Fully Differential Study of Capture with Vibrational Dissociation in p + H_2 Collisions

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Synopsis A kinematically complete experiment on dissociative capture through vibrational excitation was performed. Depending on the molecular orientation either single-center or molecular two-center interference is observed. The interpretation is supported by a calculation describing the projectile coherence properties in terms of wavepackets.

We have performed a kinematically complete experiment on dissociative capture in 75 keV p + H_2 collisions. Proton fragments, resulting from dissociation of the target molecule, were momentum-analyzed using a COLTRIMS apparatus and measured in coincidence with the scattering angle-analyzed projectiles neutralized in the collision.

Different transverse coherence lengths for projectile scattering in the x- and y-directions were realized by placing a pair of collimating slits in front of the target. The distance of the y-slit from the target was much larger than for the x-slit resulting in coherence lengths of $\Delta x = 1.0$ a.u. and $\Delta y = 3.3$ a.u.

From the recoil-ion momentum the molecular orientation and the KER were extracted. Fully differential cross sections (FDCS) were obtained for KER fixed at 0 to 2 eV. At such small KER values dissociation cannot proceed through a transition to a repulsive electronic state. Rather, it is caused by a vibrational excitation, i.e. the second electron in the molecule remains in the ground state.

Data were obtained for two molecular orientations. Both were perpendicular to the initial beam axis. One was also perpendicular to the transverse component of the momentum transfer q_{tr} while the second was parallel to q_{tr}. Coherent and incoherent FDCS were obtained by setting for each orientation an additional condition for projectile scattering in the y- and x-direction, respectively.

In Fig. 1, the coherent to incoherent FDCS ratios are shown for the perpendicular (left panel) and parallel orientations (right panel) as a function of the projectile scattering angle. In both cases, pronounced structures are observed showing that projectile coherence effects are present. However, the shape of the structures is quite different for both orientations. For the perpendicular orientation the structures are interpreted as due to single-center and for the parallel orientation as due to molecular two-center interference.

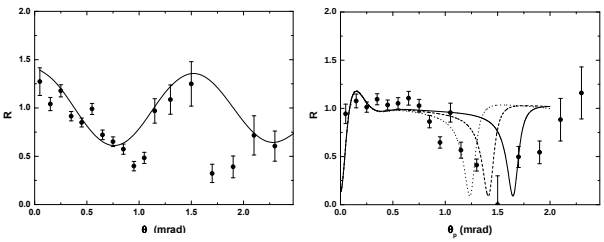

Fig. 1 Coherent to incoherent FDCS ratios for the perpendicular (left panel) and parallel orientations (right panel).

The curve in the left panel shows the single-center interference term suggested by Sharma et al. [1], which reproduces the data very well. The curves in the right panel show eikonal calculations, in which the projectile coherence properties are described in terms of a wave packet [2], for three different internuclear distances D within the Franck-Condon regime. The data are consistent with the calculation assuming that a spectrum of all Ds within the Franck-Condon region contribute to dissociation.

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References

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