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The Nature of Neutrino Oscillation

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Abstract: *The paper deals with investigation of a mechanism of the neutrino oscillation. The question is analyzed why the mass and aroma neutrino changes. The difference in mixing neutrino and quarks is established as well.*

Keywords: *Neutrino oscillation, Aroma neutrino Leptons, Model of Cabibbo, Standard Mode.*

1. Introduction

The paper [1 has considered the features of the nature of neutrino and role of neutrino in the modern Universe. They have given some recommendations how to increase the efficiency of experiments in research work dealing with the properties of neutrino. Some conclusions concerning the treatment of results proposed in the paper have been drawn and certain proposals on a change of their strategy have been made. In the present work we pay special attention on the properties of neutrino oscillation and on the mechanism of this surprising phenomenon.

2. Main Results

Lepton numbers violation is closely connected with a small weight of neutrino, see [2]. However, a small weight of neutrino influences on another properties of neutrino as well. Under the assumption of stability of the left-right symmetry and by means of the data on neutrino oscillation the weights of neutrino have been calculated in the framework of the present paper,

$$m_1 = (7.1 \pm 0.2) \times 10^{-3}\, eV$$
$$m_2 = (11.3 \pm 0.3) \times 10^{-3}\, eV \qquad (1)$$
$$m_3 = (50.15 \pm 3) \times 10^{-3}\, eV$$

Under the assumption that the invisible Universe consists of the easy neutrino matter in article the estimation of size of easy neutrino has been spent

$$m_1 = (10.8 \pm 0.03) \times 10^{-3}\, eV$$
$$m_2 = (14 \pm 0.03) \times 10^{-3}\, eV \qquad (2)$$
$$m_3 = (50 \pm 3) \times 10^{-3}\, eV$$

The order of size proposed in (2) does not contradict to another one given in (1). Leptons and quarks participate in a weak interactions by means of V-A currents constructed from the left fermions

$$\begin{pmatrix} \nu_e \\ e^- \end{pmatrix}, \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}, \begin{pmatrix} u \\ d \end{pmatrix} \qquad (3)$$

Interaction of all charged currents is characterized by the universal constant communication G. To expand universality it is necessary to enter a doublet

$$\begin{pmatrix} c \\ s \end{pmatrix} \qquad (4)$$

Made of heavier quarks. There is disintegration

$K^{+} \rightarrow \mu^{+} \nu_{\mu}$

Meson K^{+} consists of *u*- and $\bar{s}$ - quarks. It contradicts the stated scheme which supposes only the weak transitions $u \leftrightarrow d$ and $c \leftrightarrow s$. To avoid a definition of a new constant for explanation of a decay of the type $K^{+} \rightarrow \mu^{+} \nu_{\mu}$, we modify doublets of quarks. Also we assume that the charged current binds the "turned" quark states

$$\begin{pmatrix} u \\ d' \end{pmatrix}, \begin{pmatrix} c \\ s' \end{pmatrix} \qquad (5)$$

where

$$d' = d \cos \theta_c + s \sin \theta_c \qquad (6)$$

$$s' = -d \sin \theta_c + s \cos \theta_c \qquad (7)$$

According to Cabibbo [4] we define an arbitrary parameter θ_c - angle of a quark mixing called Cabibbo angle. Weak interactions in (5) have connected to a quark s' with the fascinated quark *c*. Thus besides the transition $d' \leftrightarrow u$ we have also the transition $c \leftrightarrow s'$. Due to these reasons the authors have come to an assumption about the quark existence some years prior to its detection. The charged current binds the left quark states $u \leftrightarrow d'$ and $c \leftrightarrow s'$, where d' and s' are the orthogonal combinations of the physical quarks with the certain aromas *d* and *s* which can be interpreted as the eigenstates of the operator for the mass of quarks:

$$\begin{pmatrix} d' \\ s' \end{pmatrix} = \begin{pmatrix} \cos \theta_c & \sin \theta_c \\ -\sin \theta_c & \cos \theta_c \end{pmatrix} \begin{pmatrix} d \\ s \end{pmatrix} \qquad (8)$$

Mixing of the quarks is described by a unique parameter, the Cabibbo θ_c-angle. Originally the hypothesis GIM had the aim to provide the absence of transitions $s \leftrightarrow d$, in which aroma changes, but the electric charge remains. Experimental acknowledgement of absence of the neutral currents changing strangeness is very impressing. Available experimental data are perfectly described by model of Cabibbo. The consent seems to be too good, since the expected amendments connected with a symmetry breakdown are 10-20%. The obtained value $\sin \theta$ for the lepton hyperon decay

$$\sin \theta_c = 0.230 \pm 0.003 \qquad (9)$$

Fits reasonable the values from the data on meson decay

$$\sin \theta_c = 0.212 \pm 0.005 \text{ , } \sin \theta_c = 0.2691 \pm 0.005 \qquad (10)$$

Such a mixing in interactions of quarks and leptons has received a confirmation in generalization of Cabibbo's idea and GIM. At the same time the character of this phenomenon is approximated. And distribution of this technique on mixing neutrino with small masses can make essential changes on a process mechanism.

Absence in lepton sector in the Standard Model of the mixing Cabibbo-angles represents a degeneration of neutrino masses. All neutrinos have identical masses. Actually there is no mass matrix. Absence of physically important corners of mixing leads to preservation laws for lepton aromas - e, μ, τ numbers. Such processes $\mu \rightarrow e\gamma$ are forbidden. There will be the new features connected with neutrino oscillations with small mass. Oscillations mean that as a result of weak disintegrations a bunch neutrino, moving to vacuum. The bunch neutrino other aroma can spontaneously turn for example $\nu_e \leftrightarrow \nu_\mu$. The most of elements of such phenomena were studied for the first time in [5]. The mass matrix of neutrino, as well as in case of quarks, should be not diagonal and complex. By means of unitary turns it is led to a diagonal kind. So there is a dependence on model.

