Contribution ID: 148

Type: Parallel

## The Rydberg Constant and Proton Size from Atomic Hydrogen

Saturday, 2 June 2018 16:40 (30 minutes)

Precision measurements of atomic hydrogen (H) have long been successfully used to extract fundamental constants and to test bound-state quantum electrodynamics. Both the Rydberg constant  $R_{\infty}$  and the proton root mean square charge radius  $r_{\rm p}$  can be determined by H spectroscopy, requiring the measurement of at least two transition frequencies. With the very precisely measured 1S-2S transition frequency serving as a corner stone [1], the current limitation is the measurement precision of other H transition frequencies. Moreover, the CODATA 2014 value [2] for  $r_{\rm p}$ , containing the H spectroscopy world data and elastic scattering results, disagrees by 5.6 standard deviations ( $\sigma$ ) with the much more precise value extracted from spectroscopy of muonic hydrogen ( $\mu$ p) [3].

Using a cryogenic beam of H atoms optically excited to the initial 2S state, we measured the 2S-4P transition in H with a relative uncertainty of 4 parts in  $10^{12}$  [4]. Combining our result with the 1S-2S transition frequency yields the values of the Rydberg constant  $R_{\infty} = 10973731.568076(96) \text{ m}^{-1}$  and  $r_{\rm p} = 0.8335(95)$  fm. Our  $r_{\rm p}$  value is 3.7 $\sigma$  smaller than the CODATA value, but in good agreement with the  $\mu$ p value.

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[2] P.J. Mohr et al., Rev. Mod. Phys. 88, 035009 (2016).

[3] A. Antognini et al., Science 339, 417 (2013).

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Session Classification: QCDHS / PPHI

Track Classification: QCDHS