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Testing the dark origin of neutrino masses with oscillation experiments

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Based on 2503.08439 by A. Cheek, L. Visinelli and **H.-Y. Zhang**

Dynamic neutrino mass?

Some motivations: Lorenz et al. (PRD, 2021)

- Redshift-dependent bounds on $\sum m_\nu$
- Recent DESI results indicate some tension in $\sum m_\nu$ DESI Collaboration (JCAP, 2025)
- Relating the two puzzles

For ultralight DM $10^{-19} \lesssim m_\phi \ll 10\text{eV}$

$$\Delta m^2_{ij} \sim \Delta m^2_{ij\,D}(\boldsymbol{x}) \cos^2(m_\phi t)$$

DM density-dependent

Time modulation

assuming relativistic neutrinos

For specific realization of "dark" neutrino mass, see:
Capozzi, Shoemaker and Vecchi (JCAP, 2018)
Choi, Chun and Kim (Phys.Dark Univ., 2020)
Huang, Lindner, Martinez-Mirave and Sen (PRD, 2022)
ChoeJo, Kim and Lee (PRD, 2023)
Sen and Smirnov (JCAP, 2024)
Plestid and Tevosyan (2024)
Lee (2024)

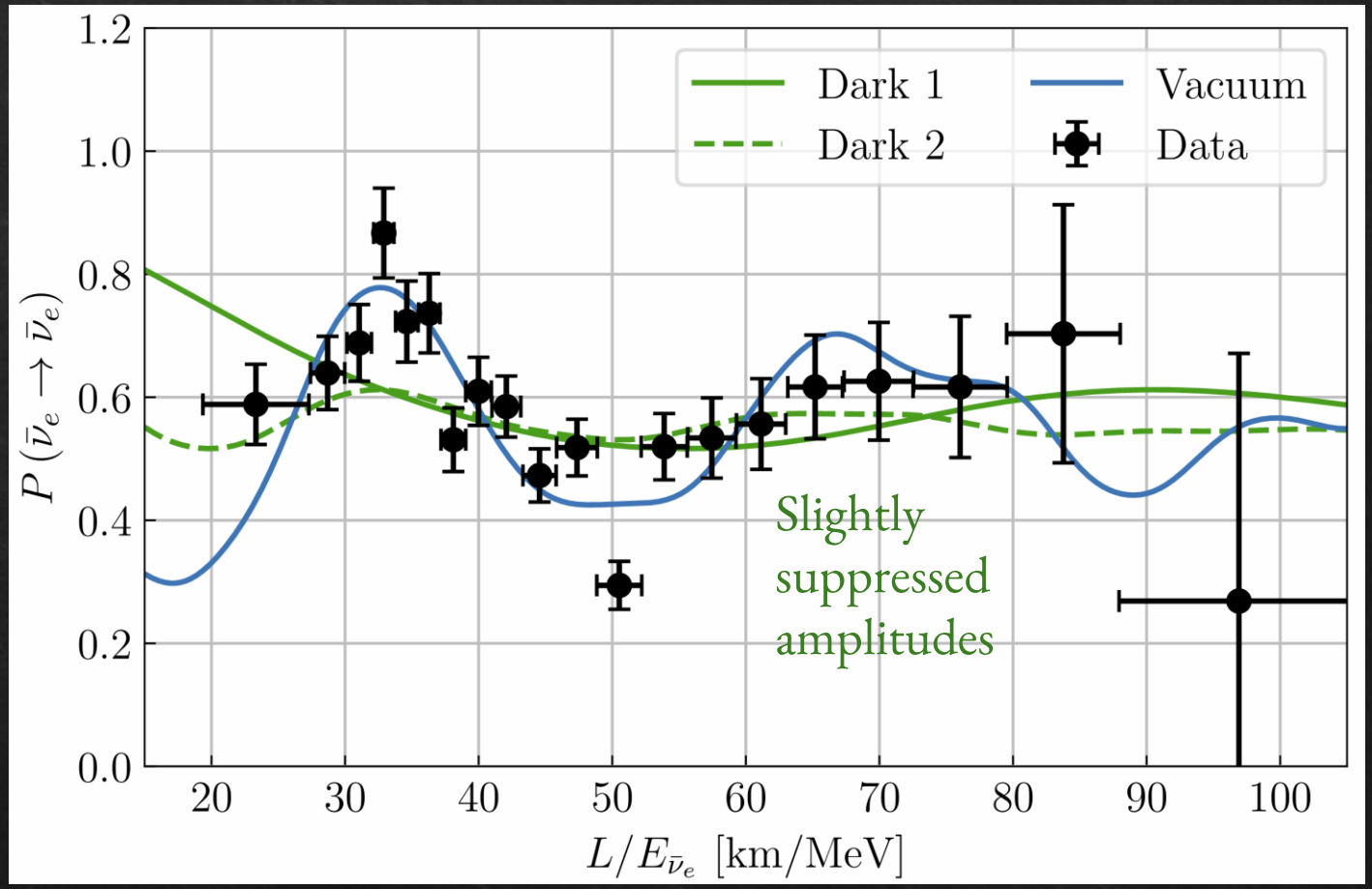
Dark matter mass << 10^{-14} eV

$$T_{\rm exp} \sim \mathcal{O}(10)\text{days}$$

