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Ionization and Excitation in Collisions between Antiprotons and Hydrogen Atoms

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Synopsis Coupled-state cross sections have been determined for ionization and excitation in collisions between 1-16000 keV antiprotons and H($1s$) atoms using two- and one-center Sturmian bases.

Coupled-state cross sections have been determined for ionization and excitation to states up to H($3d$) in collisions between 1 keV to 16 MeV antiprotons and H($1s$) atoms [1] using the same two-center 176-Sturmian s, p, d and 220-Sturmian s, p, d, f bases as well as a one-center 280-Sturmian s, p, d, f basis as for proton projectiles [2]. The two-center bases are used at energies up to 200 keV, while in the present case one-center bases are used at energies of at least 5 keV rather than being restricted to higher energies as for proton projectiles. The sensitivity of cross sections to basis size and type has been studied in detail. Differences between 176-state and 220-state cross sections for ionization and each individual excitation process oscillate with energy within a range of about $2 \times 10^{-18}\text{cm}^2$, leading to percent differences of only a few percent for the dominant channels (ionization and excitation to the $2p$ state) and 10-20% for excitation for the weaker channels ($3s, 3d$). Conservation of probability, integrated over impact parameters, is usually found to hold to at least 0.0007%. A comparison and strong contrast at lower energies is made with results for proton projectiles, while all cross sections approach the high energy (first-Born) limits to better than 1% by 16 MeV, the same for both protons and antiprotons. The use of a double-center basis for antiproton projectiles, in spite of there being no capture channels, was suggested and carried out by Toshima with a large Gaussian basis [3], providing both additional variational freedom and allowance for effects centered on the antiproton, including depletion of the charge-cloud. These effects appear to be unimportant at the considered energies, and so the main effect of the two-center basis may be to somewhat speed basis convergence. The present cross sections will be compared with recent [4] and earlier coupled-state and numerical results, as well as with experimental ionization results [5].

References

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