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Oscillation Physics with Reactor Antineutrinos in JUNO

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The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation, multi-purpose neutrino experiment currently under construction in the South of China. Located in an underground laboratory 700 meter deep (1800~m.w.e.), JUNO features a 20-kiloton liquid scintillator (LS) target enclosed in a 35.4-meter-diameter acrylic sphere. The central detector is instrumented with 17,612 20-inch and 25,600 3-inch photomultiplier tubes, providing about 78% optical coverage.

JUNO's primary goals are to determine the neutrino mass ordering (NMO) and to perform high-precision measurements of the oscillation parameters Δm^2_{21} and $\sin^2(\theta_{12})$, using reactor antineutrinos emitted by eight nuclear reactors located approximately 52.5~km away. The detector's design is optimized to achieve an unprecedented energy resolution of 3% at 1~MeV and to have an uncertainty on non-linearities in the energy scale to better than 1%.

Thanks to its optimized baseline, which corresponds to the first solar oscillation maximum, JUNO can simultaneously probe both solar and atmospheric oscillation effects. The energy-dependent phase shift in the oscillated spectrum provides sensitivity to the NMO in vacuum-dominant conditions, enabling a 3σ determination with about 7 years of data-taking, corresponding to an exposure of 6.5~years~$\times$~26.6~$\mathrm{GW_{th}}$.

Furthermore, JUNO's large target mass and excellent energy resolution will allow it to independently measure four oscillation parameters (Δm^2_{21}, Δm^2_{31}, $\sin^2(\theta_{12})$, and $\sin^2(\theta_{13})$) reaching sub-percent precision for the first three, within the first two years of data taking.

This talk will focus on probing neutrino oscillation physics with reactor antineutrinos in JUNO and its potential in this new era of sub percent measurements in the neutrino sector.

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