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NEUTRINO OSCILLATIONS IN THE SCHEME OF CHARGE (COUPLE CONSTANT) MIXINGS

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Осцилляции нейтрино в схеме смешивания зарядов (констант связей)

В стандартной теории осцилляций нейтрино используется схема массовых смешиваний, т. е. параметры осцилляций выражаются через элементы массовой матрицы. В данной работе рассматриваются осцилляции нейтрино, генерированные смешиванием зарядов (констант связей слабых взаимодействий). Получены выражения для углов смешивания и длин осцилляций. Также вычислены выражения для вероятностей переходов трех нейтринных осцилляций. Осцилляции нейтрино в этой схеме (механизме) являются реальными, если массы нейтрино равны, и виртуальными, если массы нейтрино не равны.

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Neutrino Oscillations in the Scheme of Charge (Couple Constant) Mixings

In the standard theory of neutrino oscillations, a scheme of mass mixings is used, i. e. oscillation parameters are expressed in terms of mass matrix. In this work, neutrino oscillations generated by charge (the weak interaction couple constant) mixings are considered. Expressions for angle mixings and lengths of oscillations are obtained. The expressions of the probability for three-neutrino oscillations are given. Neutrino oscillations in this scheme (mechanism) are virtual if neutrino masses are not equal and real if neutrino masses are equal.

The investigation has been performed at the Laboratory of Particle Physics, JINR.

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1. INTRODUCTION

The suggestion that, by analogy with $K^0, \overline{K}^0$ oscillations, there could be neutrino–antineutrino oscillations ($\nu \to \bar{\nu}$) was considered by Pontecorvo [1] in 1957. It was subsequently considered by Maki et al. [2] and Pontecorvo [3] that there could be mixings (and oscillations) of neutrinos of different flavors (i. e. $\nu_e \to \nu_\mu$ transitions).

In the general case there can be two schemes (types) of neutrino mixings (oscillations): mass mixing schemes and charge mixing scheme (as it takes place in the vector dominance model or vector boson mixings in the standard model of electroweak interactions) [4].

In the standard theory of neutrino oscillations [5] it is supposed that physically observed neutrino states ν_e, ν_μ, ν_τ have no definite masses (in this case we cannot formulate the law of energy momentum conservation in strict form in the reactions with neutrino participations [4]) and they are directly produced as mixture of the ν_1, ν_2, ν_3 neutrino states. And if neutrino oscillations are generated by the neutrino mass matrix, then neutrino mixing parameters are expressed via elements of the neutrino mass matrix.

The mass Lagrangian of two neutrinos (ν_e, ν_μ) has the following form (for simplification the case of two neutrinos is considered):

$$\begin{aligned} \mathcal{L}_M = -\frac{1}{2}\left[m_{\nu_e}\bar{\nu}_e\nu_e + m_{\nu_\mu}\bar{\nu}_\mu\nu_\mu + m_{\nu_e\nu_\mu}(\bar{\nu}_e\nu_\mu + \bar{\nu}_\mu\nu_e)\right] \equiv \\ \equiv -\frac{1}{2}(\bar{\nu}_e, \bar{\nu}_\mu)\begin{pmatrix} m_{\nu_e} & m_{\nu_e\nu_\mu} \\ m_{\nu_\mu\nu_e} & m_{\nu_\mu} \end{pmatrix}\begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix}, \end{aligned} \quad (1)$$

which is diagonalized by rotation on the angle θ and then this Lagrangian (1) transforms into the following one (see [5]):

$$\mathcal{L}_M = -\frac{1}{2}\left[m_1\bar{\nu}_1\nu_1 + m_2\bar{\nu}_2\nu_2\right], \quad (2)$$

where

$$m_{1,2} = \frac{1}{2}\left[(m_{\nu_e} + m_{\nu_\mu}) \pm \left((m_{\nu_e} - m_{\nu_\mu})^2 + 4m^2_{\nu_\mu\nu_e}\right)^{1/2}\right],$$

and angle θ is determined by the following expression:

$$\mathrm{tg}(2\theta) = \frac{2m_{\nu_e\nu_\mu}}{(m_{\nu_\mu} - m_{\nu_e})}, \quad (3)$$

$$\begin{aligned} \nu_e &= \cos\theta\nu_1 + \sin\,\theta\nu_2, \\ \nu_\mu &= -\sin\,\theta\nu_1 + \cos\theta\nu_2. \end{aligned} \tag{4}$$

Then ν_e, ν_μ masses are

$$\begin{aligned} m_{\nu_e} &= m_1 \cos^2\theta + m_2 \sin^2 i\theta, \\ m_{\nu_\mu} &= m_1 \sin^2\,\theta + m_2 \cos^2\theta, \end{aligned} \tag{5}$$

in contrast to the primary supposition that ν_e, ν_μ, μ_τ neutrinos have no definite masses.

