LOW-TEMPERATURE ANTIHYDROGEN-ATOM SCATTERING

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Recently the ATHENA and ATRAP groups at CERN managed to produce antihydrogen atoms at low temperatures [1]. Future goals of these experiments are to trap the antihydrogen atoms and perform spectroscopic measurements comparing antihydrogen with ordinary hydrogen. Such measurements can test the CPT theorem for baryons and leptons.

The new experimental progress has also stimulated interest in low temperature atom-antiatom collisions. Such collisions have several properties that make them qualitatively very different from ordinary atom-atom collisions. One obvious difference is that in the Coulombic nucleus-antinucleus interaction is *attractive*. Hence, the nucleus and antinucleus have a finite probability of overlapping in an atom-antiatom collision. Therefore it is necessary to include the strong nuclear force between the nucleus and antinucleus. The strong nuclear force leads both to annihilation processes and to a change in the elastic cross section.

I will discuss how the strong nuclear force may be incorporated in calculations of low-energy antihydrogen-atom scattering. In particular I will discuss a scattering-length method, which has been applied to antihydrogen-hydrogen and antihydrogen-helium scattering [2, 3, 5].

In addition to annihilation, antihydrogen-atom scattering can result in a number of collisional reactions such as elastic scattering, rearrangement to protonium and positronium, and even radiative association leading to formation of unusual short-lived atom-antiatom molecules. According to threshold laws inelastic processes will always dominate over elastic scattering at sufficiently low energies. I will present rates for the most important processes, with particular emphasis on the lowest energy (or temperature) at which elastic scattering dominates. This energy sets limits the possiblity of cooling antihydrogen via thermal contact with ordinary matter. I will also mention some of the theoretical difficulties connected with the rearrangement process.

References

[1] M. Amoretti *et al.*, *Nature* **419**, 456 (2002); G. Gabrielse *et al.*, *Phys. Rev. Lett.* **89**, 213401 (2002); G. Gabrielse *et al.*, *Phys. Rev. Lett.* **89**, 233401 (2002).

[2] S. Jonsell, P. Froelich, S. Eriksson, and K. Strasburger, *Phys. Rev. A* **70**, 062708 (2004).

[3] S. Jonsell, A. Saenz, P. Froelich, B. Zygelman, and A. Dalgarno, *J. Phys. B* **37**, 1195 (2004). c

[4] E. A. G. Armour, Y. Liu, and A. Vigier, *c* *J. Phys. B* **38**, L47 (2005).

[5] S. Jonsell, A. Saenz, P. Froelich, B. Zygelman, and A. Dalgarno *Canadian J. Phys.* in press.