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NSI Effects in Next-Generation Neutrino Experiments

Neutrino 2020 - Poster Session

Non-Standard Interactions

- Proposed to quantify new physics in the neutrino sector beyond mass generation.
- Charged Current: production and detection

$$\mathcal{L}_{\text{CC-NSI}} = -2\sqrt{2}G_F \epsilon^{ff'X}_{\alpha\beta}\left(\bar{\nu}_\alpha \gamma^\mu P_L \ell_\beta\right)\left(\bar{f}'\gamma_\mu P_X f\right)$$

(where $X = R, L$)

Focus

- Neutral Current: propagation in matter

$$\mathcal{L}_{\text{NC-NSI}} = -2\sqrt{2}G_F \epsilon^{fX}_{\alpha\beta}\left(\bar{\nu}_\alpha \gamma^\mu P_L \nu_\beta\right)\left(\bar{f}\gamma_\mu P_X f\right)$$

- Gives rise to a generalised matter potential, modified Hamiltonian

$$V_{NSI} = \sqrt{2}G_F N_e \begin{pmatrix} \epsilon_{ee} & \epsilon_{e\mu} & \epsilon_{e\tau} \\ \epsilon^*_{e\mu} & \epsilon_{\mu\mu} & \epsilon_{\mu\tau} \\ \epsilon^*_{e\tau} & \epsilon^*_{\mu\tau} & \epsilon_{\tau\tau} \end{pmatrix}$$

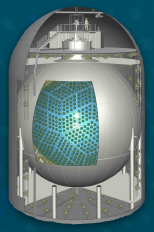
$$P\left(\nu_\alpha \to \nu_\beta\right) = \left| \left\langle \nu_\beta \left| e^{-i(H+V_{\text{NSI}})L} \right| \nu_\alpha \right\rangle \right|^2$$

- NSI can imitate CP-violation and cause degeneracies in measurements of solar mixing angle and mass ordering (MSW LMA-Dark solution)

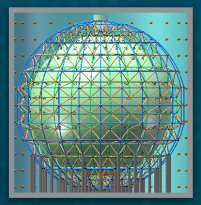
References

Hyper-K Design Report
Front.in Phys. 6 (2018) 10
Nuclear and Particle Physics Proceedings (2014): 111-113.

KamLAND ⇨ JUNO



KamLAND

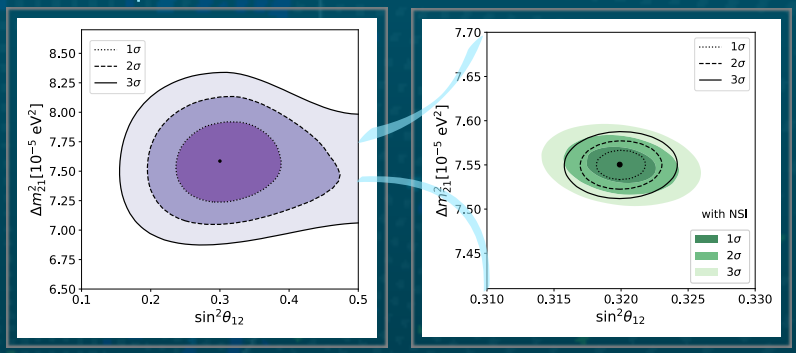


JUNO

- Fiducial Volume: 1 kton vs. 20 kton liquid scintillator
- Average baseline: 180 km vs. 53 km
- Principal measurement: reactor neutrinos through IBD events ($\bar{\nu}_e$ disappearance prob.)
- Advantages of JUNO: larger statistics, better energy resolution

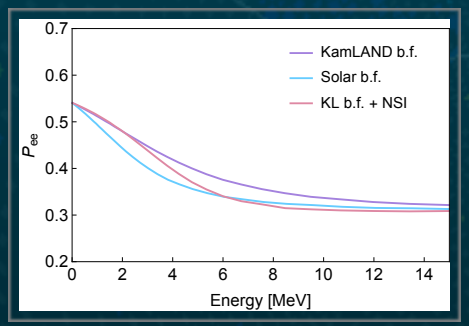
NSI effects cannot be distinguished in KamLAND

All NSI params free



Comparison between sensitivities of KamLAND (left) and JUNO (right) to solar parameters, both with and without NSI effects in the latter case.

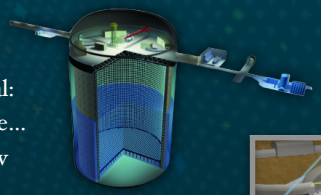
$$\begin{bmatrix} \epsilon = -0.2 \\ \epsilon' = 0.0 \end{bmatrix}$$



ν_e survival probability for ^8B neutrinos (day only)

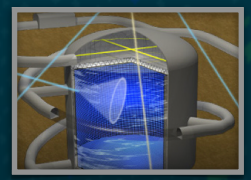
Super-K ⇨ Hyper-K

- Fiducial Volume: 22.5 kton ⟶ 187 kton
- Continuing multipurpose research potential: solar, atmospheric, supernova, long-baseline...
- For T2HK, upgraded near detector and new intermediate detector proposed
- Possibility of second tank in Korea being explored



SK

HK



Next steps

- χ^2 minimisation of NSI parameters.
- Explore viability of NSIs in THEIA experiment.
- Compare results obtained for a 1-tank design of Hyper-K with realistically low energy threshold with a 2-tank design involving higher E threshold due to lower overall photocoverage (vs. SK's 40%).