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# Nuclear structure from laser spectroscopy of light muonic atoms and ions

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Marc Diepold for the CREMA collaboration (*)

Muonic atoms and ions are hydrogen-like systems that are formed when negative muons are stopped in ordinary matter, replacing all of the atom's electrons by a single muon. The muon's Bohr radius is 200 times smaller than the corresponding electronic Bohr radius in ordinary H-like ions due to the 200 times larger mass of the muon. This results in a increased sensitivity (200^3) to the finite charge and magnetic radius of the nucleus.

We have recently determined the proton charge radius by laser spectroscopy of the 2S-2P transition ("Lamb shift") in muonic hydrogen [1,2]. Our value of Rp=0.84087(39) fm is ten times more accurate, but 7 sigma discrepant from the world average, which is based on elastic electron-proton scattering and precision spectroscopy of electronic hydrogen. This so-called "proton radius puzzle" has sparked great interest in both atomic and nuclear physics [3]. Physics beyond the Standard Model has also been
proposed to solve the problem.

To shed new light on this discrepancy, we have measured the Lamb shift in muonic deuterium and extracted a value of the charge radius of the deuteron. In addition, our most recent experiment [4] has succeeded to measure the Lamb shift in both the mu4He+ and mu3He+ ions, and will be able to provide a ten times more accurate value for the charge radii of the lightest helium isotopes.

(*) Charge Radius Experiment using Muonic Atoms

[1] R. Pohl et al. (CREMA coll.), Nature 466, 213 (2010).
[2] A. Antognini et al. (CREMA coll.), Science 339, 417 (2013).
[3] R. Pohl et al., Ann. Rev. Nucl. Part. Sci 63 (2013) (review in advance).
[4] A. Antognini et al. (CREMA coll.), Can. J. Phys. 89, 47 (2011).

**Primary author:** Mr DIEPOLD, Marc (Max Planck Institut für Quantenoptik)

**Presenter:** Mr DIEPOLD, Marc (Max Planck Institut für Quantenoptik)