right-hand side. What is the matter?! The matter is that the general form of the mass formula for a relatively free electron occurring in a three-dimensional space and interacting only with the gravitating field is

$$m_ec^2 = (m_{\text{const}}c^2 + m_{\text{rot}}c^2) - (e/2\alpha)(e/r). \tag{51}$$

Then, obviously, in accordance with Bohr principle of complementarity the annihilation mass of the electron will correspond to the Abraham energy-momentum tensor and the magnetospectrometric mass of the electron will correspond to the Minkowski energy-momentum tensor. Thus, the mass formula

(51) reveals the dynamic mechanism of the Bohr principle of complementarity: the mass defect (binding energy) plays the role of a quenching factor for the translational (corpuscular) energy or rotational (wave) energy depending on the character of interaction with the outer world in conformity with the requirement of the principle «to prepare a state» within the framework of the laws of energy conservation in nature. Consequently, the principle of complementarity in quantum mechanics is superior in a sense to conservation laws, it is organically linked to the mathematical tools of quantum mechanics and is not mere abstract reasoning as was widely and primitively thought of it in the past century.

This all, firstly, agrees with Fock's principle of relativity for means of observation [19, P. 13]: instruments and means of observation, including human sense organs (which are a sort of instruments built into the human organism), are a necessary intermediate between the human mind and the atomic objects under study; the means of observation must be described on the basis of classical abstractions but with allowance for Heisenberg–Bohr relations. Then, for example, it is possible to answer Blokhintsev's rhetorical question: In what way was the quantum state prepared in the dinosaurs' age? The answer is obvious: for example, the selective function for, say, light was performed by the retina of the dinosaur's eye.

Secondly, all the aforesaid agrees with Neumann's theorem on completeness of quantum mechanics, the proof of which is consistent only if it simultaneously involves both canonically conjugate operators. But de Broglie, who found it to be in conflict with the Bohr principle of complementarity, raised the problem of generalization of quantum mechanics again in the 1950s after 20 years of silence. He was supported by Bohm (hidden parameters).

5. PROTOVOLCHOK IS A «BRICK» OF MICROPARTICLES

Within field mechanics this conflict is eliminated by the above-mentioned dynamic mechanism of the Bohr principle of complementarity. According to the Neumann theorem, the self-conjugate Neumann algebra is the Hilbert subalgebra (*left* and *right*) if and only if the Neumann algebra (or its unit sphere) is closed in weak, strong, or ultrastrong topology which is not uniform operator one. This additional structure of the topological space is characteristic of the Pontryagin space [23], which is an indefinite-metric Hilbert space where, as in the Minkowski space–time, metric is not definite (time-like or space-like). And, as has been found out [see the comprehensive paper to be published], planimetry of the Friedmann–Lobachevsky space [14] appears in the Pontryagin space in the form of chronogeometry just as the Lobachevsky planimetry (17) appears in the Galilean space–time. Nevertheless, analyzing the proton mass formula within the theory of potentials below, we shall find the physical cause of inevitable probabilistic interpretation of quantum mechanics.

In what follows translational mass formulas for other particles will be given without allowance for precession and nutation of protovolchoks in the gravitating field in a two-dimensional (time and angle) space for conceptual physical transparency of these formulas.

Generalized Lagrange solutions for the three-body problem [24] with qualitative main characteristics of elementary particles and nuclei were obtained in terms of fundamental constants without a single parameter within field mechanics for microsystems of protovolchoks interacting with each other.

It has turned out that the muon (μ) consists of two protovolchoks and one antiprotovolchok. By the antiprotovolchok is meant an antiparticle in the Dirac representation because, as said above, the Dirac equation for a free relativistic electron, as illustrated by solution of the Lamb problem, has actually turned out to be an equation of the protovolchok in the gravitation field. Based on the exact generalized triangular Lagrange solution to the three-body problem, the mass formula for the muons was derived:

$$m_\mu c^2 = \left(3 \cdot \left(\frac{m_0 c^2}{2\alpha}\right)\right) + \left(\frac{e}{2\alpha}\right)\left(\frac{2 \cdot \dfrac{e}{2\alpha}}{\dfrac{1}{3} r_{\rm B}} - \frac{\dfrac{1}{3}e}{r_0},\right) = 105.634\,064\,\mathrm{MeV}; \quad (52)$$

$$m_{\mu,\mathrm{expt}} c^2 = 105.658\,389\,(34)\,\mathrm{MeV}\,[21, 22],$$

where $(m_0 c^2/2\alpha)$ is the mass of the protovolchok in the muon, $r_B = (\hbar/m_0 e^2)$ is the Bohr radius.

