Towards the hyperfine spectroscopy of ground-state antihydrogen atoms

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A precise comparison of both hydrogen and its counterpart antihydrogen will provide a sensitive test of the CPT symmetry. The ASACUSA collaboration has developed a cusp trap system consisting of an antiproton trap, a positron source and trap, a cusp trap, and a spectrometer line to measure the hyperfine transition frequency of ground-state antihydrogen atoms at the CERN Antiproton Decelerator. In 2012, antihydrogen atoms were synthesized by injecting an ultra-slow antiproton beam into a positron plasma in the cusp trap. Figure 1 shows the electrical potential configuration on axis in the cusp trap. To counteract the axial separation of antiprotons and positrons, and to prolong the antihydrogen production period, an rf-assisted direct injection scheme was developed. As a result, we succeeded in detecting an beam of antihydrogen 2.7m downstream of the production region, where perturbing residual magnetic fields were small[1]. The next step towards the precision spectroscopy is to prepare more intense and colder beam. One possible improvement is to keep axial energy spread of antiprotons after the transportation as small as possible. During the AD shutdown in 2013, we developed such a scheme using protons. The axial energy spread of the proton beam was reduced by a factor of 6. The development of the antihydrogen beam source for in-flight spectroscopy as well as the optimization of extraction and transportation of antiprotons will be discussed.

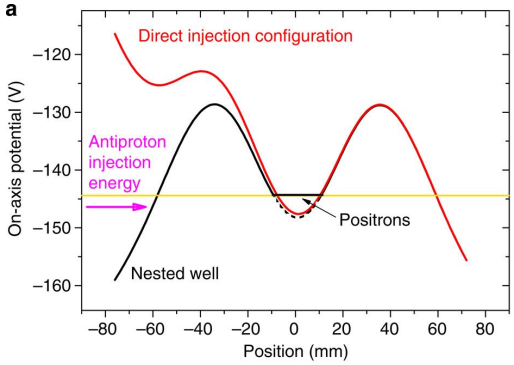

Figure 1: *Illustration of the direct injection scheme, which is used to produce antihydrogen atoms. A positron plasma is confined and compressed at the center of the nested well. The potential is opened when antiprotons are injected into the positron plasma[1].*

References

[1] N. Kuroda *et al.* Nature Communications **5**:3089 (2014)