The probability of $\nu_e \to \nu_e$ is given by the following expression:

$$P(\nu_e \to \nu_e) = 1 - \sin^2(2\theta)\sin^2((m_2^2 - m_1^2)/2p)t, \tag{6}$$

where

$$\sin\,\theta = \frac{1}{\sqrt{2}}\left[1 - \frac{|m_{\nu_\mu} - m_{\nu_e}|}{\sqrt{(m_{\nu_\mu} - m_{\nu_e})^2 + (2m_{\nu_e\nu_\mu})^2}}\right] \tag{7}$$

or

$$\sin^2(2\theta) = \frac{(2m_{\nu_e\nu_\mu})^2}{(m_{\nu_e} - m_{\nu_\mu})^2 + (2m_{\nu_e\nu_\mu})^2}. \tag{8}$$

Then the nondiagonal mass term $m_{\nu_e\nu_\mu}$ of the mass matrix in (1) can be interpreted as width of $\nu_e \leftrightarrow \nu_\mu$ transitions [4].

In this standard theory of neutrino oscillations, neutrino oscillations are real even if neutrino masses are different; therefore, the law of energy momentum conservation is violated. In the corrected theory of neutrino oscillations [6] the law of energy momentum conservation is fulfilled and neutrino oscillations are virtual if neutrino masses are different and real if neutrino masses are equal.

It is necessary to note that in physics all the processes are realized through dynamics. Unfortunately, in the above considered mass mixings scheme the dynamics is absent. Probably, this is an indication of the fact that this scheme is an incomplete one, i. e. this scheme requires a physical substantiation. Below we consider neutrino oscillations which appear in the scheme of charge (couple constant) mixings, i.e. by using dynamics [4].

2. THEORY OF NEUTRINO OSCILLATIONS IN THE FRAMEWORK OF CHARGE MIXINGS SCHEME

At first we consider a case of two-neutrino mixings (oscillations) and then we consider the case of three-neutrino oscillations.

2.1. The Case of Two-Neutrino Mixings (Oscillations) in the Charge Mixings Scheme. In this scheme (or mechanism) the neutrino mixings or transitions can be realized by mixings of the neutrino fields by analogy with the vector dominance model ($\gamma - \rho^0$ and $Z^0 - \gamma$ mixings), the way it takes place in the particle physics. Then, in the case of two neutrinos, we have

$$\begin{aligned} \nu_1 &= \cos\theta\nu_e - \sin\theta\nu_\mu, \\ \nu_2 &= \sin\theta\nu_e + \cos\theta\nu_\mu. \end{aligned} \tag{9}$$

The charged current in the standard model of weak interactions for two lepton families has the following form:

$$j^\alpha = \left(\bar{e}\bar{\mu}\right)_L \gamma^\alpha V \begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix}_L ,$$

$$V = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}, \tag{10}$$

and then the interaction Lagrangian is

$$\mathcal{L} = \frac{g}{\sqrt{2}} j^\alpha W^+_\alpha + \text{h.c.} \tag{11}$$

and

$$\begin{aligned} \nu_e &= \cos\theta\nu_1 + \sin\theta\nu_2, \\ \nu_\mu &= -\sin\theta\nu_1 + \cos\theta\nu_2. \end{aligned} \tag{12}$$

The Lagrangian (10), (11) can be rewritten in the following form:

$$\mathcal{L} = \frac{g}{\sqrt{2}} j^\alpha W^+_\alpha + \text{h.c.}, \tag{13}$$

where j^α is

$$j^\alpha = \left(\bar{e}\bar{\mu} \right)_L \gamma^\alpha \begin{pmatrix} \nu_1 \\ \nu_2 \end{pmatrix}_L .$$

And the mass matrix is

$$\begin{pmatrix} m_1 & 0 \\ 0 & m_2 \end{pmatrix}.$$

In this case the neutrino oscillations cannot take place, and even if neutrino oscillations take place, then there must be $\nu_1 \leftrightarrow \nu_2$ neutrino oscillations but not $\nu_e \leftrightarrow \nu_\mu$ oscillations.