Relation (52), as follows from the analysis of this formula, is a synthesis of two fundamental formulas of nuclear physics and magnetic dynamics generalized to the microcosm. One of them, the main one, is a semiempirical mass formula for nuclides in nuclear physics, which holds for nuclides from hydrogen to heavy elements of the periodic table inclusive,

$$\Delta m_n c^2 = m_{n,\,\mathrm{expt}} c^2 - (m_n(A - Z) + m_p Z)\, c^2, \qquad (53)$$

unambiguously defining the nucleus as stationary or radioactive depending on the sign of the mass defect. In this case the mass defect is equal to the decay energy of the nucleus if its value is positive and it is used in atomic power production. The other formula

$$\vec{F}_L, \mathrm{magn.} = \vec{\mu}_{\rm H}\left(\vec{H} - \frac{1}{c}[\vec{v}, \vec{E}]\right), \qquad (54)$$

is the known magnetic analogue of the Lorentz force in magnetic dynamics and is also used for separation of isotopes.

In (52) $\mu_{\rm H} = \mu_D$, $(2 \cdot (e/2\alpha))$ is the Dirac bipole of the protovolchok; $\frac{1}{3}e$ is the fractional Coulomb charge of the protovolchok relative to the center of inertia of the muon in agreement with the fact that the Coulomb charge is, as established [2, 6], a mechanical moment of the generalized Umov–Poynting vector for the energy density. According to (53), the positive value of the muon mass defect means that the muon is radioactive and thus «loose», i. e. that there occurs considerable precession and nutation of its protovolchoks in the gravitating field.

The mass of the protovolchok $(m_0c^2/2\alpha)$ results from its mass formula having the same structure as the mass formula for the electron in the gravitating field (51) [2] but with the boundary condition imposed on the protovolchok radius in the case of the muon

$$(e/2\alpha)(e/r_{\rm pr})\Big|_{r_{\rm pr}=(e^2/m_0c^2)} = \frac{m_0c^2}{2\alpha}, \tag{55}$$

where (e^2/m_0c^2) is the radius of the protovolchok and not the classical radius of the electron as was thought in the past century, which confirms again that the relativistic Dirac equation is the equation of the protovolchok which is in fact always relativistic.

The mass formula for the proton (p) was derived from solution of the 27-body problem by the cascade method, when the problem is reduced to successively finding Lagrange solutions to the three-body problem from centers of inertia of subsystems of protovolchoks $\left(3\cdot\left(3\cdot\left(3\cdot\left(\frac{m_0c^2}{2\alpha}\right)\right)\right)\right)$ interacting with each other:

$$m_pc^2 = \left(3\cdot\left(3\cdot\left(3\cdot\left(\frac{m_0c^2}{2\alpha}\right)\right)\right)\right) - 3\left(\frac{e}{2\alpha}\right)\times$$
$$\times\left(\frac{3\cdot\left(2\cdot\left(\frac{e}{2\alpha}\right)\right)}{\frac{1}{3}r_B} + \frac{\frac{1}{3}\left(\frac{1}{3}e\right)}{r_0}\right) = 938.272\,14\ \text{MeV}; \tag{56}$$

