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Neutrino interactions importance to Nuclear Physics

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We review the general interplay between Nuclear Physics and neutrino-nucleus cross sections at intermediate and high energies. As motivation for the more specific talks that will be given on the corresponding workshop sessions, we first introduce the general formalism of neutrino scattering from nuclei and define the observables of interest for nuclear physics such as response functions, asymmetries and polarization observables. Very general and useful properties of cross sections and response functions and their connection to electron scattering and scaling will be briefly described. We then introduce the different nuclear models and theoretical ingredients of relevance for neutrino reactions at the energy regime of interest. Some of the nuclear and reaction mechanism ingredients that will be discussed using those models are electro-weak current matrix elements, long Range nuclear correlations (RPA), final state interactions (FSI), finite-size effects, Coulomb corrections, and relativistic effects. Theoretical results will be shown for different reaction channels, charge-changing and neutral current quasielastic scattering, Delta excitation and coherent pion production, for kinematics going from low to high energy and for different kind of observables and reactions, inclusive cross sections, integrated cross sections, angular distributions, polarization observables, etc. Nuclear models for which we will show results are Local Fermi Gas (LFG), Relativistic Fermi Gas (RFG), Shell Model (SM), Relativistic Mean Field (RFG) and Super-Scaling Analysis (SuSA) model. Some particular topics that we will briefly discuss are theoretical uncertainties on the ratios of interest for experiments on atmospheric neutrinos, influence of strangeness content inside the nucleon on neutral current scattering, nuclear effects on lepton polarization, and predictions of flux-averaged coherent pion production cross sections at T2K and MiniBoone energies.

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