$$T_{\rm exp} \gg \frac{\pi}{m_\phi}$$

$$T_{\rm exp} \ll t_{\rm dB}$$

- Time averaged probabilities
- Constant amplitudes



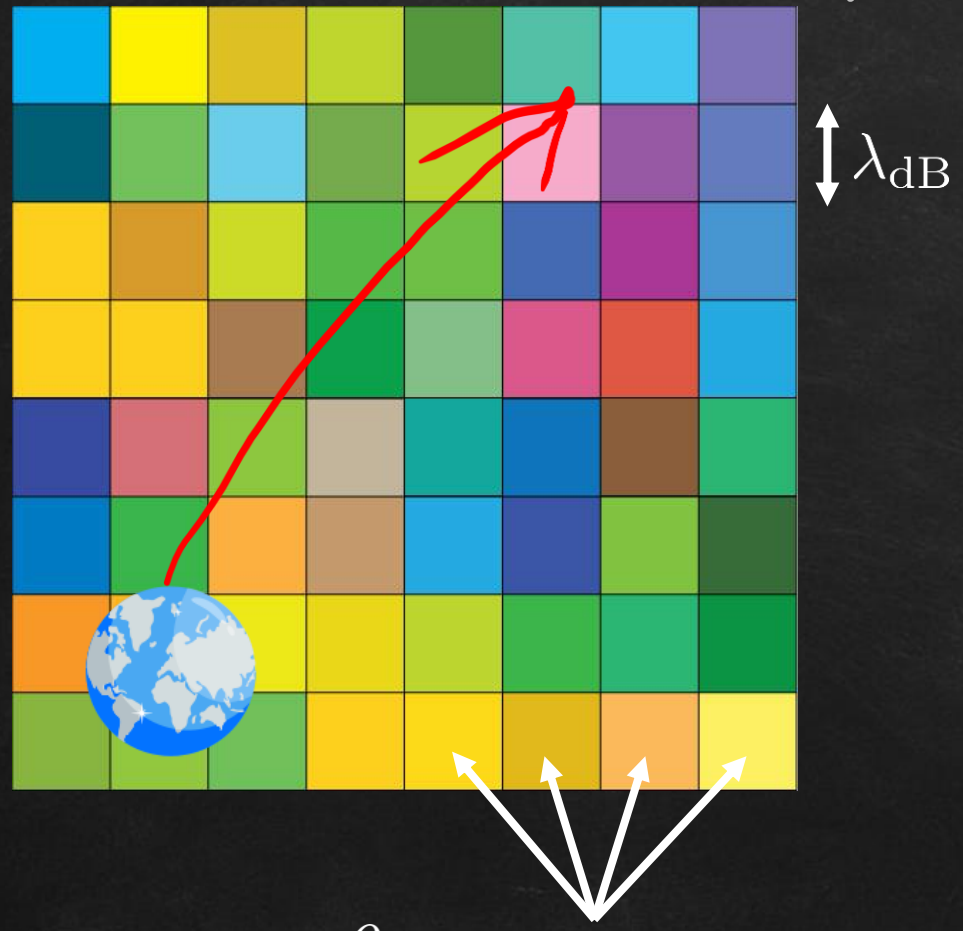
Vacuum mass is favored at 4.5σ

Data from KamLAND experiment

Dark matter mass >> 10^{-14} eV

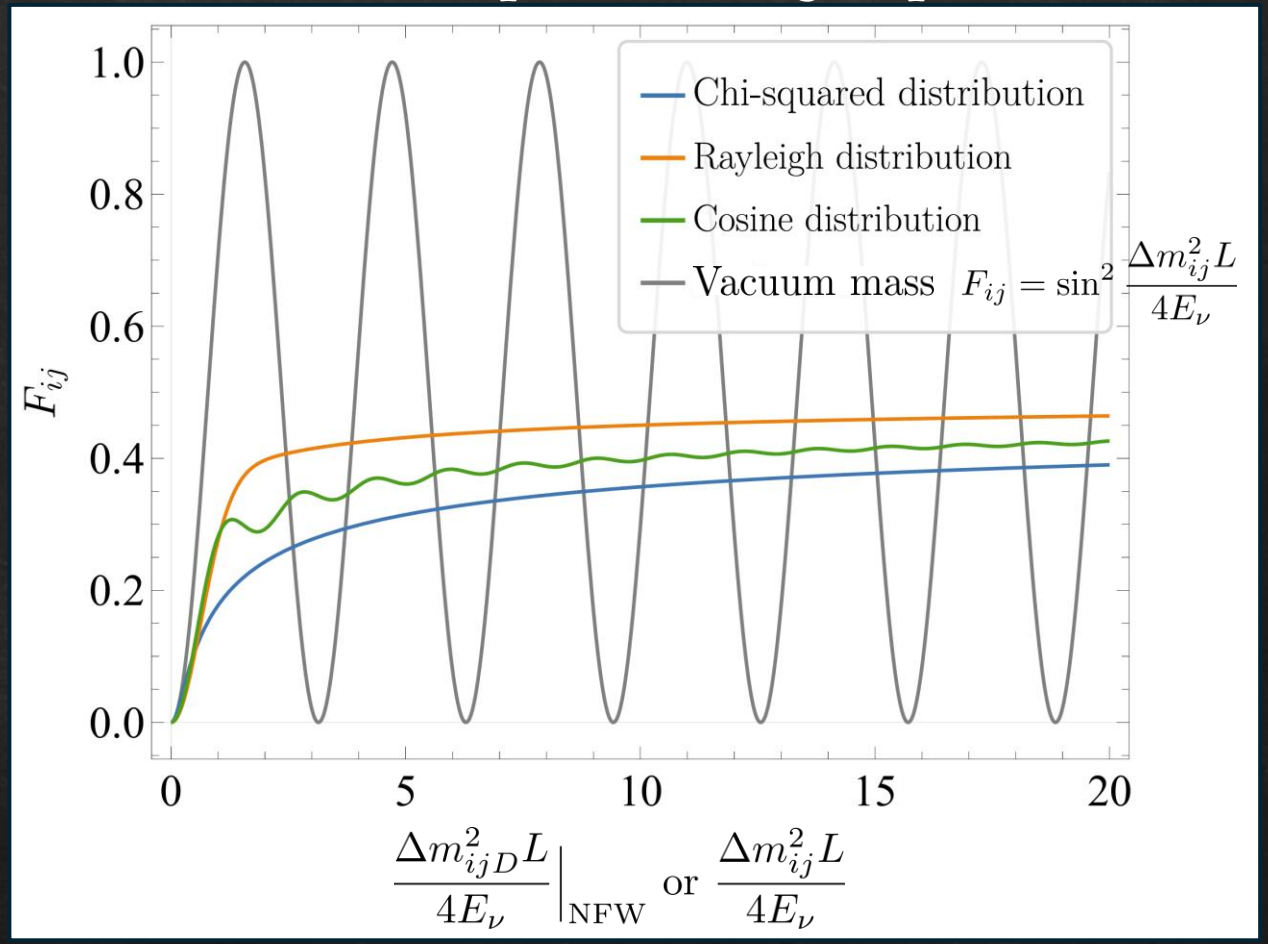
$T_{\rm exp} \gg t_{\rm dB}$

Colors: Values of dark matter density



$$\frac{\rho_{\rm dm}}{\rho_{\rm NFW}} \sim \text{random}$$

Both time- and space-averaged probabilities



Oscillation amplitudes are suppressed in a model-independent way