Mass Distribution of elementary fermions

Li-Gong Mishulan (miligong@foxmail.com)
Guizhou University

Short Report

Keywords: Mass Hierarchies, Neutrino Oscillations, Quantum Physical Mechanism

Posted Date: May 10th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-465956/v3

Mass Distribution of elementary fermions

L.-G. Mishulan*

[1] College of Big Data and Information Engineering, Guizhou University, Guiyang 550025, China.

[2] Department of Physics and Astronomy, Qiannan Normal University for Nationalities, Duyun 558000, China

Correspondence and requests for materials should be addressed to L.-G. M. (email: miligong@foxmail.com)

Through careful analysis of the observational data on the mass of elementary fermions, we determine that an intrinsic pattern does exist. A geometric progression is proposed to describe the mass distribution of elementary fermions, and using the observational data of neutrino oscillations, we estimate the masses of neutrino.

All three generations of quarks and charged leptons are known to have mass, and previous experiments on neutrino oscillations show that at least two types of neutrinos have mass [1,2]. According to the Standard Model (SM), the masses of elementary particles are observed due to spontaneous symmetry breaking [3, 4]. However, the neutrino masses are extremely small. Is the theoretical basis for neutrino masses the same as for the masses of other elementary fermions? In this paper, we study the mass distribution of quarks and leptons and estimate the mass of neutrinos.

In Table 1, we have arranged the three known generations of quarks and leptons in three columns and four rows in accordance with their masses, and the columns and rows of elementary fermions are denoted by l and n， respectively. The first generation of elementary fermions includes a down quark, an up quark, an electron, and an electron neutrino; the second generation--charm quark, strange quark, muon, and a muon neutrino; the third generation--top quark, bottom quark, tau, and tau neutrino (top to bottom); Take the mass of elementary fermions in column l and row n as m_{ln}, and put $f_n = m_{3n}/(m_{1n}+m_{2n})$ and $K_n = f_n/f_{n+1}$. Using the recommended values from the Particle Data Group (2020) [5], the following values were calculated:

$$
\begin{aligned}
&f_1 = 135.53^{+2.45}_{-2.37}; f_2 = 44^{+3}_{-5}; f_3 = 16.7357 \pm 0.0011 \\
&K_1 = 3.085^{+0.451}_{-0.242}; K_2 = 2.625^{+0.174}_{-0.294}
\end{aligned}
\quad (1)
$$

Let $m_{34} = m_3$, $m_{24} = m_2$, $m_{14} = m_1$, $\Delta m^2_{32} = m^2_3 - m^2_2$, and $\Delta m^2_{21} = m^2_2 - m^1_2$, assuming that the neutrino masses are in the normal order. When $m_1 \ll m_2$, $m_2 \simeq \sqrt{\Delta m^2_{21}}$, then $f_4 \simeq \sqrt{1+\frac{\Delta m^2_{32}}{\Delta m^2_{21}}}$. Using the data of observed neutrino oscillations [5], and equations (1), yields:

$$K_3 \simeq 2.888 \pm 0.053 \quad (2)$$

We were surprised to find that the values of K_1, K_2, and K_3 are approximately equal within the error range. Thus, the following hypothesis is proposed: **for the mass distribution of quarks and leptons in Table 1, K_n is a constant and can be denoted as K.** Here, it can be called the mass structure constant of elementary fermions. Combining equations (1) and (2), we can concluded that

$$K = \frac{K_1+K_2+K_3}{3} = 2.866^{+0.226}_{-0.196},\ f_4 = 5.839^{+0.063}_{-0.427} \quad (3)$$

Furthermore, the estimated neutrino masses are as follows:

$$m_1 = (0\text{-}0.00056)\,\text{eV};\, m_2 = (0.00857\text{-}0.00880)\,\text{eV};$$
$$m_3 = (0.04992\text{-}0.05064)\,\text{eV} \qquad (4)$$

Table 1 Mass Distribution of Elementary Fermions

Generation	l=1	l=2	l=3
n=1	d	c	t
n=2	u	s	b
n=3	e	μ	τ
n=4	ν_e	ν_μ	ν_τ

We propose the following geometric progression formula to describe the mass distribution of the elementary fermions:

$$f_n = \left(\frac{1}{\alpha} - 1\right) K^{1-n} \qquad (5)$$

where α is the fine structure constant. Using a more accurate mass measurement of charged leptons, the value of K obtained from equation (5) is 2.851050±0.000096. This can be viewed as a standard K value. Equation (5) is in very good agreement with observation for n = 1, 2, and 4. Using $\alpha = c\mu_0 e^2/2h$, where e is the elementary charge, μ_0 is the magnetic constant, h is Planck's constant, and c is the speed of light in a vacuum, equation (5) can be rewritten as follows:

$$e_h^2\left(\frac{1}{K^{n-1}} - \frac{1}{K^n}\right) = e^2\left(\frac{1}{K^{n-1}} - \frac{1}{K^n}\right) + e^2\left(f_n - f_{n+1}\right) \qquad (6)$$

where $e_h = \pm\sqrt{2h/c\mu_0}$, which can be called a vacuum charge. The vacuum charge is considered the basic unit that makes up the vacuum field. We propose that K^n in equation (6) characterizes the quantum state of the vacuum field, which can be called a space quantum state. Further, the transition of a vacuum field from one space quantum state to another space quantum state is defined as the space transition of the vacuum field. We propose f_n characterizes some quantum state of an elementary fermion field, then the quantum transition from the state f_n to f_{n+1} can be defined as a mass transition of the elementary fermion field. According to equation (6), the mass transition of the elementary fermion field is caused by the space transition of the vacuum field.

References

1. Abe, S. et al. (KamLAND Collaboration), Precision measurement of neutrino oscillation parameters with KamLAND. *Phys. Rev. Lett.* **100**, 221803 (2008)

2. Ashie, Y.et al. (Super-Kamiokande Collaboration), Measurement of atmospheric neutrino oscillation parameters by Super-Kamiokande I. *Phys. Rev. D.* **71**, 112005 (2005)

3. Nambu, Y. Nobel Lecture: Spontaneous symmetry breaking in particle physics: A case of cross fertilization. *Rev. Mod. Phys.* **81**, 1015 (2009)

4. Peter W. Higgs. Noble Lecture: Evading the Goldstone theorem. *Rev. Mod. Phys.* **86**, 851 (2014)

5. Zyla P. A. et al. (Particle Data Group), Review of particle physics. *Prog. Theor. Exp. Phys.* **2020**,

083C01 (2020).