



Contribution ID: 296

Type: Oral Presentation

Precision Test of CPT Symmetry via Ground State Hyperfine Spectroscopy in Antihydrogen at ALPHA

On Behalf of ALPHA Collaboration

CPT symmetry is a fundamental principle in the Standard Model of particle physics. Antihydrogen, the simplest atom of antimatter, is ideal for testing CPT invariance by comparing its properties with those, very well known, of hydrogen. The ALPHA experiment at CERN focuses on producing, confining, and studying antihydrogen. Antihydrogen is synthesized by merging positrons and antiprotons in a Penning–Malmberg trap, with magnetic confinement achieved using a superconducting solenoid and octupole magnets.

We report on the techniques used to measure the hyperfine levels of the antihydrogen 1S state at ALPHA. This measurement is conducted in a non-zero magnetic field configuration, where the energy state degeneracy is fully resolved by the ≈ 1 T field used for antihydrogen confinement. Of the four hyperfine spectral lines, which differ according to the relative spin orientations of the positron and antiproton, only two correspond to trappable states. The hyperfine levels are measured by inducing positron spin-flip transitions from trappable to untrappable states using microwave radiation directed into the trap. Detection of antihydrogen annihilation is performed using a multilayer Silicon Vertex Detector (SVD), capable of reconstructing pion tracks and determining the annihilation vertex. The results obtained during the 2023 and 2024 data-taking campaigns will be presented.

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Session Classification: Parallel session

Track Classification: Fundamental Symmetries and Interactions