Contribution ID: **132** Type: **Talk**

(Anti-)hydrogen spectroscopy for tests of CPT and Lorentz invariance

Friday, November 11, 2022 2:30 PM (30 minutes)

Cold antihydrogen, the bound state of an antiproton and a positron, is an ideal laboratory to test the fundamental CPT symmetry, one of the cornerstones of the Standard Model (SM) of particle physics, by comparing its energy levels to ordinary hydrogen. Hydrogen is one of the best studied atoms experimentally, the two best-known transitions being the 1S-2S two-photon transition and the ground-state hyperfine transition. The ALPHA collaboration at CERN-AD has obtained first experimental results for both transitions in a Penning trap, and ASACUSA is preparing a measurement using a beam. As CPT is strictly conserved in the SM, its observation would immediately point to new physics, e.g., originating from string theory where the CPT theorem is not necessarily valid, or other reasons like decoherence. No theoretical framework exists that predicts CPT violation, but the Standard Model Extension (SME) is a phenomenological model useful to classify and compare measurements of different properties of matter and antimatter. As the SME is based on Lorentz invariance violation, it can be tested by experiments with matter only. E.g., using a beam of cold hydrogen atoms initially built to characterize the in-beam method, ASACUSA has performed experiments on the orientation dependence of an external static magnetic field for hydrogen hyperfine measurements, and preparations are under way to study the hyperfine structure of deuterium. An overview will be given on the current and planned experiments and their implications on the search for CPT violation.

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Session Classification: Plenary

Track Classification: All