

An on-shell perspective on neutrino oscillations and non-standard interactions

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Basic idea

- Apply on-shell formalism to neutrino oscillations.
- Complementary to other approaches based on QFT and QM.

Features

- No fields and Lagrangians, only amplitudes:

$$\cancel{\mathcal{L}} \quad \cancel{\phi(x)} \quad \mathcal{M}$$

- Only particles and symmetries as inputs:

$$\nu, W, e, SU(2)_L \times U(1)_Y, U(1)_{EM}$$

Features

- Production and detection 3 point amplitudes are completely fixed by Lorentz invariance:

$$\mathcal{M}(\nu \bar{e} W) = \text{fixed}$$

- This amplitude includes all possible new physics effects.

Features

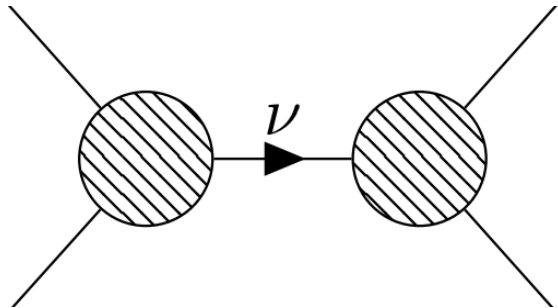
- Connection between EW broken and unbroken phases

$$\mathcal{M}_{\text{massive}} \xrightarrow{\frac{m}{E} \ll 1} \mathcal{M}_{\text{massless}}$$

- Recover the PMNS matrix.
- Takes into account different EFTs: SMEFT and ν SMEFT.

Features

- Oscillation amplitude is computed at tree-level through polology (unitarity+locality):



The diagram shows two shaded circular vertices connected by a horizontal arrow labeled ν . Each vertex has two external lines extending outwards, representing a neutrino propagator at tree level.

$$\simeq \mathcal{M}_P \frac{1}{p^2 - m_\nu^2} \mathcal{M}_D$$

- Near on-shellness of the neutrino is manifest.
- All new physics is parametrized!

Conclusions

- On-shell methods provide new insights on neutrino oscillations.
- Relies strongly on first principles.
- Low-energy amplitudes are all-order expansions in EFTs.

Thanks for the attention!