Also there is no possibility of direct check of the experimental data similar to model of Cabibbo. Mass conditions participating in gauge interaction

$$\nu_\alpha = \sum_i U_{\alpha i}\nu_i \qquad (11)$$

Where $\nu_\alpha = \nu_e, \nu_\mu, \nu_\tau$ - conditions of the neutrino, participating in weak interaction, and $\nu_i = \nu_1, \nu_2, \nu_3$ - conditions of a mass matrix with own values m_1, m_2, m_3. U - unitary matrix can be presented just as a matrix Kobayashi - Maskawa for corners of mixing of quarks:

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} c_1 & s_1c_3 & s_1s_3 \\ -s_1c_2 & c_1c_2c_3 - s_2s_3e^{i\delta} & c_1c_2s_3 + s_2c_3e^{i\delta} \\ -s_1s_2 & c_1s_2s_3 + c_2s_3e^{i\delta} & c_1s_2s_3 - c_2c_3e^{i\delta} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix} \qquad (12)$$

where $c_i = \cos\theta_i$, $s_i = \sin\theta_i$. There are no bases to expect that these corners in something are similar to corners of the Cabibbo - Kobayashi - Maskawa. If at the moment of time $t = 0$ there is a bunch of pure ν_e *- conditions* that it represents itself superposition of own conditions of a mass matrix:

$$\left|\nu_e(o)\right| = c_1\left|\nu_1\right| + s_1c_3\left|\nu_2\right| + s_1s_3\left|\nu_3\right| \qquad (13)$$

Condition evolution in time is defined by own values of the operator of energy. It is supposed that all neutrino in a bunch own conditions of amass matrix possess one impulse answer own values of the operator of energy

$$E_i^2 = p^2 + m_i^2 \qquad (14)$$

or

$$\left|\nu_e(t)\right| = c_1e^{-iE_1t}\left|\nu_1\right| + s_1c_3e^{-iE_2t}\left|\nu_2\right| + s_1s_3e^{-iE_3t}\left|\nu_3\right| \qquad (15)$$

The probability to find out neutrino ν_α at the moment of time t is given by expression $\left|\nu_\alpha\right\|\nu(t)\right|^2$. So for example the probability to find out ν_e is equal

$$P_{\nu_e\to\nu_e}(t) = 1 - 2c_1^2s_1^2c_3^2\left[1-\cos(E_1-E_2)t\right] - 2c_1^2s_1^2s_3^2\left[1-cos\ (E_1-E_3)t\right] \\ - 2s_1^4s_3^2c_3^2\left[1-\cos(E_2-E_3)t\right] \qquad (16)$$

At $p \gg m_i$ the length of neutrino oscillations is defined by

$$l_{ij} = \frac{2\pi}{E_i - E_j} \qquad (17)$$

At $x \gg l_{ij}$ a harmonic smooth out and average intensity will be observed only

$$P(\nu_e \to \nu_e) = 1 - 2c_1^2s_1^2 - 2s_1^1s_3^2c_3^2 \qquad (18)$$

The least possible average value is equal $P\,\nu_e \to \nu_e = 1/3$.

Similarly

$$P(\nu_e \to \nu_\mu) = 2c_1^2s_1^2c_2^2 + 2s_1^2s_3^2c_3^2\left(s_2^2 - c_1^2c_2^2\right) + 2s_1^2s_2s_3c_1c_2c_3\ cos\ \delta\left(s_3^2 - c_3^2\right) \qquad (19)$$

$$P(\nu_e \to \nu_\mu) = 2c_1^2s_1^2c_2^2 + 2s_1^2s_3^2c_3^2\left(c_2^2 - c_1^2s_2^2\right) + 2s_1^2s_2s_3c_1c_2c_3\ cos\ \delta\left(s_3^2 - c_3^2\right) \qquad (20)$$

It is difficult to explain the singularity of the oscillations phenomenon with traditional quantum the theory. Possibility neutrino one aroma spontaneously to turn in neutrino other aroma reflects of energy - impulse measurements in such processes. It is necessary to remember that for neutrino oscillations we should have nonzero mass neutrino. It is impossible to consider introduction of a similar matrix of mixing completely justified. Actually there are unknown elements in a mechanism of neutrino oscillations in particularly why the mass and aroma neutrino changes. Nevertheless research of this needs to be continued at studying neutrino oscillations. Thus there can be useful offers in our work [1]. We notice at first that harmonics thus $x \gg l_{ij}$ smooth out and average intensity is observed only (18). And possible average value of intensity is $P_{\nu_e \to \nu_e} = 1/3$. So mixing angles c_i and s_i can have only a little significant character, unlike quarks. It can appear that instability neutrino, as quantum gyroscopes, in a kind of small mass neutrino and small spin 1/2, unlike photon, is capable to lead to effect of smoothing out harmonics. Thus it is necessary to change experiment strategy at research the mechanism of neutrino oscillations.

3. Conclusion

While investigating the mechanism of neutrino oscillation it is necessary to change the experimental strategy of the infinite repetition of the Pontecorvo experiment. At that, the proposals provided within the paper [1] can help. The trials to get theoretically the relationships between the masses of light and heavy neutrinos seem to be doubtful as well.

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Author's Biography

Dr. Vladimir Efrosinin, since 1972 a Senior Scientist at the Institute for Nuclear Research Russian Academy of Sciences, priority scientific interest is the Elementary-Particle Physics. At the present time he deals with a problem of neutrino including evaluation of the role of neutrinos in the modern Universe.