Derivation of Neutron's Magnetic Moment on the basis of Dynamic Model of Elementary Particles

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Abstract. The first precise derivation of the neutron's magnetic moment on the basis of the Dynamic Model of Elementary Particles (DM), beyond quantum electro- and chromodynamics, is presented in this paper. A new insight into the nature of the neutron's magnetic moment is different in principle from that one widespread currently in physics. The material of this paper is coupled with the preceding work devoted to the precise derivation of the electron's magnetic moment, which is based on the same concept. Results obtained are the most stringent test of validity of the DM.

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1. Introduction

The following natural questions made their appearance after the first observation of the magnetic moment of the neutron. What is the nature of the magnetic moment of the neutron, which is an electrically neutral particle? And, accordingly, how it can be calculated? Obviously, an answer to these questions we should seek in the structure of neutrons. The latter is currently the realm of Quantum Chromodynamics (QCD). QCD studies numerous observable properties of nucleons, including their magnetic moments, and on the basis of the resulting data makes a try for building appropriate models. Other theories of modern physics are unable for shedding light on the nucleon's structure and the nature of its magnetic moment.

An understanding of the structure of nucleons is still one of the key problems in physics. According to QCD, neutrons can have a magnetic moment because they are composed of the charges constituents - quarks - hypothetical particles ("hypothetical" because they are never seen as free particles). Unfortunately, the QCD theory cannot produce a clear unified explanation of the observed features obtained in experiments on accelerators, which become more and more complicated and expansive. From our point of view, the absence of an essential achievement in understanding the nature of nucleons' magnetic moments and, hence, the nucleons' structure is a result of the well-known imperfection of the Standard Model of Elementary Particles (SM). This is why theorists regard magnetic moments of nucleons as "abnormal", recognizing by this the inability of the SM to give a clear explanation of the above phenomena.

The ratios of the proton and neutron magnetic moments, μ_p and μ_n, to the nuclear magneton, μ_N, are equal, respectively, to the following values:

$$\mu_p / \mu_N = 2.792847356(23) \tag{1.1}$$

and

$$\mu_n / \mu_N = -1.91304273(45)\,, \tag{1.2}$$

where nuclear magneton is

$$\mu_N = e\hbar / 2m_0 c = 5.05078324(13) \cdot 10^{-27}\ J \cdot T^{-1} \tag{1.3}$$

(the data presented here were taken from the current "CODATA recommended values").

For the explanation of the above "abnormality", physicists did not find anything better of the concept of "virtual particles", already used for explaining the magnetic moment "anomaly" of the electron [1-5]. According to this concept, strong interaction of hadrons conditions their mutual transformation. In particular, it is assumed that the neutron emits virtual negative π-meson and is transformed on the definite time into a proton. So that the neutron's magnetic moment is considered as a result of motion of these virtual charged particles (negative π-mesons). According to QCD, π-mesons are a specific kind of quark-antiquark pair. Analogously, the proton is virtually "dissociate" on the definite time on a neutron and virtual positive π-meson, and "abnormality" of its magnetic moment is a result of this circumstance as well.

Different assumptions are used in order to obtain a simultaneous fitting of the ratio of the neutron and proton magnetic moments. A first-order calculation for proton/neutron magnetic moments based on the quark model one can find, for instance, in the textbook by Giffiths [6]. One of the fundamental studies based on the above approach can be found in [7].

A modern trend in the theory of magnetic moments of nucleons is usage of the three quark model of nucleons with *up*, *down*, and *strange* quarks [8-14]. The value of -2/3 obtained in this model for the neutron/proton magnetic moment ratio is nearly the experiment value [15]. The current CODATA data gives

$$\mu_n / \mu_p = -0.68497934(16)\,. \tag{1.4}$$

In the work by G. Strobel [16], differences between magnetic moments of a proton and neutron are explained in the three quark model by allowing the strange quark wave function to be spin dependent. Namely he assumes that the wave functions for the spin parallel and the spin antiparallel quarks differ. In one of the last works on this subject [17], an approximate fitting to the experimental ratio is achieved owing to introducing a difference between the constituent quarks masses in the nucleon of about 15%. A general overview of the theory of "strangeness" in the nucleon one can find also in [18-21].