At this point some questions arise. Where have we taken ν_e, ν_μ neutrinos if in the weak interactions, given by expression (13), ν_1, ν_2 neutrinos are produced? From the all existent accelerator experiments it is well known that in the weak interactions ν_e, ν_μ neutrinos are produced and that the l_{ν_e}, l_{ν_μ} lepton numbers are well conserved ones. Obviously we must solve this problem. So, ν_1, ν_2 neutrinos are eigenstates of the weak interactions when we take mixing matrix V into account and ν_e, ν_μ neutrinos are eigenstates of the weak interactions with W, Z^0 boson exchanges. Then we have to rewrite the Lagrangian of the weak interaction in the correct form to describe neutrino productions and oscillations correctly. Then

$$\mathcal{L} = \frac{g}{\sqrt{2}} j^\alpha W^+_\alpha + \text{h.c.}, \tag{14}$$

where j^α is

$$j^\alpha = \begin{pmatrix} \bar{e}\bar{\mu} \end{pmatrix}_L \gamma^\alpha \begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix}_L .$$

How are the lepton numbers violated? It is necessary to suppose that after ν_e, ν_μ production the violation of lepton numbers takes place, i. e.

$$\begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix}_L = V \begin{pmatrix} \nu_1 \\ \nu_2 \end{pmatrix}_L , \quad V = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}, \tag{15}$$

and then ν_e, ν_μ neutrinos become superpositions of ν_1, ν_2 neutrinos:

$$\begin{aligned} \nu_e &= \cos\theta \nu_1 + \sin\theta \nu_2, \\ \nu_\mu &= -\sin\theta \nu_1 + \cos\theta \nu_2. \end{aligned} \tag{16}$$

Taking into account that the charges of ν_1, ν_2 neutrinos are g_1, g_2, we get

$$g\cos\theta = g_1, \quad g\sin\theta = g_2, \tag{17}$$

i.e.

$$\cos\theta = \frac{g_1}{g}, \quad \sin\theta = \frac{g_2}{g}. \tag{18}$$

Since $\sin^2\theta + \cos^2\theta = 1$, then

$$g = \sqrt{g_1^2 + g_2^2}$$

and

$$\cos\theta = \frac{g_1}{\sqrt{g_1^2 + g_2^2}}, \quad \sin\theta = \frac{g_2}{\sqrt{g_1^2 + g_2^2}}. \tag{19}$$

Since we suppose that $g_1 \cong g_2 \cong \frac{g}{\sqrt{2}}$, then

$$\cos\theta \cong \sin\theta \cong \frac{1}{\sqrt{2}}. \tag{20}$$

In the general case the couple constants g_1, g_2 and g can have no connections and then we obtain only expressions (19).

What happens with the neutrino mass matrix in this case? The primary neutrino mass matrix has the following diagonal form:

$$\left(\begin{array}{cc} m_{\nu_e} & 0 \\ 0 & m_{\nu_\mu} \end{array} \right), \tag{21}$$

since in the weak interactions (with W, Z^0 bosons) the lepton numbers are conserved and then ν_e, ν_μ are eigenstates of these interactions.

It is interesting to note that the same situation takes place in the quark sector when we consider $K^0, \overline{K}^0$ oscillations. In the strong interactions only d, s, b quarks are produced and the aroma numbers are well conserved in these interactions, i. e. these states are eigenstates of the strong interactions. Then oscillations appear at violating the aroma numbers by the weak interactions with the Cabibbo–Kobayashi–Maskawa matrices.

