Determination of the Neutrino Mass

Anatoly V. Belyakov
E-mail: belyakov.lih@gmail.com

The neutrino mass in four different independent formulations have been successfully calculated on the basis of the mechanistic interpretation of J. Wheeler's geometrodynamics concept. Mechanical analogue of the weak interaction is presented. Its adequacy is confirmed by the various variants for calculating the neutrino mass. The calculated mass agrees well with the indirect estimation of the neutrino mass obtained on the basis of cosmological data. It has been established that neutrinos can change its structure and properties, in particular, a magnetic moment, that leads to changes in the power of detected neutrinos flow (neutrino oscillations). The time constant of neutrino oscillations is calculated.

1 Introduction

The geometrodynamics of the famous scientist John Archibald Wheeler, who passed away in 2008, does not seem to find favor among modern physicists.

According to J. Wheeler's geometrodynamic concept charged microparticles are considered therein as singular points located in a non-unitary coherent two-dimensional surface and connected to each other through "wormholes", current tubes, or current force lines of the input-output (source-drain) kind in an additional dimension, thus forming a closed contour. However, "wormholes" in space, if they are not considered as purely mathematical constructions, in its physical embodiment can only be vortex formations of some kind substance that has the properties of an ideal fluid.

Assuming their existence, consistently developing and complicating the concept, one has managed to develop the mechanistic model, in which the properties of objects in both the microcosm and space scales are grounded and defined by using only the most general physical laws [1–4]. The determination of the neutrino mass and the calculation of other characteristic parameters provided out later in this article are the final confirmation of the correctness of the chosen model.

Experiments on the direct measurement of the neutrino mass, based on the kinematics of weak decays, to date do not give the exact value of neutrino masses, but only set the upper limit for it (the limit is permanently decreasing). The lowest limit is obtained indirectly by studying cosmological data on the relict radiation, the galaxies recession and other. According Adam Moss and Richard Battye's analysis of the data of Planck Space Telescope and their comparison with gravitational lensing observations on distant galaxies gives an upper limit for the total amount of neutrino masses of about 0.320 ± 0.081 eV [5].

2 Initial conditions

Recall that, in the proposed model, from a purely mechanistic viewpoint the *charge* only manifests the degree of the nonequilibrium state of physical vacuum; it is proportional to the momentum of physical vacuum in its motion along the contour of the vortical current tube. Respectively, the *spin* is proportional to the angular momentum of the physical vacuum with respect to the longitudinal axis of the contour, while the *magnetic interaction* of the conductors is analogous to the forces acting among the current tubes [1].

In such a formulation the electric constant ε_0 makes sense the linear density of the vortex current tube

$$\varepsilon_0 = \frac{m_e}{r_e} = 3.233 \times 10^{-16} \text{ kg/m}, \tag{1}$$

and the value of *inverse magnetic constant* makes sense of the centrifugal force

$$\frac{1}{\mu_0} = c^2 \varepsilon_0 = 29.06\, n \tag{2}$$

appearing due to rotation of an element of the vortex tube having the mass m_e and the classical radius r_e with the light velocity c; this force is equivalent to the force acting between two elementary charges at the given radius.

Elementary particles are like vortex structures in an ideal fluid which can stay in two extreme forms: the vortex *at the surface* along the X-axis (let it be the analogue of a fermion of the mass m_x), and the vortex thread or a *sub-surface* vortical current tube having of the peripheral velocity υ, the radius r and the length l_y along the Y-axis (let it be the analogue of a boson of the mass m_y). These structures oscillate inside a real medium, passing through one another (forming an oscillation of oscillations) showing that a mass (an energy) can have two states and pass from one form to another.

In paper [2], proceeding from the conditions of conservation of charge and constancy parameters μ_0 and ε_0, the parameters of the vortex thread m_y, υ, r for an arbitrary p^+–e^--contour were defined as

$$m_y = (an)^2\, m_e\,, \tag{3}$$

$$\upsilon = \frac{c_0^{1/3}\, c}{(an)^2}\,, \tag{4}$$

$$r = \frac{c_0^{2/3}\, r_e}{(an)^4}\,, \tag{5}$$

where n is the quantum number, a is the inverse fine structure constant, c_0 is the dimensionless light velocity $c/[\text{m/sec}]$.

