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First measurement of a charge-exchange reaction cross-section for antihydrogen

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On behalf of the GBAR collaboration

The properties of antimatter with respect to matter have been explored with utmost accuracy, except for its gravitational behaviour. The GBAR experiment, based at CERN's AD/ELENA facility, is designed to investigate the weak equivalence principle by measuring the free-fall acceleration of antihydrogen in the Earth gravitational field.

To achieve this, the goal is to produce antihydrogen ions through two successive charge-exchange reactions:

$\overline{p} + \mathrm{Ps} \rightarrow \overline{H} + e^-$

$\overline{H} + \mathrm{Ps} \rightarrow \overline{H}^+ + e^-$

After cooling down to a very low velocity, one positron from the ion is laser-detached and the remaining neutral $\overline{H}$ is left for a free fall measurement.
The production of $\overline{H}^+$ [2] depends on the cross section of the second charge-exchange reaction —which is unknown. To address this, an experiment is being conducted in 2025 to measure the cross section of the matter-equivalent reaction, known as SPHINX..

In 2022, the successful production of 6 keV antihydrogen atoms was demonstrated for the first time [1] [3]. Building on this, the 2024 beam time led to more than a tenfold increase in the $\overline{H}$ production rate, making it possible to measure the antihydrogen production cross section at two different energies.

In this presentation, I will describe the experimental setup and its operation, and show the first results obtained for the antihydrogen production cross section.

References

[1] J. P. Merrison et al., *Hydrogen Formation by Proton Impact on Positronium*, Phys. Rev. Lett. 78, 2728 (1997).

[2] Jochen Walz and Theodor Haensch. A proposal to measure antimatter gravity using ultracold antihydrogen atoms : Fundamental physics on the iss. General Relativity and Gravitation, 36, 03 2004.

[3] P. Adrich et al., *Production of antihydrogen atoms by 6 keV antiprotons through a positronium cloud*, Eur. Phys. J. C 83, 1004 (2023).

Author: GEFFROY, Sarah

Co-author: LUNNEY, David (Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France)

Presenter: GEFFROY, Sarah

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