$$m_{p,\text{expt}}c^2 = 938.272\,31\,(28)\ \text{MeV}\,[21,22].$$

Thus it follows that the proton consists of 14 antiprotovolchoks and 13 protovolchoks making up a symmetry group E_6 of 27 particles. The valence antiprotovolchok is responsible for the external characteristics of the proton. The last term in (56) with the sign opposite to that of the similar term in (54), a vector product, is related to a particular orientation of bipoles of protovolchoks in the proton. A difference of 170 eV at the level of $\sim$1 GeV from the experimental value, much smaller than the similar muon mass difference (52), is due to its compactness resulting from the stability of the proton (negative mass defect in (56)). Obviously, the «gluon» is nothing but a fundamental Josephson quant of the magnetic flux arising between the opposite poles of the bipoles of the interacting protovolchoks in the proton (56), which has different quantum states in conformity to the Pauli principle, similar to hypothetical «color gluons» in quantum chromodynamics [25]. This confirms Dirac's conclusion [10] about discreteness of the magnetic charge and reality of the known relation between the Dirac monopole and the Josephson quantum of the magnetic flux. The independent cascade protovolchok subsystem in the proton $(3 \cdot (m_0 c^2/2\alpha))$ is, if compared with (52), nothing but a quantum state of the «outsider» muon in the proton, belonging to no family of elementary particles, which is a «preon». The preon was introduced in the phenomenological model theory of particles [26] as a hypothetical structureless point particle which leptons and quarks are assumed to consist of in order to explain existence of generations of fermions. Then the quark-like subsystem $(3 \cdot (3 \cdot (m_0 c^2/2\alpha)))$ is nothing but the quantum state of the τ lepton in the proton, according to its three-lepton decay modes and according to the symmetry group E_6 which also arises from consideration of fermion generation symmetry groups. The numerator in the last term in (56) $\left(\frac{1}{3}\left(\frac{1}{3}e\right)\right)$ confirms that the quark charge is external with respect to the charge of the structure preon (52) in conformity to the fact that the charge is the mechanical moment of the Umov–Poynting vector for the energy density [2, 6].

When quantum mechanics was being elaborated in the first half of the last century, the electron and the proton were treated as point objects, and this was why most physicists did not accept the probabilistic interpretation of quantum mechanics. If, following the requirement of the Bohr principle of complementarity, one «prepares» states of, say, hydrogen atoms in the gaseous state by exposing them to the electron beam, the reason for this interpretation becomes quite clear: this the dynamic space–time structure of the proton and electron. The potential energy of the electron occurring in the hydrogen atom in various excited states formed within a finite time is discrete and depends on its inelastic collisions in the ground state with beam electrons. Results of these collisions depend in turn upon the position of the colliding electrons in relation to the position of the valence protovolchok in the proton where it moves. Thus, the probabilistic interpretation of quantum mechanics arises from dependence of the potential energy of a particle upon its position relative to another particle with which it interacts, in contrast to the kinetic energy of the particle in question, which depends only upon its relative velocity.

Then, the mass formula for the neutron is derived in the following form:

$$m_n c^2 = m_p c^2 + \left(\frac{e}{2\alpha}\right)\left(\frac{2 \cdot \left(\frac{e}{2\alpha}\right)}{\frac{1}{3} r_\text{B}} + \frac{e}{r_0}\right) = 939.549\,65 \text{ MeV}; \qquad (57)$$

$$m_{n,\ \text{expt}} c^2 = 939.565\,63\,(28) \text{ MeV [21,22]}.$$

The positive mass defect in (57) unambiguously indicates that the neutron is radioactive and thus the neutron is a «loose» dynamic system. The neutron has one more protovolchok «stuck» to the proton and interacting externally with the proton by one pole of its Dirac bipole and by its Coulomb charge. That the protovolchok–proton interaction is external is confirmed by the integer Coulomb charge in the numerator of the last term in (57). As a result, the neutron may interact by the other pole of the bipole of the external protovolchok with another proton, as in the deuteron, for example. Therefore, nuclear forces depend upon *orientation* in agreement with the observed facts. For example, the neutron and the proton are held together making up a deuteron nucleus only if their spins are parallel (an experimental fact not substantiated by modern phenomenological model theories of the nucleus). In addition, it becomes clear why nuclear forces are *noncentral* (which is also only an experimental fact).

All the aforesaid is confirmed by the derived mass formula for the neutron

$$m_d c^2 = (m_p c^2 + m_n c^2) - \left(\frac{e}{2\alpha}\right)\left(\frac{3\cdot\left(2\cdot\left(\frac{e}{2\alpha}\right)\right)}{\frac{1}{3}r_{\mathrm{B}}} - \frac{\left(\frac{1}{3}e\right)}{\pi r_0}\right) = \\ = (m_p c^2 + m_n c^2) - 2.245\,30\ \mathrm{MeV}; \quad (58)$$

$$\Delta m_{d,\ \mathrm{expt}} c^2 = -2.245\,79\ \mathrm{MeV}\ [21,22].$$

The minus sign of the mass defect means that the deuteron is stable and thus compact with the mass differing from the experimental value by 490 eV at the level of $\sim$ 2 GeV. The denominator πr_0 in the last term and the factor 3 of the first terms in parentheses in (58) indicates that the neutrons «slides» over the proton and thus the proton may interaction with one or several neutrons (also only the known fact — *saturation* of nuclear forces), e. g. in tritium.

