Explanation and Calculation of the Gallium Anomaly Using a Neutrino Model Based on Wheeler's Geometrodynamics

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Based on Wheeler's geometrodynamics, a mechanism of the transition of an electron neutrino to a sterile one is proposed. The neutrino deficit (gallium anomaly) is explained, and its magnitude is calculated, consistent with the experimental values recently obtained in the Baksan Experiment on Sterile Transitions (BEST experiment).

The gallium anomaly is a commonly accepted term for a distinct deficiency in the number of neutrinos detected from artificial gallium sources relative to the expected value. The deficit in electron neutrinos from artificial sources (as well as solar, reactor, and other sources) is interpreted as evidence of oscillations between electron neutrinos ν_e and sterile neutrinos ν_s.

For example, the Baksan Experiment on Sterile Transitions (BEST) [1] investigated the deficit in electron neutrinos ν_e registered in gallium-based radiochemical measurements using Cr^{51} neutrino sources, in which, when gallium is irradiated by neutrinos, Ge^{71} is formed. The ratio of the measured Ge^{71} production rate to the expected rate ranges from 0.79 ± 0.05 to 0.77 ± 0.05. The registered rates were 20–24% lower than expected, thereby confirming the anomaly. These results indicate a possible sterile neutrino mass with Δm^2 (> 0.5 eV^2).

As follows from recent Neutrino-4 experiments [2], sterile neutrinos exist. However, they are not formed through oscillations. Rather, they are formed either through the transition of a neutrino, being in a vortex tube state at the moment of birth, carrying only spin (torsion), to a closed-contour state [3], or through partial energy transfer from the produced electron neutrino to the carrier medium, forming a circulation contour with the parameters of a closed neutrino, which is more probable. In [3], it was calculated that the neutrino masses m_{ν_e} at the moment of birth and in closed form are the same and equal to $4.33 \times 10^{-7} m_e$ (0.222 eV).

Let us recall that, according to the accepted model based on Wheeler's geometrodynamics [4], the primary basis of material objects is a surface of finite thickness, disturbances on which propagate as surface waves. The unit radiative cell of the material-spatial medium is taken to be the contour of a toroid shape, where the medium circulates along its circular radius R and simultaneously spirals around the longitudinal circular axis of the torus along the radius r [5]. It is known that a surface wave has longitudinal and transverse components. It is assumed that a neutrino, at the moment of its birth, as part of an elementary material-spatial cell, belongs to the *transverse component* of the surface wave (like a photon); it travels along the circular axis of the torus and rotates relative to it at the speed of light.

For a sterile neutrino to form, some of the energy of the original electron neutrino must be transferred to the longitudinal component of the surface wave to create a circulation contour (a mechanical analogy: a small gear rotates a large one), i.e., for the neutrino to emerge in a closed form and then, obviously, for it to transform into the most stable form of a sterile neutrino. Any contour, by definition, has a momentum equal to its charge, and, accordingly, its formation requires an energy of at least Mv^2 [6].

The parameters of the contour: its boson mass M, the velocity of the medium along the contour ν, the length of the contour l, the radius of the vortex thread r filling the vortex tube of radius r_e, in units of the electron mass m_e, its radius r_e and the speed of light c, respectively, are equal to

$$M = l = (an)^2, \tag{1}$$

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

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

where $c_0 = \frac{c}{[\mathrm{m/sec}]}$ means the dimensionless speed of light, a is the inverse fine structure constant, and n is the main quantum number.

In the paper [3] it is shown that the neutrino vortex thread in the limit has the Planck size $r = r_h = (\hbar\gamma/c^3)^{1/2}$, which is $5.74 \times 10^{-21}\, r_e$. Then the quantum number for the neutrino in closed form, bearing in mind (3), is

$$n_{\nu_e} = \frac{c_0^{1/6}}{a r_h^{1/4}}. \tag{4}$$

In [7] it is shown that under the condition that the **gravitational energy-mass of the particle means to be equal to the energy-mass of the compressed contour**, i.e., when $m_\nu = lr$, the most stable form of a closed neutrino (a sterile neutrino) is formed with a mass depending only on the gravitational constant γ and the electron density ρ_e, equal to m_e/r_e^3:

$$m_{\nu_s} = \left(18\pi\gamma\rho_e \times [\mathrm{sec}^2]\right)^{-1} = \\ = 6.52 \times 10^{-6}\, m_e\, (3.33 \text{ eV}); \tag{5}$$

then its quantum number under the mentioned condition, taking into account (1) and (3), is

$$n_{\nu_s} = \frac{c_0^{1/3}}{a m_{\nu_s}^{1/2}}. \quad (6)$$

To form a closed neutrino in two forms (right and left), it is necessary to transfer part of the energy from the original form of the electron neutrino to the medium to excite circular circulation in it; this share (i.e., the energy ratios in units of $m_e c^2$), taking into account (1), (2) and (4), will be

$$\frac{Mv^2}{m_{\nu_e}} = \frac{2c_0^{1/3} r_h^{1/2}}{m_{\nu_e}} = 0.235. \quad (7)$$

Thus, 23% of electron neutrinos, due to energy loss, cannot be detected in the gallium experiment, which is entirely consistent with the BEST results. In addition to losses associated with the gallium anomaly, electron neutrinos, moving away from the source at the speed of light, also undergo changes in their configuration related to the time constant [3], and their deficit was detected at a large distance from the source by the large neutrino detector KamLAND [8].

Heavy (sterile) neutrinos are apparently formed by the summation of several closed contours of light neutrinos. This quantity is proportional to the ratio of their energies or, as follows from the formulas above, inversely proportional to the square of the ratio of their quantum numbers, and then

$$\frac{E_{\nu_s}}{E_{\nu_e}} = \frac{m_{\nu_s}}{c_0^{1/3} r_h^{1/2}} = 129 \sim a. \quad (8)$$

Thus, approximately a light neutrinos are required to form a sterile neutrino. Moreover, it can be shown that approximately a of such neutrinos are required to transfer the angular momentum (spin) $\hbar$, which in units of $m_e c r_e$ is equal to a, if the angular momentum of a closed neutrino is expressed as $2\pi \times MvL$ and the linear parameter L is taken to be the geometric mean of the contour axes $(l r_h)^{1/2}$.

These neutrinos, unlike electron neutrinos, do not participate in the weak interaction, belong to the longitudinal component of the surface wave, and are predominantly gravitational objects. They obviously inherit a change in their configuration from the primary electron neutrino in accordance with its time constant (they oscillate). Since their energy and velocity depend on the source energy, the oscillation period for sterile neutrinos at low energies can be very small, as demonstrated by the results of the Neutrino-4 experiment [2].

The traditional oscillation theory, according to some researchers — see Christian G. Barker [9], — although consistent with many data sets, does not explain a number of features and is essentially an interpretation of these data. Indeed, neutrino masses have never been measured directly, their oscillatory structure is inferred rather than observed, a sinusoidal oscillation shape is assumed and then adjusted, solar neutrinos exhibit a single fundamental suppression rather than several cycles, etc.

According to Barker's model, it is not the internal interference of mass states that occurs, but rather the property of each neutrino to have a thin coherent shell that accumulates a geometric phase as it moves through media of varying densities. When this accumulated phase reaches a half-integer threshold, the shell collapses into a new configuration; This suggests the presence of extended geometric structures in quantum systems. Indeed, recent experiments have shown that the spatial extent of a neutrino wave packet (6.2×10^{-12} m) is significantly greater than the size of atomic nuclei [10].

This idea is generally consistent with the aforementioned diagram of neutrino structure (vortex tube, contour) and the change in their configuration in accordance with the neutrino time constant.

The noted inconsistencies in the oscillation theory raise the question: is the theory of oscillations valid and necessary? At the same time, the presented model, based on Wheeler's geometrodynamics, proposes the structure of different types of neutrinos and the mechanism for their interconversion, explains the nature of the gallium anomaly with a quantitative calculation of the neutrino deficit, explains the deficit of electron neutrinos from various sources, and explains the oscillations of sterile neutrinos.

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