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Deuteron VVCS and nuclear structure effects in muonic deuterium at N3LO in pionless EFT

We calculate the forward unpolarised doubly-virtual Compton scattering (VVCS) off the deuteron in the framework of pionless effective field theory, up to next-to-next-to-next-to-leading order (N3LO) for the longitudinal and next-to-leading order (NLO) for the transverse amplitude. The charge elastic form factor of the deuteron, obtained from the residue of the longitudinal VVCS amplitude, is used to extract the value of the single unknown two-nucleon one-photon contact coupling that enters the longitudinal amplitude at N3LO.

Using the obtained deuteron VVCS amplitude as a high-precision model-independent input, we examine the two-photon-exchange (TPE) corrections to the Lamb shift of muonic deuterium, and find substantial differences with the recent dispersive evaluations. Namely, the elastic contribution appears to be larger by several standard deviations, thus ameliorating the current discrepancy between theory and experiment on the size of TPE effects. We investigate the correlation between the values of the deuteron charge and Friar radii and argue that it can be used to judge on the quality of a parametrisation of the deuteron charge elastic form factor. We also study other related effects, such as the TPE contribution to the proton-deuteron isotope shift and the spin-independent deuteron generalised polarizabilities.

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