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Towards a pulsed beam of antihydrogen for tests of the Weak Equivalence Principle for antimatter

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The Antimatter Experiment: Gravity, Interferometry, Spectroscopy (AEgIS) collaboration, based at CERN's Antiproton Decelerator (AD) complex, is working towards the production of a pulsed horizontal beam of antihydrogen atoms. The detection of the vertical deflection of such a beam will provide a direct measurement of the gravitational acceleration of antimatter and thus constitute a novel way of probing the Weak Equivalence Principle (WEP).
In 2018, AEgIS has successfully demonstrated the individual production of antihydrogen atoms as a pulsed, isotropic source by means of a charge exchange reaction: antiprotons were captured from the AD inside a Penning-Malmberg trap, further cooled, and combined with positronium atoms, which were previously laser-excited to Rydberg states, to form antihydrogen.
Since then, the Extra Low ENergy Antiproton ring (ELENA) has been installed in the AD complex as an additional decelerator, having commenced its operation in autumn of 2021. ELENA yields an increased number of even colder antiprotons from which AEgIS aims at fully benefiting. For this purpose, the AEgIS apparatus has undergone several upgrades, including a full transformation of the anti-H production into a collinear scheme with a newly constructed production trap and positronium converter, the installation of a new laser system, as well as the complete rebuild and automation of the experimental control system.
Given these improved conditions and the resulting expected increased rates of antihydrogen production, AEgIS is moving towards the formation of a horizontal beam to directly investigate the influence of gravity on the anti-H atoms, profiting by the precise knowledge of the production time in the pulsed scheme. Such a measurement will be a first step towards probing the WEP for antimatter and represent a test of the CPT theorem, which assumes complete symmetry between matter and antimatter systems.
This contribution will give an overview of the status of the improved AEgIS setup and results obtained during the first beam times with ELENA as well as the progress towards the formation of a pulsed beam of antihydrogen.

Category

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