The Baryon-Antibaryon Symmetry Experiment (BASE)

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BASE is a multinational collaboration which is making precision measurements of the proton g-factor [1,2]. We are now building an apparatus at the Antiproton Decelerator (AD) of CERN to make comparison measurements of antiprotons and protons [3]. Such comparisons are interesting because the Standard Model is necessarily symmetric with respect to the combined CPT operation. This symmetry implies exact equality between the fundamental properties of particles/antiparticles. Any measured—and confirmed—violation would constitute a significant challenge to the Standard Model. The precision to which the proton/antiproton magnetic g-factors are known to agree was recently extended (by a competing group) from 10^{-3} to $4.4\cdot10^{-6}$ [4]. This remarkable achievement is a preamble to comparisons at a level of 10^{-9} and beyond, which will be reached using the elegant “double-trap” method.

The exceptionally clean experiment consists of measuring the cyclotron and Larmor frequencies of a single (anti)proton in a Penning trap at 4K, with the g-factor given by $g = 2\nu_L/\nu_c$. The interaction with the trapped particle is primarily through image currents induced in the trap electrodes. These currents—on the level of fA—are coupled into cryogenic detection systems: high-Q resonators with matched, cryogenic preamplifiers. An eigenfrequency of a cold particle is measured by determining the exact location of a notch, due to a single particle, in the thermal noise spectrum of a high quality-factor resonator. Additionally, injected RF power is used to couple motional degrees of freedom, and also to induce spin flips. The cyclotron frequency ν_c is determined by a combination of the three motional eigenfrequencies in the “precision trap,” a Penning trap with highly homogeneous magnetic field. The measurement of the Larmor frequency is more challenging and requires tracing out the spin flip resonance curve. Moreover, although the spin flip drive is applied in the precision trap, the spin state can only be determined by adiabatic transfer to a second Penning trap (the so-called “analysis trap”). This second Penning trap has an intentional inhomogeneity of the magnetic field which causes a slight spin-dependent difference (~200 mHz) in the axial frequency (~1 MHz). These two Penning traps form the heart of the experiment, but additional subsystems are of course required for a functional experiment. These include systems for trapping and storing antiprotons from the AD, cryogenic systems, a highly stable superconducting magnet, low-noise electronics, and temperature stabilization. We will present an overview of the BASE project and current status.

[1] Adreas Mooser *et al*, arXiv:1303.1359 (2013), accepted by PRL
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[3] Stefan Ulmer *et al*, CERN-SPSC-2013-002 ; SPSC-TDR-002 (2013)
[4] Jack DiSciacca *et al*, arXiv:1301.6310 (2013), accepted by PRL