Problems

Xun-Jie XU

Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China

■ Problem 1 (for students interested in experimental physics):

Compute the total event numbers of reactor and solar neutrinos elastically scattering off ^{12}C at the JUNO far detector with 1 year $\times$ 20 kt exposure.

Suggestions:

For simplicity, you can assume (i) monochromatic fluxes; (ii) zero detection threshold of nuclear recoils; (iii) the number of $^{12}\mathrm{C} \approx 20\ \mathrm{kt}/m_{\mathrm{atom}}$ with $m_{\mathrm{atom}} \approx 12$ GeV. Note that these assumptions may be far from realistic. So you are encouraged to explore further with more realistic assumptions.

■ Problem 2 (for students interested in theoretical physics):

Given the following toy model,

$$\mathcal{L} = \overline{\psi}(i\partial\!\!\!/ - m_\psi)\psi + \frac{1}{2}(\partial_\mu\phi)^2 - y\overline{\psi}\phi\psi\,,$$

compute the cross section of $\phi + \langle\psi\psi\rangle \to \phi + \langle\psi\psi\rangle$ where $\langle\psi\psi\rangle$ denotes the bound state of two ψ particles due to the yukawa interaction $y\overline{\psi}\phi\psi$.

Suggestions:

For simplicity, you can assume that (i) ϕ is massless; (ii) $\langle\psi\psi\rangle$ is in the ground state, with the center of mass at rest. You are also encouraged to draw a plot to quantitatively illustrate the loss of coherence, e.g. a plot showing how the total cross section varies when the energy of the incoming ϕ increases from very low to very high values.