Prospects in finding neutrino oscillation mechanism and it's impatct on oscillation picture

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General framework of neutrino oscillations

- Note that we are limited only to $\overset{(-)}{\nu}_\mu$ or $\overset{(-)}{\nu}_e$ appearance/disappearance detection and Z width strongly suppresses additional active neutrino flavours except for $\overset{(-)}{\nu}_\tau$.
- So far no explicit effect of sterile neutrino was found but there are experimental anomalies for short baselengths and possible neutrino-antineutrino asymmetry [arXiv:1805.12028].
- Experiment suggests unitarity of the mixing matrix holds [arXiv:1308.5700, arXiv:1508.05095] and trigonometric functions do not exceed their limits [T2K preliminary].
- Majorana masses, Dirac masses or mixed masses of neutrino yields different oscillation pictures and can be potentially distinguished [https://doi.org/10.1016/j.physletb.2018.03.016].

General framework of neutrino oscillations

To get insight into neutrino mass generation mechanism we should first answer the following question.

Can we have more rich phenomenology for neutrino oscillations and can we check it?

For a given number of neutrino species the oscillation picture will be the same, e.g. for two flavor mixing

$$i\frac{\partial}{\partial t}\begin{pmatrix}|\nu_e\rangle \\ |\nu_\mu\rangle\end{pmatrix} = H\begin{pmatrix}|\nu_e\rangle \\ |\nu_\mu\rangle\end{pmatrix}, \tag{1}$$

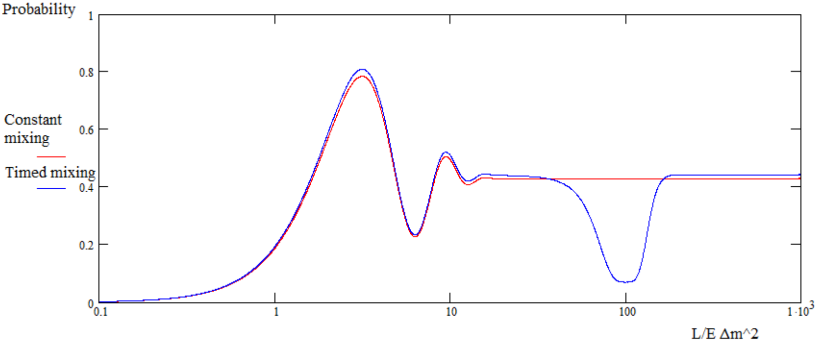
where under high energy approximation

$$H = \frac{1}{2E}\begin{pmatrix}0 & 0 \\ 0 & \Delta m^2\end{pmatrix} + \begin{pmatrix}a & 0 \\ 0 & 0\end{pmatrix}. \tag{2}$$

That yields known oscillation probability.

Example of parametrized mixing

However it is not the case when mixing matrix depends on arbitrary parameters.
Indeed, we can let U be $U(t)$, such that $UU^{+} = I$ and $\nu_i = \sum_{\alpha} U_{\alpha i}\, \nu_{\alpha}$.
We will illustrate that for two flavor mixing. On the picture below the appearance probability for initially absent type of neutrino as a function of $\frac{L}{E}\Delta m^2$ and Gauss averaging is given.



Another opportunities

The function for a given example is illustrative. Such dependence might explain short baseline neutrino anomalies. There is also an opportunity for other parameters to influence the neutrino mixing.

- One of interesting opportunities is the dependence $U = U(a)$ where a is the cosmological scale factor.
- Another is that for the general case

$$i\sigma_\mu \partial^\mu \psi_L - \eta_{D,R} m_{D,R} \psi_R - \eta_L m_L (i\sigma_2) \psi_L^* = 0 \tag{3}$$

$$i\bar{\sigma}_\mu \partial^\mu \psi_R - \eta_{D,L} m_{D,L} \psi_L - \eta_R m_R (i\sigma_2) \psi_R^* = 0 \tag{4}$$

$m_{D,R}$ and $m_{D,L}$ can be nonsymmetrical.

Another dependencies for the mixing matrix are possible.

Prospects of neutrino mass description

How can it be justified? The most simple case is that we jost don't need such a complications. When the mixing matrix is parameter-dependent we have generalised Dirac equation

$$(\gamma_\mu \partial_\mu - m(x))\,\varphi = 0 \tag{5}$$

where $x \in X$ — parameter from some domain X.
In this case we have an effective mass for neutrino and some Lagrangian term disturbing it. For a given term it is possible to constrain it from the current experimental data.

The most interesting feature of neutrino as spinor field however is that we don't have experimental evidence for right neutrino or left antineutrino.

Conclusion

- There are many possibilities for neutrino mass matrix being parameter-dependent. That requires additional mechanism disturbing neutrino mass.
- An illustratory example of such a mechanism was given.
- Additional experiments can be performed to shed light on the neutrino mass mechanism [arXiv:1403.6344].