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Laser spectroscopy of muonic atoms and the proton charge radius

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Laser spectroscopy of muonic hydrogen [1,2] yielded a proton rms charge radius which is 4% (or ~ 6 sigmas) smaller than the CODATA value [3]. This discrepancy is now called the “proton radius puzzle” [4]. Also the deuteron charge radius from muonic deuterium [5] is 6 sigmas smaller than the CODATA value, but consistent with the smaller proton inside the deuteron.

These smaller charge radii, when combined with precision measurements of the 1S-2S transitions in regular (electronic) hydrogen [6] and deuterium [7], yield a 6 sigmas smaller value of the Rydberg constant [8], compared to the CODATA value.

In this talk I will report about a new measurement of the Rydberg constant from the 2S-4P transition in regular hydrogen performed in Garching [9], which supports the smaller, “muonic” value. Even more recently, a new measurement of the 1S-3S transition in Paris, however, confirmed the larger proton radius [10].

The situation is further complicated by new measurements in electronic and muonic helium. I will attempt to give an overview of the situation.

- [1] Pohl et al. (CREMA Coll.), Nature 466, 213 (2010)
- [2] Antognini et al. (CREMA Coll.), Science 339, 417 (2013)
- [3] Mohr et al. (CODATA 2014), Rev. Mod. Phys. 88, 035009 (2016)
- [4] Hill, EPJ Web Conf. 137, 012023 (2017)
- [5] Pohl et al. (CREMA Coll.), Science 353, 669 (2016)
- [6] Parthey et al., PRL 107, 203001 (2011)
- [7] Parthey et al., PRL 104, 233001 (2010)
- [8] Pohl et al., Metrologia 54, L1 (2017)
- [9] Beyer et al., Science 358, 79 (2017)
- [10] Fleurbaey et al., arxiv 1801.08816 PRL, accepted (2018)

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