Constraining CPT violation with Hyper-Kamiokande and ESSnuSB

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Abstract

- It is expected that the neutrino experiments can provide more stringent bound on CPT invariance violation than the existing bounds from the kaon sector.
- Future long-baseline experiments will play a crucial role in understanding the CPT symmetry of the universe.
- We investigated the sensitivities of Hyper-Kamiokande (T2HK and T2HKK), ESSnuSB and DUNE to constrain the CPT violating parameters.

Introduction

- Simultaneous transformation of Charge conjugation, Parity and Time reversal $\Longrightarrow$ CPT Transformation.
- SM is invariant under Lorentz or CPT symmetry.
- CPT theorem $\Longrightarrow$ particles and anti-particles will have same mass and life-time.
- Till now no conclusive evidence for CPT violation is found in any experiment.
- Neutrino sector has the potential to provide stringent bound on CPT invariance violation.
- If the CPT symmetry is not invariant, we need two different sets of parameters for neutrinos and anti-neutrinos.

$$|\nu_\alpha\rangle = \sum_{i=1}^{3} U_{\alpha i}(\theta_{12}, \theta_{13}, \theta_{23}, \delta_{CP})|\nu_i\rangle \ . \tag{1}$$

$$|\overline{\nu}_\alpha\rangle = \sum_{i=1}^{3} U^*_{\alpha i}(\overline{\theta}_{12}, \overline{\theta}_{13}, \overline{\theta}_{23}, \overline{\delta}_{CP})|\overline{\nu}_i\rangle \ . \tag{2}$$

- CPT violating parameters in neutrino sector that we are considering for this study

$$\Delta(\delta_{CP}) = |\delta_{CP} - \overline{\delta}_{CP}| \tag{3}$$

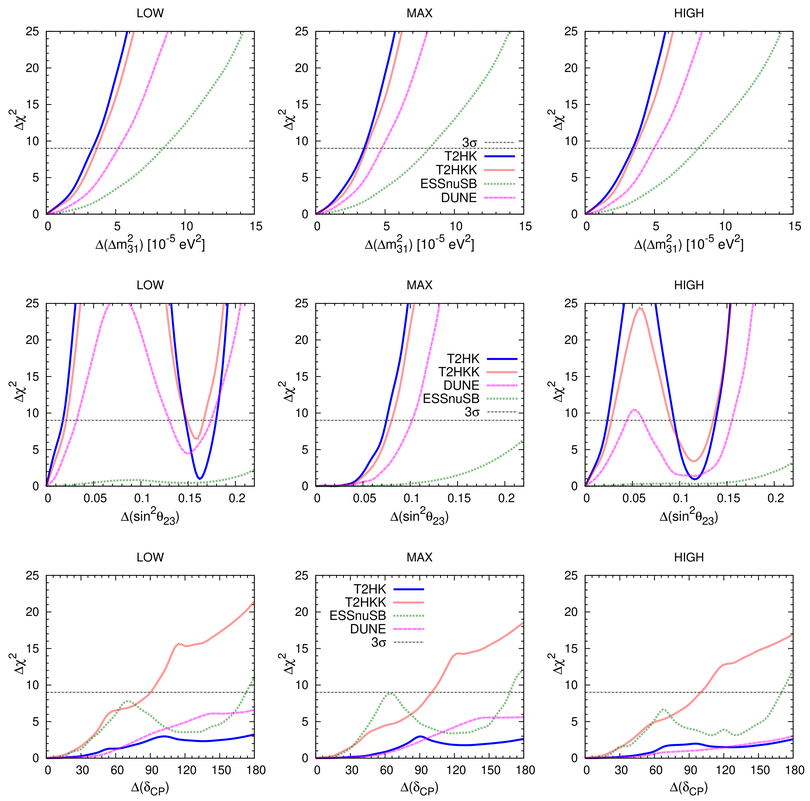
$$\Delta(\Delta m^2_{31}) = |\Delta m^2_{31} - \Delta\overline{m}^2_{31}| \tag{4}$$

$$\Delta(\sin^2\theta_{23}) = |\sin^2\theta_{23} - \sin^2\overline{\theta}_{23}| \tag{5}$$

Simulation Details

- In this work, we obtained the bound on CPT violation in Δm^2_{31}, $\sin^2\theta_{23}$ and δ_{CP} in the upcoming Hyper-Kamiokande (T2HK and T2HKK), European Spallation Source ν-Beam (ESSnuSB) and Deep Underground Neutrino Experiment (DUNE).
- We used *GLoBES* package to simulate these experiments.
- *ESSnuSB* ($2\nu + 8\overline{\nu}$)*:* POT = 27×10^{22}
- *T2HK and T2HKK* ($1\nu + 3\overline{\nu}$)*:* POT = 27×10^{21}
- *DUNE* ($5\nu + 5\overline{\nu}$)*:* POT = 10×10^{21}

Results and Conclusion



- *T2HK* and *T2HKK* are giving better bounds on $\Delta(\Delta m^2_{31})$ than *ESSnuSB* and *DUNE*.
- In the second row, Higher and lower octants plots are showing degeneracies.
- For maximal θ_{23}, the CPT violation senitivity of all the experiments increses with the increse of $\Delta(\sin^2\theta_{23})$ value.
- *ESSnuSB* $\rightarrow$ very low sensitivity to $\Delta(\sin^2\theta_{23})$ for all values of θ_{23}.
- *T2HKK* $\rightarrow \Delta(\delta_{CP}) < 100^\circ$ at 3σ C.L.

- **Conclusion:**
- *T2HKK* and *ESSnuSB* are quite sensitive to δ_{CP}.
- *T2HK*, *T2HKK* and *DUNE* are sensitive to atmospheric mixing parameters.
- *T2HK* gives most stringent limits on $\Delta(\Delta m^2_{31})$ and $\Delta\sin^2\theta_{23}$.
- *T2HKK* will provide best bound on $\Delta(\delta_{CP})$.

References

Reference:

[1] G. Luders, Ann. Phys. (NY) 2 (1957), 1.

[2] V. A. Kostelecky and M. Mewes, Phys. Rev. D **70**, 031902 (2004),hep-ph/0308300.

[3] G. Barenboim, C. A. Ternes and M. Tórtola, Phys. Lett. B **780** (2018), 631-637 doi:10.1016/j.physletb.2018.03.060 [arXiv:1712.01714 [hep-ph]].