Thus, what was thought of as «strong interaction» in the past century has turned out to be in fact the first term of the magnetic analogue of the Lorentz force generalized to the microcosm, with ensuing *charge independence* of nuclear forces. And «electroweak interaction» has turned out to be actually the second term of the above-mentioned analogue. It should be borne in mind that *nuclear* interaction, being a consequence of *strong* interaction occurring inside the nucleon, has nevertheless a different analytical form (*short-range effect* of these forces) because the nucleon has a boundary in the form of the Ampere sheet (a mathematical surface dividing the «northern» and «southern» poles of the magnetic bipoles of the upper protovolchoks in the nucleon — the two-layer Lyapunov potential (1898)), which also defines the boundary of the Heisenberg–Bohr uncertainty. In addition, it should be mentioned that it was the Lyapunov potential which Yukawa introduced in nuclear theory without paying attention to it though at that time the Lyapunov potential could already be found in university textbooks on the theory of potential [see the comprehensive].

6. A WAY TO DERIVE MASS FORMULAS FOR MICROPARTICLES

To provide a complete idea of deriving the above mass formulas, it should be mentioned that formulation of protovolchok field mechanics resulted in revealing a new field (inert), interaction of which with the heavy point of the protovolchok is responsible for the «rest mass» of elementary particles and for the «hidden» mass in the Metagalaxy [2]. This field together with the Newton gravitation field make up the gravitating field of the Universe. The latter can be thought of as a generalization of Heaviside's hypothesis [27], who proposed that gravitation should be described by equations similar to Maxwell electrodynamics equations. Heaviside also showed that those equations should involve a second field similar to the magnetic field.

As a result, Planck units expressed in terms of $\hbar$, c, and G (Newton gravitation constant) are generalized in this gravitating field. For example, in accordance with the relation between the electromagnetic and gravitating charges established in [2] the Planck mass unit $m_{pl}^2 = (\hbar c/G)$ is generalized within protovolchok field mechanics to the protovolchok mass in the Gaussian system of units in the form

$$m_0^2 = \frac{\hbar c}{\chi^2}\beta, \tag{59}$$

where $\beta = (1/2 - \alpha)$ is the same constant as α, but belonging to the gravitating field; χ^2 is the gravitating field constant with the Gaussian system dimensions of the Newton gravitation constant which algebraically enters into χ^2 in a certain proportion together with the inert gas constant χ^2.

Presence of the constant β in Nature closes the problem of «hidden mass» in galactic clusters named after Zwicky who formulated it [2]. As was established by Zwicky in the 1930s, the mass of the galactic clusters found from their luminosity, i. e. actually with allowance for the electromagnetic interaction alone, is about or of order of magnitude smaller than the mass found on the basis of the Newton law of gravitation and the assumption that these clusters exist due to the corresponding Newton forces. Then, based on the ratio $(\beta/\alpha) \approx 6.7 \cdot 10^1$, which indicates how many times the inert interaction is stronger than the electromagnetic one, and on its agreement with the modern ratio of the «hidden mass» to the «visible mass» one can explain this problem as resulting from the fact that for known reasons Eddington took into account only the electromagnetic interaction when deriving the luminosity law [2].

Relation between the Coulomb, magnetic, gravitating (gravitation and inert), and photon ($\hbar c$) charges was obtained in [2] from generalization of the results of

Fock [14, P. 475–482] and Weyl [28] with allowance for the Heaviside hypothesis. Fock demonstrated that Lorentz transformations could not be derived by using only two postulates of the special theory of relativity and ignoring the third one: a requirement of invariance of the equation of the light front. As a result, in addition to Lorentz transformation he also got fractional-linear M'obius transformations, also forming a point group, which turn into an identity if a rectilinearity and uniformity conservation condition is imposed strictly locally on the motion in space time, which agrees with Weyl's conclusion [28] about this problem, as Fock pointed out.

Within field mechanics of the protovolchok, its heavy point moves along the topological M'obius band. Since the M'obius band is *not oriented* from the topological point of view, in the Newton law gravitation charges have a *neutral* sign (*), unlike Coulomb charges, whose signs (+, −) result from the above-mentioned locality condition. Since the Coulomb charge, like the gravitation one, is the mechanical moment of the generalized Umov–Poynting vector for the gravitating density [2, 6], it automatically turns all known electromagnetic interactions to local laws of the gravitating field which governs binding of protovolchoks together into microsystems and ensuing formation of macrosystems of them.

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