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Investigating Energy Mixing Dynamics of Magnetically Trapped Antihydrogen

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The ALPHA (Antihydrogen Laser PHysics Apparatus) experiment, based at CERN, investigates the matter-antimatter asymmetry problem by producing and trapping neutral antihydrogen to compare it with hydrogen. ALPHA has performed the first measurement of the 1S-2S transition in antihydrogen, as well as the first observations of the ground state hyperfine splitting, 1S-2P Lyman-alpha transition, and the effect of gravity on the motion of antimatter. Neutral antihydrogen is trapped in ALPHA at a magnetic minimum using an octupole magnet and short solenoids to provide radial and axial confinement, respectively. However, the radial components of the octupole and short solenoid fields combine to produce azimuthal asymmetries in the magnetic field. This effect, in combination with field asymmetries from the end turns of the octupole magnet, can cause trapped antiatoms to exchange or mix axial and transverse energy components. The timescale over which these energy components are exchanged is of particular interest to ALPHA. Energy mixing has never been directly experimentally investigated, and the timescale has never been measured. Understanding the motion of trapped antiatoms will inform simulations that can be used to further the precision of ALPHA's experimental results. Additionally, energy mixing studies will inform both analysis and design for a variety of antimatter experiments, including laser cooling of antihydrogen, microwave spectroscopy, 1S-2S and 1S-2P spectroscopy, and measurements of gravity's effect on antimatter. I will present the first direct experimental evidence of antihydrogen energy mixing in ALPHA and the impact of these results on future experiments aiming to investigate the matter-antimatter asymmetry problem.

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