

Open system approach to neutrinos propagating in a ultralight scalar background

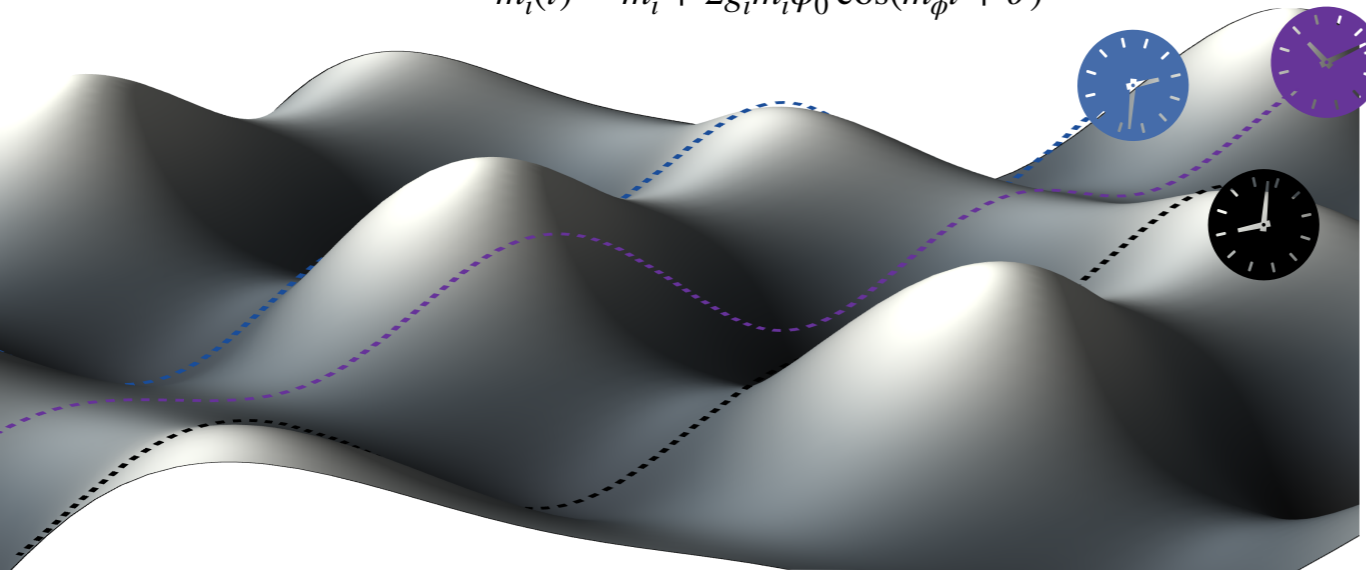
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Neutrino masses become time dependent

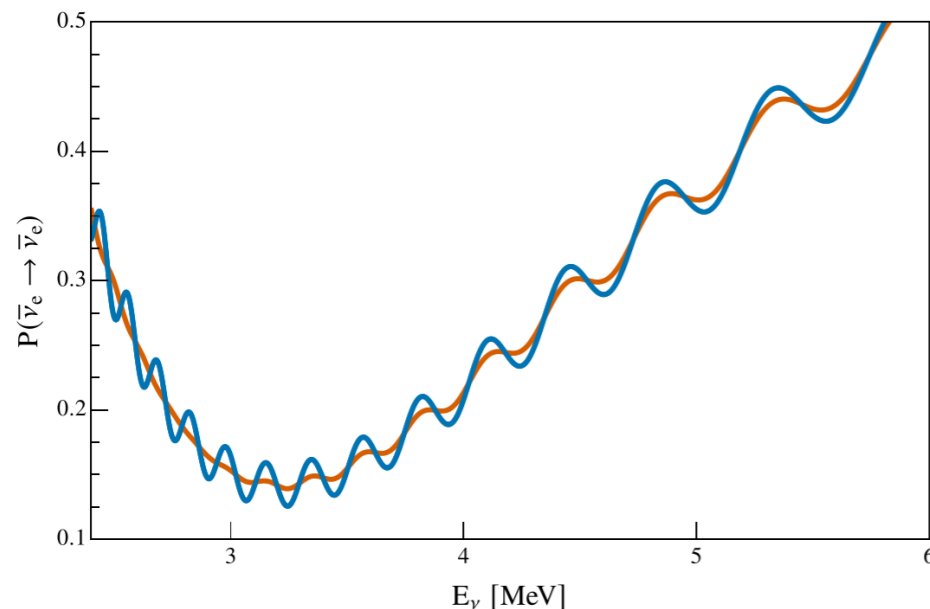
When coupled to a ultralight scalar, neutrino masses acquire a time dependence, with frequency set by the scalar mass. Our work explores the regime where $m_\phi t \ll 1$ for one neutrino, but the field oscillates over the scale of the experimental data taking period.

