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Opinion

Simple way to calculate neutrino masses

Lev I Buravov*

Institute of Problems of Chemical Physics RAS, RF, Chernogolovka, Russia

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***Corresponding author:** Lev I Buravov, Institute of Problems of Chemical Physics RAS, RF, Chernogolovka, Russia, E-mail: buravov@icp.ac.ru

The formula of neutrino masses was received on the basis of simple physical assumptions, and neutrino masses of 3 types were calculated for the moment of their birth

It was shown in [1] that when an elementary particle is emitting Higgs virtual bosons in the form of spherical waves, this particle creates its own confining potential, as a result of the impulse recoil, due to which the mass of the particle is stabilized during its lifetime.

Allowance for the confining potential allows, in particular, to calculate the mass ratio for elementary particles e, μ, π^0, $\pi^\pm$, K^0, $K^\pm$ [2] and calculate the neutrino masses of three types ν_e, ν_μ and ν_τ [1,3] for the moment of their birth in the decay and the other processes.

It was shown in [4-7] that neutrinos have a complex internal structure as a result of virtual transitions $\nu_\ell \leftrightarrow \ell^- + W^+$, $\tilde{\nu}_\ell \leftrightarrow \ell^+ + W^-$, where the subscript ℓ means e, μ or τ, W - intermediate vector bosons, carriers of weak interaction with mass M_W = 80.4 GeV/c^2 [8]. Taking into account such virtual transitions, in [4-7] it was found that the square of the electromagnetic neutrino radius is:

$$\langle r^2(\nu_\ell)\rangle = (3G_F/8\sqrt{2}\,\pi^2\hbar c)[(5/3)\mathrm{Ln}\alpha + (8/3)\mathrm{Ln}(M_W/m_\ell) + \eta] \tag{1}$$

where G_F = 8.95 x 10^{-44} Mev cm³ is the constant of weak interaction, $\alpha = e^2/\hbar c \cong 1/137$, the numerical constant $\eta \cong 1 \div 2$. For the mean value η = 1.5, taking into account $m_e c^2$ = 0.511 Mev, $m_\mu c^2$= 105.66 MeV and $m_\tau c^2$ = 1777 MeV, it follows from (1) that the characteristic values of the squares of the neutrino radii are:

$$\langle r^2(\nu_e)\rangle \cong 3\cdot 10^{-33}\,\mathrm{cm}^2,\ \langle r^2(\nu_\mu)\rangle \cong 1.3\cdot 10^{-33}\,\mathrm{cm}^2,\ \langle r^2(\nu_\tau)\rangle \cong 4.2\cdot 10^{-34}\,\mathrm{cm}^2 \tag{2}$$

Naturally, we must refer these values $\langle r^2(\nu_\ell)\rangle$ to the moment of birth of the corresponding neutrinos, while they do not change their status in their move.

To determine the neutrino masses in [1,3], the following assumptions were made:

1. Although neutrinos do not have an electric charge, they apparently have a *small* electrostatic energy, due to that the spatial distribution of opposite *small* electric charges,created by virtual pairs (ℓ, W) in neutrino structure, is different. In this case, the neutrino's electrostatic energy has the value $U(\nu_\ell) = \delta(\nu_\ell)e^2/r$, where r is the electromagnetic radius of the neutrino, $\delta(\nu_\ell)$ is an unknown small dimensionless parameter related to the charge distribution in the structure of ν_ℓ.

2. The virtual rest energy of the neutrino consists of a confining potential $W_S = \sigma 4\pi r^2$ and an electrostatic energy:

$$E = \sigma 4\pi r^2 + \delta(\nu_\ell)e^2/r \tag{3}$$

3. The quantity σ is the same for all leptons (i.e. neutrinos, e, μ, τ), and pions and kaons.

The energy constant σ was determined earlier in [2] using the neutral pion mass m_0 = 134.963 MeV / c^2 on the basis of the initial model assumption that the muon, pion and kaon elementary particles in the stopped state can be represented as resonators for quanta of virtual neutrinos excited inside the elastic spherical lepton shell with "surface tension" σ and radius R. The number and type of these quanta are determined from the decay scheme of these elementary particles: 2- for the muon , 3- for the pion and 21 minimal quanta- for the kaon.

