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The Role of Nuclear Physics in Neutrino Oscillation Experiments

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Neutrino oscillation experiments have revealed that neutrinos have mass, providing the first clear evidence of physics beyond the Standard Model. These experiments are essential to achieve key goals in neutrino physics, such as measuring the CP-violating phase, determining neutrino mixing angles and mass ordering, and probing possible new physics. Future facilities such as DUNE and Hyper-Kamiokande aim to obtain these measurements with unprecedented precision.

In current and future accelerator-based neutrino experiments, detectors are composed of complex nuclei such as oxygen, carbon, or argon. Because neutrino beams are not monochromatic, a detailed understanding of neutrino–nucleus scattering across a broad energy range is essential to reduce systematic errors in neutrino energy reconstruction and oscillation analyses.

Reliable predictions of these interactions require advanced nuclear models that account for various nuclear effects. The relativistic mean-field (RMF) model provides an independent-particle description of the nucleus within a microscopic, quantum-mechanical framework, allowing consistent assessment of nuclear effects across different interaction channels.

In this talk, I will discuss several nuclear effects relevant to neutrino–nucleus cross sections at low and intermediate energies within the relativistic mean-field framework, focusing on quasielastic and single-pion production processes that are particularly important for neutrino oscillation experiments.

L. Alvarez-Ruso et al., Progress in Particle and Nuclear Physics 100 (2018)

R. González-Jiménez et al., Phys. Rev. C 100, 045501 (2019).

T. Franco-Munoz et al., Phys.Rev.C 108, 064608 (2023).

J. García-Marcos et al., Phys.Rev.C 109, 024608 (2024).

T. Franco-Munoz et al., J.Phys.G 52, 025103 (2025).

Abstract

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