$$m_i(t) = m_i + 2g_i m_i \phi_0 \cos(m_\phi t + \theta)$$



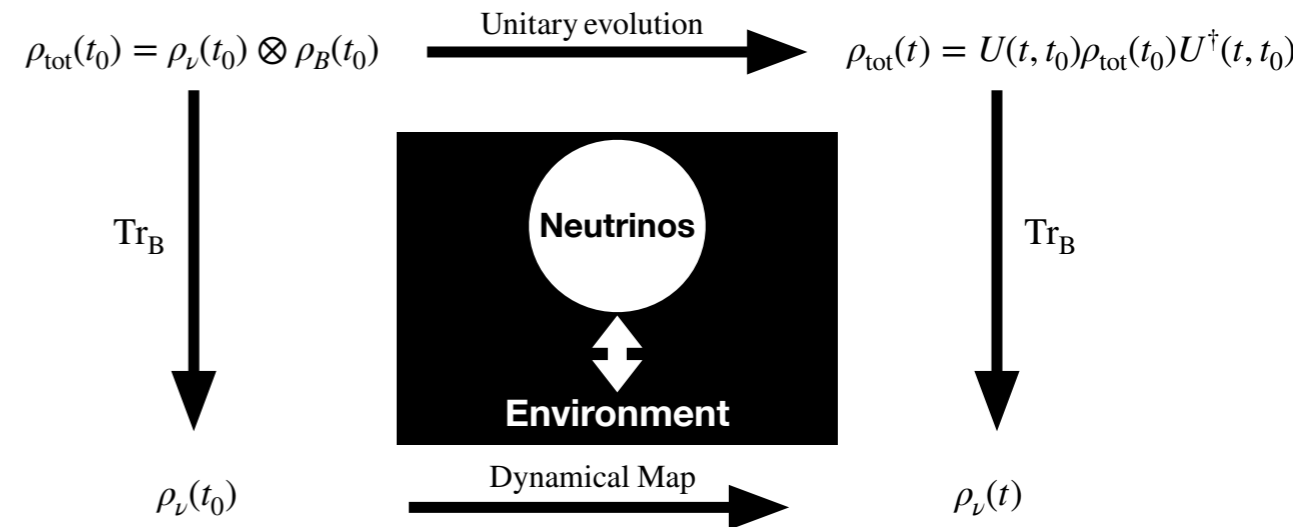
Reduced dynamics

$$\frac{\partial \bar{\rho}(t)}{\partial t} = -i[H_0, \bar{\rho}(t)] - \frac{\phi_0^2 t}{2E^2} \left(\{\hat{A}_\nu^\dagger \hat{A}_\nu, \bar{\rho}(t)\} - 2\hat{A}_\nu \bar{\rho}(t) \hat{A}_\nu^\dagger \right), \hat{A}_\nu = \hat{g} \hat{m}_\nu$$



Open system framework

The open system approach is useful when we want to follow only the neutrino degrees of freedom, treating the scalar as a static background. It modifies the unitary dynamics so that the neutrino evolution still accounts for the interaction with the scalar field.



Ultralight background

$$\exp \left[-\frac{(\eta \Delta m^2)^2 L^2}{E^2} \right]$$

Wave packet

$$\exp \left[-\frac{|\Delta m^2| L^2}{32 \sigma_x^2 E^4} \right]$$

General approach

$$\exp \left[-\Gamma_0 \left(\frac{E}{E_0} \right)^n L \right]$$

$$P(\nu_\alpha \rightarrow \nu_\beta) = \frac{1}{2} \sin^2(2\theta_{12}) + \exp \left(-\frac{\eta^2 (\Delta m^2)^2 L^2}{E^2} \right) \sin^2(2\theta_{12}) \cos(2\Delta_{21})$$

Summary for people in a hurry:

- We considered neutrinos propagating through an ultralight scalar background.
- We cast the dynamics in an open system framework.
- The formalism predicts an exponential damping of neutrino oscillations scaling as L^2/E^2 .
- This provides a concrete mapping between the open system approach to neutrino oscillation and model parameters.