A.3.2. Low Energy Capture from Molecules: Electron Capture from D_2 by Low Energy Xe^{26+} and Protons--*R.D. DuBois,* R.E. Olson,* C.R. Feeler,* I. Ali and C.L. Cocke*

When a slow-moving, highly-charged projectile captures electrons from a simple molecular target (D_2 in this case), leading to dissociation, the transfer usually proceeds much faster than the subsequent dissociation of the molecule. If the projectile is slow enough, however, the dissociation occurs in the presence of the projectile, and the exchange of momentum and energy in the final state between projectile and dissociation products makes the overall process at least a three-body one for the heavy fragments. The purpose of this experiment is to identify the projectile velocity for which the transition between two-step dissociation and multi-body final state dissociation occurs and to investigate the behavior of the latter case. We have used Xe^{26+} projectiles at incident energies between 26 and 1300 keV to capture two electrons from D_2 and have used a multi-hit detector to detect the two D^+ fragments in coincidence with the outgoing charge-changed Xe ions. Proton projectiles were also used as a control. Strong departures from a simple Coulomb explosion pattern are observed in the D^+ laboratory momentum coordinates for Xe projectile energies below 260 keV. Displaying the data in terms of Jacobi momenta (momenta of the center-of-mass of the two D^+ ions, and relative momenta of these ions in their center of mass) reveals that the major process remains a two-step one nevertheless. The Coulomb explosion ring from the D^+ pair retains its shape in the relative momentum coordinates, but the center-of-mass momentum imparted to the pair in the capture is enough to seriously perturb the laboratory momenta of the D^+ fragments.

At the lowest energies, however, true three-body effects are observed. The internal energy released by exploding D^+ ions in their own center-of-mass system is found to decrease as the projectile velocity is lowered. This effect is shown in Fig. 1, which shows slices of the Coulomb explosion sphere for several collision systems. This affect is interpreted as due to the action of quadrupole and higher multipole components of the projectile field on the exploding D_2 system, where the multipole expansion is taken relative to the center of mass of this system. While the major effect of the projectile is to deflect the whole D_2^{2+} ion, which is accomplished by the dipole projectile field, the D^+ ions which explode into the direction of the projectile are retarded more than are those which explode away, and thus the effect of the quadrupole field of the projectile is to remove energy from the center of mass motion of the molecule. This is, to our knowledge, the first observation of such an effect and the first experimental separation of action of the projectile on the molecule as a whole from that on the internal degrees of freedom of the molecule. The qualitative behavior is well described by a CTMC calculation for the process. This work has been submitted for publication (Accepted Publication #4).

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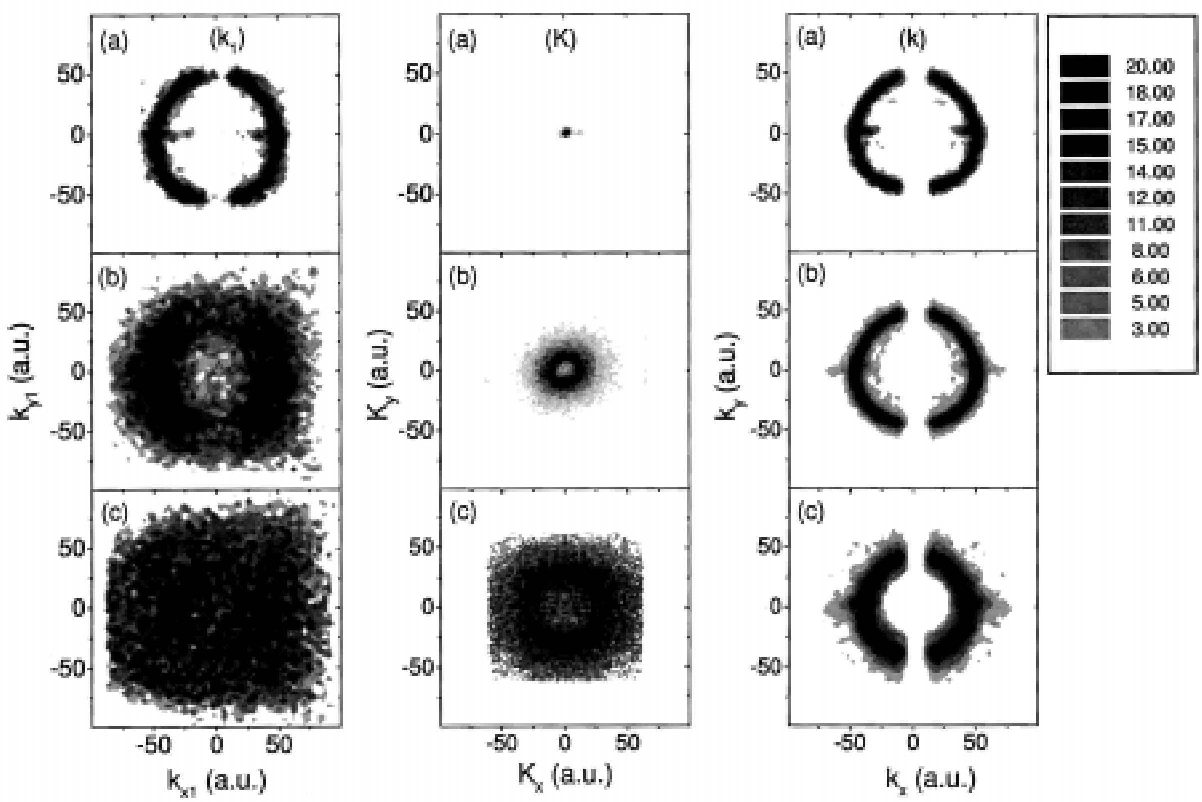

Figure 1. Momenta , transverse to the beam direction, of the D^+ fragments following double electron removal from D_2 by (a) 50 kev H^+, (b) 2 keV/u Xe^{26+} (c) 0.2 keV/u Xe^{26+}. The first column shows the transverse momenta in laboratory coordinates, where x and y are transverse to the beam direction. The second column shows the spectrum of momenta imparted to the entire molecule , while the third column shows the momenta of the two D^+ ions measured in the center-of-mass frame of the molecule. A slight reduction of the radius of the explosion ring is seen in Figure (c). Figures (a) and (c) are slices through the Coulomb explosion sphere; i.e. only events with small values of z momenta are plotted. This figure is from Accepted Publication #4.