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Developments for pulsed antihydrogen production towards direct gravitational measurement on antimatter

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A main scientific goal of the $AE\bar{g}IS$ experiment is the direct measurement of the Earth's local gravitational acceleration g on antihydrogen. The weak equivalence principle is a foundation of General Relativity. It has been extensively tested with ordinary matter but very little is known about the gravitational interaction between matter and antimatter. Antihydrogen is produced in $AE\bar{g}IS$ via resonant charge exchange reactions between cold Rydberg-excited positronium and cooled down antiprotons. The achievements towards the development of a pulsed cold antihydrogen source are presented.

Large number of antiprotons, necessary for a significant production rate of antihydrogen, are captured, accumulated, compressed and cooled down over an extended period of time. Positronium (Ps) is formed through e^+-Ps conversion in a silica porous target at 10 K temperature in a reflection geometry inside the main apparatus. The so-formed Ps cloud is then laser-excited to Rydberg levels leading to the first Ps laser excitation to the Rydberg levels in a 1T magnetic field and to the detailed characterisation of the Ps source for antihydrogen production.

Several detection techniques are extensively used to monitor antiproton and positron manipulations in the formation process of antihydrogen inside the main apparatus. Positronium detection techniques underwent extensive improvements in sensitivity in 2018. At the same time, major efforts to improve integrate and commission the various detector sensitive to antihydrogen production took place. These include an array of external scintillators and a scintillating fiber based tracking detector. Measurements based on this improved detection system will be presented.

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