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First results from a relativistic mean field theory implemented in the NEUT neutrino interaction event generator

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Neutrino oscillation experiments, such as the Tokai to Kamioka (T2K) experiment, are limited by their simulation of accurate neutrino-nucleus interactions. More in-depth theoretical knowledge of neutrino-nucleus interactions are paramount; however, implementing such knowledge in existing event generator frameworks is just as imperative. To evaluate neutrino-nucleus interactions a general framework for the relativistic nuclear many-body problem is required; this framework can be calculated to arbitrary accuracy and compared with experimental measurements.

A relativistic nuclear model containing interacting nucleons with mesons was proposed by Walecka [J.D. Walecka, Annals Phys. 83 (1974) 491-529] and is based on quantum field theory. The model is complex and computationally expensive; however, it can be approximated at higher densities by using a mean field approach in which the meson field operators are replaced by their respective expectation values. The resulting model, relativistic mean field theory (RMF), can be used to describe medium to high density nuclei through Dirac-Hartree calculations [C.J. Horowitz, Brian D. Serot, Nucl. Phys.A 368 (1981) 503-528] of the nuclear bound state. This method can be exactly solved for spherically symmetric nuclei such as ^{12}C, ^{16}O and for some nearly-spherically symmetric nuclei such as ^{40}Ar—the target nuclei used in neutrino experiments. The RMF model [R. González-Jiménez *et al.*, Phys. Rev. C 100 (2019) 4, 045501] [R. González-Jiménez *et al.*, Phys. Rev. C 101 (2020) 1, 015503] has already been used to evaluate electron and neutrino scattering on different nuclei. The RMF bound state model can then be coupled with the nucleon scattered state (the solution of the Dirac equation with a complex optical potential) to predict the hadronic current in lepton-nucleus scattering.

This talk presents the first work in implementing an RMF neutrino interaction model into the NEUT neutrino interaction event generator framework. This can provide a first glimpse into calculating an exclusive cross section using an neutrino interaction event generator and can provide the T2K experiment with a more theoretically robust model upon which to study systematic uncertainties.

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