VECTORS CURRENTS OF MASSIVE NEUTRINOS OF AN ELECTROWEAK NATURE

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The mass of an electroweakly interacting neutrino consists of the electric and weak parts responsible for the existence in it of charge, charge radius and magnetic moment. Such connections explain the formation of paraneutrinos, for example, at the polarized neutrino electroweak scattering by spinless nuclei. We derive the structural equations which relate the mass and its self components to charge, charge radius and magnetic moment of each neutrino as a consequence of unification of fermions of a definite flavor. Findings open the possibility for establishing the laboratory limits of weak masses of all Dirac types of neutrinos. Thereby, they show that the earlier measured properties of these particles may serve as a certain confirmation of the availability of mass structure of their interaction with field of emission.
In the classical electrodynamics, it has been usually assumed that all inertial mass of a particle is equal to its electric mass \([1]\). Such an implication can be explained by that elementary objects with the Coulomb behavior have no neither weak, strong nor any other type of interaction. This is, however, valid only for those particles in which the mass and charge are absent.

One of such objects may, according to the earlier presentations, be a neutrino of the Dirac nature. But unlike the original electroweak theory \([2]\), its mathematically consistent extension gives the possibility to relate the mass \(m_{\nu_l}\) to charge \(F_{1\nu_l}(q^2)\) and magnetic \(F_{2\nu_l}(q^2)\) form factors of this particle \((l = e, \mu, \tau, \ldots)\) as a consequence of the equality of cross sections \([3, 4]\) of the interaction with field of emission of both types of vector \(V_{\nu_l}\) currents. For the case when to the process answer their independent \(f_{i\nu_l}(0)\) parts, the latter is reduced to the following \([5]\):

\[
f_{1\nu_l}(0) - 2m_{\nu_l}f_{2\nu_l}(0) = 0. \tag{1}
\]

It is clear, however, that \(F_{i\nu_l}(q^2)\) include not only the static but also the dynamical components:

\[
F_{i\nu_l}(q^2) = f_{i\nu_l}(0) + R_{i\nu_l}(\vec{q}^2) + \ldots, \tag{2}
\]

where \(f_{i\nu_l}(0)\) describe the electric charge and magnetic moment, \(R_{1\nu_l}(\vec{q}^2)\) characterizes the connection between charge \(r_{\nu_l}\) radius of a neutrino and field of emission of an intermediate boson: \(R_{1\nu_l}(\vec{q}^2) = -(\vec{q}^2/6) < r_{\nu_l}^2 >.\)

Insofar as \(R_{2\nu_l}(\vec{q}^2)\) is concerned, we will start from the fact \([6]\) that each dipole moment arises as a result of a kind of charge. To such a principle corresponds in the limit of \((1)\) a connection of parameters

\[
f_{2\nu_l}(0) = \frac{f_{1\nu_l}(0)}{2m_{\nu_l}}
\]

and that, consequently, between the mass of the neutrino and its charge there exists a certain latent dependence \([5, 7]\).

This would seem contradicts charge quantization. As was, however, for the first time noted by the author \([8]\), to any type of an electrically charged particle corresponds a kind of magnetically charged monoparticle. In a given situation, each mononeutrino answers to quantization of the electric charges of all neutrinos and vice versa.
One can also as an example use an arbitrary charge, introduction of which in the framework of the standard theory is not excluded [9].

At the availability of the suggested connection, the conservation of charge in the decays of the neutron, proton, muon, tau lepton and in other reactions with neutrinos must lead to a formation in the field of emission of dileptons and paradileptons of a definite flavor [10, 11].

Another characteristic moment is the mass structure [7, 12] of gauge invariance. Thereby, fall off the possibility to explain the existence in a massive neutrino of charge and its radius by the absence of gauge invariance.

In the presence of a purely electric part of mass, the expected structure of $f_{1\nu_l}(0)$ encounter condition of the steadiness of charge in neutrino and requires the explanation from the point of view of interratio of the most diverse types of intraneutrino forces. For this we must at first recall the mass-charge duality [13], according to which, each of the Coulomb, weak and unelectroweak charges says about the existence in nature of a kind of inertial mass. Therefore, a neutrino with an electroweak behavior can have not only the electric [1] but also the weak [14] masses.

Thus, all the mass $m_{\nu_l}$ and charge $e_{\nu_l}$ of the neutrino coincide with its electroweakly united (EW) mass and charge

$$m_{\nu_l} = m_{\nu_l}^{EW} = m_{\nu_l}^E + m_{\nu_l}^W, \quad (3)$$

$$e_{\nu_l} = e_{\nu_l}^{EW} = e_{\nu_l}^E + e_{\nu_l}^W, \quad (4)$$

possessing the Coulomb ($E$) and weak ($W$) components. They constitute an intraneutrino harmony of the four types of forces [15].

For further substantiation of the legality of such a procedure one must build the functions $f_{i\nu_l}(0)$ and $< r_{\nu_l}^2 >$ in the neutrino mass structure dependence. From this purpose, we investigate here the behavior of elastic scattering of longitudinal polarized neutrinos of the Dirac nature on a spinless nucleus as a consequence of the availability of the electric, weak and electroweak masses, and also of charge, charge radius and magnetic moment of incoming fermions of vector neutral $V_{\nu_l}$ currents.