Then due to the presence of terms violating the lepton numbers, the nondiagonal terms appear in this matrix and then this mass matrix is transformed into the following nondiagonal matrix (the case when CP is conserved):

$$\left(\begin{array}{cc} m_{\nu_e} & m_{\nu_e \nu_\mu} \\ m_{\nu_\mu \nu_e} & m_{\nu_\mu} \end{array} \right), \tag{22}$$

then the mass Lagrangian of neutrinos takes the following form ($\nu \equiv \nu_L$):

$$\mathcal{L}_M = -\tfrac{1}{2}\left[m_{\nu_e}\bar{\nu}_e\nu_e + m_{\nu_\mu}\bar{\nu}_\mu\nu_\mu + m_{\nu_e\nu_\mu}(\bar{\nu}_e\nu_\mu + \bar{\nu}_\mu\nu_e)\right] \equiv$$
$$\equiv -\tfrac{1}{2}(\bar{\nu}_e, \bar{\nu}_\mu)\left(\begin{array}{cc} m_{\nu_e} & m_{\nu_e \nu_\mu} \\ m_{\nu_\mu \nu_e} & m_{\nu_\mu} \end{array} \right)\left(\begin{array}{c} \nu_e \\ \nu_\mu \end{array} \right). \tag{23}$$

Mass Lagrangian of the new states obtained by diagonalizing this matrix while rotating on angle θ has the following form (these states are namely the same weak interaction states considered above):

$$\mathcal{L}_M = -\frac{1}{2}(\bar{\nu}_e, \bar{\nu}_\mu)V^{-1}\left(\begin{array}{cc} m_{\nu_1} & 0 \\ 0 & m_2 \end{array} \right)V\left(\begin{array}{c} \nu_e \\ \nu_\mu \end{array} \right) =$$
$$= \frac{1}{2}(\bar{\nu}_e, \bar{\nu}_\mu))\left(\begin{array}{cc} m_1 cos^2\theta + m_2 sin^2\theta & (m_2 - m_1)cos\theta sin\theta \\ (m_2 - m_1)cos\theta sin\theta & m_1 sin^2\theta + m_2 cos^2\theta \end{array} \right)\left(\begin{array}{c} \nu_e \\ \nu_\mu \end{array} \right) =$$
$$= \frac{1}{2}\left[m_1\bar{\nu}_1\nu_1 + m_2\bar{\nu}_2\nu_2\right], \tag{24}$$

where ν_1, ν_2 are eigenstates and m_1, m_2 are their eigenmasses. From expressions (23), (24) we obtain

$$\begin{array}{l} \nu_1 = \cos\theta\nu_e - \sin\theta\nu_\mu, \\ \nu_2 = \sin\theta\nu_e + \cos\theta\nu_\mu, \end{array} \tag{25}$$

$$
\begin{aligned}
m_{\nu_e} &= m_1 \cos^2\,\theta + m_2 \sin^2\,\theta, \\
m_{\nu_\mu} &= m_1 \sin^2\,\theta + m_2 \cos^2\,\theta, \\
m_{\nu_e \nu_\mu} &= (m_2 - m_1)\cos\theta \sin\,\theta
\end{aligned}
\tag{26}
$$

or

$$
\begin{aligned}
m_1 &= \frac{(m_{\nu_e}\cos^2\,\theta - m_{\nu_\mu}\sin^2\,\theta)}{(\cos^2\,\theta - \sin^2\,\theta)}, \\
m_2 &= \frac{(m_{\nu_e}\sin^2\,\theta - m_{\nu_\mu}\cos^2\,\theta)}{(\cos^2\,\theta - \sin^2\,\theta)},
\end{aligned}
\tag{27}
$$

where $\sin\theta, \cos\theta$ are given by expressions (19).

Then $\Delta m^2 = m_2^2 - m_1^2$ is

$$
\Delta m^2 = \frac{(m_{\nu_\mu}^2 \cos^4\,\theta - m_{\nu_e}\sin^4\,\theta)}{(\cos^2\,\theta - \sin^2\,\theta)^2}. \tag{28}
$$

The expression for time evolution of ν_1, ν_2 neutrinos (see (25)–(27)) with masses m_1 and m_2 is

$$
\nu_1(t) = e^{-iE_1 t}\nu_1(0), \qquad \nu_2(t) = e^{-iE_2 t}\nu_2(0), \tag{29}
$$

where

$$
E_k^2 = (p^2 + m_k^2), \quad k = 1, 2.
$$

If neutrinos are propagating without interactions, then

$$
\begin{aligned}
\nu_e(t) &= \cos\,\theta e^{-iE_1 t}\nu_1(0) + \sin\,\theta e^{-iE_2 t}\nu_2(0), \\
\nu_\mu(t) &= -\sin\,\theta e^{-iE_1 t}\nu_1(0) + \cos\,\theta e^{-iE_2 t}\nu_2(0).
\end{aligned}
\tag{30}
$$

