High resolution spectroscopy of 1S-3S transition in hydrogen

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The aim of our experiment is a new determination of the proton charge radius Rp from high resolution spectroscopy on hydrogen. The proton is the simplest stable hadronic system and a precise knowledge of its properties has fundamental interests. Today the proton charge radius is determined by three different methods:
Low energy electron scattering. A thorough analysis of all the scattering data has been made by I. Sick. The result is Rp = 0.895 (18) fm. A new determination has also been done at Mainz university [1].
Hydrogen spectroscopy. Thanks to the optical frequency measurements and the Doppler free techniques, the energy shift due to the finite size of the proton can be now observed on the spectroscopy of hydrogen. The value of the proton radius extracted from the comparison between the experiment and the theory in hydrogen is Rp = 0.8760 (78) fm.
Spectroscopy of muonic hydrogen. The principle of the experiment is to measure the 2S Lamb shift in muonic hydrogen (an atom formed with a proton and a muon, μ-p). In July 2009, this experiment has been successful. The result is Rp = 0.8409 (4) fm [2]. The figure below summarizes these different determinations of Rp.

The figure 1 shows clearly a discrepancy between the new value deduced from the muonic hydrogen spectroscopy and the previous ones. We aim to contribute to the "proton charge radius puzzle" by measuring the optical frequencies of two transitions in hydrogen, firstly the 1S-3S two photon transition and, secondly, the 1S-4S two photon transition. We realized a new cw-laser source at 205 nm to perform the two-photon spectroscopy of the 1S-3S transition. Light at 894 nm from a titanium-saphir laser is mixed with the fourth harmonic of a ND:YO_4 laser in a BBO crystal (at 266 nm). We obtained up to 15 mW of continuous narrow-band laser source à 205 nm [3]. We observed the 1S-3S transition and deduced its center frequency with an uncertainty 4 times better than previous results [4]. I will present this very preliminary result and the development of a liquid nitrogen cooled hydrogen beam.

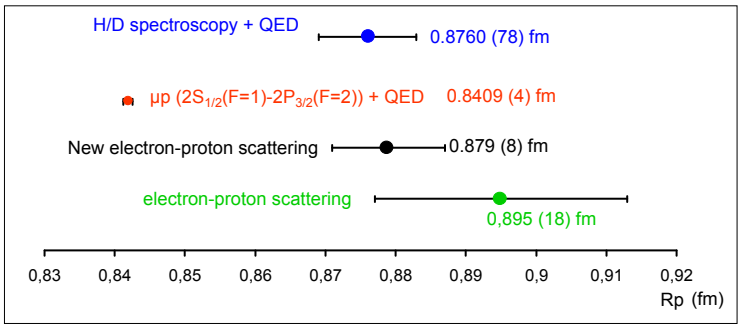

Figure 1: *The different determinations of the proton charge radius.*

References

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