The matrix elements of such transitions [16] in the limit of one-boson exchange include the following interaction parts:

$$M^E_{fi} = \frac{4\pi\alpha}{q^2 E} \bar{u}(p'_E, s') \{ \gamma_\mu [ f_{1\nu_l}^E(0) + \frac{1}{6} q^2 E < r_{\nu_l}^2 > E ] - \mu(0, s), \}$$
\[-i\sigma_{\mu\lambda}q_{E}^{\lambda}f_{2\nu_{l}}^{E}(0)\}u(p_{E}, s) < f |J_{\mu}^{\gamma}(q_{E})|i >, \tag{5}\]

\[M_{f_i}^{W} = \frac{G_{F}}{\sqrt{2}}\pi(p_{W}', s')\gamma_{\mu}g_{\nu_{l}}u(p_{W}, s) < f |J_{\mu}^{Z_{0}}(q_{W})|i >. \tag{6}\]

Here \(\nu_{l} = \nu_{l}^{L,R}(\bar{\nu}_{l}^{R,L})\), \(q_{E} = p_{E} - p_{E}', q_{W} = p_{W} - p_{W}', p_{E}(p_{W})\) and \(p_{E}'(p_{W}')\) correspond in the Coulomb (weak) scattering to the four-momentum of initial and final neutrinos of the definite helicities \(s\) and \(s'\), \(J_{\mu}^{\gamma}\) and \(J_{\mu}^{Z_{0}}\) describe the target nucleus currents at the emission of virtual photons and \(Z_{0}\)-bosons, \(g_{\nu_{l}}\) characterizes the vector component of the neutrino weak interaction with neutral currents.

The index \(E\) in \(f_{i\nu_{l}}^{E}\) and \(< r_{\nu_{l}}^{2} >_{E}\) implies the availability of a connection between these characteristics of the neutrino and an electric \(m_{\nu_{l}}^{E}\) part of its all rest mass. We see in addition that in the case of exchange by the \(Z_{0}\)-boson, only the weak \(m_{\nu_{l}}^{W}\) component of mass is responsible for the scattering.

A neutrino itself possesses simultaneously both electric and weak masses [1, 14]. This leads to those processes which originate at the expense of an electroweakly united interaction [16].

\[Re M_{f_i}^{E}M_{f_i}^{*W} = \frac{8\pi\alpha G_{F}}{\sqrt{2}q_{EW}^{2}} Re \Lambda_{EW}\Lambda_{EW}'\{\gamma_{\mu}[f_{1\nu_{l}}^{I}(0) +
\[+ \frac{1}{6}q_{EW}^{2} < r_{\nu_{l}}^{2} >_{I}] - \]
\[- i\sigma_{\mu\lambda}q_{EW}^{\lambda}f_{2\nu_{l}}^{I}(0)\}\gamma_{\mu}g_{\nu_{l}}J_{\mu}(q_{EW})J_{\mu}^{Z_{0}}(q_{EW}), \tag{7}\]

where the interference currents \(f_{i\nu_{l}}^{I}\) and \(< r_{\nu_{l}}^{2} >_{I}\) appear in the mass and charge structure dependence. Here one must have also in view of that

\[q_{EW} = p_{EW} - p_{EW}',\]

\[\Lambda_{EW} = u(p_{EW}, s)\bar{u}(p_{EW}, s),\]

\[\Lambda_{EW}' = u(p_{EW}', s')\bar{u}(p_{EW}', s').\]

For spinless nuclei of the electric \(Z\) and weak \(Z_{W}\) charges and of all Dirac types of longitudinal polarized neutrinos, the investigated process cross section, according to (5)-(7) and the standard definition

\[\frac{d\sigma_{E,W}(s, s')}{d\Omega} = \frac{1}{16\pi^2}|M_{f_i}^{E} + M_{f_i}^{W}|^2, \tag{8}\]}
may be written as
\[
d\sigma_{E,W}^{V_{\nu l}}(\theta_{E,W}, s, s') = d\sigma_{E}^{V_{\nu l}}(\theta_{E}, s, s') + \\
+ d\sigma_{I}^{V_{\nu l}}(\theta_{E,W}, s, s') + d\sigma_{W}^{V_{\nu l}}(\theta_{W}, s, s'),
\]
where the purely Coulomb contributions are equal to
\[
d\sigma_{E}^{V_{\nu l}}(\theta_{E}, s, s') = \frac{1}{2}\sigma_{\nu l}^{E}(1 - \eta_{E}^{2})^{-1}\{(1 + ss')f_{1_{\nu l}}^{E} - \\
- \frac{2}{3} < r_{\nu l}^{2} >_{E} (m_{\nu l}^{E})^{2}\gamma_{E}^{-1}]^{2} + \\
+ \eta_{E}^{2}(1 - ss')[(f_{1_{\nu l}}^{E} - \frac{2}{3} < r_{\nu l}^{2} >_{E} (m_{\nu l}^{E})^{2}\gamma_{E}^{-1}]^{2} + \\
+ 4(m_{\nu l}^{E})^{2}(1 - \eta_{E}^{2})^{2}(f_{2_{\nu l}}^{E})^{2}tg^{2}\theta_{E}/2\}F_{E}^{2}(q_{E}).
\]
To the interference scattering answers the expression
\[
d\sigma_{I}^{V_{\nu l}}(\theta_{E,W}, s, s') = \frac{1}{2}\rho_{\nu l}^{E} \sigma_{\nu l}^{E} (1 - \eta_{E}^{2})^{-1}\{(1 + ss')f_{1_{\nu l}}^{I} - \\
- \frac{2}{3} < r_{\nu l}^{2} >_{I} (m_{\nu l}^{E})^{2}\gamma_{E}^{-1}] + \eta_{E}^{2} (1 - ss')f_{1_{\nu l}}^{I} - \\
- \frac{2}{3} < r_{\nu l}^{2} >_{I} (m_{\nu l}^{E})^{2}\gamma_{E}^{-1}]tg^{2}\theta_{E}/2\}F_{I}^{2}(q_{E}).
\]
The cross section explained by the weak interaction (6) has the form
\[
d\sigma_{W}^{V_{\nu l}}(\theta_{W}, s, s') = \frac{G_{F}^{2}(m_{\nu l}^{W})^{2}}{16\pi^{2}}g_{V_{\nu l}}^{2}\eta_{W}^{2}(1 + ss')cos^{2}\theta_{W}/2 + \\
+ (1 - ss')sin^{2}\theta_{W}/2\}F_{W}^{2}(q_{W}).
\]
Here we have been used by the relations:
\[
\sigma_{\nu l}^{E} = \frac{\alpha^{2}}{4(m_{\nu l}^{E})^{2}}\gamma_{E}^{2}, \quad \rho_{\nu l}^{E} = -\frac{2G_{F}(m_{\nu l}^{EW})^{2}}{\pi\sqrt{2}\alpha}\gamma_{E}^{-1},
\]
\[
\sigma_{\nu l}^{EW} = \frac{\alpha^{2}}{4(m_{\nu l}^{EW})^{2}}\gamma_{EW}^{2}, \quad \alpha_{K} = \frac{\eta_{K}^{2}}{(1 - \eta_{K}^{2})cos^{2}(\theta_{K}/2)},
\]
\[ \gamma_K = \frac{\eta_K^2}{(1 - \eta_K^2) \sin^2(\theta_K/2)}, \quad \eta_K = \frac{m_{\nu_{\ell}}}{E_{\nu_{\ell}}}, \]

