

T2K and NO ν A tension and nonstandard neutrino interactions

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Abstract

We propose a nonstandard charged current interaction (CC-NSI) in neutrino production to relieve this tension. The CC-NSI is computed through quantum field theory (QFT) formalism, where we derive perturbative analytical formulae considering CC-NSI in the pion decay. Within this new approach, we can alleviate NO ν A and T2K tension for a CC-NSI complex parameters of order 10^{-3} . We show the new phase has a degeneracy to the Dirac CP phase of the form $\delta_{CP} \pm \phi = 1.5\pi$ being a possible source of violation of charge-parity symmetry.

Beyond Standard Model Physics

We focus on the formalism for CC-NSI developed in [1].

In special we assume a pseudoscalar coupling $\epsilon_{\alpha\beta} \equiv G_X/G_F$

where $\alpha, \beta = e, \mu$ where G_X is the Fermi-like coupling of new interaction. For $\alpha = \mu, \beta = e$ this implies that the charged pion neutrino production have additional non-standard interaction as $\pi^+ \rightarrow \mu^+ + \nu_e$ and for $\alpha = e, \beta = \mu$, we have non-standard interaction as $\pi^+ \rightarrow e^+ + \nu_\mu$. In this work we can alleviate the tension between the T2K and NO ν A allowed regions for a very tiny coupling of $\epsilon \sim 10^{-3}$ for the non-standard interaction.

In the quantum-field theory approach of Ref.[1] we can write the neutrino probability in a matter as

$$P_{\alpha\beta}^{\text{CC-NSI}} = \sum_{kj} e^{-i\Delta_{kj}} (1_{3\times 3} - p_{\alpha\epsilon}) \mathcal{U}_{\alpha k}^* (1_{3\times 3} - p_{\alpha\epsilon}) \mathcal{U}_{\alpha j} \mathcal{U}_{\beta k} \mathcal{U}_{\beta j}^*, \quad (1)$$

where the blue terms in above equation are the CC-NSI contribution for the neutrino oscillation probability. The ϵ is complex parameter and new CP CC-NSI phases appear.

