Nuclear structure effects in the Lamb shift of μH and μD

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This presentation concentrates on the two-photon-exchange corrections to the Lamb shift in muonic hydrogen (μH) and muonic deuterium (μD). These effects are the subleading $O(\alpha^5)$ and higher effects of the nuclear structure, and their detailed knowledge is necessary, for instance, for a precise extraction of the nuclear radii from the Lamb shift in muonic atoms [1].

In an ideal case, the bulk of these effects can be extracted from the data on the inclusive electron scattering off the respective nucleus, using the dispersion relations [2]. Specifically, the two-photon-exchange contributions are connected to the spin-independent nuclear structure functions that encode the unpolarised inclusive electron scattering cross section [2]. However, there is a part, the subtraction contribution, that arises due to a subtraction in the dispersion relation and thus cannot directly be inferred from experimental data. This term is particularly important in μH, and one way to quantify it is using the covariant baryon chiral effective field theory (BχEFT).

In heavier muonic atoms, starting from μD, the purely nuclear subtraction contribution is convergent [3], while the contributions of individual nucleons are suppressed. However, the quantity and quality of the data on the nuclear structure functions are not satisfactory, which makes ab initio calculations of the two-photon-exchange contributions the preferable method [4].

In this presentation, I will discuss the results obtained for the two-photon-exchange effects in μH based on BχEFT, concentrating on the subtraction contribution [5]. Furthermore, I will discuss the respective results for μD, calculated in the pionless effective field theory [6, 7], with emphasis on the single-nucleon contribution (which, in turn, is based on the BχEFT results for μH). In particular, I will stress that the subtraction contribution dominates the theoretical uncertainty in μH, and that the single-nucleon two-photon exchange, despite being suppressed compared to the purely nuclear effects, is significant in μD. The latter effect, as well as its uncertainty, is even more important in heavier muonic atoms. This provides a strong motivation for further studies aimed at constraining the electromagnetic properties of the nucleons, such as the electric and magnetic polarisabilities.

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