\[ F_E(q_E^2) = Z F_c(q_E^2), \quad F_i(q_{EW}^2) = Z Z_W F_c^2(q_{EW}^2), \]
\[ F_W(q_W^2) = Z_W F_c(q_W^2), \quad q_K^2 = -4(m_{\nu_{\ell}})^2(\gamma_K^{-1}), \]
\[ Z_W = \frac{1}{2}\{\beta_V^{(0)}(Z + N) + \beta_V^{(1)}(Z - N)\}, \]
\[ A = Z + N, \quad M_T = \frac{1}{2}(Z - N), \]
\[ \beta_V^{(0)} = -2 \sin^2 \theta_W, \quad \beta_V^{(1)} = \frac{1}{2} - 2 \sin^2 \theta_W, \]
\[ g_{V_{\nu_{\ell}}} = -\frac{1}{2} + 2 \sin^2 \theta_W, \quad K = E, EW, W. \]

where \( \theta_K \) correspond to the Coulomb, electroweakly united and weak scattering angles at the energies \( E_{\nu_{\ell}}^K \), the functions \( F_c(q_K^2) \) are responsible in these processes for charge \( (F_c(0) = 1) \) distribution of a nucleus with an isospin \( T \) and its projection \( M_T \), \( \beta_V^{(0)} \) and \( \beta_V^{(1)} \) denote the constants of hadronic vector neutral current isoscalar and isovector parts.

The presence of self interference terms \( (f_{E_{\nu_{\ell}}}^E)^2 \) and \( < r_{\nu_{\ell}}^A >_E \) in (10) is explained by the formation of one of the left \( (s = -1) \)-right \( (s = +1) \) and the right-left [11] or of the left - and right-handed [17] paraneutrinos:

\[ (\nu_1^L, \bar{\nu}_1^R), \quad (\nu_1^R, \bar{\nu}_1^L), \quad (\nu_2^L, \bar{\nu}_2^L), \quad (\nu_2^R, \bar{\nu}_2^R). \]

Their appearance in the nuclear Coulomb field can also be explained by the contribution \( f_{E_{\nu_{\ell}}}^E < r_{\nu_{\ell}}^2 >_E \) of the mixed interference between the interactions with photon of the neutrino charge and charge radius. They of course appear as well as at the expense of weak neutral currents. In the latter case from (12) and its structural components \( g_{V_{\nu_{\ell}}}^2 \), we are led to a correspondence principle that the nature of dirfermions depends on an interaction type. Therefore, the availability of mixedly interference contributions \( g_{V_{\nu_{\ell}}} f_{I_{\nu_{\ell}}} \) and \( g_{V_{\nu_{\ell}}} < r_{\nu_{\ell}}^2 >_I \) in the scattering cross section (11) can also confirm the fact that the existence of paraneutrinos with an electroweak behavior is, by itself, not excluded.

Here it is relevant to note that (8) doubles the value of mixedly interference terms. But the number of different and those phenomena which lead to
their formation coincide. Such a symmetry explains the separation of any type of the mixedly interference cross section into the two.

