Deexcitation and cooling techniques for precision measurements with antihydrogen

Antihydrogen is routinely produced at CERN in a broad range of Rydberg states. The experiments located around the Antiproton Decelerator (AD) aim to perform precision measurements on these anti-atoms with a main focus on spectroscopy of ground-state atoms (1S-2S transition or GS-HFS) and to study gravitational interaction for which GS is also required to minimize the sensitivity of the H to electromagnetic fields.

So far antihydrogen in GS is accumulated only via spontaneous decay in magnetic traps, which is not an option for in beam experiments like AEGIS or ASACUSA, which will have to rely on an active deexcitation method. Assuming a formation of H at 50K, the stimulated deexcitation should ideally happen within a few or tens of microseconds. This will either allow the formation of a beam of GS atoms via magnetic focusing or allow the re-excitation to well-defined states for Stark acceleration.

Since collaborations at the AD have adopted different H formation mechanisms, excitation schemes were developed, which fulfill the specific requirements of the respective formation scheme. This is especially of importance since resonant charge exchange (CE) is a pulsed production scheme whereas 3 body recombination (3BR) operates in a continuous mode.

My poster will present several mechanisms which have been investigated to efficiently and rapidly deexcite H atoms. The main idea is to couple the many Rydberg states produced (either via electric and magnetic fields [1] or via THz and microwave light [2]) to each other, in order to be able to drive the population down with lasers to states which spontaneously decay fast enough.

Furthermore, we found the fast manipulation of Rydberg states to have potential applications for cooling of H held in magnetic traps. The mechanism relies on fast deexcitation of circular states at the edge of the magnetic trap to reduce the potential energy of the system when it is at its maximum, an idea which was pointed out by Cesar and Pohl et al. [3, 4] and that we further investigated and optimized in the framework of the studied deexcitation techniques.

Primary author: NOWAK, Lilian (University of Vienna (AT))
Presenter: NOWAK, Lilian (University of Vienna (AT))
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