Among other works on this subject, one can mention also the work by R. Mills [22]. He derives the magnetic moment of a neutron as the sum of: the magnetic moment of a so-called "constant orbitsphere" of charge $-e$ and mass m_n (which correspond to the β particle), the magnetic moment of a proton, and "the magnetic moment associated with changing an up quark/gluon to a down quark/gluon".

In spite of many attempts by QED and QCD to explain the magnetic moment of nucleons, the problem is still open, and physicists seek new ways for a less complicated solution. Here is an opinion by E. Beise who represents leading researchers in their area [23]. "The ratio of the proton and neutron magnetic moments one can understand from their valence quark structure, as well as ratios of other baryon magnetic moments. But the absolute magnitudes cannot yet be calculated within the context of QCD, nor the dynamical distributions of charge and magnetism either". And so on.

The current experimental value of the neutron magnetic moment, according to the CODATA 2006 recommended values, is

$$\mu_n = -0.96623641(23) \cdot 10^{-26}\ J \cdot T^{-1}. \tag{1.5}$$

This quantity is approximately in 1.46 times less in absolute value than that for the proton.

Thus, a reason of the difference between two magnetic moments, of a proton and neutron, is not yet clearly understood by modern physics. Both magnetic moments are studying exceptionally in the framework of quantum electro- and chromodynamics. There are no, more or less, serious works on this subject with use of classical approaches. In our opinion, the current status quo in this area is a result of the sad fact that physicists (based on the SM, exhausted itself completely) still do not know the true nature of mass and charges of elementary particles. They also know nothing about the origin of magnetic charges. And what is more, the fundamental error of physics, namely an assignment of a non-existed proper angular moment (spin) of the $\hbar/2$ value [24] first to an electron, and later on to nucleons and other particles-"fermions", makes it impossible in principle to solve the problem of magnetic moments of nucleons without different fittings. Accordingly, an abstract mathematical fitting is currently the main method on the way to achieve a correspondence of the resulted theoretical data with experiment.

Fortunately, at present, owing to the DM recently developed which is beyond QED and QCD [25] and the indicated work devoted to the electron's spin [24], the above and other questions accumulated in modern physics have obtained convincing and relatively simple solutions. There are already a series of publications on the relevant questions. A new of principle insight into the nature of the magnetic moment of an electron based on the DM and the derivation of the latter are gained in [26]. Precise calculations of the observable quantity performed on the new basis are the most stringent test of the validity of new concepts.

According to the DM, elementary particles are dynamic spherical formations of a derfinite internal structure (not considered here) being in dynamic equilibrium with environment through the wave process of the definite fundamental frequency ω inherent in the atomic and subatomic levels. Longitudinal oscillations of their spherical wave shells in the radial direction provide an interaction of the particles with other objects and the ambient field of matter-space-time. Accordingly, a nucleon just like any spherical microobject, including an electron, is in a continuous dynamic equilibrium with environment through the wave process of a definite frequency ω (recalling a micropulsar).

A pulsing spherical wave shell of a particle separates its external space from inner, *i.e.*, from ambient wave fields. Longitudinal oscillations of the pulsing *spherical* wave shell in the radial direction provide an interaction (more correctly *exchange* of matter-space and motion-rest, or *matter-space-time* to say shortly) with the surrounding field-space and with other particles.

One of the advantages of the DM, as against the SM, is that the DM reveals the nature of mass and charge of elementary particles. It turned out, owing to the DM, that the rest mass does not exist. And that we usually call as the mass of elementary particles is actually the *associated mass* which is the *measure of exchange* (interaction) of matter-space-time.

The DM distinguishes the *longitudinal exchange* and the *transversal exchange*. Therefore, two notions of mass exist, correspondingly: the *associated mass in longitudinal exchange* and the *associated mass in the transversal exchange*. The latter exhibits itself in cylindrical fields generated during the motion of particles.

The formula of *associated mass* in the *longitudinal exchange* has the form

$$m = \frac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k^2 r^2}, \tag{1.6}$$

where r is the radius of the wave spherical shell of a particle; $\varepsilon_0 = 1 g \cdot cm^{-3}$ is the *absolute unit density* and ε_r is the *relative density*;

$$k = 2\pi / \lambda = \omega / c \tag{1.7}$$

is the wave number corresponding to the *fundamental frequencies* ω, ω_e or ω_g, of the field of exchange (which are characteristic of the subatomic level of the Universe). The two fundamental frequencies define, respectively, electromagnetic (including strong) and gravitational interactions [27, 28]. The DM deals with physical quantities expressed in the absolute system of units by integer powers of three *basic units* of *matter, space,* and *time* (*g, cm,* and *s*).