Wherein, referring to the constancy ε_0 (linear density), it is clear that the relative length of the tube current in the units of r_e is equal the boson mass m_y in the units of m_e, i.e.

$$l_y = m_y = (an)^2 . \tag{6}$$

In the framework of the model, the particles themselves are a kind of a contour of a subsequent order, formed by the intersection of the X-surface with the current tube, and they have their own quantum numbers defining the influence zone of these microparticles.

In [2] we determined that

$$n_p = \left(\frac{2c_0}{a^5}\right)^{1/4} = 0.3338 \tag{7}$$

for a proton, while for the electron we have $n_e = (n_p)^{1/2} = 0.5777$.

To calculate the mass of an arbitrary fermion m_i a formula was obtained

$$m_i = m_e \left(\frac{n_e}{n_i}\right)^{14} . \tag{8}$$

Hereinafter all the numerical values of the mass, size and speed are given in dimensionless units: as the respective proportions of the electron mass m_e, its radius r_e and the speed of light c.

It is important to note that the vortex tube contour (which the vortex thread fills helically) can be regarded as completely "stretched", i.e. elongated proportionally to $1/r$ or, contrary, extremely "compressed" i.e. shortened proportionally to $1/r$ and filling all the vortex tube of the radius r_e. In the latter case its compressed length $L_p = l_y\, r$ is numerically equal to the energy of the contour boson mass in the mass-energy units $m_e c^2$.

Indeed, because $r = v^2$, the numerical values of the aforementioned quantities (expressed in dimensionless units) are in all cases identical, and for an arbitrary axis are

$$L_{p_i} = l_i\, r_i = m_i\, r_i = m_i\, v^2 = \frac{c_0^{2/3}}{(an_i)^2} . \tag{9}$$

It is obvious that the mass of an arbitrary boson in the mass-energy units matches its own numerical value m_y only in the case of ultimate excitation of the vortex tube wherein we have $r \to r_e$ and $v \to c$.

When considering a closed contour having contra-directional currents from the balance of the magnetic and gravitational forces recorded in a "Coulombless" form, the characteristic size of the contour comes as a *geometric mean* of two linear values [2], which in the r_e units has the form:

$$l_k = (l_i\, r_i)^{1/2} = \left(\frac{z_{g_1} z_{g_2}}{z_{e_1} z_{e_2}}\right)^{1/2} (2\pi\gamma\rho_e)^{1/2} \times [\text{sec}], \tag{10}$$

where z_{g_1}, z_{g_2}, z_{e_1}, z_{e_2}, r_i, l_i are gravitational masses and charges expressed through the mass and charge of the electron, the distance between the current tubes and theirs length, γ is the gravitational constant, while ρ_e is the electron density $m_e/r_e^3 = 4.071 \times 10^{13}$ kg/m^3.

In the $p^+\!-e^-$-contour, proton quarks become an active part of the proton mass, and are involved in the circulation. Their mass as z_g enters into the equation (10). When a proton and an electron are approaching, for example, in the case of e-capture, the contour becomes deformed and reduced.

3 Determination of the neutrino mass from the conditions of weak interaction

Let the neutrino is a particle having fermion and boson parts; the latter is separated in the weak interaction process (for example, when electron-proton absorption occurs) from the proton-electron X-contour into the region Y; see Figure 1. Let us find the neutrino mass *on the basis on the parameters of the neutrino vortex tube*.

