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# Estimates of the Charges and Size of the Three Types of Neutrinos

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## Abstract

It is the current belief of the Physics Community that neutrinos are bereft of Charge because of Conservation of Charge in decay processes such as Beta Decay and are point particles with no physical size or shape. It is the purpose of this paper to calculate the charges and the size of the electron neutrino, the muon neutrino, and the tau neutrino based on data available of their rest masses using the charges and rest masses of the electron, muon, and tau leptons from the Standard Model of Particle Physics Table. We base our calculations on the premise that Energy can create both Mass and Charge. Charge by itself is not conserved in any process that produces neutrinos. Only Total Energy is conserved.

## Keywords

Electron Neutrino, Muon Neutrino, Tau Neutrino, Standard Model of Particle Physics, Beta Decay, Total Energy

## 1. Introduction

Originally after the discovery of the three neutrinos, it was believed that neutrinos were bereft of mass, charge, and size, until the Nobel Prize of 2015 was awarded for the discovery of neutrino oscillations, which shows that neutrinos have mass [1]. Their rest masses as an upper limit later appeared in the Standard Model of Particle Physics.

The Physics community believed after that Nobel Prize event that neutrinos were given a mass but continued to have zero charge to conserve charge. Neutrinos were also believed to be point particles.

Based on Beta Decay, the electron neutrinos and anti-neutrinos carry charge which is created from the Energy difference between a neutron and a proton and the Binding Energy change within the nucleus. It was not brought to the attention of the Physics Community until recently that besides mass Energy can also create charge [2].

It is the purpose of this paper to prove that neutrinos and anti-neutrinos carry charge since they are created along with their respective leptons and anti-leptons and to estimate what that charge is based on current data of neutrino rest masses and their lepton rest masses and charge as specified in the Standard Model of the Particle Physics Table. We are also able to estimate the size of the neutrino based on earlier calculations of the electron size.

We use the rest mass to rest charge ratio of an electron to be equal to the rest mass to rest charge ratio of the electron anti-neutrino to estimate the charge of the anti-neutrino because the distribution of Energy between mass and charge for the electron and the electron anti-neutrino should be equal in proportion since they are created together as they are expelled from the nucleus during Beta minus and Beta plus Decay (neutron → proton + electron + electron anti-neutrino and proton → neutron + positron + electron neutrino). Giving neutrinos a charge implies that charge is not conserved in Beta Decay. The same rule applies to the muon and the tau leptons and their respective neutrinos (Muon → electron + electron anti-neutrino + muon neutrino. Tau → Electron + electron anti-neutrino + tau neutrino and Tau → Muon + muon anti-neutrino + tau neutrino). It is total energy, which is the sum of the mass and charge, including the binding energy change within the nucleus, along with the energy of motion of all particles involved that is conserved in all these processes.

Based on the proportionality rule stated above:

The charge of an electron neutrino would equal $q_{v_e} = 1.6 \times 10^{-19}$ C × (<2.2/0.511 × $10^6$) < $6.9 \times 10^{-25}$ C, using values of the mass of the electron (0.511 MeV/$c^2$) and (<2.2 eV/$c^2$) of the mass of the electron neutrino from the Standard Model of Particle Physics.

In a similar manner, we calculate the charge of the muon and tau neutrinos to be:

$$q_{v_\mu} = 1.6 \times 10^{-19}\ \text{C} \times (0.17\ \text{MeV/c}^2 / < 105.7\ \text{MeV/c}^2) < 2.6 \times 10^{-22}\ \text{C}.$$

$$q_{v_\tau} = 1.6 \times 10^{-19}\ \text{C} \times (15.5\ \text{MeV/c}^2 / < 1.777\ \text{MeV/c}^2) < 1.4 \times 10^{-21}\ \text{C}.$$

By equating the rest mass energy to its rest charge energy as was done earlier to calculate the electron radius [3] we get the electron neutrino to be a sphere of radius:

$$r_{v_e} = \left(q_{v_e}\right)^2 \Big/ \left(24\pi\epsilon_0 m_{v_e} c^2\right) < 2\times10^{-21}\ \text{m}.$$

Also, $r_{v_\mu} = \left(q_{v_\mu}\right)^2 \Big/ \left(24\pi\epsilon_0 m_{v_\mu} c^2\right) < 3.8\times10^{-21}\,\text{m}.$

And, $r_{v_\tau} = \left(q_{v_\tau}\right)^2 \Big/ \left(24\pi\epsilon_0 m_{v_\tau} c^2\right) < 1.2\times10^{-21}\ \text{m}.$

Since all three neutrino masses $m_{v_e}$, $m_{v_\mu}$, and $m_{v_\tau}$, are indicated as an upper limit in the Standard Model of Particle Physics, their sizes $r_{v_e}$, $r_{v_\mu}$, and $r_{v_\tau}$, can also be calculated only as an upper limit. All three neutrinos should have the same spherical size of radius approximately equal to the order of $10^{-21}$ m.

## 2. Conclusion

The values of the charges of the three neutrinos should be changed in the Standard Model of Particle Physics Table from zero to $<6.9 \times 10^{-25}$ C for the electron neutrino, to $<2.6 \times 10^{-22}$ C for the muon neutrino, and to $<1.4 \times 10^{-21}$ C for the tau neutrino. In addition, all three neutrinos should be listed in Physics Textbooks to have the same size radius approximately equal to the order of $10^{-21}$ m which is about five orders of magnitude smaller than the radius of the electron which is $4.68 \times 10^{-16}$ m. The miniscule size of neutrinos indicates their quantum nature and their weak interaction with matter since they can zip right through the empty spaces that exists within the atom.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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