Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **2698** Type: **Poster Competition (Graduate Student) / Compétition affiches (Étudiant(e) 2e ou 3e cycle)**

55 - Development of a Novel 650 MHz Resonator for Microwave Spectroscopy of Antihydrogen

Tuesday 4 June 2019 17:25 (2 minutes)

The Antihydrogen Laser Physics Apparatus (ALPHA) Collaboration seeks to measure properties of antihydrogen and compare them to its matter counterpart, hydrogen, to perform precision tests of symmetries between matter and antimatter. Comparisons of hyperfine transition frequencies in positronic ground state antihydrogen with hydrogen provide an opportunity to test fundamental symmetries such as charge parity time (CPT) symmetry. The 1 T field in which we confine the antiatoms and perform spectroscopy is high enough that transitions between hyperfine levels amount to either a positron spin flip or an antiproton spin flip. Positron spin resonance (PSR) transitions occur around 30 GHz in 1 T and have been investigated previously [1, 2]. Anti-atoms trapped in the vicinity of a magnetic minimum undergo a PSR transition, causing them to be ejected and resulting in an annihilation event. Nuclear magnetic resonance (NMR) transitions are more challenging, and have not yet been studied: an antiproton spin flip simply converts an antihydrogen atom in one trapped state to another.

A local maximum in the NMR frequency between trapped states occurs in the vicinity of 0.65 T, at 650 MHz. This provides an opportunity to make a measurement that is first order independent of magnetic field. However, the free space wavelength of radiation at this frequency, 46 cm, presents a challenge. It will not propagate down the 4 cm diameter Penning trap in which our experiments are performed.

I will describe a novel structure that will simultaneously act as a Penning trap electrode and as a 650 MHz resonator capable of producing the microwave magnetic fields needed for an antihydrogen spectroscopy experiment. This device is subject to severe design constraints. From a geometric perspective it is required to be a 2-cm long, 4-cm diameter tube, with 1 mm thick walls. From an electrostatic perspective it must act like a conducting Penning trap electrode with a high degree of cylindrical symmetry. And from an electrodynamic perspective it must support a highly stable and precisely tuned mode at 650 MHz that generates a transverse oscillating magnetic field on axis.

[1] Amole, C. <i>et al.</i> Resonant quantum transitions in trapped antihydrogen atoms. <i>Nature</i> 483, 439–443 (2012).
[2] Ahmadi, M., <i>et al.</i> Observation of the hyperfine spectrum of antihydrogen. <i>Nature</i> 548, 66 –69 (2017).

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Session Classification: DAMOPC Poster Session & Student Poster Competition Finals (26) | Session d'affiches DPAMPC et finales du concours d'affiches étudiantes (26)

Track Classification: Division of Atomic, Molecular and Optical Physics, Canada / Division de la physique atomique, moléculaire et photonique, Canada (DAMOPC-DPAMPC)