Time-resolved laser Coulomb explosion imaging of ultrafast molecular dynamics induced in N_2, O_2 and CO by interaction with intense laser field

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Synopsis: We present a series of pump-probe experiments with 8 fs 800 nm laser pulses to study the evolution of a nuclear wave packet in molecular nitrogen, oxygen and carbon monoxide following an interaction with intense laser field. We also present classical and quantum simulations of a nuclear wave packet motion which account well for our experimental data.

In our work we employed COLTRIMS and VMI technique in combination with pump-probe experiment to continue study nuclear dynamics of diatomic molecules following their interaction with short intense near IR laser pulses [1]. Kinetic energy release spectra for N_2, O_2 and CO reveal the same main features as those for H_2 and D_2: dissociation and bound nuclear wave packet motion. However, these features are much more complex due to many available intermediate charged states Fig.1.

In the experiment we used two pulses of the same duration 8 fs and wavelength 800 nm but different intensity in the range of 5×10^{14}-5×10^{15}Wcm^{-2} produced from a single pulse by Mach-Zender interferometer. Pump pulse initiates dynamics in a molecule. Probe pulse induces multiple ionization which results in Coulomb explosion. The recoil fragments are collected and analyzed to measure KER as a function of delay between the pump and probe.

Experimental KER spectra for nitrogen molecule for breakup channel $N_2^{4+}\rightarrow N^{2+}+N^{2+}$ are presented on Fig.1. Intermediate charged states for dissociation dynamics are indicated: N_2^{+}, N_2^{2+} and N_2^{3+}. Each parent ion is also characterized with a set of contributing electronic states. To recover the detailed information about nuclear motion from experimental plots we performed a series of classical and quantum simulations. Calculated spectra are in a very good agreement with experimental ones.

Similar experiments and calculations were carried out for oxygen O_2 and carbon monoxide CO diatomic molecules.

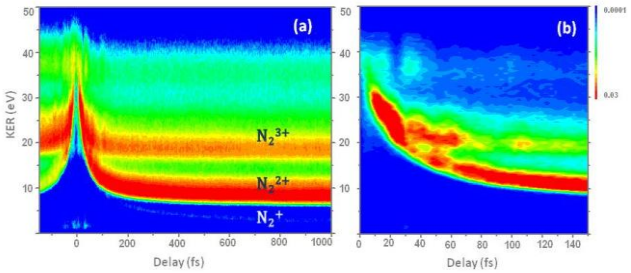

Fig. 1. Time-dependent kinetic energy release (KER) spectra (integrated over 4π angle) for N_2 for $N^{2+}+N^{2+}$ breakup channel. COLTRIMS technique. Pump pulse 8fs, intensity - 8×10^{14} W/cm^2; probe pulse 8fs, intensity - 17×10^{14} W/cm^2. (a) shows full spectrum with intermediate charged states indicated. (b) the same spectrum zoomed on the short delays part.

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References

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