MAPPING OF COHERENT NUCLEAR WAVEPACKET DYNAMICS IN D_2^+ WITH ULTRASHORT LASER PULSES

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Fast ionization of D_2 leads to the coherent population of many vibrational states of D_2^+. Usually, only the squared absolute values of the vibrational state amplitudes, known as Franck-Condon factors, are observed since insufficient experimental time resolution averages out all coherence effects. We propose a Coulomb explosion imaging method to visualize the coherent motion of bound wavepackets using ultrashort (5 fs), intense pump-probe laser pulses. With this type of experiment, decoherence times in the fs to ps range could be directly measured, providing essential information for coherent control.

In order to simulate such a type of experiment, we solve the time-dependent Schrödinger equation in a 2D collinear model (along the laser polarization axis) for D_2^+ with one dimension for the electronic and the nuclear coordinate, respectively. For the time propagation of the wavepackets, we use the Crank-Nicholson split-operator technique. Momentum distributions are derived using the "virtual detector" method [1].

We demonstrate the Coulomb explosion imaging of both dissociating and bound nuclear wavepackets. For dissociation, we consider the v = 0 ground state of D_2^+ interacting with two 25 fs pulses of 0.3 PW/cm^2 intensity and variable delay. Our calculation reproduces qualitatively results of a previous pump-probe experiment [2]. The reconstructed bound wavepackets from a simulation of a pump-probe study with D_2 (v = 0) as initial state using intense ultrashort pulses are shown in Figure 1.

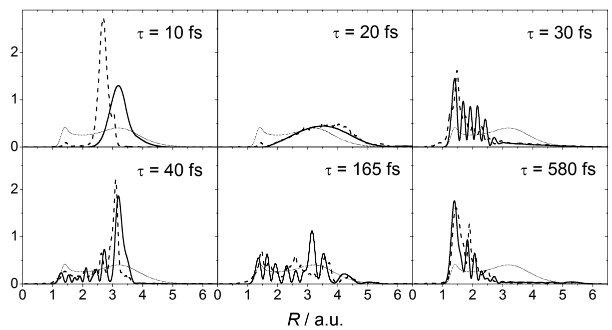

Figure 1: Snapshots of the coherent nuclear motion in D_2^+ following ionization of D_2 (v = 0) in a 5 fs, 1 PW/cm^2 laser pulse for various delays τ of the probe pulse. Solid curves: original density $|\Phi(R,\tau)|^2$. Dashed curves: reconstructed probability density. The time-independent Franck-Condon distribution is given by the dotted curve.

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References

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