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Exact Two-Photon Exchange Contribution to Elastic Lepton-Proton Scattering: A Low-energy Effective Theoretical Approach

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We evaluate the exact two-photon exchange (TPE) correction to the unpolarized elastic lepton-proton scattering at small momentum transfer using a low energy effective field theory, heavy baryon chiral perturbation theory. The infrared divergent four- point box diagram with one heavy proton propagator is evaluated analytically via dimensional regularization. We present a numerical comparison of the finite (physical) part of our exact result with one based on the widely used soft-photon approximation. It is found that the exact contributions are around 150-200% more than the SPA contribution depending upon the beam energy and lepton mass. We estimate the charge asymmetry for both electron-proton and muon-proton scattering in the MUSE kinematic region.

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