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The Rydberg Constant and Proton Size from Atomic Hydrogen

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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_∞ and the proton root mean square charge radius r_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_p, containing the H spectroscopy world data and elastic scattering results, disagrees by 5.6 standard deviations (σ) with the much more precise value extracted from spectroscopy of muonic hydrogen (μp) [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 $R_\infty = 10973731.568076(96)\ \mathrm{m}^{-1}$ and $r_\mathrm{p} = 0.8335(95)$ fm. Our r_p value is 3.7σ smaller than the CODATA value, but in good agreement with the μp value.

[1] C.G. Parthey *et al.*, Phys. Rev. Lett. **107**, 203001 (2011).

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[4] A. Beyer *et al.*, Science **358**, 79 (2017).

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