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New insights into the proton radius puzzle and nuclear structure from muonic deuterium

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In 2010 the CREMA collaboration measured the rms charge radius of the proton via laser spectroscopy of the 2S-2P Lamb shift in muonic hydrogen [1, 2]. Very recently the charge radius of the deuteron was determined [3]. Both measurements yield very precise charge radii but both values result 7 standard deviations away from the expected values, given by CODATA [4]. Follow-up measurements of the Lamb shift in muonic helium-3 and -4 ions have also been performed [5]. However, the data analysis is still ongoing and the theory needed for the extraction of the charge radii is not complete yet.

In this talk our recent result, the new deuteron charge radius will be discussed. Furthermore an outlook towards our upcoming results from muonic helium will be given. For muonic deuterium as well as for muonic helium an update on the recent progress in theory is presented where remaining questions are discussed and apparent inconsistencies between different sources especially in the two-photon exchange (TPE) contributions are resolved. These TPE contributions are of particular interest as they limit the accuracy of the extracted charge radii.

The results shown in this talk shed new light on the proton radius puzzle and give new insights in nuclear structure contributions.

[1] R. Pohl et al. - The size of the proton, Nature 466, 213 (2010)

[2] A. Antognini et al. - Proton Structure from the Measurement of 2S-2P Transition Frequencies of Muonic Hydrogen, Science 339, 417 (2013)

[3] R. Pohl et al. - Laser spectroscopy of muonic deuterium, Science 353, 6300 (2016).

[4] P.J. Mohr et al. - CODATA recommended values of the fundamental physical constants: 2010, Rev. of Mod. Phys. 84, 1527 (2012)

[5] A. Antognini et al. - Illumination the proton radius conundrum: the μHe^+ Lamb shift, Can.J.Phys. 89, 47-57 (2011)

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