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On the uncertainty of CEvNS cross sections

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To consistently incorporate radiative corrections in coherent elastic neutrino-nucleus scattering (CEvNS), we develop and apply an effective field theory framework to provide precise predictions for CEvNS cross sections and neutrino flavor-dependent cross-section ratios for spin-0 nuclei. Additionally, I analyze (anti)neutrino energy spectra from radiative muon, pion, and kaon decays, which serve as key (anti)neutrino sources. I present the comprehensive error budget accounting for uncertainties at the nuclear, nucleon, hadron, and quark levels, with a perturbative error added in quadrature. In the 20-100 MeV energy range, the dominant uncertainty arises from the neutron distribution inside nuclei, while at lower energies, hadronic contributions become the primary limitation. In this update, I refine the treatment of hadronic uncertainties in CEvNS cross sections at very low energies, significantly reducing the current error estimate. These improvements have direct implications for all neutral-current processes in this energy regime, including parity-violating electron scattering, (anti)neutrino-electron scattering, and atomic parity violation.

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