Tracing Young-type Interference Effects in Electron-Impact Ionization of Aligned H_2 Molecule

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Synopsis We report a combined experimental and theoretical (e,2e) study for H_2 by high-energy electron-impact (E_0 = 520 eV). The molecular alignment is determined experimentally. We observe oscillations in the fully differential cross section as function of the molecular alignment angle which can be reproduced using a Multi-Center Distorted Wave method (MCDW) while the standard two-center interference treatment using a coherent sum of two effective atomic amplitudes fails completely.

Interferences of coherent electron waves emitted from multi-center systems or traveling along several indistinguishable paths are ubiquitous in physics. One prominent example is their observation for electron emission from diatomic molecules induced by photo-absorption in analogy with Young's double slit experiment. [1]. The simplest models are based on this scenario by using single center outgoing waves which are coherently summed up for all emission centers in the molecule [2]. Two center interferences were also considered for the (e,2e) reaction where, so far, all experiments have averaged over the molecular spatial alignment which is one essential parameter to determine the interference pattern, see e.g. [3].

Here we present fully differential cross sections (FDCS) for fast (520 eV) electron-impact on H_2 with the H_2^+ final ionic ground state. A small fraction of ions dissociates such that the measurement of the proton momentum vector allows to determine the molecular spatial alignment during the collision. Experimentally a reaction microscope [4, 5] is used to detect both outgoing electrons and the proton in a triple coincidence measurement. Theoretically a Multi-Center Distorted Wave method (MCDW) is used and, alternatively, the standard interference factor (1 + cos($\chi \cdot \rho$)) is multiplied with the atomic hydrogen FDCS. Here ρ is the internuclear vector. $\chi = \mathbf{k_e} - \mathbf{q}$ where $\mathbf{k_e}$ is the momentum of ejected electron and $\mathbf{q}$ is the momentum transferred by the projectile.

In Fig. 1 we see strong alignment dependent variations of the FDCS (b) which are well reproduced by MCDW (c) while the pure interference description (d) fails clearly. This is most likely due to the rather low energy of the ejected electron of E_2 = 10 eV which does not justify a spherical wave description as it is used in the derivation of the interference factor. Experiments with higher ejected energy (E_2 = 100 eV) are underway to trace the interference effect. More results will be discussed at the conference.

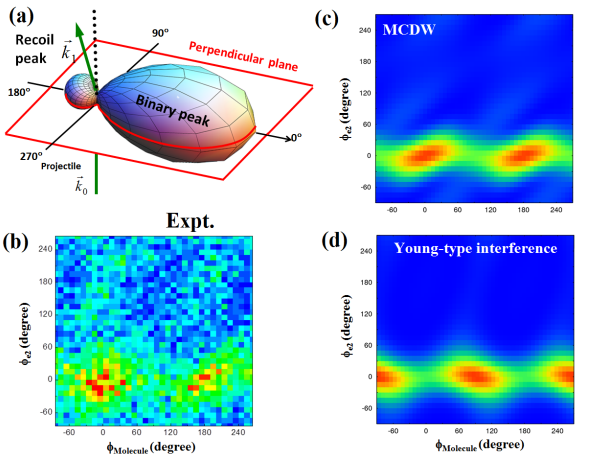

Figure 1. FDCS as function of the molecular alignment angle $\phi_{Molecule}$ and the ejected electron angle ϕ_{e2} both in the plane perpendicular to the incoming projectile beam (ϕ_{e2} = 0° is the direction of the binary lobe maximum. Projectile scattering angle θ_1 = -20°, ejected electron energy E_2 = 10 eV. a) Coordinate frame. b) experimental data. c) MCDW calculation d) interference factor multiplied with DW theory for atomic hydrogen.

References

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