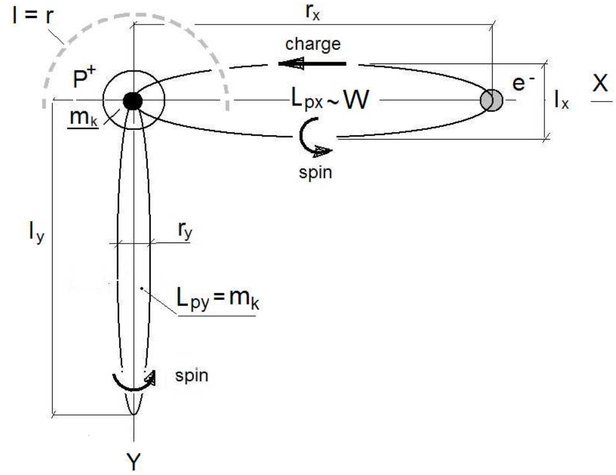

Fig. 1: Scheme of formation of the neutrino.

For the X-contour, referring to (9), its energy-mass in units of $m_e c^2$ is

$$L_{p_x} = \frac{c_0^{2/3}}{(an_x)^2} . \tag{11}$$

It is necessary to define the same parameters n_y and L_{p_y} for the neutrino. Because of the special stability of the neutrino, one can assume that its structure is characterized by all possible balances and symmetries.

Proceeding from energy balance, we assume that the active part of the proton, i.e. the quark energy-mass, is equal to the neutrino boson vortex tube energy-mass

$$m_k = L_{p_y} = \frac{c_0^{2/3}}{(an_y)^2} . \tag{12}$$

For the $p^+ - e^-$-X-contour it is accepted: $z_{g_1}/z_{e_1} = 1$, $z_{e_2} = 1$ and $z_{g_2} = m_k = L_{p_y}$. Then, using (9), from (10) we get:

$$\frac{L_{p_x}}{L_{p_y}} = 2\pi\gamma\rho_e \times [\sec^2]. \qquad (13)$$

Assume, due to symmetry, that the contour large axis along X-axis and the neutrino vortex tube along Y-axis are equal, i.e., $r_x = l_y$. Then, referring to (5) and (6), the relation between the quantum parameters X and Y-contours is

$$n_y\, n_x^2 = \frac{c_0^{1/3}}{a^3}\,. \qquad (14)$$

Proceeding from the formulas (11–14), as a result, we have

$$L_{p_x} = c_0^{4/9}\left(2\pi\gamma\rho_e \times [\sec^2]\right)^{1/3} = 1.51\times 10^5\ (77\,\text{GeV}), \quad (15)$$

$$L_{p_y} = m_k = \frac{c_0^{4/3}}{L_{p_x}^2} = 8.83\ (4.51\text{MeV}), \qquad (16)$$

as well as the quantum parameter of the neutrino vortex tube

$$n_y = \frac{c_0^{1/3}}{aL_{p_y}^{1/2}} = 1.643. \qquad (17)$$

Now, according to the equation (8) the neutrino fermion mass is found:

$$m_\upsilon = \left(\frac{n_e}{n_y}\right)^{14} = \left(\frac{0.5777}{1.643}\right)^{14} = 4.39\times 10^{-7}\ (0.225\ \text{eV}). \quad (18)$$

Additional sequels appear: the X-contour energy-mass is very close to a W-boson mass (80 GeV), and the estimated mass of a quark agrees well with that of the d-quark (4.8 MeV).

In more detailed consideration of the weak interaction, process the possibility of finding the neutrino mass *from the conservation of energy and symmetry* is detected. In the process of e-capture, the proton-electron X-contour is reduced and deformed in the Y-region. Being already the neutrino Y-contour, it contains the neutrino mass instead of the electron mass. Let us assume that at some intermediate state, before the allocation in the vortex tube form, Y-contour still maintains its momentum (the unit charge). In this case the formula (15) includes a neutrino mass m_υ (in the m_e units), and, at $z_{e_2} = 1$, applies to the neutrino contour. It has the form:

$$(L_{p_x})_\upsilon = c_0^{4/9}\, m_\upsilon^{1/3}\left(2\pi\gamma\rho_e \times [\sec^2]\right)^{1/3}. \qquad (19)$$

At the same time the X-contour initial energy-mass L_{p_x} has been transformed into the proton active part energy-mass (i.e., the quark mass $(L_{p_y})_\upsilon$). Then, referring to (16), we can write

$$L_{p_x} = (L_{p_y})_\upsilon = \frac{c_0^{4/3}}{(L_{p_x})_\upsilon^2}\,. \qquad (20)$$

