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The hyperfine structure of antihydrogen

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Low-energy antiprotons are an ideal tool to study fundamental symmetries, especially CPT symmetry, by the precision spectroscopy of exotic atoms containing an antiproton. The investigation of the hyperfine structure of such atoms allows first of all the determination of the antiproton magnetic moment, the most precise value of which was obtained recently by the ASACUSA collaboration at the Antiproton Decelerator of CERN [1], albeit with a precision of order 10^-3.

As a next step, ASACUSA is preparing an experiment to measure the ground-state hyperfine structure GS-HFS of antihydrogen, which promises much higher accuracy because the corresponding quantity for hydrogen is measured to relative precision of 10^−12 in the hydrogen maser. In a first phase a beam of polarized antihydrogen atoms [2] formed by a so-called cusp trap [3] will be used, which will allow the determination of the GS-HFS to better than 10^-6. This accuracy will already be enough to observe an influence of the finite size of the antiproton, provided the magnetic moment of the antiproton is measured independently in a Penningtrap, as it is planned by two other groups at the AD. In a second phase the Ramsey method of separated oscillatory fields will be used to increase the precision by one order of magnitude.

Within the AEgIS collaboration SMI will pursue a third phase, using the ultra-low energy antiproton beam to increase the precision further and to work towards the ultimate goal of performing GS-HFS measurements with an atomic fountain of laser-cooled antihydrogen atoms.

[1] T. Pask et al., Phys. Lett. B 678 (2009) 55.
[2] E. Widmann et al., CERN-SPSC 2003-009., E. Widmann et al., NIM B214 (2004) 31.
[3] Y. Enomoto et al., Phys. Rev. Lett. 105 (2010) 243401.

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