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Capture of Slow Antiprotons by Atoms, Molecules, and Ions

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I will describe the capture of antiprotons by atoms, ions, and molecules to form exotic systems, as well as capture of other heavy negative particles (μ^-, π^-, K^-) that lend insight into the $\bar{p}$ capture problem.* Particular emphasis will be placed on relevance to upcoming ASACUSA experiments and corroboration of critical features. Capture by even the hydrogen atom presents great challenges for theoretical treatment. The wide variety of methods used include perturbative, two-state adiabatic and diabatic, time-independent quantum mechanical, time-dependent semiclassical and quantum mechanical and quasi-classical treatments. A few of these methods, as well as the Fermi–Teller model, have also been applied to heavier atomic targets. Most of the methods, other than the quasi-classical formulations, are not yet up to treating the dynamical electron correlation and multiple ionization found to be important in capture by multi-electron atoms, or the vibronic coupling found to be important in capture by simple molecules. The essential elements of potentially more rigorous quantum-mechanical theories will be characterized. The experimental data on capture states and relative capture probabilities in mixtures will also be discussed. The connection of existing experimental data to the theoretical capture calculations is fairly tenuous, but forthcoming experiments with antiprotons promise direct tests of some of the recent theoretical findings. New analysis of the of the angular and energy distributions of e^- and $\bar{p}$ resulting from antiproton collisions with the noble-gas atoms will be presented to help determine appropriate detector characteristics.

*J. S. Cohen, Rep. Prog. Phys. **67**, 1769-1819 (2004).