TOWARDS THE COMPLETE IMAGING OF MOLECULAR DYNAMICS IN ULTRA-SHORT LASER FIELDS

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Reaction microscope-based, complete and time-resolved Coulomb explosion mapping of vibrating and dissociating D_2^+ molecules with femtosecond time-resolution allowed us to perform an inter-nuclear distance- (R-) dependent Fourier analysis of the corresponding wave-packets [1]. Our calculations demonstrate that the obtained two-dimensional R-dependent frequency spectra enable the complete characterization of the wave-packet dynamics and directly visualize the field-modified molecular potential curves in intense, ultra-short laser pulses, including `bond softening' and `bond hardening' processes.

In this poster we demonstrate this novel experimental and theoretical scheme for the complete mapping and characterization of molecular potential curves, which are dynamically modified by a 6-7 fs, intense laser pulse [2]. In a proof-of-principles effort, using the fundamental deuterium molecular ion, we introduce a technique for imaging the shape of the molecular potential and the nodal structure of its bound vibrational wave function and show how both are modified by shaping the laser field (Figure). Our method relies on the Fourier transformation, w(R,f), over a sampling time T of the time- and R-dependent probability density w(R,t) of the D_2^+ nuclear wave packet. The nuclear wave packet can be either calculated [1] or experimentally reconstructed in pump-probe experiments [3].

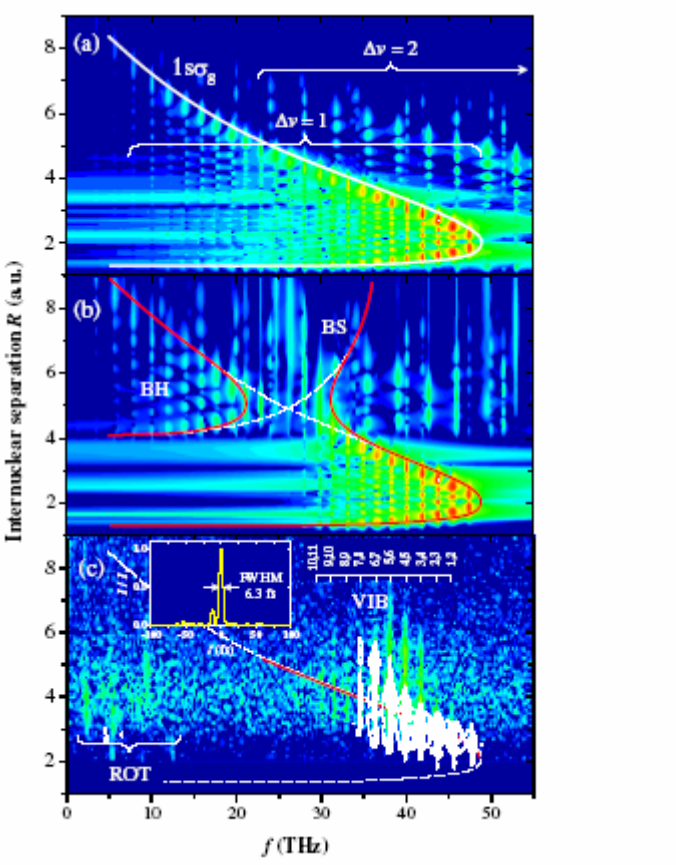

Figure. Power spectrum $|w(R,f)|^2$ as function of the frequency f and R for T=3 ps. (a): numerical field-free wave packet propagation of an initial Franck-Condon distribution. (b): as (a) but with a 50 fs pedestal of 0.01 PW/cm^2 preceding the probe pulse causing `bond softening' (BS) and `bond hardening' (BH). (c): Experimental distribution extracted from coincident D^+ pairs with vibrational (VIB) and rotational (ROT) contributions. White contours: numerical results using the actual laser pulse profile (see inset).

References

[1] B. Feuerstein and U. Thumm, Phys. Rev. A **67**, 063408 (2003).
[2] B. Feuerstein *et al.*, Phys. Rev. Lett., submitted
[3] Th. Ergler *et al.*, Phys. Rev. Lett .**97**, 19301 (2006).