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Proton polarisability contribution to the Lamb shift in muonic hydrogen at fourth order in chiral perturbation theory¹

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The recent determination of the proton charge radius from the Lamb shift in muonic hydrogen [1] gives a value that differs by many standard deviations from the CODATA value [2] and from the results of recent electron scattering experiments [3]. In the theoretical calculations [4], the least-well-determined contribution is the “proton polarisability” contribution. This is the part of the two-photon exchange which involves proton excitations. The dominant effect can be determined via dispersion relations from the proton structure functions, but a subtraction term remains [5,6]. This subtraction term is the amplitude $T_1(0, Q^2)$ for forward, zero-energy, doubly-virtual Compton scattering, which we calculate in heavy-baryon chiral perturbation theory, to fourth order in the chiral expansion and with the leading contribution of the $\gamma N \Delta$ form factor. This provides a model-independent expression for the amplitude in the low-momentum region, which is the dominant one for its contribution to the Lamb shift, and allows us to significantly reduce the theoretical uncertainty in the latter [7].

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¹Work carried out with M. C. Birse