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Pulsed Production of Antihydrogen in AEgIS

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Low-temperature antihydrogen atoms are an effective tool to probe the validity of the fundamental laws of Physics, for example the Weak Equivalence Principle (WEP) for antimatter, and -generally speaking- it is rather intuitive that colder atoms will increase the level of precision.

After the first production of cold antihydrogen in 2002 [1], experimental efforts have progressed substantially, with really competitive results already reached by adapting to cold antiatoms some well-known techniques previously developed for ordinary atoms. Unfortunately, the number of antihydrogen atoms that can be produced in dedicated experiments is many orders of magnitude smaller than of hydrogen atoms, so the development of novel techniques to enhance the production of antihydrogen with well defined (and possibly controlled) conditions is essential to improve the sensitivity.

We present here some experimental results achieved by the AEgIS Collaboration (based at the CERN AD - Antiproton Decelerator) on the production of antihydrogen in a pulsed mode where the production time of 90\% of atoms is known with an uncertainty of $\sim$ 250 ns [2]. The pulsed antihydrogen source is generated by the charge-exchange reaction between Rydberg positronium (produced via the implantation of a pulsed positron beam into a mesoporous silica target, and excited by two laser pulses) and antiprotons (trapped, cooled and manipulated in usual Penning-Malmberg traps):
+Ps$^* \rightarrow \bar{H}^* + e^- where Rydberg positronium atoms, in turn, are produced through the implantation of a pulsed positron beam into$

The pulsed production (which is a major milestone for AEgIS) makes it possible to select the antihydrogen axial temperature and opens the door for the tuning of the antihydrogen Rydberg states, their de-excitation by pulsed lasers and the manipulation through electric field gradients.

In this talk, we present the results achieved by AEgIS before the Long Shutdown 2 (LS2) as well as the ongoing improvements to the system, aimed at exploiting the lower energy and more intense antiproton beam from ELENA.

[1] M.Amoretti et al., Nature 419, 456 (2002)

[2] C.Amsler et al., Commun Phys 4, 19 (2021)

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