VERY SLOW H^+ + D(1*s*) HALF COLLISIONS

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Sub-eV collisions between protons and deuterium atoms have long been a proving ground for theorists for two primary reasons: first, the simplicity of the system makes it ideally suited for studying electron translation factors; and second, HD^+ structure calculations are challenging since there is no symmetry under exchange of nuclei, and as a result, the calculations must extend beyond the Born-Oppenheimer approximation. Despite the theoretical interest, there have been very few experiments below 10 eV, due to difficulties in controlling the collision energy. A new experimental approach allows the measurement of H^+ + D(1*s*) collisions down to a few meV, lower by more than an order of magnitude and with better energy resolution than previous measurements.

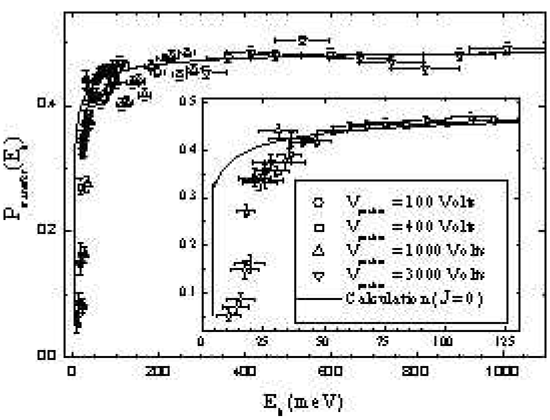

Figure 1: Experimental and theoretical results for charge transfer in the H^+ + D(1*s*) half collision system. V_{pusher} is a measure of the strength of the extraction field

This new experimental approach uses the ground state dissociation (GSD) of HD^+ to produce H^+ + D(1s) "half" collisions[1,2]. Fast proton impact with neutral HD initiates vertical transitions that populate the vibrational continuum of the $HD^+(1s\sigma)$ state about 1% of the time, resulting in a very slow dissociation. The half collision energy is determined *a posteriori* from the measured momentum vector of each charged fragment using a COLTRIMS-style apparatus[3].

For the half collision system, the coupled channels problem is solved using a variational *R*-matrix approach with incoming-wave boundary conditions. The Franck-Condon transition from the neutral molecule is taken into account by projecting the outgoing waves onto the ground state of the HD molecule. The coupled channels calculations are solved in a similar manner for the "full" collision system[4]. The experimental results, shown in Figures 1 and 2, provide a direct test of the half collision calculations. The experimental and theoretical results are in good agreement, except in the region very near the charge transfer threshold, where systematic problems with the subtraction of contaminant H_2^+ molecular ions plague the experiment. Since similar computational techniques are used for both the full and half collision systems, these experimental results can also probe calculations of full collisions at much lower energies than previously accessible. Improvements in the experiment should allow measurements of the threshold behavior in charge transfer and resonances in the elastic channel.

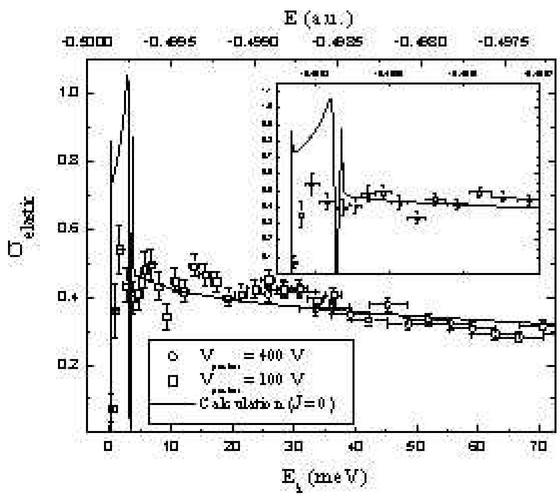

Figure 2: Experimental and theoretical results for elastic scattering in the H^+ + D(1*s*) half collision system. The structure in the calculations below E_k = 3.7 meV is due to two J = 0 Feshbach resonances[2,4].

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References:

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