Thus, if we sum each of (10)-(12) over \( s' \), one can write (9) in the form

\[
d\sigma_{E,W}^{V_{\eta}}(\theta_E,W,s) = d\sigma_{E}^{V_{\eta}}(\theta_E,s) + \frac{1}{2} d\sigma_{I}^{V_{\eta}}(\theta_EW,s) + \frac{1}{2} d\sigma_{I}^{V_{\eta}}(\theta_EW,s) + d\sigma_{W}^{V_{\eta}}(\theta_W,s),
\]

where the purely Coulomb scattering cross section behaves as

\[
d\sigma_{E}^{V_{\eta}}(\theta_E,s) = d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},s) + \frac{1}{2} d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E}, < r_{\nu_{1}}^{2} > E,s) + \frac{1}{2} d\sigma_{E}^{V_{\eta}}(\theta_E,f_{2\nu_{1}}^{E},< r_{\nu_{1}}^{2} > E,s) + d\sigma_{E}^{V_{\eta}}(\theta_E,< r_{\nu_{1}}^{2} > E,s) + d\sigma_{E}^{V_{\eta}}(\theta_E,f_{2\nu_{1}}^{E},s),
\]

\[
\frac{d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},< r_{\nu_{1}}^{2} > E,s)}{d\Omega} = \frac{d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},s'=s)}{d\Omega} + \frac{d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},s'=-s)}{d\Omega} = \]

\[
= \sigma_{o}^{E}(1 - \eta_{E}^{2})^{-1}(1 + \eta_{E}^{2}tg\frac{\theta_{E}}{2})(f_{1\nu_{1}}^{E})^{2}F_{E}^{2}(q_{E}^{2}),
\]

\[
\frac{d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},< r_{\nu_{1}}^{2} > E,s')} {d\Omega} = \frac{d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},< r_{\nu_{1}}^{2} > E,s'=s)}{d\Omega} + \frac{d\sigma_{E}^{V_{\eta}}(\theta_E,f_{1\nu_{1}}^{E},< r_{\nu_{1}}^{2} > E,s'=-s)}{d\Omega} = -\frac{2}{3}(m_{\nu_{1}}^{E})^{2}e_{E}^{-1}\sigma_{o}^{E}(1 - \eta_{E}^{2})^{-1} \times \]

\[
\times (1 + \eta_{E}^{2}tg\frac{\theta_{E}}{2})f_{1\nu_{1}}^{E} < r_{\nu_{1}}^{2} > E F_{E}^{2}(q_{E}^{2}),
\]

\[
\frac{d\sigma_{E}^{V_{\eta}}(\theta_E,< r_{\nu_{1}}^{2} > E,s')} {d\Omega} = \frac{d\sigma_{E}^{V_{\eta}}(\theta_E,< r_{\nu_{1}}^{2} > E,s'=s)}{d\Omega} + \frac{d\sigma_{E}^{V_{\eta}}(\theta_E,< r_{\nu_{1}}^{2} > E,s'=-s)}{d\Omega} =
\]

7
\[ = \frac{4}{9} (m_{\nu l}^E)^4 \gamma_\nu^2 \sigma_o^E (1 - \eta_E^2)^{-1} \times \]
\[ \times (1 + \eta_E^2 t g \frac{\theta_E}{2}) < r_{\nu l}^E > E \ F_E^2 (q_E^2), \tag{19} \]

\[ \frac{d\sigma_{Vl}^E (\theta_E, f_{2\nu l}, s)}{d\Omega} = \frac{d\sigma_{Vl}^E (\theta_E, f_{2\nu l}, s' = -s)}{d\Omega} = \]
\[ = 4 (m_{\nu l}^E)^2 \eta_E^2 \sigma_o^E (1 - \eta_E^2)^2 (f_{2\nu l}^E)^2 F_E^2 (q_E^2) t g \frac{\theta_E}{2}. \tag{20} \]

An interference term corresponding in (15) to the electroweakly united processes becomes equal to

\[ d\sigma_{Vl}^{I} (\theta_{EW}, s) = d\sigma_{Vl}^{I} (\theta_{EW}, g_{Vl}, f_{I1\nu l}, s) + \]
\[ + d\sigma_{Vl}^{I} (\theta_{EW}, g_{Vl}, < r_{\nu l}^2 > I, s), \tag{21} \]

\[ \frac{d\sigma_{Vl}^{I} (\theta_{EW}, g_{Vl}, f_{I1\nu l}, s)}{d\Omega} = \frac{d\sigma_{Vl}^{I} (\theta_{EW}, g_{Vl}, f_{I1\nu l}, s' = s)}{d\Omega} + \]
\[ + \frac{d\sigma_{Vl}^{I} (\theta_{EW}, g_{Vl}, f_{I1\nu l}, s' = -s)}{d\Omega} = \]
\[ = \rho_{EW} \sigma_o^{EW} (1 - \eta_{EW})^{-1} \times \]
\[ \times (1 + \eta_{EW}^2 t g \frac{\theta_{EW}}{2}) g_{Vl} f_{I1\nu l} F_I (q_{EW}^2), \tag{22} \]

\[ \frac{d\sigma_{I}^{Vl} (\theta_{EW}, g_{Vl}, < r_{\nu l}^2 > I, s)}{d\Omega} = \frac{d\sigma_{I}^{Vl} (\theta_{EW}, g_{Vl}, < r_{\nu l}^2 > I, s' = s)}{d\Omega} + \]
\[ + \frac{d\sigma_{I}^{Vl} (\theta_{EW}, g_{Vl}, < r_{\nu l}^2 > I, s' = -s)}{d\Omega} = \]
\[ = -\frac{2}{3} (m_{\nu l}^{EW})^2 \gamma_{EW}^{-1} \rho_{EW} \sigma_o^{EW} (1 - \eta_{EW}^2)^{-1} \times \]
\[ \times (1 + \eta_{EW}^2 t g \frac{\theta_{EW}}{2}) g_{Vl} < r_{\nu l}^2 > I \ F_I (q_{EW}^2). \tag{23} \]
A purely weak interaction of partially longitudinally polarized neutrinos with neutral currents is described by the cross section

\[
d\sigma^V_{\nu l}(\theta_W, g_{\nu l}, s) = d\sigma^V_{\nu l}(\theta_W, g_{\nu l}, s' = s) + d\sigma^V_{\nu l}(\theta_W, g_{\nu l}, s' = -s) = \frac{G_F^2(m_{\nu_l}^W)^2}{8\pi^2}\eta_W^{-2}(1 + \eta_W^2g_W^2\theta_W^2)g_{\nu_l}^2 F_W^2(q_W^2)\cos^2\theta_W^2.
\] (24)

