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Positronium for antihydrogen production in the AEGIS experiment

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The primary goal of the AEGIS collaboration (Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy) is to measure for the first time precisely the gravitational acceleration of antihydrogen, $\bar{H}$, a fundamental issue of contemporary physics, using a beam of antiatoms. Indeed, although indirect arguments have been raised against a different acceleration of antimatter with respect to matter, nevertheless some attempts to formulate quantum theories of gravity, or to unify gravity with the other forces consider the possibility of a non-identical gravitational interaction between matter and antimatter.
We plan to generate $\bar{H}$ through a charge-exchange reaction:

$$Ps^* + \bar{p} \rightarrow \bar{H}^* + e^-$$

between excited Ps and antiprotons coming from the Antiproton Decelerator facility at CERN. This reaction offers the advantage to produce sufficiently cold antihydrogen to make feasible a measurement of gravitational acceleration with reasonable uncertainty (of the order of 1%). Since the cross section of the above reaction increases with n^4, n being the principal quantum number of Ps, it is essential to generate Ps in a highly excited (Rydberg) state. This will occur by means of two laser excitations of Ps emitted from a nanoporous silica target: a first UV laser (at 205 nm) will bring Ps from the ground to the $n = 3$ state; a second laser pulse (tunable in the range 1650-1700 nm) will excite Ps to the final state. We recently demonstrated both steps of this process [1].
The present paper gives an overview of the AEGIS experiment, describes its current status and discusses how its first goal is thought to be achieved.

[1] S. Aghion et al. (AEGIS collaboration), *Phys. Rev.* **A94**, 012507 (2016)