Contribution ID: **1477** Type: **Invited Speaker / Conférencier invité**

DNP Thesis Prize: Probing Trapped Antihydrogen: In situ diagnostics and resonant transitions

Tuesday 14 June 2016 16:15 (30 minutes)

Antihydrogen is the simplest pure anti-atomic system and an excellent candidate to test the symmetry between matter and antimatter. In particular, a precise comparison of the spectrum of anytihydrogen with that of hydrogen would be an excellent test of Charge-Parity-Time symmetry. The ALPHA antihydrogen experiment is able to produce and confine antihydrogen atoms in an Ioffe-Pritchard type magnetic neutral atom trap. Once confined, resonant transitions (eg. positron spin resonance transitions, 1S - 2S transitions) in the anti-atoms can be excited. In order to determine the resonant frequencies, the magnetic field seen by the antihydrogen atoms must be measured. This presents a significant challenge because the nature of the ALPHA apparatus effectively eliminates the possibility to insert magnetic probes into the antihydrogen trapping volume. Furthermore, because of the highly inhomogeneous nature of the magnetic trapping fields, external probes will not be able to measure the relevant magnetic fields.

To solve this problem ALPHA developed an in situ magnetometry technique based on the cyclotron resonance of an electron plasma in a Penning trap. This technique can measure the local field seen by the antihydrogen atoms and therefore determine the resonant frequency of the desired transition. With this technique ALPHA was able to perform the first ever resonant interaction with antihydrogen atoms by exciting the positron spin flip transition. This talk will present our in situ magnetometry technique, the methods used to excite and identify positron spin flip transitions in antihydrogen, and future spectroscopic measurements being pursued by ALPHA.

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Session Classification: T3-1 Hadronic Structure (DNP) / Structure hadronique (DPN)

Track Classification: Nuclear Physics / Physique nucléaire (DNP-DPN)