Contribution ID: **12** Type: **not specified**

Sympathetically cooled positrons for enhancement of antihydrogen production rate

Thursday 4 April 2024 16:30 (30 minutes)

The ALPHA experiment produces and traps antihydrogen atoms by slowly mixing antiprotons and positrons in a Penning-Malmberg trap. Using various techniques, ALPHA measures many properties of these atoms, for example, their interaction with gravity [1], allowing for a comparison between antihydrogen and hydrogen. Accumulating a large number of atoms (in the order of thousands) is imperative for the increase in data-taking rate as well as for the decrease of statistical errors. Thus, increasing the amount of antihydrogen available for experimentation is key for improvements in our studies of fundamental symmetries.

Many efforts to increase the production rate over the years have demonstrated that one of the parameters that most influences it is the temperature of the positron cloud during the mixing process of the species. [2] Under the 3T region, cyclotron cooling allows the positrons to cool down to about 15K. This yielded a trapping rate of about 20 antihydrogen atoms every 4 minutes.

Using a laser-cooled Be+ cloud, we can sympathetically cool the e+ to cryogenic temperatures [3], in this work, we describe the development and implementation of this technique during antihydrogen production at ALPHA, resulting in an almost 5-fold increase in stacking rate.

[1] Anderson, E.K., Baker, C.J., Bertsche, W. et al. Observation of the effect of gravity on the motion of antimatter. Nature 621, 716–722 (2023).

[2] Ahmadi, M., Alves, B.X.R., Baker, C.J. et al. Antihydrogen accumulation for fundamental symmetry tests. Nat Commun 8, 681 (2017).

[3] C. J. Baker et al., Nat Commun 12, 6139 (2021)

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Session Classification: Plasma related Physics