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Precise predictions for high-energy neutrino propagation in matter

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High-energy neutrinos represent a key pillar of multi-messenger astronomy and offer significant opportunities to advance fundamental physics. The interpretation of the results from high-energy neutrino detection experiments requires a good understanding of the attenuation processes that they undergo as they travel through the Earth. Here we present a novel framework, NuPropEarth, to evaluate the impact of matter effects in the propagation of high energy neutrinos. Precise calculations of the neutrino-nucleon cross- sections with state-of-the-art perturbative and non-perturbative inputs are provided by the HEDIS module of GENIE. We adopt proton parton distribution functions (PDFs) constrained by charm production from LHCb that can be reliable applied down to small values of Bjorken x. We compare our calculations with other publicly available tools such as NuFate and NuTauSim, and trace back the origin of eventual differences. We quantify the dependence of the resulting neutrino attenuation with respect to the Earth model, the incidence angle, and the spectral index of the incoming flux. For the first time, we assess the impact of nuclear corrections in the attenuation rates and demonstrate that these now represent the dominant source of theoretical uncertainties. Our results provide an important contribution to the scientific harvest of ongoing and next-generation high-energy neutrino detection experiments.

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