As a result, considering (15) and (19) from (20) we obtain:

$$m_\upsilon = \left(2\pi\gamma\rho_e \times [\sec^2]\right)^{-3/2} \qquad (21)$$

that gives 4.5×10^{-7} (0.23 eV), the amount actually coincided with the result of the formula (18). With making the similar actions under the condition of the short axes equality $r_y = l_x$, then the same result has been got. In this case, contrary, $L_{p_y} = (L_{p_x})_\upsilon$ that apparently corresponds to the inverse process of the neutron in proton transformation.

Finally, the neutrino mass can be derived from the *conditions of complete symmetry*, i.e. from the state that is intermediate between the neutron and the proton when the X and Y-contours merge into one symmetrical contour at the zero point coordinates. This state apparently occurs only under some distinctive amount of the neutrino contour charge, namely — it is the charge value per one structure unit of the standard contour (per one photon) or e_0/a [1].

Indeed, since for a symmetrical contour $n_x = n_y$, $l = r = c_0^{2/9}$ and $L_{p_x} = L_{p_y} = c_0^{4/9}$, then by introducing into the initial formula (10) $z_{e_2} = 1/a$ from (19) we obtain

$$m_\upsilon = a^{-1}\left(2\pi\gamma\rho_e \times [\sec^2]\right)^{-1}, \qquad (22)$$

that gives 4.28×10^{-7} (0.219 eV), the same amount as the resulting from the formulas (18) and (21).

Note that if a single photon has a linear size of $1/a$ of the standard contour length, i.e. the value of $c_0^{2/3}/a$, then the neutrino has a similar size of $c_0^{2/3} m_\upsilon$ or $0.192\, r_e$. This value is about 1/3 of the proton diameter; it is the linear quark dimension along the axis X. Indeed, since for the quark we have $n = 0.48$, then $r_x = c_0^{2/3}/(an)^{3.5} = 0.194\, r_e$ [2]. This coincidence additionally points to the correctness of the proton quark model, as set out earlier.

Full symmetry and the combining of the $p^+ - e^-$-contour and the neutrino contour are possible only in a special excited state of the nucleon. In reality, the electromagnetic interaction (nominal axis X) and weak interaction (nominal axis Y) are realized separately, and then only in a certain scale range, forming three generations of elementary particles [2]. That is, here is a *mechanical analogue of spontaneous electroweak symmetry breaking in the SM*.

Thus, the proposed model clearly describes the process of the weak interaction (how a proton absorbs an electron). The proton-electronic contour is reduced until the energy-mass becomes equal to the energy of W-particles. Then it transmits this energy and momentum (charge) to the proton, transforming it into an excited state (the neutron); further the contour is allocated into Y-region as the neutrino vortex tube with the parameter $n_y = 1.643$, keeping its spin and having the value of energy-mass equal to that of the light d-quark.

4 Determination of the neutrino mass from the limit conditions

At last, the neutrino mass is possible to be found directly from the magnetic-gravitational equilibrium conditions; from the equation (10), by substituting the limit conditions.

A vortex thread or tube in a non-viscous medium can be either closed or having an output to the surface of X, that is having a charge. The neutrino has no detectable charge and, therefore, it represents a closed structure or a contour.

Assume that Planck's size $r_h = (\hbar\gamma/c^3)^{1/2}$ has a physical meaning and it is the minimum size of the elementary neutrino vortex contour, i.e., $r_i = r_h = 1.616 \times 10^{-35}$ m or $5.735 \times 10^{-21}\, r_e$. Then, taking into account (5) and (6), a geometric mean is obtained from (10) as

$$l_k = c_0^{1/6} r_h^{1/4}. \tag{23}$$

In [2] it is shown that any electron vortex tube includes three vortex zones. But as one of the zones needs to be double, there should in general be four vortex threads each containing one-quarter of the electron total momentum (charge). Therefore, the elementary neutrino should be viewed as a pair of the closed vortex threads. Accordingly, two types of neutrinos are possible there: a pair of left-right rotation and, conversely, a pair of right-left rotation, obviously, as a neutrino and an antineutrino.

