

Antiprotonium formation in antiproton-H collisions and positronium formation in positron-Na (Li) collisions : A hyperspherical close-coupling approach

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We have used the recently developed hyperspherical close coupling method (HSCC) for general three-body Coulomb systems [1] to study the antiprotonium formation in low-energy antiproton collisions with H and the positronium formation in positron collisions with Na and Li targets for incident energies below 10 eV. For positron collisions with Na, recent experiment [2] indicates that the positronium formation cross sections at energies below 2 eV are much higher than the two existing theoretical calculations [3,4] based on the close-coupling method. For Li target, the close-coupling calculations have been found to be in agreement with experiment. We have calculated the positronium formation cross sections for these two collision systems and our results for positron on Na are in agreement with the other theoretical calculations, but not the experiment.

With the recent availability of low-energy antiprotons, it would become possible to study protonium "atoms" in the near future. Protonium can be formed in the collisions between antiprotons and H and would be formed initially in highly excited Rydberg states near $n=30$ [5]. While some theoretical models have been used to estimate the total formation cross sections [6,7], the detection is likely to depend on the spectroscopic identification and thus information on the specific $(n \ell)$ states distribution would be needed. Any straightforward close-coupling calculations is nearly impossible since the number of channels would run into thousands. We have developed a method to eliminate the channels which are expected to be not important for the collision process of interest. Starting with the adiabatic potential curves, we calculate the overlap matrix of channels from which we obtain the diabatic potential curves. This diabaticization procedure can be carried out directly from large hyperradius all the way to the small distances. We have tested the procedure for the fictitious protonium with mass equal 100 and it is possible

to reduce the number of important channels to just a few from about 50, depending on the degree of accuracy in the calculations needed. Extension of the method to real protonium formation cross sections is underway.

Reference:

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