Antimatter under the Microscope: High-Precision Comparisons of the Fundamental Properties of Antiprotons and Protons

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According to the Standard Model of particle physics, the Big Bang has produced equal amounts of matter and antimatter. On the other hand, cosmological observations imply that the visible part of the universe is entirely made out of matter. This striking inconsistency, one of the hottest topics of modern physics, inspires experiments to compare the fundamental properties of matter-antimatter conjugates at lowest energy and with high precision. The BASE collaboration at the CERN antiproton decelerator is performing such high-precision comparisons with protons and antiprotons. Using advanced, ultra-stable, cryogenic particle traps and superconducting detectors with single particle sensitivity, we have performed the most precise measurement of the proton-to-antiproton charge-to-mass ratio with a fractional precision of 11 significant digits [1]. In another measurement, we have invented a novel spectroscopy method, which allowed for the first ultra-high precision measurement of the antiproton magnetic moment with a fractional precision of 1.5 parts in a billion [2]. Together with our recent measurement of the proton magnetic moment [3] this improves the precision of previous experiments [4] by more than three orders of magnitude.

In my talk I will review the recent achievements of BASE and will outline strategies to further improve our high-precision studies of matter-antimatter symmetry. In future studies we will profit from the high sampling rate of our experiments and will apply time-base methods to investigate our antimatter datasets for time dependent phenomena imposed by physics beyond the Standard Model.

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