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As shown in [1,2], this assumption implies that the virtual rest energy of a neutral pion is written as

$$E = \sigma 4\pi R^2 + 4.5\hbar\pi c/R \tag{4}$$

where the value $\hbar\pi c/R$ is the energy of one quantum of virtual neutrino in the resonator.

After minimizing the virtual energy E by R , we obtain the equation

$$m_o\, c^2 = 3\pi\sigma^{1/3}(4.5\hbar c)^{2/3} \tag{5}$$

and the value of σ is

$$\sigma = 4\times 3^{-7}\pi^{-3}(m_o c^2)^3/(\hbar c)^2 = 3.724\times 10^{23}\ \text{Mev/cm}^2 \tag{6}$$

The neutrino mass could be found by finding the minimum of the virtual energy (3), but since the value of $\delta(\nu_\ell)$ is not known, we should use equation

$$m(\nu_\ell)c^2 = 12\sigma\pi\, r_m^{\,2} = f\, r_m^{\,2} \tag{7}$$

which is obtained by minimizing the virtual energy (3), where the coefficient $f = 12\sigma\pi \cong 1.404\cdot 10^{25}$ MeV / cm², r_m is the value of r corresponding to the minimum of the rest energy (3).

Substituting the values of $<r^2(\nu_\ell)>$ from (2) into formula (7) instead of $r_m^{\,2}$, we find:

$$m(\nu_e)c^2 \cong 4.3\cdot 10^{-2}\text{eV},\ \ m(\nu_\mu)c^2 \cong 2\cdot 10^{-2}\text{eV},\ \ m(\nu_\tau)c^2 \cong 6\cdot 10^{-3}\text{eV} \tag{8}$$

Similar values were found for the base neutrino masses (ν_1, ν_2, ν_3) in [9] on the basis of the experimental results of the Super-Kamiokande neutrino Laboratory [10] in the case of supposition of inverse neutrino masses hierarchy :

$$m_1c^2 = 0.049\ \text{eV},\ m_2c^2 = 0.050\ \text{eV},\ m_3c^2 = 0.0087\ \text{eV} \tag{9}$$

Formula (7) for neutrino masses with allowance for (1) can be transformed to the form:

$$m(\nu_\ell) = 3^{-5}\sqrt{2}\,\pi^{-4}\, F\,[(5/3)\,\text{Ln}\alpha + (8/3)\,\text{Ln}\,(M_W/\,m_\ell) + \eta]\; m_o \tag{10}$$

where the dimensionless small value $F = G_F(m_oc^2)^2 / (\hbar c)^3 = 2.116\times 10^{-7}$.

Using the alternative formula for neutrino charge radius [11]

$$<r^2(\nu_\ell)> = (G_F/4\sqrt{2}\,\pi^2\hbar c)[3+ 4\text{Ln}(M_W/\,m_\ell)] \tag{11}$$

we will get masses of the similar order but somewhat larger :

$$m(\nu_e)c^2 \cong 5.8\times 10^{-2}\text{eV},\ m(\nu_\mu)c^2 \cong 3.4\times 10^{-2}\text{eV},\ m(\nu_\tau)c^2 \cong 2.1\times 10^{-2}\text{eV} \tag{12}$$

Knowing the neutrino masses (8), we find the values of $\delta(\nu_\ell)$:

$$\delta(\nu_e) \cong 1.10\times 10^{-11},\ \delta(\nu_\mu) \cong 3.17\times 10^{-12},\ \delta(\nu_\tau) \cong 5.6\times 10^{-13} \tag{13}$$

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