The charge in the DM is an alternate quantity and defined as the *rate of mass exchange* at the fundamental frequency. Two notions of charge correspond to two aforementioned notions of mass: the *longitudinal* ("*electric*") *charge* and the *transversal* ("*magnetic*") *charge*. The transversal charge appears at the motion of particles. Just the transversal charge defines the distinction of the proton's magnetic moment as against the neutron's magnetic moment.

The following relation connects the exchange charge Q, both longitudinal and transversal, with the associated mass m:

$$Q = m\omega; \tag{1.8}$$

its dimensionality is $g \cdot s^{-1}$. Thus, according to the DM, every particle of the mass m has the definite exchange charge. The *exchange charge of an electron* at the longitudinal exchange and at the level of the fundamental frequency ω_e is

$$e = m_e \omega_e = 1.702691582 \cdot 10^{-9}\ g \cdot s^{-1}, \tag{1.9}$$

where $m_e = 9.10938215(45) \cdot 10^{-28}\ g$, and the fundamental frequency of the subatomic level is

$$\omega_e = 1.869162534 \cdot 10^{18}\ s^{-1}. \tag{1.10}$$

The electron's exchange charge of the absolute value (1.9) is regarded in the DM as the *minimal quantum of the rate of exchange of matter-space-time.*

Principal elements of the DM theory and the notion of central exchange are considered in detail, in particular, in the work [25], accessible in Internet. The transversal exchange is responsible for the difference of the proton's magnetic moment as compared to the neutron magnetic moment. The proton's magnetic moment is the subject of the next paper; therefore, the transversal exchange will be considered there.

We proceed now to derive the magnetic moment of a neutron. This derivation follows, as was mentioned above, the approach and the data of the work [26] devoted to the electron's magnetic moment. Accordingly, we must consider the present paper as a natural continuation of the work [26], which is based on the DM as well. Along with fundamental parameters discovered in the framework of the DM, we use 2006 CODATA recommended values.

2. Neutron's magnetic moment

Although the true structure of neutrons has actually remained a mystery, one of the main features firmly known from experiment is that neutrons are composed of a proton and an electron, and the neutron's mass is the combination of these constituents. Thus, to all appearances, a neutron is a binary system of proton and electron. Energy excess with respect to its ground state, formed by a free proton and a free electron is 0.78 MeV. Free neutrons decay by beta decay $n \to p + e^{-} + \tilde{\nu}_e$ with a mean life of 885.7 *s*. During decay, a part of the energy excess carries away an antineutrino. This fact along with other data known from the literature allows us to regard an individual neutron as a paired system, similar to the hydrogen atom, in an excited state. In other words, we have the right to suppose that neutrons in a free state are a kind of the unstable isotopes of protium, of the simplest hydrogen atom, ${}_1^1H$ [28]. Thus, in the case of a neutron, we actually deal with an expanded paired wave system, and natural specific features of wave motion of the system and its constituents must be taken into consideration as perturbations.

According to the DM [25], the wave motion with incessant exchange causes oscillations of the wave shell and the centre of mass of a nucleon, with the amplitude

$$A_s = \frac{A\hat{e}_l(kr)}{kr}, \tag{2.1}$$

where

$$A = r_0\sqrt{\frac{2hR}{m_0 c}}, \tag{2.2}$$

$$\hat{e}_l(kr) = \sqrt{\pi kr/2}\,(J_{l+1/2}(kr) \pm iY_{l+1/2}(kr)), \tag{2.3}$$