For a pair of the vortex threads at $z_{e_1} = z_{e_2} = \frac{1}{4}\, e_0$ and at $z_{g_1} = z_{g_2}$, having in mind (23), from (10) it should be:

$$z_g = m_v = \frac{c_0^{1/6} r_h^{1/4}}{(32\pi\gamma\rho_e \times [\text{sec}^2])^{1/2}}\,, \tag{24}$$

that gives 4.31×10^{-7} (0.220 eV), the amount actually coinciding with the results of the formulas (18), (21), and (22). It should be noted that these results are only the ones of its kind since these formulas include only the fundamental constants.

Thus, the two states of the neutrino are obtained — *at the moment of birth in the form of a vortex tube and in its ultimate state in the form of a closed structure*, and the fermion neutrino mass in the initial state turned out equal to the gravitational mass of the neutrino vortex threads in the ultimate state. Is it possible to reconcile these very different states? Perhaps, it must be admitted that since the neutrino's vortex tubes initially contain all four single vortex threads then further the neutrino transforms into two potentially possible final forms (neutrino and antineutrino) maybe passing some intermediate states.

As for the muon and the tau-neutrinos, the electron mass in the formula (10) can be formally replaced by the masses of the muon and the tau-particles, provided that the linear density of the contour tube remains unchanged (that is not obvious). Then, as follows from the above formulas, the contours' parameters are changed, and the contours are deformed "stretching" along their axes; the X-contour energy-mass increases as the cube root of the relative weight of the microparticle. For the muon contour $L_{p_x} = 456\,$GeV, which is equal to twice the value of the total energy-mass of the standard $p^+\!-e^-$-contour (229 GeV) [1]. For the τ-contour $L_{p_x} = 1170\,$GeV. This value is the sum of the neutrino energy and that of the expected boson energy-mass of the third generation, the heaviest one, which is not yet registered in experiment; that is, having the value of about 1000 GeV, which matches to the value defined earlier in [2]. As follows from the above formulas masses of the muon and the tau-neutrinos must be much less than that of the electron neutrino, and the resulting formulas give different results that may indicate instability of these neutrinos, like other particles of the second and third generations.

The fact of the neutrino transformation is derived from the model and confirmed by the experimentally detected neutrino oscillations.

5 Neutrino magnetic properties and its oscillations

The neutrino boson vortex tube retains the electron spin, and has a magnetic moment μ. The magnetic moment is determined relative to the axis Y. By definition, the μ is the product of the charge × the velocity × the path. Suppose that for the vortex thread the peripheral speed is v, while the path is πr. Revealing v and r through (4) and (5), as a result we obtain

$$\mu = \frac{\pi c_0\, c\, e_0\, r_e}{(an)^6}\ \text{Am}^2. \tag{25}$$

(Ampere at a "Coulombless" system is equivalent to the acting force.)

The neutrino magnetic moment in the moment of its allocation μ_{v_0} according to formula (25) at $n_y = 1.643$ is 9.81×10^{-31} Am^2. Moreover, it appears that this value with high accuracy is equal to the geometric mean of the proton magnetic moment μ_p and the vortex tube magnetic moment with average parameter l_k (Compton wavelength), which complies to $n_y = 8.07$ [2]. Its magnetic moment $\mu_k = 6.99 \times 10^{-35}$ Am^2, which corresponds to 0.75×10^{-11} Bohr's magneton. That is,

$$\mu_{v_0} = \left(\mu_p \mu_k\right)^{1/2}. \tag{26}$$

Such a large magnetic moment of neutrinos are not detected, but what is significant, it is the magnetic moment μ_k close to 10^{-11} Bohr's magneton that requires the neutrino to explain the anticorrelation of the registered neutrino flow with the magnetic flow near the sun surface. It is assumed that the neutrino magnetic moment interacts with the magnetic field in the outer convective layers of the sun, which leads to the spin precession of neutrinos changing its helicity from left to right; and the right neutrinos are not registered by detectors [6, 7]. The same neutrino magnetic moment is required because of some astrophysical limitations regarding the dynamics of stars [7].

