Angular dependence of the strong-field ionization in randomly oriented hydrogen molecules

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Synopsis: Use coincident detection of ionized electrons and deuteron fragments to investigate angular anisotropy of tunneling ionization and correlate electron energy spectra with molecular structure.

We report two experiments on D_2 using electron-ion coincidence momentum spectroscopy using COLTRIMS. In both experiments we measure electron momentum in coincidence with momentum of one D^+ ion.

In the first experiment we used 50 fs circularly polarized pulses of 1850 nm wavelength to measure angular anisotropy of tunneling ionization for D_2. By measuring the relative angle between an ionized electron and deuteron resulting from field dissociation of the molecular ion produced by a circularly polarized pulse we deduce the angular dependence of the molecular ionization probability without having to align the molecules first. We determined that with 50fs pulses of 1850nm wavelength and 2×10^{14} W/cm^2 intensity neutral D_2 molecules are 1.15 times more likely to be ionized when the laser electric field is parallel to the molecular axis than for the perpendicular orientation. This is in excellent agreement with our theoretical model which is based on solving the time dependent Schrödinger equation in the velocity gauge using single active electron approximation and two dimensional Cartesian coordinates.

In the second experiment, we used pump-probe technique with two few-cycle (7.5 fs) 800 nm pulses separated by variable time delay. Neutral molecule is singly ionized with a weak pump pulse and then the dissociating molecular ion is exploded by a stronger probe pulse. The fragments (electrons and ions) of the reaction are detected in coincidence at various time delays. Gating the electron energy spectra on pump-probe delays and kinetic energies of D^+ (both related to internuclear separation) we observe an interesting evolution of these spectra indicative of changing electronic structure of the dissociating D_2^+ molecular ion.

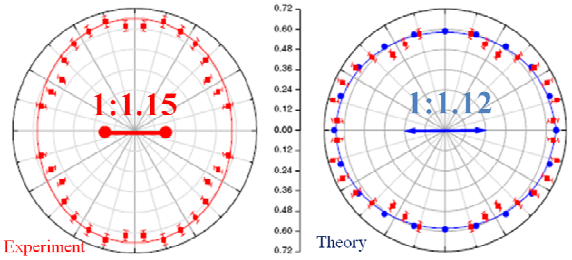

Fig. 1. The experimental and calculated distribution of the relative angles between the ion and electron momenta.

The electron ionization angular dependence exhibits a weak anisotropy with an ionization yield ratio of 1.15 ±0.05 favoring the ionization of molecules that are aligned parallel to the electric field. Our numerical model generated, which accurately predicts the measured anisotropy, as well as its intensity dependence for both, our experiment [3] at 1850nm and Staudte *et al.*'s [1] at 800nm wavelength.

References

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