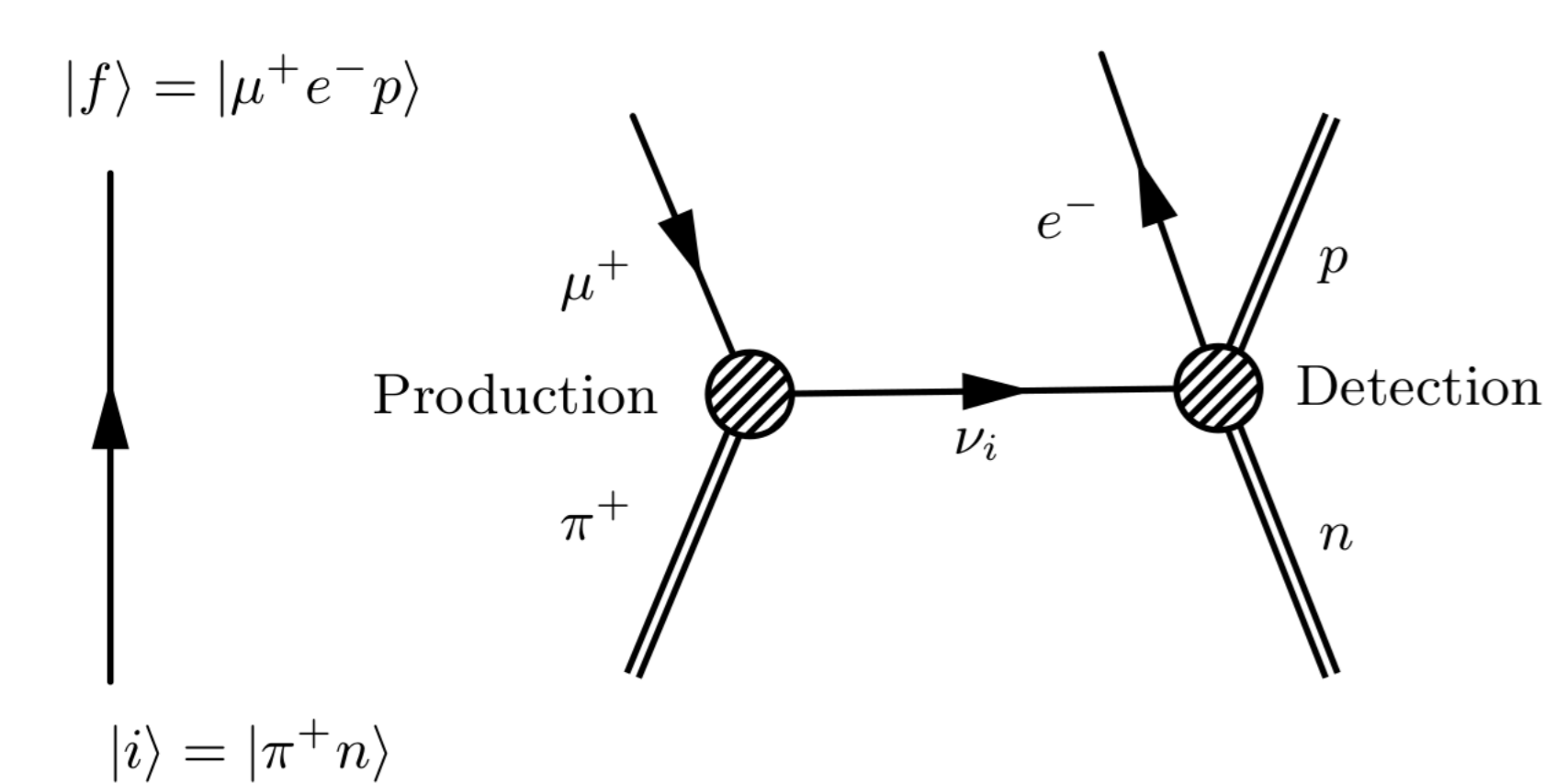


Figure 1: Allowed region for T2K (pink), NO ν A (blue) and for combined analysis (black line), for NO in the $\sin^2 \theta_{23}$ vs. δ_{CP} space, for 90% confidence level. In the left panel we show the standard oscillation scenario, in the middle panel we show the case with $\epsilon_{e\mu} \neq 0$ and in the right panel the case with $\epsilon_{\mu e} \neq 0$. The dots are the respective best-fit values.

Analysis and Results

We used the Globes program to simulate all the upcoming long baseline neutrino oscillation experiments T2K and NO ν A. From our analysis we have found that the preferred solution is for $\epsilon \neq 0$.

Figure 2 shows how the allowed region for the mixing parameter θ_{23} and the CP phase Δ_{CP} are in each scenario.

