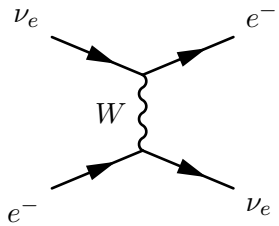
CP-Violating Neutrino Non-Standard Interactions in Long-Baseline-Accelerator Data

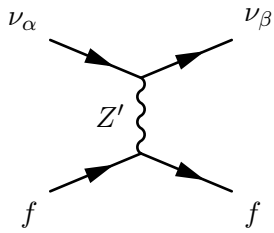
By **Peter B. Denton** with Julia Gehrlein and Rebekah Pestes: 2008.01110 (PRL)

SM Matter effect:

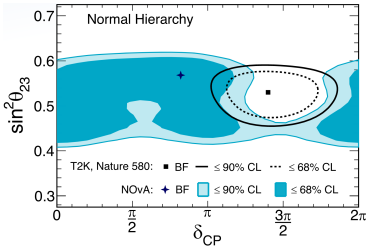


L. Wolfenstein PRD 17, 2369 (1978)

What if there is a new "matter effect" style interaction?



- modifies oscillations
- sort of measured:
- compare solar and KamLAND



A. Himmel 10.5281/zenodo.3959581

T2K & NOvA see different δ_{CP}

NSI effect $\propto \rho E$

	ρ [g/cc]	E [GeV]
T2K	2.6	0.6
NOvA	2.84	1.9

Does NSI fit?

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How big of NSI?

$$|\epsilon_{e\mu}| \approx \frac{s_{12}c_{12}c_{23}\pi\Delta m^2_{21}}{2s^2_{23}} \times \left|\frac{\sin\delta_{\text{T2K}} - \sin\delta_{\text{NOvA}}}{a_{\text{NOvA}} - a_{\text{T2K}}}\right| \approx 0.22$$

... and the phase?

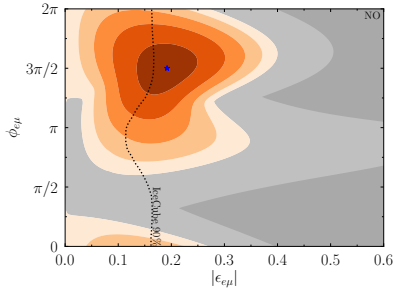
$$\cos(\delta_{\text{true}} + \phi_{e\beta}) \approx -1$$

$$\delta_{\text{true}} \approx \delta_{\text{T2K}} \approx 1.5\pi$$

$$\Rightarrow \quad \phi_{e\beta} \approx 1.5\pi$$

Fit the data:

- NOvA & T2K app & dis
- Daya Bay
- KamLAND
- $\Rightarrow$ reactors have no matter effect



Where do we go from here?

- NOvA & T2K will improve
- DUNE & HK will improve more
- IceCube & SK are comparably sensitive
- COHERENT too (depends on mediator)

Backup

NSI review

$$\mathcal{L}_{\rm NSI} = -2\sqrt{2}G_F \sum_{\alpha,\beta,f,P} \epsilon^{f,P}_{\alpha\beta}(\bar{\nu}_\alpha \gamma^\mu P_L \nu_\beta)(\bar{f}\gamma_\mu P f)$$

Models with large NSIs consistent with CLFV:

Y. Farzan, I. Shoemaker 1512.09147 Y. Farzan, J. Heeck 1607.07616 D. Forero and W. Huang 1608.04719
K. Babu, A. Friedland, P. Machado, I. Mocioiu 1705.01822 PBD, Y. Farzan, I. Shoemaker 1804.03660
U. Dey, N. Nath, S. Sadhukhan 1804.05808 K. Babu, et al. 1907.09498 Y. Farzan 1912.09408

Affects oscillations via new matter effect

$$H = \frac{1}{2E}\left[UM^2U^\dagger + a\begin{pmatrix} 1+\epsilon_{ee} & \epsilon_{e\mu} & \epsilon_{e\tau} \\ \epsilon^*_{e\mu} & \epsilon_{\mu\mu} & \epsilon_{\mu\tau} \\ \epsilon^*_{e\tau} & \epsilon^*_{\mu\tau} & \epsilon_{\tau\tau} \end{pmatrix}\right]$$

Matter potential: $a \propto G_F \rho E$

B. Dev, K. Babu, PBD, P. Machado, et al. 1907.00991