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Searches for exotic physics by comparing the fundamental properties of protons and antiprotons at BASE

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The Standard Model is the most successful theory in physics. However, it does leave several questions open, such as for example the striking matter-antimatter imbalance in the visible Universe, or the origin of dark matter. These questions can be probed by ultra-high precision comparisons of the fundamental properties of protons and antiprotons, like the charge-to-mass ratio or the magnetic moment, which are the specialties of the BASE collaboration at CERN. To this end, BASE is performing spectroscopy of single trapped antiprotons and protons using superconducting detectors in an advanced cryogenic Penning trap system. The flag result of the BASE collaboration is the measurement of the antiproton magnetic moment with a fractional precision of 1.5 parts in a billion [1], which improved previous measurements by more than three orders of magnitude. We also reported a measurement of the antiproton-to-proton charge-to-mass ratio with a fractional precision of 69 p.p.t. [2], which constitutes one of the most stringent tests of the CPT invariance in the baryon sector. Additionally, the sophisticated experimental setup of the BASE experiment allowed us to contribute to searches of dark matter candidates, by constraining the interaction of antiprotons with axion-like particles (ALPs) [3] and recently, by demonstrating a new method of testing the ALP to photon conversion using our ultra-sensitive superconducting single-particle detectors [4].

In my talk, I will review the recent achievements of BASE, will report on recent progress in improving the frequency resolution of the experiment, and will outline strategies to further improve our high-precision studies of matter-antimatter symmetry to anticipated precision at the parts per trillion level.

[1] C. Smorra et al., Nature 550, 371 (2017).
[2] S. Ulmer et al., Nature 524, 196 (2015).
[3] C. Smorra et al., Nature 575, 310 (2019).
[4] J. A. Devlin et al., Physical Review Letters 126.4 (2021): 041301.

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