Tutorial Session on Neutrino Properties

Date and Time: 21st November, 11:00 AM to 12:30 PM

Question no. 1

It was mentioned in the second lecture (slide no. 36) that there are three light active neutrinos: ν_e, ν_μ, and ν_τ. How do we know that there are three light active neutrinos?

Answer of question no. 1

Follow the discussion during the tutorial and also go through the nice article written in Particle Data Group (PDG) accessible through the following link:

http://pdg.lbl.gov/2016/reviews/rpp2016-rev-light-neutrino-types.pdf

Question no. 2

In the second lecture (slide no. 25), $\nu_\alpha \to \nu_\alpha$ survival probability was discussed. While expressing Δm^2 in eV^2, L is in km, and E is in GeV, we obtain a factor 1.27 in the argument. Derive this factor. Also, in the expression of the oscillation length:

$$L_{ij}^{osc} = \frac{4\pi E}{\Delta m_{ij}^2} \simeq 2.48\, m\, \frac{E\,(\mathrm{MeV})}{\Delta m_{ij}^2\,(\mathrm{eV}^2)} = 2.48\, km\, \frac{E\,(\mathrm{GeV})}{\Delta m_{ij}^2\,(\mathrm{eV}^2)}\,, \tag{1}$$

we have a factor 2.48. Derive this factor.

Answer of question no. 2

Use the concept of Natural units: $c = \hbar = 1$ (lecture 2, slide no. 24) and follow the discussion during the tutorial.

Question no. 3

During the second lecture (slide no. 27), the famous slide that Professor Takaaki Kajita showed during the Neutrino Conference in 1998 was discussed. Can we get an idea about how did they get 6.2σ discovery in favour of oscillation from the plot?

Answer of question no. 3

Use the simple Gaussian χ^2 method and follow the discussion during the tutorial.

Question no. 4

Can we quickly realise the factor 1/6 in slide no. 32 of lecture 2?

Answer of question no. 4

Use the expression for $\nu - e$ scattering cross-section and follow the discussion during the tutorial.

Question no. 5

Using one mass scale dominance (OMSD) approximation, derive the simple expressions for oscillation probabilities.

Answer of question no. 5

Follow the discussion during the tutorial.

Question no. 6

Derive the expression for E_μ given in slide no. 29 of the first lecture.

Answer of question no. 6

Follow the discussion during the tutorial.

Question no. 7

Explain why $\frac{\mathrm{Br}(\pi^+ \to e^+ \nu_e)}{\mathrm{Br}(\pi^+ \to \mu^+ \nu_\mu)} = \frac{m_e^2 (m_\pi^2 - m_e^2)^2}{m_\mu^2 (m_\pi^2 - m_\mu^2)^2} = 1.283 \times 10^{-4}$

Answer of question no. 7

Follow the discussion during the tutorial.