Among (15)-(24) the cross sections (18) and (23) have the negative signs. This says in favor of a latent connection between the electric charge of the neutrino and its charge radius. The latter together with (1) allows to conclude that on the availability of a non-zero mass, the neutrino must possess simultaneously each of currents of the vector nature.

To define their mass structure, it is desirable to replace (9) averaging the cross sections (10)-(12) over \(s\) and summing over \(s'\) for

\[
d\sigma^V_{\nu l}(E,W)(\theta_E,W) = d\sigma^V_{\nu l}(E)(\theta_E) + \frac{1}{2}d\sigma^V_{I}(E,W) + \frac{1}{2}d\sigma^V_{I}(E,W) + d\sigma^V_{W}(\theta_W).
\] (25)

Its components may be presented as

\[
d\sigma^V_{\nu l}(\theta_E) = d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}) + \frac{1}{2}d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}, < r_{\nu_l}^2 > E) +
\]

\[
+ \frac{1}{2}d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}, < r_{\nu_l}^2 > E) +
\]

\[
+ d\sigma^V_{\nu l}(\theta_E, < r_{\nu_l}^2 > E) + d\sigma^V_{\nu l}(\theta_E, f_{2\nu_l})
\]

\[
d\sigma^V_{I}(\theta_{EW}) = d\sigma^V_{I}(\theta_{EW}, g_{\nu l}, f_{1\nu_l}) + d\sigma^V_{I}(\theta_{EW}, g_{\nu l}, < r_{\nu_l}^2 > I)
\]

\[
d\sigma^V_{W}(\theta_W) = d\sigma^V_{W}(\theta_W, g_{\nu l}).
\] (28)

Any part of each of (26)-(28) coincides with the corresponding cross section from (16), (21), (24) and that, consequently, we find

\[
d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}) = d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}, s),
\] (29)

\[
d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}, < r_{\nu_l}^2 > E) = d\sigma^V_{\nu l}(\theta_E, f_{1\nu_l}, < r_{\nu_l}^2 > E, s),
\] (30)
therefore constitute a kind of set of cross sections
tially ordered flux of unpolarized and longitudinal polarized fermions. It can
of (15) and (25) constitutes the naturally united subclass:
It is already clear from them that (9) describes the scattering of a par-
The compound structure of both elements of (36) testifies about that any
\[
d\sigma_{E,i}^V(\theta_E, < r_{vl}^2 > E) = d\sigma_{E,i}^V(\theta_E, < r_{vl}^2 > E, s),
\]
\[
d\sigma_{E,i}^V(\theta_E, f_{2vl}^E) = d\sigma_{E,i}^V(\theta_E, f_{2vl}^E, s),
\]
\[
d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, f_{1vl}^I) = d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, f_{1vl}^I, s),
\]
\[
d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, < r_{vl}^2 > I) = d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, < r_{vl}^2 > I, s),
\]
\[
d\sigma_{W,i}^V(\theta_W, g_{vl}) = d\sigma_{W,i}^V(\theta_W, g_{vl}, s).
\]

It is already clear from them that (9) describes the scattering of a partially ordered flux of unpolarized and longitudinal polarized fermions. It can therefore constitute a kind of set of cross sections
\[
d\sigma_{E,W}^V = \{d\sigma_{E,W}^V(\theta_{E,W}, s), \ d\sigma_{E,W}^V(\theta_{E,W})\}.
\]

The compound structure of both elements of (36) testifies about that any of (15) and (25) constitutes the naturally united subclass:
\[
d\sigma_{E,W}^V(\theta_{E,W}, s) = \{d\sigma_{E,W}^V(\theta_E, f_{1vl}^E, s), \ \frac{1}{2}d\sigma_{E,W}^V(\theta_E, f_{1vl}^E, < r_{vl}^2 > E, s),
\]
\[
\frac{1}{2}d\sigma_{E,W}^V(\theta_E, f_{1vl}^E, < r_{vl}^2 > E, s), \ d\sigma_{E,W}^V(\theta_E, < r_{vl}^2 > E, s),
\]
\[
d\sigma_{E,i}^V(\theta_E, f_{1vl}^E, s), \ \frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, f_{1vl}^I, s),
\]
\[
\frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, f_{1vl}^I, s), \ \frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, < r_{vl}^2 > I, s),
\]
\[
\frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, < r_{vl}^2 > I, s), \ d\sigma_{W,i}^V(\theta_W, g_{vl}, s)\},
\]
\[
d\sigma_{E,W}^V(\theta_{E,W}) = \{d\sigma_{E,W}^V(\theta_E, f_{1vl}^E), \ \frac{1}{2}d\sigma_{E,W}^V(\theta_E, f_{1vl}^E, < r_{vl}^2 > E),
\]
\[
\frac{1}{2}d\sigma_{E,W}^V(\theta_E, f_{1vl}^E, < r_{vl}^2 > E), \ d\sigma_{E,W}^V(\theta_E, < r_{vl}^2 > E),
\]
\[
d\sigma_{E,i}^V(\theta_E, f_{1vl}^E), \ \frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, f_{1vl}^I),
\]
\[
\frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, f_{1vl}^I), \ \frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, < r_{vl}^2 > I),
\]
\[
\frac{1}{2}d\sigma_{I,i}^V(\theta_{EW}, g_{vl}, < r_{vl}^2 > I), \ d\sigma_{W,i}^V(\theta_W, g_{vl})\}.
\]
These subsets, according to (29)-(35), must have the same size. This implies that their elements correspond in nature to one of the above-mentioned differmions, because of which all components of cross sections (15) and (25) coincide.

