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Fully Differential Study of Ionization of H2 by p Impact Near Velocity Matching

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We have measured fully momentum-analyzed scattered projectiles and recoil ions, produced in ionization of H2 by 75 keV p impact, in coincidence. The ejected electron momentum was deduced from momentum conservation. From the data we extracted fully differential cross sections for fixed projectile energy losses of 50,53,57, and 60 eV, for various fixed scattering angles theta_p, and for electrons ejected into the scattering plane as a function of the emission angle. Here, an energy loss of 57 eV corresponds to an electron speed equal to the projectile speed. The data were compared to two conceptually very similar distorted wave calculations. In the FDCS two separate peak structures can be seen, one near the direction of the momentum transfer q and one in the direction of the initial projectile beam direction. The former, known as the binary peak, is a signature of a first-order mechanism. The latter, to which we refer as the forward peak, is a result of a higher-order mechanism, known as post-collision interaction PCI, involving at least 2 interactions between the projectile and the active electron. The first interaction lifts the electron to the continuum and in the second interaction the electron and the scattered projectile attract each other towards the initial beam axis. As expected, the forward to binary peak intensity ratio maximizes at the matching velocity (energy loss of 57 eV).

The data were compared to continuum distorted wave –eikonal initial state (CDW-EIS) and 3-body distorted wave (3DW) calculations, respectively. While at theta_p = 0.1 mrad both calculations are in reasonable agreement with experiment, increasing discrepancies and differences between both models are observed with increasing theta_p. At the largest theta_p there is not even qualitative agreement. There, PCI effects are most pronounced in the ex-perimental data and much stronger in the 3DW model compared to the CDW-EIS calculations. Considering that both theoretical approaches are conceptually very similar these surprisingly large differences demonstrate the high sensitivity of the FDCS to the details of the few-body dynamics in this kinematic regime.

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Primary author: Prof. SCHULZ, Michael (Missouri University of Science & Technology)

Presenter: Prof. SCHULZ, Michael (Missouri University of Science & Technology)

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