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Mini Review

# Calculation of Neutrino Masses for the Moment of their Birth

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## Abstract

In the article, the author presented his original explanation for the origin of small masses of mysterious neutrino particles. A formula for neutrino masses was obtained for the moment of their birth, using results for the neutrino charge radius, received by several theoretical groups, and the masses of three types are calculated. The paper assumes that the main contribution to the neutrino mass (2/3) comes from their small electrostatic energy.

More Information

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## Introduction

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 confining potential (as a result of the effect of momentum 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 $e, \mu, \pi^0, \pi^{\pm}, K^0, K^{\pm}$ [2] and calculate the neutrino masses of three types $\nu_e$, $\nu_\mu$, and $\nu_\tau$ [1] for the moment of their birth in the decay and the other processes.

## Discussion

It was shown in [3-6] 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 $\ell$ means $e$, $\mu$ or $\tau$, W – intermediate vector bosons, carriers of weak interaction with mass $M_W = 80.4\ \mathrm{GeV}/c^2$. Taking into account such virtual transitions, in [3-6] it was found that the square of the electromagnetic neutrino radius is:

$$<r^2(\nu_\ell)>=(3G_F/8\pi^2 2^{1/2}\hbar c)[(5/3)\mathrm{Ln}\alpha+(8/3)\mathrm{Ln}(M_w/m_\ell)+\eta \quad (1A)$$

here $\eta$ = 1-2, $G_F$ = 8.95 x $10^{-44}$ MeV cm$^3$ is the constant of weak interaction, $\alpha = e^2/\hbar c \approx 1/137$.

For the mean value $\eta$ = 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 (1A) that the characteristic values of the squares of the neutrino radii are:

$$<r^2(\nu_e)> \approx 3 \times 10^{-33} \mathrm{cm}^2, <r^2(\nu_\mu)> \approx 1.3 \times 10^{-33} \mathrm{cm}^2, <r^2(\nu_\tau)> \approx 4.2 \times 10^{-34} \mathrm{cm}^2 \quad (2A)$$

Using the alternative formula for charge neutrino radius [7], we have:

$$<r^2(\nu_\ell)>=(3G_F/8\pi^2 2^{1/2}\hbar c)[(8/3)\mathrm{Ln}(M_w/m_\ell) + 2] \quad (1B)$$

and the characteristic values of the squares of the neutrino radii are:

$$<r^2(\nu_e)> \approx 4.1 \times 10^{-33} \mathrm{cm}^2, <r^2(\nu_\mu)> \approx 2.3 \times 10^{-33} \mathrm{cm}^2, <r^2(\nu_\tau)> \approx 1.4 \times 10^{-33} \mathrm{cm}^2 \quad (2B)$$

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

1. Although neutrinos do not have an electric charge, they have a *small* electrostatic energy due to the spatial distribution of opposite *small* electric charges created by virtual pairs ($\ell$, W) 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 $\nu_\ell$.
2. The virtual rest energy of the neutrino consists of a confining potential $W_S = \sigma 4\pi r^2$ and an electrostatic energy:

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

3. The quantity $\sigma$ is the same for all leptons (i.e. neutrinos, $e$, $\mu$, $\tau$), and pions and kaons.

The energy constant $\sigma$ was determined earlier in [2] using the neutral pion mass $m_o$ = 134.963 MeV/$c^2$

based on 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" lepton shell:

$$\sigma = 4 \times 3^{-7}\pi^{-3}(m_0c^2)^3/(\hbar c)^2 \ (=3.724 \times 10^{23} \text{ Mev/cm}^2) \quad (4)$$

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 the equation which is obtained by minimizing the virtual energy (3):

$$m(\nu_\ell)c^2 = 12\sigma\pi r_m^{\ 2} = f\, r_m^{\ 2} \quad (5)$$

where the coefficient

$$f = 12\sigma\pi = 1.404 \times 10^{25} \text{ MeV/cm}^2 \quad (6)$$

$r_m$ is the value of $r$ , corresponding to the minimum of the rest energy (3).