Another important circumstance is the fact that between the fermions of each of paraparticles (13) and (14) there exists a sharp flavor symmetrical dependence [11, 17]. Such a connection gives the right to use the flavor symmetry as a theorem [3, 4] about the equality of compound parts of cross sections of the neutrino interaction with electroweak currents.

So it is seen that the possible pairs of elements from sets (37) and (38) establish the forty two ratios. Jointly with the expressions of cross sections (29)-(35), the latter are reduced to the twenty one explicit equations.

To show their structural picture, it is sufficient to choose the five from the original relations:

\[ \frac{d\sigma^{V_\nu}(\theta_W, g_{V_\nu})}{d\sigma^E(\theta_E, f^E_{iv_\nu})} = 1, \quad \frac{2d\sigma^{V_\nu}(\theta_W, g_{V_\nu})}{d\sigma^I(\theta_{EW}, g_{V_\nu}, f^I_{1v_\nu})} = 1, \quad (39) \]

\[ \frac{d\sigma^{V_\nu}(\theta_W, g_{V_\nu})}{d\sigma^E(\theta_E, < r^2_{\nu_\nu} > E)} = 1, \quad \frac{2d\sigma^{V_\nu}(\theta_W, g_{V_\nu})}{d\sigma^I(\theta_{EW}, g_{V_\nu}, < r^2_{\nu_\nu} > I)} = 1. \quad (40) \]

It is not excluded, however, that the discussed processes depend not only on the fermion properties but also on the structure of a nucleus itself.

For elucidation of nature of the neutrino, it is desirable to use a nucleus with zero spin and isospin. Therefore, if \( N = Z \) then inserting the exact values of cross sections from (29)-(35) in (39) and (40), it is not difficult to constitute those equalities which at the large energies (\( E^{K}_\nu \gg m^{K}_\nu \)) when

\[ \lim_{\eta_K \to 0, \theta_K \to 0} \frac{\eta_K^2}{(1 - \eta_K^2) \sin^2(\theta_K/2)} = -2, \]

\[ \lim_{\eta_E \to 0, \theta_E \to 0} \frac{\eta_E^2 \sin^{-2}(\theta_E/2)}{(1 + \eta_E^2 \tan^2(\theta_E/2)) \cos^2(\theta_E/2)} = 4, \]

lead us to the system

\[ f^E_{1v_\nu}(0) = \pm g_{V_\nu} \frac{G_{F} m^{E}_\nu m^{W}_\nu}{2\pi\sqrt{2} \alpha} \beta^{(0)}_{V}, \quad (41) \]
\[ f_{2\nu_l}^E(0) = \pm g_{\nu_l} \frac{G_F m_{\nu_l}^W}{4\pi \sqrt{2\alpha}} \beta_{\nu_l}^{(0)}, \]

(42)

\[ f_{1\nu_l}^I(0) = g_{\nu_l} \frac{G_F (m_{\nu_l}^W)^2}{2\pi \sqrt{2\alpha}} \beta_{\nu_l}^{(0)}, \]

(43)

\[ < r_{\nu_l}^2 >_E = \pm g_{\nu_l} \frac{3G_F}{2\pi \sqrt{2\alpha}} \frac{m_{\nu_l}^W}{m_{\nu_l}^E} \beta_{\nu_l}^{(0)}, \]

(44)

\[ < r_{\nu_l}^2 >_I = g_{\nu_l} \frac{3G_F}{2\pi \sqrt{2\alpha}} \left( \frac{m_{\nu_l}^W}{m_{\nu_l}^E} \right)^2 \beta_{\nu_l}^{(0)}. \]

(45)

Thus, we have the possibility on the basis of these solutions and their logical predictions about that \( f_{1\nu_l}(0) = f_{1\nu_l}^E(0) + f_{1\nu_l}^I(0), \)
\( f_{2\nu_l}(0) = f_{2\nu_l}^E(0), \)
\( < r_{\nu_l}^2 >_E = < r_{\nu_l}^2 >_E + < r_{\nu_l}^2 >_I \) to establish the mass picture of the neutrino vector currents

\[ f_{1\nu_l}(0) = -g_{\nu_l} \frac{G_F m_{\nu_l}^W m_{\nu_l}^{EW}}{\pi \sqrt{2\alpha}} \sin^2 \theta_W, \]

(46)

\[ f_{2\nu_l}(0) = -g_{\nu_l} \frac{G_F m_{\nu_l}^W}{2\pi \sqrt{2\alpha}} \sin^2 \theta_W, \]

