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# Measurement of the charge exchange cross sections between positronium and (anti)proton and (anti)hydrogen

The antiprotons will be provided by the ELENA facility at the Antiproton Decelerator, at CERN. They will then be slowed down to 1-10 keV by a decelerator device and focused on a dense positronium cloud, where reactions (1) and (2) will take place . To produce this target cloud, we will use an intense source of positronium that we are developing for the CERN GBAR (Gravitational Behaviour of Antihydrogen at Rest) experiment. A low energy linac-based slow positron generator loads a positron accumulator - a multi-electrode Penning-Malmberg trap with 5 T magnetic field. Positrons are cooled by a cold electron plasma, and collected in a potential well. An intense positron pulse is then ejected from the trap onto a converter target made of porous silica, in which positronium will be produced in a cavity with reflective walls, at low kinetic energy. It will be then excited by a pulsed laser beam to its 3d and 2p levels to enhance antihydrogen (ion) production. 3d excitation will be done with an existing laser setup (developed by LKB), using a Doppler-free two-photon reaction induced by two 410 nm laser pulses. For the 2p excitation a 243 nm pulsed laser will be built.

Before working with antimatter, we will measure the production cross section of hydrogen via the charge exchange reaction between protons and excited positronium: $p + Ps \rightarrow H + e^+$ (3), and the subsequent four-body reaction $H + Ps \rightarrow H^- + e^+$(4). In this experiment a proton source will be used. The cross sections determined by the experiment will be compared with the theoretical predictions.

## Summary

We will measure the production cross section of an antimatter ion, the antihydrogen ion. It will be produced by means of a two-step reaction: first the charge exchange reaction $\bar{p} + Ps \rightarrow \bar{H} + e^-$ (1) and then $\bar{H} + Ps \rightarrow \bar{H}^+ + e^-$ (2), in which antihydrogen produced in the first reaction interacts with another positronium to create an antihydrogen ion.
The results of the experiment will be an important step towards the gravitational measurement of antihydrogen atoms (GBAR project), since the apparatus developed is an essential part of the GBAR instrumentation.

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