Using the expression for ν_1 and ν_2 from (25), and putting it into (20), one can get the following expression:

$$
\begin{aligned}
\nu_e(t) = &\left[e^{-iE_1 t}\cos^2\,\theta + e^{-iE_2 t}\sin^2\,\theta\right]\nu_e(0) + \\
&+ \left[e^{-iE_1 t} - e^{-iE_2 t}\right]\sin\,\theta\cos\,\theta\nu_\mu(0), \\
\nu_\mu(t) = &\left[e^{-iE_1 t} sin^2\theta + e^{-iE_2 t}\cos^2\,\theta\right]\nu_\mu(0) + \\
&+ \left[e^{-iE_1 t} - e^{-iE_2 t}\right]\sin\,\theta\cos\,\theta\nu_e(0).
\end{aligned}
\tag{31}
$$

The probability that neutrino ν_e produced at time $t = 0$ will be transformed into ν_μ at time t is an absolute value of amplitude $\nu_\mu(0)$ in (31) squared, i. e.

$$
\begin{aligned}
&P(\nu_e \to \nu_\mu) = \mid (\nu_\mu(0) \cdot \nu_e(t)) \mid^2 = \\
&= \frac{1}{2}\sin^2(2\theta)\left[1 - \cos\left((m_2^2 - m_1^2)/2p\right)t\right],
\end{aligned}
\tag{32}
$$

where it is supposed that $p \gg m_1, m_2$ and $E_k \simeq p + m_k^2/2p$.

The expression (32) presents the probability of neutrino flavor oscillations. The angle θ (mixing angle) characterizes the value of mixing. The probability $P(\nu_e \to \nu_\mu)$ is a periodical function of distances, where the period is determined by the following expression:

$$L_o = 2\pi \frac{2p}{\mid m_2^2 - m_1^2 \mid}. \tag{33}$$

And probability $P(\nu_e \to \nu_e)$ that the neutrino ν_e produced at time $t = 0$ is preserved as ν_e neutrino at time t is given by the absolute value of the amplitude of $\nu_e(0)$ in (31) squared. Since the states in (31) are normalized states, then

$$P(\nu_e \to \nu_e) + P(\nu_e \to \nu_\mu) = 1. \tag{34}$$

So, we see that flavor oscillations caused by nondiagonality of the neutrinos mass matrix violate the law of the $-\ell_e$ and ℓ_μ lepton number conservations. However in this case, as one can see from (34), the full lepton numbers $\ell = \ell_e + \ell_\mu$ are conserved.

It is necessary to stress that neutrino oscillations in this scheme (mechanism) are virtual if neutrino masses are different and real if neutrino masses are equal and these oscillations are preserved within the uncertainty relations.

2.2. The Case of Three-Neutrino Mixings (Oscillations) in the Charge Mixings Scheme. In the case of three neutrinos we can choose parameterization of the mixing matrix V in the form proposed by Maiani [7]:

$$V = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_\gamma & s_\gamma \\ 0 & -s_\gamma & c_\gamma \end{pmatrix} \begin{pmatrix} c_\beta & 0 & s_\beta \\ 0 & 1 & 0 \\ -s_\beta & 0 & c_\beta \end{pmatrix} \begin{pmatrix} c_\theta & s_\theta & 0 \\ -s_\theta & c_\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}, \tag{35}$$

$$\begin{aligned} c_{e\mu} = \cos\theta \quad s_{e\mu} = \sin\theta, \quad c_{e\mu}^2 + s_{e\mu}^2 = 1; \\ c_{e\tau} = \cos\beta, \quad s_{e\tau} = \sin\beta, \quad c_{e\tau}^2 + s_{e\tau}^2 = 1; \\ c_{\mu\tau} = \cos\gamma, \quad s_{\mu\tau} = \sin\gamma, \quad c_{\mu\tau}^2 + s_{\mu\tau}^2 = 1. \end{aligned} \tag{36}$$

It is not difficult to come to consideration of the case of three neutrino types ν_e, ν_μ, ν_τ.