$$k = \omega/c = 1/\lambda\!\!\!^{-}, \qquad kr = z_{p,s}, \tag{2.4}$$

A is the constant factor; r_0 is the radius of the wave shell of a nucleon equal to the Bohr radius; $J(kr)$ and $Y(kr)$ are Bessel functions; *k* is the wave number; ω is the oscillation frequency of the pulsating spherical shell of the nucleon equal to the fundamental "carrier" frequency of the subatomic and atomic levels ω_e (we consider here only the "electromagnetic" field level); $z_{p,s} = kr$ are the roots (zeros and extrema) of the Bessel cylindrical functions, $J_{l+1/2}(kr)$ and $N_{l+1/2}(kr)$ (or $Y_{l+1/2}(kr)$). They are designated, correspondingly, as $j_{l+1/2,s}$, $y_{l+1/2,s}$, $j'_{l+1/2,s}$, and $y'_{l+1/2,s}$. Analogously, zeros and exstrema of the Bessel spherical functions are designated as $a_{l,s} = j_{l+1/2,s}$, $b_{l,s} = y_{l+1/2,s}$, $a'_{l,s}$, and $b'_{l,s}$ [29].

Being a dynamic wave microformation, a nucleon oscillates also as a whole in a node of the spherical wave field of exchange [26, 28] with the amplitude

$$\Psi = \frac{A_m}{z_{p,s}}, \tag{2.5}$$

where

$$A_m = \lambda\!\!\!^{-}_e\sqrt{\frac{2Rh}{m_0 c}}, \tag{2.6}$$

$$\lambdabar_e = \frac{c}{\omega_e} \tag{2.7}$$

is the *wave radius*, ω_e is the fundamental frequency of the subatomic level. The amplitude A_m is the characteristic amplitude of oscillations on the sphere of the wave radius (at $z_{p,s} = kr = 1$), and it is the radius r_m of oscillatory motion of the center of mass of the nucleon.

As the proton mass is $m_0 = 1.672621637(83) \cdot 10^{-24}\,g$, the fundamental frequency of the subatomic level is $\omega_e = 1.869162534 \cdot 10^{18}\,s^{-1}$, the Planck constant is $h = 6.62606896(33) \cdot 10^{-27}\,erg \cdot s$, and the speed of light is $c = 2.99792458\,10^{10}\,cm \cdot s^{-1}$, the Rydberg constant R and the wave radius $\lambdabar_e$ are equal, correspondingly, to

$$R = \frac{R_\infty}{1 + m_e / m_0} = 109677.5833\,cm^{-1}, \tag{2.8}$$

and

$$\lambdabar_e = 1.603886514 \cdot 10^{-8}\,cm. \tag{2.9}$$

Note that the wave radius $\lambdabar_e$ (2.9) is equal to one-half of the average value of interatomic distances in crystals that is not a random coincidence. The latter shows the wave character of interaction of nodes in crystals just at the fundamental frequency ω_e (1.10) (details on this matter one can find in [27, 28]).

Hence, the radius r_m of oscillatory motion of the center of mass of the neutron in the wave field has the value

$$r_m = A_m = \lambdabar_e \sqrt{\frac{2Rh}{m_0 c}} = 2.73065189 \cdot 10^{-12}\,cm. \tag{2.10}$$

The wave motion of a nucleon as a central object of the field, with respect to a displacement r, generates an elementary longitudinal (“electric”) moment, moment of the basis,

$$p_E = qr \tag{2.11}$$

and the corresponding transversal (“magnetic”) moment, moment of the superstructure,

$$\mu = \frac{\upsilon}{c} qr, \tag{2.12}$$

where $q = m\omega_e$ is the *exchange charge*, and υ is the *oscillatory speed* of the nucleon shell. It should be stressed once more that the *exchange charge q* (defined as the *rate of exchange of matter-space-time*) is inherent in all dynamic microobjects viewed in the framework of the DM. The absolute value of the electron exchange charge *e* represents the *minimal quantum of the rate of the exchange*, $e = m_e\omega_e$. In a case of a free neutron, as an exited paired proton-electron wave system, the exchange of the spherical wave field of a proton and the wave field of an oscillating electron (realized with a certain strength dependent on the values of the corresponding exchange charges) are mutually balanced, like in the hydrogen atom, but during the mean life of a neutron. The latter is also the time of an existence of the definite magnetic moment observed at measurement.

