Some words about fundamental problems of physics

Part 8: The neutron magnetic moment

George Shpenkov

According to the theory of quantum electrodynamics (QED), the neutron, as a neutral particle, should not have a magnetic moment. However, experience shows that it is not so. The neutron has a magnetic moment; its value (data of 2006) is of 1.46 times less than the magnetic moment of the proton and opposite in sign (direction),

$$\mu_p = 1.410606662(37)\cdot 10^{-26}\, J\cdot T^{-1}, \quad \mu_n = -0.96623641(23)\cdot 10^{-26}\, J\cdot T^{-1}. \qquad (1)$$

It was a surprise to physicists. An origin of the magnetic moment of the neutron was/is not clear; therefore this moment has been called "anomalous". Since the QED theory has proved incapable to resolving the problem, attempts for its solution were/are undertaken in quantum chromodynamics (QCD). According to the QCD the anomalous magnetic moment of the neutron (and proton) occurs due to hypothetical particles, quarks, allegedly constituents of nucleons. Fractional charges are ascribed to these mystic particles in the QCD. Besides, for explaining the origin of magnetic moments of nucleons, the QCD uses the concept of "virtual particles" adopted from the QED. Fallacy of this notion has been discussed in Part 3 of this article.

The proton and neutron are considered in the QCD as consisting of 3 quarks of two kinds, up and dawn (*p* = *uud* and *n* = *ddu*), and 3 massive photons called gluons. According to the QCD, the strong interaction of hadrons (protons and neutrons belong to this class of elementary particles) is due to their mutual transformation. Namely, the neutron, emitting a negative virtual π–meson, transforms for a time in the proton. So that, the neutron magnetic moment is seen as the result of charge redistribution due to appearance and disappearance of the negative-charged virtual π–mesons. The latter are regarded as a specific kind of the pair of quark-antiquark. Similarly, the proton virtually "dissociates" at the certain time into a neutron and a positive-charged virtual π-meson, and the "anomaly" of its magnetic moment is a result of the charge redistribution as well. Thus, in accordance with the QCD, the charge redistribution of protons and neutrons, continuously occurring in time, generates the magnetic moments of the nucleons (as well as their quadrupole moments).

A modern trend in attempts to describe magnetic moments of nucleons is the use of three-quark model of nucleons with the *up*, *dawn*, and *strange* quarks ... However, we will not go here into the wilds of this theory, the logical end of the construction of which is not seen. Despite numerous attempts by QED and QCD to explain the magnetic moment of the nucleons, the problem remains open. Physicists seek new ways for the less complex solutions. To the point, I would like to recall the readers that the solution of the problem on the origin of magnetic moments of nucleons is exceptionally important, because, in essence, with its solution, as a consequence, it is solved the fundamental problem of physics on the structure of nucleons. Therefore now, bound principally to the quark model of nucleons and having no advancements in solving the above problem, QCD theorists are trying at least to adjust by different ways the structure of nucleons to coordinate it to the ratio of the magnetic moments of the neutron and proton, μ_n / μ_p, known from experience (1).

As for the calculation of absolute values of the magnetic moments with a reasonable accuracy, this problem is not solved in the framework of the QCD. And, in general, in our opinion, the problem is unsolvable in principle in the QCD.

Why do theorists still cannot derive the magnetic moments of nucleons (proton and neutron)? In my opinion, the answer is simple: because their theories are not adequate to the physical reality, as virtual ones in essence. For this reason, in particular, a complete theory of strong interactions cannot be built as well. As clearly demonstrated in the previous 7 Parts of this article, all difficulties in solving the fundamental problems of physics are due to the abstract mathematical essence of the modern theories limited by the framework of the Standard Model (SM). A lack of knowledge about the structure of elementary particles as possible close to reality, i.e., ignorance of their physical structure, is abnormal state in physics. As a result of the abstract mathematical essence of the SM, it is ignorance of the origin of the mass and the nature of charge of elementary particles, as well as a lack of awareness about other real fundamental parameters inherent in the atomic and subatomic levels of the Universe. The abstract mathematical essence of modern theories makes it impossible in principle to solve the problem of the magnetic moments of nucleons without arbitrary abstract speculations and adjusting.

It should be noted that the problem of the mass and charge of elementary particles has been solved some time ago beyond the SM. But the saddest thing in this case is that this fact, though known and not denied, but, unfortunately, still is not loudly recognized. It is persistently overlooked by the official physics, as if the solution has not been found yet. The reason of silence about these discoveries is that the above mentioned solution was found not in the framework of generally accepted mainstream theories, but on the basis of an alternative theory, moreover, semiclassical. As everyone knows, a slighting relation of scholars in the official physics is characteristic to such theories. Ignoring the unique solutions, paying no heed to them, suppression of the achievements (which are at the level of scientific discoveries) of scientists who is not working in leading scientific schools, and not related to these, unfortunately, is a flawed standing practice in official physics. As a result, the abstract mathematical adjustment is still the main method of modern theoretical physics used for the accomplishment of a correspondence of its theories to the experiment.

