Asymmetric dissociation of H_2 and D_2 by a two-color laser field

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Synopsis: Two-color (800 nm and 400 nm) short (45 fs) linearly polarized pulses are used to ionize and dissociate $H_2(D_2)$ into a neutral hydrogen (deuterium) atom and a proton(deuteron). The yields and energies of the ions are measured left and right along the polarization vector. As the relative phase of the two colors is varied, strong yield asymmetries are found in the ion energy regions corresponding to bond softening, above-threshold dissociation and rescattering. A model based on the dynamic coupling by the laser field of the gerade and ungerade states in the molecular ion accounts for many of the observed features.

It is known that few-cycle carrier-envelope-phase-stabilized laser pulses can be used to control electron localization in the dissociation of the hydrogen molecular ion [1], resulting is left-right asymmetry of the ion emission. Here we report experiments which demonstrate a similar control achieved by scanning the relative phase between two-color (800 and 400nm) many-cycle pulses. The superposition of the two colors generates, in an easily reproducible and robust manner, the required asymmetric light-field. A neutral $D_2(H_2)$ gas is ionized and dissociated by the light pulse and the D^+ (H^+) ions from the dissociation of D_2^+ (H_2^+) are detected using both a velocity-map-imaging system (VMI) [1] and/or a stereo-phasemeter [2]. A sample of the VMI results is shown in Fig. 1, where the asymmetry of deuteron emission from D_2^+ is shown as a function of the ion energy and the relative phase of the two colors. The yield of the fragments, measured as a function of the ion kinetic energy, shows a clear left-right asymmetry oscillation in the bond-softening, above-threshold-dissociation and rescattering channels. In the energy region of the CREI the asymmetry vanishes, as it should since this channel corresponds to double ionization. We have measured the asymmetry dynamics in the different fragmentation channels as a function of the two-color field intensity.

We compare our results with the results of a theoretical model. For the bond-sofetning and above-threshold-ionization channels the initial ionization event is assumed to launch a wave packet onto the gerade potential curve of the molecular ion, and the subsequent coupling of gerade and ungerade states by the asymmetric laser field is followed. For the rescattering channel, the ungerade channel is directly populated. Many features of the experimental data can be reproduced by the model.

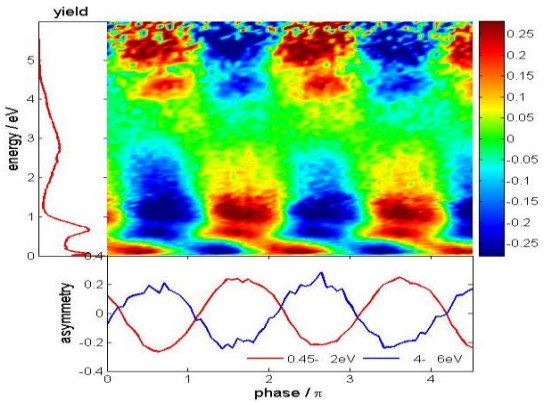

Fig. 1. Asymmetry [(yield $_{left}$-yield $_{right}$)/total yield] plotted as a function of the phase angle of the 400 nm radiation, relative to that of the 800 nm radiation, and the d^+ ion energy. The panel on the left shows the total yield of ions versus energy, while the lower panel shows the yields from the 0.45-2 eV (mainly above-threshold dissociation) and 4-6 eV (mainly rescattering) channels.

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[References

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