The spectrum of amplitudes (2.1) is defined by roots of Bessel functions, $z_{p,s} = kr$, hence, the spectrum of *amplitude magnetic moments* of the nucleon, corresponding to the amplitude (2.1), is described [28] by the formula

$$\mu = \frac{\upsilon}{c} q \frac{A\hat{e}_l(z_{p,s})}{z_{p,s}}. \tag{2.13}$$

The subscript p in $z_{p,s}$ indicates the order of Bessel functions and s, the number of the root. The last defines the number of the radial spherical shell. Zeros of Bessel functions define the radial shells with zero values of radial displacements (oscillations), *i.e.*, the shells of stationary states [28].

One of the constituents of the displacement r is defined by the amplitude r_m (2.10) with which the neutron oscillates as a whole in the spherical field of exchange. Assuming that $\upsilon = \upsilon_0 = \alpha c$ ($\alpha = 7.2973525376 \cdot 10^{-3}$), the exchange charge $q = e$, and $z_{p,s} = z_{0,s}$, so that $|\hat{e}_0(kr_s)|^2 = 1$, we arrive at the corresponding elementary quantum of the magnetic moment of the neutron of the value

$$\begin{aligned}\mu_m = \frac{\upsilon_0}{c} eA_m &= -3.392873403 \cdot 10^{-23} g \cdot cm \cdot s^{-1} = \\ &= -0.9571119163 \cdot 10^{-26} J \cdot_0 T^{-1}\end{aligned}. \tag{2.14}$$

The quantity obtained is, in absolute value, the *main constituent of magnetic moments of nucleons*, both a proton and a neutron. The quantity (2.14) insignificantly differs in absolute value from the experimental value (1.5) for the neutron.

Small deviations of the amplitude (2.6), *i.e.*, deviations of the predominated wave motion, are appeared mainly owing to the natural reason. The matter is that the wave shell oscillates with respect to the center of mass of the neutron well. These small deviations, defined by the formula (2.1), superimpose on the oscillatory motion of the nucleon with the amplitude (2.10), defining thus the second in value term responsible for the neutron's magnetic moment. According to (2.1), for the case of $z_{p,s} = z_{0,s}$, this additional term is defined by the value of oscillations of the wave shell of the radius r_0 of the amplitude

$$\delta r_1 = \frac{r_0}{z_{0,s}} \sqrt{\frac{2Rh}{m_0 c}}. \tag{2.15}$$

Neutron's magnetic moment is measured during the mean life of the neutron being in a free state. So we deal with a paired proton-electron metastable system, where the only electron, having leaved the inner space of the neutron, is in a highly exited energetic state near the wave shell of the core. Therefore, we have the right to take a root of Bessel functions responding to one of the zeros for the somewhat remote neutron wave shell with respect to the first one. Let us take the zero $z_{0,s} = y_{0,12} = 35.34645231$ [29], responding to the solution of the radial equation for one of the *kinetic* neutron shells [27, 28, 30, 31], and then we have

$$\delta r_1 = \frac{r_0}{y_{0,12}}\sqrt{\frac{2Rh}{m_0 c}} = 2.548871862\cdot 10^{-14}\, cm\,, \tag{2.16}$$

where $r_0 = 0.52917720859\cdot 10^{-8}\, cm$ is the Bohr radius.

Thus, according to the above obtained, the oscillatory-wave motion of the neutron generates first the magnetic (transversal) moment of the value μ_m (2.14). Second, small deviations from this motion, caused by perturbations of neutron's oscillations as a whole in the spherical field of exchange and defined by (2.16), generate an additional term:

$$\delta\mu_1 = \frac{e\upsilon_0}{c}\delta r_1\,, \tag{2.17}$$

which must be taken into account.

According to the DM, an electron is a spherical dynamic microobject, like a proton or any elementary particle. Therefore, oscillations of the centre of mass of the electron itself, as a whole, with respect to the center of mass of the neutron, also occur. And all formulas of the DM, obtained for the dynamic spherical microobjects, are valid for the electron as well. The second, smallest in value, additional term of μ takes into account these oscillations [26]; its amplitude is

$$\delta r_2 = \frac{r_e}{z_{0,s}}\sqrt{\frac{2Rh_e}{m_0 c}}\,, \tag{2.18}$$

where r_e is the wave radius of the electron [28]. The latter is derived from the formula of mass of elementary particles (1.6), where $m = m_e$, $k = k_e = \omega_e / c$, $r = r_e$. Calculations give

$$r_e = 4.17052597\cdot 10^{-10}\, cm\,. \tag{2.19}$$

The physical quantity

$$h_e = 2\pi m_e \upsilon_0 r_e \tag{2.20}$$

is the limiting *proper* action of the electron (analogous to the Planck *orbital* action, $h = 2\pi m_e \upsilon_0 r_0$) under the condition that the limiting oscillatory speed of the wave shell of the electron is equal to the Bohr speed, *i.e.*, $\upsilon_0 = \alpha c = 2.187691254\cdot 10^8\, cm\cdot s^{-1}$.