So it is logical to assume that the neutrino magnetic moment, an originally very large magnitude, rapidly decreases to the value of about 10^{-11} Bohr's magneton at the intersection of the Sun's surface, and in the neutrino ultimate state it becomes absolutely negligible. The reason for this is the transformation of the neutrino contour, which is analogous to the process of the transformation of a neutron into a proton.

Indeed, if the counter comprises several vortex threads with co-directed currents, they must be rotated relative to the longitudinal axis. At the same time, since by definition an elementary unit of the model medium (vortex thread) is absolutely inelastic and at the same time is absolutely deformed, the closed counter must be deformed ("turned out") in different structures by changing its parameters.

From the equality of the magnetic and inertial (centrifugal) forces for the vortex threads the peripheral rotation speed relative to the longitudinal axis of the contour is obtained

$$v_0 = \frac{(z_{e_1} z_{e_2})^{1/2}\, r_e}{(2\pi)^{1/2} \times [\text{sec}]}\,. \qquad (27)$$

This speed does not depend on the length of the vortex threads and distances between them and for the unit charges is 1.124×10^{-15} m /sec.

Earlier [2], it was found that the *time constant* of the transformation process (the ratio of the counter size to the peripheral speed) has appeared equal to the neutron lifetime.

Similarly, the time constant for the neutrino can be expressed in the forms $\tau_v = r_y / v_0$. Then, referring to (5), with $n = 1.643$, we obtain $\tau_v = 4.37 \times 10^{-4}$ sec (the time constant should be increased with the decrease of the residual charge of the neutrino). During this time the neutrinos having the speed of light move away from the source at a distance of 1.31×10^5 m. If they would transform to another form, a decrease in their number would be registered when the detector would be displaced from the source at a distance not less than the calculated value.

It is the distance the largest neutrino detector KamLAND (Kamioka Liquid Scintillator Anti-Neutrino Detector, Honshu island, Japan) has registered a decrease of the neutrino flow in the nuclear reactor antineutrino experiments [8]); see Figure 2 (the data are taken from [8]).

6 Conclusion

Thus, one value of the neutrino mass has been derived by theoretical methods. Moreover, the same result was then obtained in four different formulas and three of them on the basis of the classical mechanistic model (actually through the analogue of spontaneous electroweak symmetry breaking in the SM). The results coincided with the indirect estimate of the neutrino mass derived from cosmological data. It was established that neutrinos may exist in various forms. It arises in the form of the electron neutrino with the mass of about 0.22 eV and further during the transition to its final state with the same mass may possibly change its parameters like the mass and magnetic moment, which results in the changes of a detectable power neutrino flow (oscillations). It is possible that the muon-neutrinos and tau-neutrinos are not stable. Apparently, they are the intermediate states of the totally stable electron neutrino.

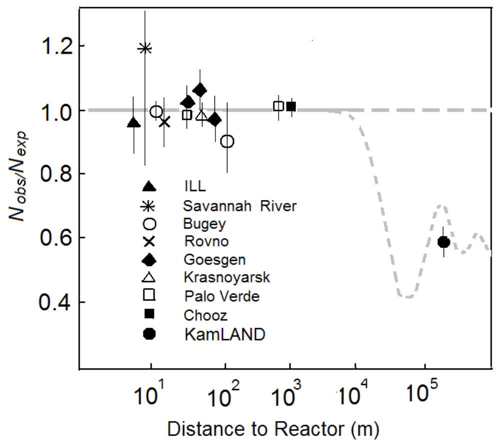

Fig. 2: The ratio of the measured neutrinos flows in the expected ones if there is no oscillations for experiments with reactor neutrinos.

The fact that the same neutrino mass is obtained in several ways may indicate that the values of other fundamental constants can also be obtained through the neutrino mass, which apparently is a key element of matter.

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