From the preceding 1-7 Parts of this article, it follows that at the transition from abstract mathematical theories of the SM to physical ones, in particular, to the theories of the Wave Model (WM), at once the simple logically consistent solutions are found for all cases without exception. For example, such a solution was achieved in the case when we have dealt with the "anomalous" magnetic moment, referred to in Part 3. In this Part of the article, we will demonstrate the validity of the WM again, in this case on an example of the derivation, on its basis, the magnetic moment of the neutron [1].

The true structure of the neutron is covered by a profound mystery. But one of the main features, well-established from experience, is that free neutrons are unstable and decompose on the average of approximately during 885.7 s into a proton and an electron, and that the mass of the neutron is a combination thereof. It is assumed that during the lifetime, the β-decay of free neutrons occurs following the scheme: $n \rightarrow p + e^{-} + \tilde{\nu}_e$. But there is no experimental evidence that this process produces an antineutrino. It is impossible to register such a hypothetical event. Therefore, the above scheme of the β-decay of free neutrons is inconclusive. There are alternative schemes. For example, it is believed that the true mass of a neutron is different from the currently accepted and that a free neutron during its lifetime initially absorbs a neutrino, and only then decomposes following the scheme: $n + \nu \rightarrow p + e^{-}$ [2] ... But let's not go into the details of the β-decay of the neutron, it is not so important here. The main thing for us is an initial condition for our solution of the problem on the neutron magnetic moment, that is, that the neutron is a binary proton-electron system.

Based on the postulate on the wave nature of the Universe, of all processes and objects in it, we came to the wave theory of elementary particles called the Dynamic Model (DM) [3, 4]. In accordance with the DM, the nucleons, a neutron and a proton, as well as any other fundamental particle, are dynamic wave microformations, reminiscent of wave resonance structures caused by the interference of waves in a three-dimensional spherical space.

With use of the DM theory, we have solved in recent years a number of the problems of modern physics, including a problem of the magnetic moments of nucleons. In the case of the neutron, in accordance with the DM, we deal with a coupled wave system. And all peculiarities of the wave motion of the system as a whole and its components separately have to be taken into account that was realised in our works [1].

The incessant wave motion and, accordingly, the unceasing wave exchange causes oscillations of the wave spherical shells and a center of the mass of the particles, including electrons and nucleons, with the amplitude defined by the equation

$$A_s = A\frac{\hat{e}_l(kr)}{kr}, \tag{1}$$

where

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

$J_{l+1/2}(kr)$ and $Y_{l+1/2}(kr)$ are the Bessel functions; k is the wave number; $z_{p,s} = kr$ are roots (zeros and extremes) of the Bessel functions [5].

From Eq. (1) it follows, in particular, that a nucleon, being a dynamic wave microformation, as a wave node of the standing spherical waves, oscillates, as a whole, with the amplitude

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

where

$$\lambda\!\!\!^{-}_e = \frac{c}{\omega_e} \tag{2a}$$

is the fundamental wave radius, corresponding to the fundamental frequency ω_e of the atomic and subatomic levels; R is the Rydberg constant; h is the Planck constant; m_0 is the associated mass of a proton; c is the basis speed of the wave exchange at the atomic and subatomic levels equal to the speed of light in vacuum.

Small perturbations of the amplitude (2) are primarily due to the fact that the wave spherical shell simultaneously oscillates with respect to the center of the mass of a nucleon. These small deviations, defined by (1), are

$$\delta r_1 = \frac{r_0}{z_{0,s}} \sqrt{\frac{2Rh}{m_0 c}}\,, \tag{3}$$

where r_0 is the radius of the wave shell of a nucleon equal to the Bohr radius. The deviations with the amplitude (3), superimposed on the deviations with the amplitude (2), change (modulate) the amplitude of the oscillatory motion of a nucleon.

In addition, in the case of the neutron, we should take into account the perturbations of the next order of smallness related to the oscillations of the center of the mass of the electron, as a whole, relative to the center of the mass of the neutron,

$$\delta r_2 = \frac{r_e}{z_{0,s}} \sqrt{\frac{2Rh_e}{m_0 c}}\,. \tag{4}$$

Here $h_e = 2\pi m_e \upsilon_0 r_e$ is the proper action of the electron (analogous to the Planck 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 υ_0; r_e is the radius of the wave spherical shell of the electron, calculated in the DM; m_e is the associated mass of the electron.