For the case of (2.18), we take the root of Bessel functions $z_{0,s} = j_{0,12} = 36.91709835$ responding to the zero of the twelfth potential shell. In view of this, (2.18) yields the value

$$\delta r_2 = \frac{r_e}{j_{0,12}}\sqrt{\frac{2Rh_e}{m_0 c}} = 5.3994661\cdot 10^{-16}\, cm\,. \tag{2.21}$$

Thus, the total magnetic moment of the neutron μ_n contains three constituents:

$$\mu_n = \mu_m + \delta\mu_1 + \delta\mu_2 = e\frac{\upsilon_0}{c}(r_m + \delta r_1 + \delta r_2)\,. \tag{2.22}$$

In view of the above considered, the expanded form of the theoretical value for the total magnetic moment of the neutron $\mu_n(th)$ is

$$\mu_n(th) = \frac{e\upsilon_0}{c}\left[\left(\lambda\!\!\!^{-}_e + \frac{r_0}{y_{0,12}}\right)\sqrt{\frac{2Rh}{m_0 c}} + \frac{r_e}{j_{0,12}}\sqrt{\frac{2Rh_e}{m_0 c}}\right]. \qquad (2.23)$$

The substitution of numerical values for all quantities entered in (2.23) gives the following theoretical values for two constituent moments and the total magnetic moment of the neutron:

$$\begin{aligned}\mu_n(th) &= -(0.3392873403 + 0.003167008 + 0.0000670891)\cdot 10^{-22}\ g\cdot cm\cdot s^{-1} = \\ &= -0.342521437\cdot 10^{-22}\ g\cdot cm\cdot s^{-1}\end{aligned} \qquad (2.24)$$

In the SI units, since $1T = 10^4/\sqrt{4\pi}\ cm\cdot s^{-1}$, Equality (2.24) is rewritten as

$$\begin{aligned}\mu_n(th) &= -(0.957111915 + 0.008933964 + 0.0001892549)\cdot 10^{-26}\ J\cdot T^{-1} = \\ &= -0.96623513\cdot 10^{-26}\ J\cdot T^{-1}\end{aligned} \qquad (2.25)$$

We see that the theoretical value of $\mu_n(th)$ obtained practically coincides with the current "2006 CODATA recommended value" accepted for the magnetic moment of the neutron:

$$\mu_{n,CODATA} = -0.96623641(23)\cdot 10^{-26}\ J\cdot T^{-1}. \qquad (2.26)$$

3. Neutron's magnetic moment as associated moment of the wave exchange

The magnetic moment of a neutron can be estimated also in another way. The state vector S of a dynamic object with the associated mass m, relatively to some wave axis, is defined [34] as

$$S = mr, \qquad (3.1)$$

where r is amplitude of a harmonic displacement.

The following momentum defines a general change of the state

$$P = \frac{dS}{dt} = \frac{dm}{dt}r + m\frac{dr}{dt}\ , \qquad (3.2)$$

where

$$P_d = \frac{dm}{dt}r = qr \qquad (3.3)$$

is the *dynamic* momentum, and

$$P_k = m\frac{dr}{dt} = m\upsilon \qquad (3.4)$$

is the *kinematic* momentum.

The dynamic momentum is simultaneously the moment of the *rate of mass exchange*, because $q = dm/dt$ [28, 34]. At the level of basis, (3.3) represents the electric moment, but at the level of superstructure P_d represents the magnetic moment.

