Electron attachment and quantum coherence

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Well-known Fano profiles due to direct and resonant electron scattering from atoms and molecules are classic examples of quantum coherence [1], while Young type interference observed in the emitted electron channel in electron impact ionization of homonuclear diatomic molecules suggests a quantum coherence in the two paths originating from two atoms [2]. However, all these experiments study emitted electron channels.

We present the first ever evidence of quantum coherence in electron attachment that leads to formation of coherent superposition of anion resonance states [3]. Our measurements show that resonant electron attachment to H_2 and its subsequent dissociation into $H + H^-$ is unexpectedly asymmetric about the nuclear axis. Here, the momentum distribution obtained for H^- ions produced by electron attachment near 14 eV shows significant forward-backward asymmetry. The amount of asymmetry observed in the case of D_2 is substantially different from that of H_2. No such asymmetry is observed for the 4 eV resonance. We explain this counter intuitive phenomenon as coherent excitation of two resonances of odd and even parity. The ensuing interference of the two quantum paths leads to the asymmetry in the angular distributions of H^-.

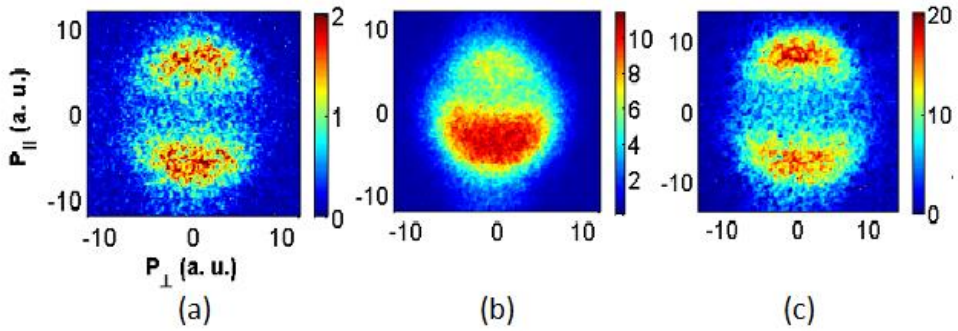

Figure 1: Momentum images of (a) H^- from H_2 at 4.5 eV and (b) at 14.5 eV electron energy obtained from dissociative electron attachment. (c) Momentum image of D^- from D_2 on attachment of 14.5 eV electrons. The direction of the electron beam is from bottom to top.

This symmetry breaking may be compared with that observed in photodissociation arising from interference between effective one photon and two photon absorption paths [4]. The coherence in this process is brought in by the absorbed photons. In contrast, electron attachment leads to transfer of multiple values of angular momentum. Hence, such a process carries inherent coherence among different angular momenta transfer channels stemming from a single electron attachment.

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[4] Ray D *et al* 2009 *Phys. Rev. Lett.* **103** 223201