(47)

\[ < r_{\nu_l}^2 > = -g_{\nu_l} \frac{3G_F}{2\pi \sqrt{2\alpha}} \frac{m_{\nu_l}^W}{m_{\nu_l}^E} \left( 3 - \frac{(m_{\nu_l}^E)^2 + (m_{\nu_l}^W)^2}{(m_{\nu_l}^{EW})^2} \right) \sin^2 \theta_W. \]

(48)

Unification of (46) and (47) suggests a connection

\[ f_{1\nu_l}(0) - 2m_{\nu_l}^{EW} f_{2\nu_l}(0) = 0. \]

(49)

Its comparison with (1) establishes (3) and thereby convinces us once again that any of all types of charges leads to the appearance of a kind of the dipole moment [6]. According to this principle, (46)-(48) must give the normal size of the neutrino studied properties.

From a general point of view, they may be renormalized as \( e_{\nu_l}^{norm} = e f_{1\nu_l}(0), \)
\( \mu_{\nu_l}^{norm} = e f_{2\nu_l}(0), \)
\( < r_{\nu_l}^2 >_{norm} = < r_{\nu_l}^2 >. \)

Furthermore, if we suppose that in the case of a neutrino, the Schwinger value of magnetic moment [19] has an estimate \( \mu_{\nu_l}^{anom} = (\alpha/2\pi) \mu_{\nu_l}^{norm}, \)
\( \) in a similar way one can get from (46)-(48) the following functions

\[ e_{\nu_l}^{anom} = -g_{\nu_l} \frac{eG_F m_{\nu_l}^W m_{\nu_l}^{EW}}{2\pi^2 \sqrt{2}} \sin^2 \theta_W, \]

(50)
\[ \mu_{\nu_l}^{\text{anom}} = -g_{\nu_l} \frac{eG_F m_{\nu_l}^W}{4\pi^2\sqrt{2}} \sin^2 \theta_W, \quad (51) \]

\[ < r_{\nu_l}^2 >_{\text{anom}} = -g_{\nu_l} \frac{3G_F}{4\pi^2\sqrt{2}} \frac{m_{W}^W}{m_{\nu_l}^W} \left( 3 - \frac{(m_{E_{W}})^2 + (m_{W_{l}})^2}{(m_{W_{l}}^W)^2} \right) \sin^2 \theta_W. \quad (52) \]

The basis for such an approach is that \( \mu_{\nu_l}^{\text{anom}} \) can exist only in the presence of the anomalous charge \[5, 6\] having a kind of the radius. The latter together with \( e_{\nu_l}^{\text{norm}}, \mu_{\nu_l}^{\text{norm}} \) and \( < r_{\nu_l}^2 >_{\text{norm}} \) allows to found the full charge, charge radius and magnetic moment: \( e^{\text{full}}_{\nu_l} = (1 + \alpha/2\pi)e^{\text{norm}}_{\nu_l} \), \( \mu^{\text{full}}_{\nu_l} = (1 + \alpha/2\pi)\mu^{\text{norm}}_{\nu_l} \), \( < r_{\nu_l}^2 >_{\text{full}} = (1 + \alpha/2\pi) < r_{\nu_l}^2 >_{\text{norm}} \).

Comparing \((46)-(48)\), it is easy to observe the characteristic dependence of each of \( f_{1\nu_l}(0) \) and \( < r_{\nu_l}^2 > \) on the size of \( m_{E_{W}} \) and \( m_{W_{l}} \) which may serve as an indication to the existence of both types of masses.

The absence of one of components of mass would imply that itself does not exist at all. Nevertheless, if we consider the case when \( m_{K_{\nu_l}} = m_{\nu_l} \), equations \((50)-(52)\) take the form

\[ e_{\nu_l}^{\text{anom}} = -g_{\nu_l} \frac{eG_F m_{\nu_l}^2}{2\pi^2\sqrt{2}} \sin^2 \theta_W, \quad (53) \]

\[ \mu_{\nu_l}^{\text{anom}} = -g_{\nu_l} \frac{eG_F m_{\nu_l}}{4\pi^2\sqrt{2}} \sin^2 \theta_W, \quad (54) \]

\[ < r_{\nu_l}^2 >_{\text{anom}} = -g_{\nu_l} \frac{3G_F}{4\pi^2\sqrt{2}} \sin^2 \theta_W. \quad (55) \]

It has been mentioned above that our implications refer to any Dirac neutrino interacting according to the standard electroweak theory. This gives the right to apply to the case when \( g_{\nu_l} = 1, \beta_{V}^{(0)} = 1 \). At such a choice of constants, \((41)-(45)\) replace \((53)-(55)\) by

\[ e_{\nu_l}^{\text{anom}} = \frac{eG_F m_{\nu_l}^2}{4\pi^2\sqrt{2}}, \quad \mu_{\nu_l}^{\text{anom}} = \frac{eG_F m_{\nu_l}}{8\pi^2\sqrt{2}}, \quad (56) \]

\[ < r_{\nu_l}^2 >_{\text{anom}} = \frac{3G_F}{4\pi^2\sqrt{2}}. \quad (57) \]

The second of them coincides with the value of the neutrino anomalous magnetic moment obtained recently \[20\] in an universal scheme of the \((V - A)\) interaction as a consequence of one-loop phenomena.
At first sight, comparison of (57) and
\[ < r_{\nu_l}^2 >_{\text{anom}} = \frac{G_F}{4\pi^2\sqrt{2}} \left[ 3 - 2 \log \left( \frac{m^2}{M_W^2} \right) \right] \]  
(58)
shows that our formula does not depend on a lepton mass. On the other hand, the earlier finding connection (58) in an opinion of the authors [21] themselves requires the equality to zero of the neutrino self mass.

