Measurement of the hydrogen hyperfine splitting in a beam: results & prospects

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The goal of the ASACUSA CUSP collaboration at the Antiproton Decelerator of CERN is to measure the ground-state hyperfine splitting of antihydrogen down to relative precisions of $10^{-6} - 10^{-7}$ using an atomic spectroscopy beamline. A milestone was achieved in 2012 through the successful detection of 80 antihydrogen atoms 2.7 meters away from their production region. This was the first observation of "cold" antihydrogen in a magnetic field free region [1]. However the spectroscopy measurement is currently limited by the low flux of ground state antihydrogen atoms at the exit of the formation region [2].

In parallel to the work on the antihydrogen production, the spectroscopy beamline intended to be used for antihydrogen spectroscopy was tested with a source of hydrogen. This led to a measurement at a relative precision of 10^{-9} which constitutes the most precise measurement of the hydrogen hyperfine splitting in a beam [3]. This measurement also enabled to forecast the necessary conditions to achieve a measurement at the ppm level with antihydrogen.

The hyperfine splitting in hydrogen was determined using extrapolation of one of the ground state hyperfine transitions measured at different external magnetic fields. The apparatus has since been modified to allow simultaneous measurement of two transitions which in principle allows a determination of the zero-field hyperfine splitting will less atoms; something of great interest for the antihydrogen experiment.

I will review the experimental techniques used and the latest results obtained as well as the prospects for further measurements on hydrogen using the same apparatus for tests of Lorentz symmetry.

[1] N. Kuroda *et al.*, Nature Communications **5**, 3089 (2014).
[2] C. Malbrunot *et al.*, Phil. Trans. R. Soc. A **376** 20170273; DOI: 10.1098/rsta.2017.0273 (2018)
[3] Diermaier *et al.*, Nature Communications **8**,15749 (2017)