For the first and second families (at ν_e, ν_μ neutrino oscillations) we get

$$\begin{aligned} \cos\theta = \cos\theta_{\nu_e\nu_\mu} = \frac{g_1}{\sqrt{g_1^2 + g_2^2}}, \\ \sin(2\theta) = \frac{2g_1g_2}{g_1^2 + g_2^2}. \end{aligned} \tag{37}$$

Then the probability of $\nu_e \to \nu_e$ is given by the following expression:

$$P(\nu_e \to \nu_e) = 1 - \sin^2(2\theta)\sin^2\left(\pi t(m_2^2 - m_1^2)/2p_{\nu_e}\right), \tag{38}$$

In the case $g_1 \cong g_2$

$$\sin\,\theta_{\nu_e\nu_\mu} \cong \cos\,\theta_{\nu_e\nu_\mu} \cong \frac{1}{\sqrt{2}}. \tag{39}$$

For the first and third families (at ν_e, ν_τ neutrino oscillations) we get

$$\begin{gathered}\cos\,\beta = \cos\,\beta_{\nu_e\nu_\tau} = \frac{g_1}{\sqrt{g_1^2 + g_3^2}},\\ \sin\,(2\beta) = \frac{2g_1g_3}{g_1^2 + g_3^2}.\end{gathered} \tag{40}$$

Then the probability of $\nu_e \to \nu_e$ is given by the following expression:

$$P(\nu_e \to \nu_e) = 1 - \sin^2(2\beta)\sin^2\left(\pi t(m_3^2 - m_1^2)/2p_{\nu_e}\right). \tag{41}$$

In the case $g_1 \cong g_3$

$$\cos\,\beta_{\nu_e\nu_\tau} \cong \sin\,\beta_{\nu_e\nu_\tau} \cong \frac{1}{\sqrt{2}}. \tag{42}$$

For the second and third families (at ν_ν, ν_τ neutrino oscillations) we get

$$\begin{gathered}\cos\,\gamma = \cos\,\gamma_{\nu_\mu\nu_\tau} = \frac{g_2}{\sqrt{g_2^2 + g_3^2}},\\ \sin\,(2\gamma) = \frac{2g_2g_3}{g_2^2 + g_3^2}.\end{gathered} \tag{43}$$

Then the probability of $\nu_\mu \to \nu_\mu$ is given by the following expression:

$$P(\nu_\mu \to \nu_\mu) = 1 - \sin^2(2\gamma)\sin^2\left(\pi t(m_3^2 - m_2^2)/2p_{\nu_\mu}\right). \tag{44}$$

In the case $g_2 \cong g_3$

$$\cos\,\gamma_{\nu_\mu\nu_\tau} \cong \sin\,\gamma_{\nu_\mu\nu_\tau} \cong \frac{1}{\sqrt{2}}. \tag{45}$$

So the neutrino mixings (oscillations) appear due to the fact that at neutrino production the eigenstates of the weak interactions (i. e. ν_e, ν_μ, ν_τ neutrino states) are generated but not the eigenstates of the weak interaction violating lepton numbers (i. e. ν_1, ν_2, ν_3 neutrino states). And when neutrinos are passing through vacuum, they are converted into superpositions of ν_1, ν_2, ν_3 neutrinos, and through these intermediate states the oscillations (transitions) between ν_e, ν_μ, ν_τ neutrinos are realized.

3. CONCLUSIONS

It is necessary to note that in physics all the processes are realized through dynamics. Unfortunately, in the standard theory of neutrino oscillations based on the mass mixings scheme (mechanism), the dynamics is absent. Probably, this is an indication of the fact that this scheme is an incomplete one, i. e. this scheme requires a physical substantiation.

In this work, neutrino oscillations generated by the weak interaction couple constant (charge) mixings were considered [4] (as it takes place in the model of vector dominance [8] or in the electroweak interactions model [9] at vector boson mixings). Expressions for angle mixings and lengths of oscillations were obtained. The expressions of probabilities for three-neutrino oscillations were given. Neutrino oscillations in this scheme (mechanism) are virtual if neutrino masses are different and real if neutrino masses are equal.

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