Thus, we have all main constituents of oscillatory displacements caused by perturbations inherent in the neutron considered as a coupled proton-electron wave microsystem. Now for further consideration one needs to recall some basic definitions. The wave motion of an elementary particle, as a central object of the field, generates an elementary longitudinal (electric) moment caused by the displacement *r*,

$$p_E = qr\,, \tag{5}$$

and corresponding to it the transversal (magnetic) moment,

$$\mu = \frac{\upsilon}{c} qr \, . \tag{6}$$

Here $q = m\omega_e$ is the exchange charge of a particle of the associated mass *m*, υ is the oscillatory speed of its wave shell. The absolute value of the exchange charge of an electron represents a minimal quantum of the rate of exchange, $e = m_e \omega_e$. In the case of a free neutron, regarded as a coupled proton-electron wave system being in an excited state (in contrast to the hydrogen atom), the exchange of a spherical wave field of a proton and a transversal wave field of an electron is unstable and mutually balanced only for a short period of the neutron lifetime.

Therefore, the magnetic moment of a free neutron is measured during its lifetime, when the neutron is in a metastable very excited (threshold with respect to its decay) energy state. For this reason, we choose for the calculation one of the roots (zeros) of Bessel functions corresponding to the higher wave radial shells characteristic for exited states. We selected the value of the root $z_{0,s} = y_{0,12} = 35.34645231$ [5], corresponding to the solution of the radial component of the wave equation for one of the higher kinetic wave shells of the neutron. We also assume that $\upsilon = \upsilon_0$, and the exchange is realized by the elementary quanta of exchange *e*, i.e., the exchange charge $q = e$ (in absolute value).

Using the above parameters and taking into account all 3 components of the displacement *r* (Eqs. (2) - (4)), we arrive at the following theoretical formula in an expanded form, that allowed us to perform the precise calculation of the neutron magnetic moment μ (6):

$$\mu_n(th) = \frac{e\upsilon_0}{c} \left[\left(\lambda\!\!\!^{-}_e + \frac{r_0}{y_{0,12}} \right) \sqrt{\frac{2Rh}{m_0 c}} + \frac{r_e}{j_{0,12}} \sqrt{\frac{2Rh_e}{m_0 c}} \right] . \tag{7}$$

After substituting the numerical values of all above parameters into (7) (all the data and details of the calculation are given in [1]), with due account the sign of the exchange charge, we obtain

$$\mu_n(th) = -0.96623513 \times 10^{-26} \, J \cdot T^{-1} . \tag{8}$$

This value with high accuracy coincides with the recommended (CODATA, 2006) value of the neutron magnetic moment:

$$\mu_{n,CODATA} = -0.96623641(23) \times 10^{-26} \, J \cdot T^{-1} \tag{9}$$

Thus, the next fundamental problem, unsolvable in the Standard Model, was solved in the framework of the Wave Model. From this fact it follows that we must recognize the validity of the DM theory on which basis this and other solutions were implemented. The corresponding solution performed with use of the DM for the proton magnetic moment will be discussed further in 9th Part of the article.

As has been mentioned at the beginning, the solution of the problem on the origin of the magnetic moments of nucleons solves in principle the major fundamental problem of physics on the structure of nucleons. In this regard, our arguments in favour of the wave nature of elementary particles, including nucleons, and hence, in favour of the wave nature of atoms, have obtained the firm proof to their validity. And as an important consequence, the conclusion drawn in Part 3 about erroneousness of the modern nuclear model of atoms is confirmed as well.

The rigorous theoretical derivation of the neutron magnetic moment presented here, performed for the first time in physics, testifies once again to the fact that we have chosen a conceptually correct and logically consistent way to solving the fundamental problems of physics, unsolvable in principle in the framework of abstract mathematical theories of the Standard Model.

Various aspects of the semiclassical wave approach, which were not touched upon here, one can find in previous 1-7 Parts of this article and in the references.

REFERENCES

[1] G. P. Shpenkov, *Derivation of Neutron's Magnetic Moment on the Basis of Dynamic Model of Elementary Particles*, (2008); http://shpenkov.janmax.com/neutronmagmom.pdf

[2] S. A. Nikolaev, " *The evolutionary cycle of matter in the Universe* ", 5th edition (in Russian), St. Petersburg, 2009, p. 304.

[3] L. G. Kreidik and G. P. Shpenkov, *Dynamic Model of Elementary Particles and the Nature of Mass and "Electric" Charge*, REVISTA CIENCIAS EXATAS E NATURAIS, Vol. 3, No 2, 157-170, (2001); http://www.unicentro.br/editora/revistas/recen/v3n2/trc510final.pdf

[4] G. P. Shpenkov, *Theoretical Basis and Proofs of the Existence of Atom Background Radiation,* Infinite Energy, Vol. 12, Issue 68, 22-33, (2006); http://shpenkov.janmax.com/TheorBasis.pdf

[5] Bessel Functions, part. III, Zeros and Associated Values, in *Royal Society Mathematical Tables*, Volume 7, edited by F. W. J. Olver (University Press, Cambridge, 1960).

19.07.2011