1 Sakai (Hirofumi) Group

Research Subjects: Experimental studies of quantum optics and atomic/molecular physics

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Our research interests are as follows: (1) Manipulation of neutral molecules based on the interaction between a strong nonresonant laser field and induced dipole moments of the molecules. (2) High-intensity laser physics typified by high-order nonlinear processes (ex. multiphoton ionization and high-order harmonic generation). (3) Ultrafast phenomena in atoms and molecules in the attosecond time scale. (4) Controlling quantum processes in atoms and molecules using shaped ultrafast laser fields. A part of our recent research activities is as follows:

(1) All-optical molecular orientation [1]

We report clear evidence of all-optical orientation of carbonyl sulfide molecules with an intense nonresonant two-color laser field in the adiabatic regime. The technique relies on the combined effects of anisotropic hyperpolarizability interaction and anisotropic polarizability interaction and does not rely on the permanent dipole interaction with an electrostatic field. It is demonstrated that the molecular orientation can be controlled simply by changing the relative phase between the two wavelength fields. The present technique brings researchers a new steering tool of gaseous molecules and will be quite useful in various fields such as electronic stereodynamics in molecules and ultrafast molecular imaging.

(2) Dependence of the generation efficiency of high-order sum and difference frequencies in the extreme ultraviolet region on the wavelength of an added tunable laser field [2]

We investigate the dependence of the generation efficiency of sum and difference frequencies in the extreme ultraviolet (xuv) region on the wavelength of an added tunable laser field. The wavelength of the added field ranges from 600 nm to 1500 nm. The generation efficiency of sum and difference frequencies is dramatically enhanced when the wavelength of the added field is longer than that of the fundamental field for pure harmonics. The discussions are held to the added field with perturbative intensity first, and they are further extended to that with nonpertubative intensity.

(3) Effect of nuclear motion observed in high-order harmonic generation from D_2/H_2 molecules with intense multi-cycle 1300 nm and 800 nm pulses [3]

We investigate high-order harmonic generation from D_2/H_2 molecules with intense multi-cycle pulses centred both at 1300 nm (60 fs) and at 800 nm (50 fs) together with that from N_2/Ar as a reference. The experimental observations with 1300 nm pulses are different from those with 800 nm pulses both in spectral shapes and in intensity ratios I_{D_2}/I_{H_2}. The effect of nuclear motion in D_2 and H_2 is more distinctive for 1300 nm pulses than for 800 nm pulses. With multi-cycle pulses of 50–60 fs, the intensity ratios I_{D_2}/I_{H_2} are found to be higher for both 800 nm and 1300 nm pulses than those with few-cycle pulses of 8 fs, which is attributed partly to the contribution of the coupling between the $1s\sigma_g$ and $2p\sigma_u$ states in D_2^+ and H_2^+ molecular ions during the higher order returns of the electron wave packets.

[1] Keita Oda, Masafumi Hita, Shinichirou Minemoto, and Hirofumi Sakai, Phys. Rev. Lett. **104**, 213901 (2010).
[2] Yuichiro Oguchi, Shinichirou Minemoto, and Hirofumi Sakai, J. Phys. Soc. Jpn. **80**, 014301 (2011).
[3] Hiroki Mizutani, Shinichirou Minemoto, Yuichiro Oguchi, and Hirofumi Sakai, J. Phys. B: At. Mol. Opt. Phys. **44**, 081002 (2011).