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Exploiting electron parity violation: from Standard Model tests to dark matter detection predictions

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There has been recent interest in low energy, high luminosity polarized electron beams for studies of parity-violating electron scattering, such as the MESA accelerator at Mainz or an upgraded FEL facility at Jefferson Lab. Accurate measurements of the parity-violating asymmetry in elastic electron scattering from nuclei can be used to determine Standard Model couplings, such as the weak-mixing angle, or higher-order radiative corrections, as well as to extract specific information on the nuclear and nucleon structure. To this end, low uncertainties are required from modeling some confounding nucleon and nuclear structure effects, including isospin mixing, nucleon strangeness content or Coulomb distortion. We estimate the sizes and theoretical uncertainties of such effects for a proton and a carbon 12 targets. An experimental precision in the asymmetry of a few tenths of a percent may be reachable under certain kinematic conditions, that are also discussed here for the same nuclear target.

This high precision parity-violating asymmetry in elastic electron scattering can also be used to relate in a very simple manner the elastic electron-nucleus scattering cross section with the elastic weak-neutral neutrino-nucleus cross section for even-even targets or, more generally, for any target in coherent scattering. This novel relationship allows us to exploit experimentally well-determined quantities (related to electron-nucleus scattering) to predict as-yet unknown observables (weak neutral neutrino-nucleus cross sections). This idea is simply extended to link electron scattering to an even more uncertain magnitude: the detection rate of weak-interacting massive particles, that are dark matter candidates.

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