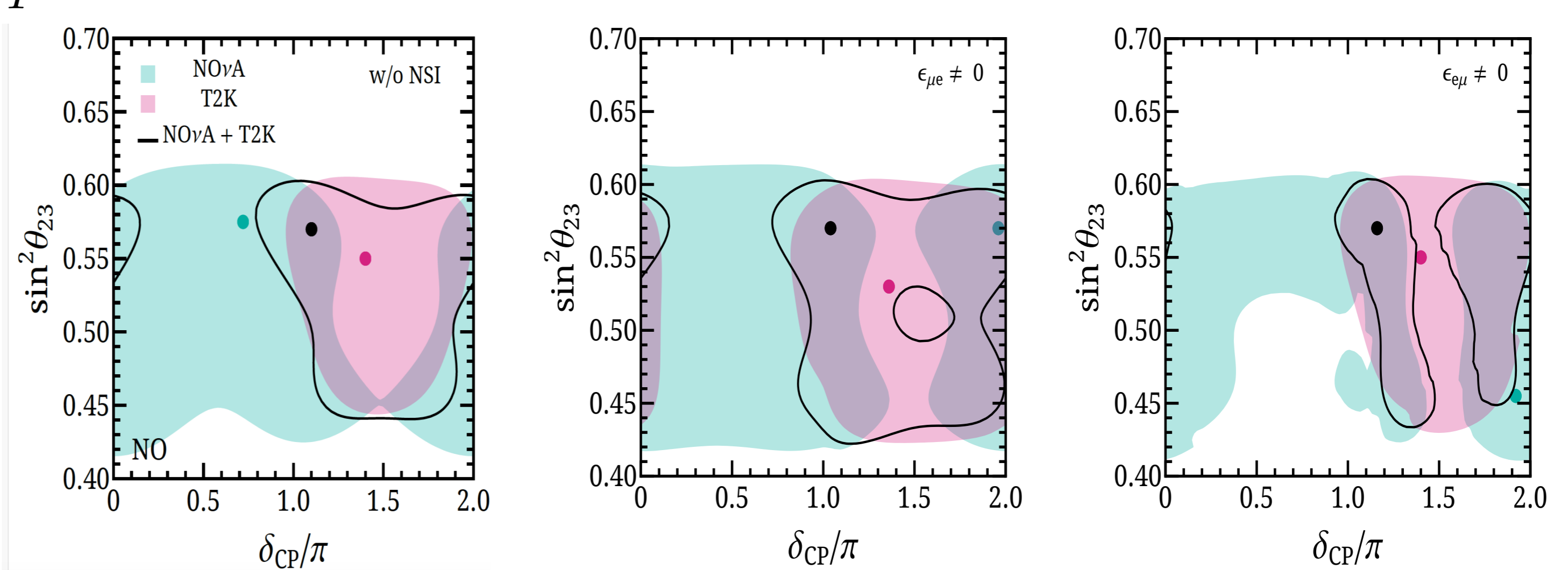


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T2K+NO ν A exclusion

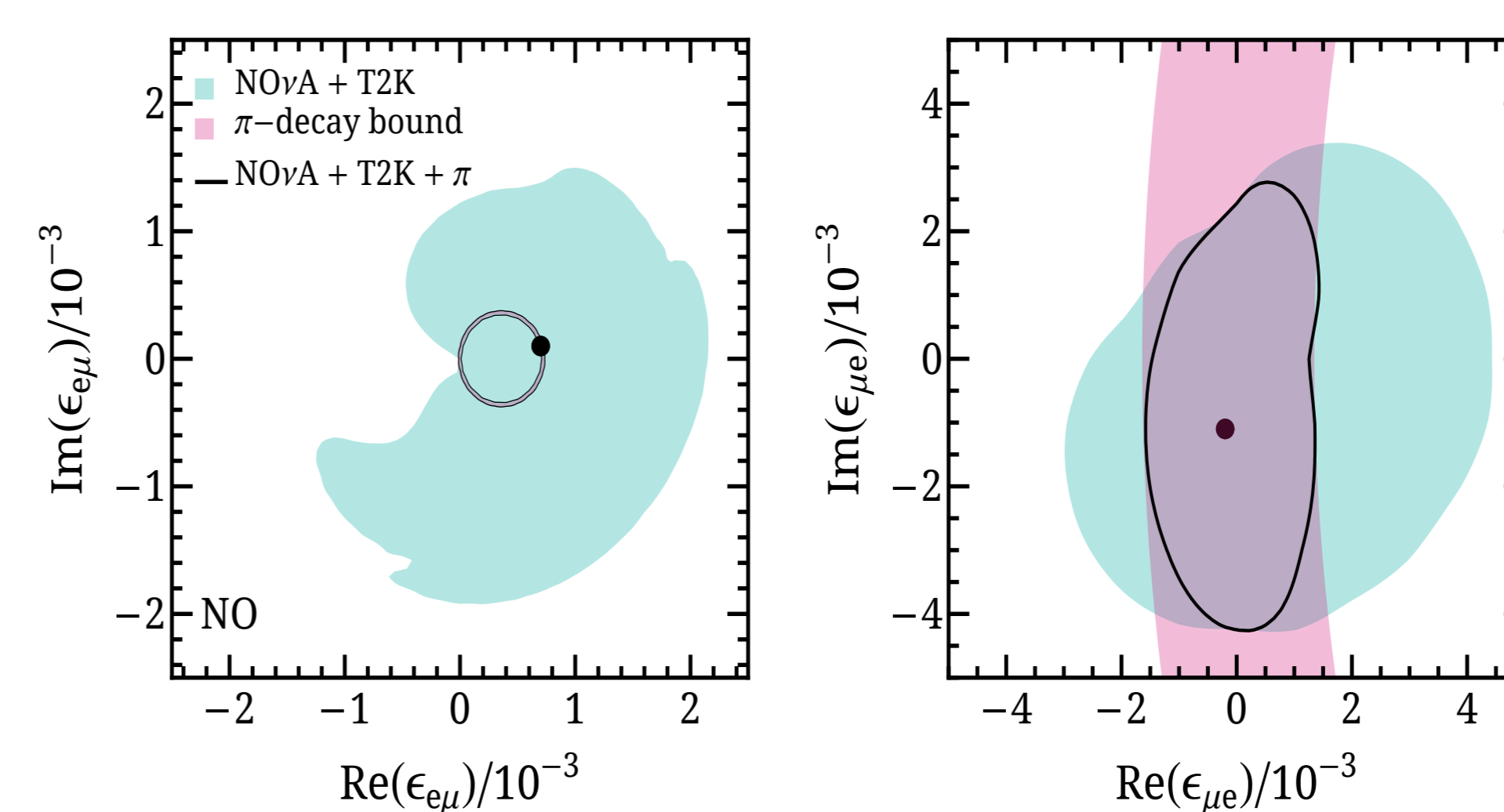


Figure 3: Bounds for $\epsilon_{e\mu}$ ($\epsilon_{\mu e}$) in the left (right) panel, coming from our analysis (blue curve), the constraints from π -decay rate (pink curve), and considering both bounds - from oscillation and π -decay experiments - (black curve) at 90% C.L. The legends are the same for both panels. The best-fit values for the combination are represented by dots.

Conclusion

In the literature, the solution for the T2K-NO ν A tension using CC-NSI was not considered before, mostly because there are stringent bounds coming directly from pion decay experiments. We showed that this bias is not justified, by explicitly considering the pion decay bounds as priors in our statistical analyses. On doing so, we have not only reduced the T2K-NO ν A tension, but also provided a better overall fit, in comparison to the standard scenario. The scenario with $\epsilon_{e\mu}$ is particularly promising, being one of the best solutions in literature. The non-zero value of the CC-NSI parameter opens a new window to understand the source of CP violation, and it can be tested in future neutrino oscillation experiments.

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