We recognize that (41)-(48) remain valid as well as for all types of leptons. Then it is possible, for example, to relate (46)-(48) to a renormalized size [22]
\[ e = -g_{\nu_e} \frac{G_F m_W m_e}{\pi\sqrt{2\alpha}} \sin^2 \theta_W, \]  
(59)
owing to which, they are expressed in units of the electron charge \( e \) and Bohr magnetons \( \mu_B = e/2m_e \) by the following manner:
\[ e_{\nu_l}^{\text{norm}} = f_{1\nu_l}(0) = \frac{m^W_{\nu_l} m_{\nu_l}}{m_e^W m_e} e, \]  
(60)
\[ \mu_{\nu_l}^{\text{norm}} = f_{2\nu_l}(0) = \frac{m^W_{\nu_l}}{m_e^W} \mu_B, \]  
(61)
\[ < r_{\nu_l}^2 >_{\text{norm}} = < r_{\nu_l}^2 > = \frac{3\mu_B}{m_e^W} \frac{m^W_{\nu_l}}{m^W_{\nu_l} m_{\nu_l}^E} \left( 3 - \frac{(m_{\nu_l}^E)^2 + (m_{\nu_l}^W)^2}{(m_{\nu_l}^W)^2} \right). \]  
(62)

Analysis of the experiments [23, 24] assumed that \( \mu_{\nu_e}^{\text{full}} < 0.74 \cdot 10^{-10} \mu_B \), \( \mu_{\nu_\mu}^{\text{full}} < 6.8 \cdot 10^{-10} \mu_B \), \( \mu_{\nu_\tau}^{\text{full}} < 3.9 \cdot 10^{-11} \mu_B \). Having (61), \( \mu_{\nu_l}^{\text{full}} \) and taking into account [22] that \( m_e^W = 9.92 \cdot 10^{-2} \text{ eV} \), we establish here the first estimates of the neutrino weak masses: \( m_{\nu_e}^W < 7.3 \cdot 10^{-12} \text{ eV} \), \( m_{\nu_\mu}^W < 6.7 \cdot 10^{-11} \text{ eV} \), \( m_{\nu_\tau}^W < 3.8 \cdot 10^{-8} \text{ eV} \).

Known laboratory data [25] for the neutrino rest mass lead to the restrictions: \( m_{\nu_e} < 2.5 \text{ eV} \), \( m_{\nu_\mu} < 0.17 \text{ MeV} \), \( m_{\nu_\tau} < 18.2 \text{ MeV} \). Insertion of (60) in \( e_{\nu_l}^{\text{full}} \) at these values of \( m_{\nu_l}^W \) and \( m_{\nu_l} \) gives \( e_{\nu_e}^{\text{full}} < 3.6 \cdot 10^{-16} \text{ e} \), \( e_{\nu_\mu}^{\text{full}} < 2.2 \cdot 10^{-10} \text{ e} \), \( e_{\nu_\tau}^{\text{full}} < 1.3 \cdot 10^{-5} \text{ e} \). The size of \( e_{\nu_l}^{\text{full}} \) may be accepted as a new estimate, if all Dirac neutrinos do not possess an equal charges. The values of \( e_{\nu_e}^{\text{full}} \) and \( e_{\nu_\tau}^{\text{full}} \) are compatible with those which follow from the experiments [26]: \( e_{\nu_e}^{\text{full}} < 2 \cdot 10^{-15} \text{ e} \), \( e_{\nu_\tau}^{\text{full}} < 4 \cdot 10^{-4} \text{ e} \).

We see that \( m_{\nu_e}^W \ll 1 \text{ eV} \), and consequently, \( m_{\nu_l}^E \approx m_{\nu_l} \). From its point of view, the charge radii \( < r_{\nu_l}^2 >_{\text{full}} \), according to (62), have the upper limits
\[< r_{\nu_e}^2 >_{full} < 2.78 \cdot 10^{-35} \text{ cm}^2, \quad < r_{\nu_\mu}^2 >_{full} < 3.76 \cdot 10^{-39} \text{ cm}^2, \quad < r_{\nu_\tau}^2 >_{full} < 2.01 \cdot 10^{-38} \text{ cm}^2. \]

Among them \( < r_{\nu_\tau}^2 >_{full} \) must be interpreted as for the first time measured charge radius of the tau neutrino, \( < r_{\nu_e}^2 >_{full} \) and \( < r_{\nu_\mu}^2 >_{full} \) essentially improve the already available facts \([24, 27]\): \( < r_{\nu_e}^2 >_{full} < 4.14 \cdot 10^{-32} \text{ cm}^2, \quad < r_{\nu_\mu}^2 >_{full} < 0.68 \cdot 10^{-32} \text{ cm}^2. \)

Thus, the existence both of an electric and of a weak components of mass is by no means excluded experimentally.

In the mass type dependence, a neutrino has a non-zero charge, charge radius and magnetic moment. It is not a wonder therefore that the above-mentioned experiments may serve as a practical confirmation of the availability of mass structure of the interaction with these currents. Of course, an observed regularity reflects the sharply expressed features of mass, charge and thereby opens the chance for creation of the unified picture of nature of elementary particles and fields.
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