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A ppb measurement of the antiproton magnetic moment

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The combined discrete symmetry under charge, parity and time reversal (CPT) is an important symmetry in the Standard Model of particle physics. It requires that conjugate fermions, such as the proton and the antiproton, have identical properties with charges and magnetic moments of opposite sign. Therefore, high-precision comparisons of proton/antiproton properties challenge the Standard Model, since any deviation would hint to yet uncovered interactions that would act differently on matter and antimatter-conjugates.

The BASE collaboration established a new experiment in the antiproton decelerator of CERN to conduct a high-precision measurement of the antiproton magnetic moment and to provide a stringent test of CPT invariance in the baryon sector. In our experiment, we store single antiprotons in a multi-Penning trap system and measure the frequency ratio of the Larmor frequency to the cyclotron frequency, the frequency ratio providing the magnetic moment of the antiproton in units of the nuclear magneton. Recently, we succeeded in developing a novel multi-trap two-particle scheme for this measurement. The successful implementation of this new method improved the relative precision of the antiproton magnetic moment to the record value of 1.5 ppb [1], which constitutes a 350-fold improvement over our previous measurement [2]. The result is in agreement with our proton magnetic moment value [3] and supports CPT invariance up to an energy resolution of 10^{-24} GeV.

To overcome limitations of previous measurements and to drastically advance our data collection rate, we separated the determinations of the Larmor frequency and the cyclotron frequency onto two particles, which were alternatingly placed in the same homogeneous magnetic field for the magnetic moment measurement. Since the spin quantum transition spectroscopy determination of the Larmor frequency requires an ultra-cold particle with less than 200 mK energy in the radial modes, this measurement scheme became possible after establishing adiabatic particle transport with a heating rate of only a few cyclotron quanta per cycle.

In my presentation, I will present our latest measurement [1], and some other recent developments from the BASE experiment.

[1] C. Smorra et al. Nature 550, 371 (19 October 2017)
https://www.nature.com/articles/nature24048

[2] H. Nagahama et al., Nat. Commun. 8, 14084(2017).

[3] A. Mooser et al. Nature 509, 596 (19 October 2017) (2014).