Substituting the values of $<r^2(\nu_\ell)>$ from (2A) and (2B) into formula (5) instead of $r_m^{\ 2}$, we find respectively:

$$m(\nu_e)c^2 \approx 4.3 \times 10^{-2}\text{eV},\ m(\nu_\mu)c^2 \approx 1.9 \times 10^{-2}\text{eV},\ m(\nu_\tau)c^2 \approx 6 \times 10^{-3}\text{eV} \quad (7A)$$

and $m(\nu_e)c^2 \approx 5.7 \times 10^{-2}$eV, $m(\nu_\mu)c^2 \approx 3.3 \times 10^{-2}$eV, $m(\nu_\tau)c^2 \approx 2 \times 10^{-2}$eV (7B)

Similar values were found for the base neutrino masses ($m_1$, $m_2$, $m_3$) in [8] based on the experimental results of the Super-Kamiokande neutrino laboratory [9] in the case of supposition of inverse neutrino masses hierarchy:

$$m_1c^2 = 0.049 \text{ eV},\ m_2c^2 = 0.050 \text{ eV},\ m_3c^2 = 0.0087 \text{ eV} \quad (8)$$

Formula (5) for neutrino masses with allowance for (1A) and (1B) can be transformed to the form (9A) and (9B) respectively:

$$m(\nu_\ell) = 3^{-5}\, 2^{1/2}\, \pi^{-4}\, F\, [(5/3) \text{ Ln}\alpha + (8/3) \text{ Ln } (M_w/m_\ell) + \eta]\, m_0 \quad (9A)$$

$$m(\nu_\ell) = 3^{-5}\, 2^{1/2}\, \pi^{-4}\, F\, [(8/3) \text{ Ln } (M_w/m_\ell) + 2\,]\, m_0 \quad (9B)$$

where the dimensionless small value

$$F = G_F\,(m_0c^2)^2/(\hbar c)^3 = 2.116 \times 10^{-7}.$$

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

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

or

$$\delta(\nu_e) \approx 1.7 \times 10^{-11},\ \delta(\nu_\mu) \approx 7.34 \times 10^{-12},\ \delta(\nu_\tau) \approx 3.5 \times 10^{-12} \quad (10B)$$

It should be noted that the sum of neutrino masses for cases (7A), (7B), and (8) is:

$$S(A) = 0.068 \text{ eV/c}^2,\ S(B) = 0.11 \text{ eV/c}^2,\ S(8) = m_1 + m_2 + m_3 = 0.1077 \text{ eV/c}^2 \quad (11)$$

and as can be seen from (11) case (B) is preferable to case (A).

Using 2 experimental equations | $(m_2)^2 - (m_1)^2$ | $\cong 7.59 \times 10^{-5}$ eV$^2$

and $|(m_3)^2 - (m_2)^2| \cong 2.43 \times 10^{-3}$ eV$^2$ we can add the third equation $m_1 + m_2 + m_3 = m(\nu_e) + m(\nu_\mu) + m(\nu_\tau) = 0.11$ eV and resolve this system of 3 equations for $m_1$, $m_2$, $m_3$ using numerical method and a computer. The results will be close to that of Hajdukovich.

## Conclusion

The mass values calculated in the article for $m(\nu_e)$, $m(\nu_\mu)$, $m(\nu_\tau)$ (for the moment of their birth) turned out to be of the same order, as the basic neutrino masses $m_1$ , $m_2$, $m_3$ obtained along with the assumption of an inverse hierarchy of neutrino masses. It should be noted that the results of calculating the neutrino masses using the Bernabeu, et al. formula, turned out to be more satisfactory. Since for the sum $m(\nu_e) + m(\nu_\mu) + m(\nu_\tau)$ = 0.11 ev/c$^2$ is close to the sum $m_1 + m_2 + m_3$ = 0.1077 ev/c$^2$ ± errors, obtained from the article of Hajdukovich.

**Supplementary information (Click here)**

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