ELECTRON CAPTURE BY O^{8+} FROM ALIGNED MOLECULAR DEUTERIUM*S. Cheng, C.L. Cocke, V. Frohne, E.Y. Kamber,[†] and S.L. Varghese[‡]

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Recently, Wang *et al.*¹ reported the calculation of electron capture cross sections for high energy protons incident on molecular hydrogen and found that interference plays an important role in collision of heavy ions of MeV/amu energy with molecules. They predicted that the electron capture cross section from H_2 molecules changes as a function of both the longitudinal momentum transferred and the molecular orientation with respect to the incident projectile beam direction.

In order to allow the theory to be compared with experiment in a more direct way, we used 1, 4, 10 and 16 MeV bare oxygen ions to bombard molecular deuterium. We looked for a dependence of the cross section on the molecular orientation, without averaging over the orientation of the molecules.

According to our previous experimental results,² when O^{8+} ions collide with D_2 molecules and capture one electron from the molecule, most of the molecules will be left either in the doubly ionized state or in one of the electronically excited states. The molecular ions in such states are not stable and subsequently dissociate into ion-ion or neutral-ion pairs. The dissociated ions carry the information about their molecular orientation when the collision happened.

The experiment was performed by applying an extraction electric field perpendicular to the beam axis to project the whole velocity distribution of the recoil ions onto a two-dimensional position sensitive detector. By additional measurement of the time-of-flight of these recoil ions, we are able to reconstruct the three-dimensional velocity distribution. From the reconstructed results, the dependence of the cross sections on the alignment of the molecular axis with respect to the beam axis was determined.

The result for 10 MeV O^{8+} ions bombarding deuterium targets is shown in Figure 1. The angle θ is defined as the angle between the internuclear axis of the molecule and the beam axis. We see a strong angle θ dependence. There are more events around $\theta = 90^\circ$ and less at 0° and 180° . This means that when the collision happens, the deuterium molecules are more likely to be in the states of orientation perpendicular to the incident beam than parallel to the beam.

A qualitative explanation of this feature is possible in terms of interference. When the molecular orientation is

perpendicular to the beam, the phase difference between amplitudes originating on the two scattering centers of the molecule is minimum resulting in a constructive interference. When the angle between the molecular orientation and the beam becomes smaller, the phase difference increases and constructive interference decreases.

Figure 1. Electron capture cross section dependence on the polar angle θ for 10 MeV oxygen bare ions in collision with deuterium molecules.

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References:

1. Y.D. Wang, J.H. McGuire, and R.D. Rivarola, Phys. Rev. A, **40**, 3673, (1989).
2. S. Cheng, C.L. Cocke, E.Y. Kamber, C.C. Hsu, and S.L. Varghese, Phys. Rev. A **42**, 214 (1990).

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