Neutrino Oscillation and the PMNS Matrix

Neutrino oscillation is a phenomenon where a neutrino oscillates into a different flavor, and it is characterized by four independent constants, which determine the elements of the PMNS matrix. Measuring the values of the PMNS matrix is of extreme importance, and many future experiments are being built for this purpose.

Quasi-Elastic Scattering

Measuring the elements of the PMNS matrix requires predicting how many neutrinos will interact in a detector. Current models give poor estimations, so our project entailed improving predictions for quasielastic scattering. In quasielastic scattering, a lepton interacts elastically with a single nucleon; because this reaction mechanism is the simplest, it allows us to easily discriminate between different models.

Nuclear Spectral Function

Commonly, simple Fermi gas-like distributions are used to approximate the distribution of nucleon energy and momentum; however, these approximations agree poorly with scattering data. Instead, we use a Spectral Function, computed from first principles, that gives a more realistic distribution of nucleon energy and momentum. The Spectral Function also includes the physics of correlated pairs of nucleons.

Electron Scattering Data

Currently, we are unable to generate a mono-energetic beam of neutrinos, so we need to be able to accurately predict the initial neutrino energy from scattering data. To test the accuracy of our model’s predictions, we have our model estimate the initial electron energy from scattering data produced by a mono-energetic electron beam. By checking how close our model’s predictions are to the known beam energy, we can measure its ability to predict initial neutrino energy.

GENIE Simulations

To compare different models of lepton-nucleus scattering, we used GENIE, a lepton-nucleus event generator. After we implemented the Spectral Function model into GENIE, we produced plots to compare this model with the more simplistic default GENIE model.

Future Work

The Spectral Function model allows for more accurate simulations of electron and neutrino scattering, and testing this model against electron scattering data has returned promising results. In the future, we hope to extend this model with more interaction channels and test against neutrino scattering data.

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