In a simplest case of the harmonic wave, the dynamic and kinematic momenta can be presented as

$$P_d = (m\omega)r = qr \tag{3.5}$$

$$P_k = mr\omega = m\upsilon \tag{3.6}$$

Dynamic and kinematic moments of the momenta, L_d and L_k, are equal to each other:

$$L_d = \frac{dm}{dt} r \cdot r = mr^2\omega = J\omega \tag{3.7}$$

$$L_k = m\frac{dr}{dt} \cdot r = m\omega r^2 = J\omega \tag{3.8}$$

If we suppose that the neutron moment of inertia is equal to

$$J = {}^2\!/_5\, m_n r_0^2$$

(as for a homogeneous spherical ball) then, according to (3.7), the dynamic moment of momentum of the neutron at the level of the limiting (fundamental) frequency ω_e, will be equal to

$$\begin{aligned} L_{d,\max} &= \frac{2}{5} m_n r_0^2 \omega_e = 3.506753661 \cdot 10^{-23}\ g \cdot cm^2 \cdot s^{-1} = \\ &= 9.892369438 \cdot 10^{-27}\ J \cdot T^{-1} \cdot cm \end{aligned} \tag{3.9}$$

where $m_n = 1.674927211(84) \cdot 10^{-24}\ g$, $r_0 = 0.52917720859 \cdot 10^{-8}\ cm$, $\omega_e = 1.869162534 \cdot 10^{18}\ s^{-1}$.

A radius of the neutron wave shell r_n depends on frequency conditions of wave exchange (*i.e.*, on the value of $k = \omega / c$ entered in (1.6)) and lies in the interval of $r_n \in (r_{\max}, r_0)$. At the level of low and middle frequencies under the condition $k^2 r_n^2 << 1$, the formula of mass (1.6) is simplified; and a radius of the limiting neutron sphere takes the value

$$r_{\max} = \sqrt[3]{\frac{m_n}{4\pi\varepsilon_0}} = 0.5108130981 \cdot 10^{-8}\ cm\ . \tag{3.10}$$

Hence, for the beginning of the interval, the minimal value of the dynamic moment of neutron momentum is

$$\begin{aligned} L_{d,\min} &= \frac{2}{5} m_n r_{\max}^2 \omega_e = 3.267586148 \cdot 10^{-23}\ g \cdot cm^2 \cdot s^{-1} = \\ &= 9.217690341 \cdot 10^{-27}\ J \cdot T^{-1} \cdot cm \end{aligned} \tag{3.11}$$

The rational golden section of the interval of the moments is

$$(L_d)_{gs} = L_{d,\min} + 0.618(L_{d,\max} - L_{d,\min}) = 9.634642023 \cdot 10^{-27}\ J \cdot T^{-1} \cdot cm \tag{3.12}$$

The *centimeter*, the reference unit of space, enters in the above formulas as the parameter of the atomic field of matter-space-time.

Hence, a value of neutron's magnetic moment responding to the golden section (the divine proportion) is

$$(\mu_n)_{gs} = \frac{(L_d)_{gs}}{cm} = 9.634642023 \cdot 10^{-27}\ J \cdot T^{-1} \tag{3.13}$$

that is close, in absolute value, to the currently accepted (according to the CODATA 2006 data) average neutron magnetic moment, $\mu_n = -9.6623641(23) \cdot 10^{-27}\ J \cdot T^{-1}$.

It should underline finally that the neutron's moments obtained are *associated* moments; they have the field character reflecting the wave exchange of matter-space-time.

3. Conclusion

The derivation of the observable quantity of the neutron's magnetic moment μ_n was realized for the first time in the framework of the DM [25], which (after it was first put forward) reconsiders a series of phenomena and experiments showing new ways to explain them in a better way.

The derivation of neutron's magnetic moment μ_n has been performed with regard of wave features for the behaviour of a neutron viewed as a combined proton-electron wave system. A relatively high precision and a less complicated way of the derivation by the DM differ the latter from theories of quantum electro- and chromodynamics, which also try to solve the neutron's problem.

Followed by precise derivations of the electron's magnetic moment [26], cosmic microwave background radiation ("relict" background) [32], and the Lamb shift [33], carried out on the basis of the DM as well, the derivation of neutron's magnetic moments presented is the next of the stringent tests of the validity of the DM.

The correctness of the absolute value of the electron's charge used for calculation of μ_n (just like for calculations of μ_e [26], the Lamb shift [33], and other properties), discovered in the DM, where it is regarded as an *elementary quantum of the rate of mass exchange* of the dimensionality $g \cdot s^{-1}$, was verified thereby.

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