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Application of electron cyclotron resonance (ECR) magnetometry for experiments with antihydrogen

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The Antihydrogen Laser Physics Apparatus (ALPHA) is based at the European Centre for Nuclear Research (CERN) antiproton decelerator facility. Using low energy antiprotons we produce, trap, and study the bound state of an antiproton and positron, antihydrogen [1]. Given the long history of atomic physics experiments with hydrogen, spectroscopy experiments with antihydrogen offer some of the most precise tests of quantum electrodynamics and charge-parity-time symmetry [1]. A test of the weak equivalence principle is also on the horizon with a major addition to the ALPHA experiment, ALPHAg, aiming to measure the free fall of antihydrogen.

All experiments in ALPHA require precise measurements of the magnetic field inside the apparatus, this is especially relevant for ALPHAg [2]. A technique developed in ALPHA determines the in situ magnetic fields by measuring the cyclotron frequency of an electron plasma. Microwave pulses on resonance with the electron cyclotron frequency, which is magnetic field dependent, heat the plasma [3]. A campaign to characterize the precision and accuracy of this technique in a high magnetic field gradient is required before a successful measurement of the effect of Earth's gravity on antimatter can be made.

I will show recent progress made towards realising this goal including the first application of this technique in a strong magnetic field gradient and methods used to experimentally distinguish the cyclotron frequency from a sideband structure.

1. Characterization of the 1S–2S transition in antihydrogen, ALPHA Collaboration, Nature, 557, 71, (2018)
2. Description And First Application Of A New Technique To Measure The Gravitational Mass Of Antihydrogen, ALPHA Collaboration, Nature Communications 4, 1785 (2013)
3. Electron Cyclotron Resonance (ECR) Magnetometry with a Plasma Reservoir, E. D. Hunter and A. Christensen and J. Fajans and T. Friesen and E. Kur and J. S. Wurtele Physics of Plasmas 27, 032106 (2020)

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