

1 Sakai (Hirofumi) Group

Research Subjects: Experimental studies of atomic, molecular, and optical 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) Laser-field-free orientation of state-selected asymmetric top molecules [1]

With combined electrostatic and shaped laser fields with a slow turn on and rapid turn off, laser-field-free orientation of asymmetric top iodobenzene molecules with higher degrees of orientation has been achieved for the first time. In order to further increase the degrees of orientation, state-selected molecules are used as a sample. It is confirmed that higher degrees of orientation is maintained in the laser-field-free condition for 5–10 ps, which is long enough to study femtosecond-attosecond dynamics in molecules, after the rapid turn off of the laser pulse. The observation of the slow dephasing time of 5–10 ps ensures future prospects in molecular orientation techniques. This accomplishment means not only that a unique molecular sample has become available in various applications but also that the present technique can be used as a new spectroscopic technique to investigate ultrafast rotational dynamics of molecules.

(2) High-order harmonics generation from aligned molecules with carrier-envelope-phase-stabilized 10-fs pulses [2]

Clear interference fringes are observed in the high-order harmonic spectra generated from aligned molecules with carrier-envelope-phase-stabilized 10-fs pulses. A detailed Fourier analysis successfully reveals that the fringes are dependent on the carrier-envelope-phase and are formed by the interference between attosecond pulses *when the harmonic chirp is significantly large*. We further examine the possibility of observing the harmonic phase change in the harmonic spectra generated from aligned CO₂, which is associated with the destructive interference in the recombination process, and in those from aligned N₂, which is associated with the contributions from multiple orbitals, HOMO and HOMO-1.

- [1] Je Hoi Mun, Daisuke Takei, Shinichirou Minemoto, and Hirofumi Sakai, “Laser-field-free orientation of state-selected asymmetric top molecules,” to appear in Physical Review A as a Rapid Communication (2014).
- [2] Yusuke Sakemi, Shinichirou Minemoto, Kosaku Kato, and Hirofumi Sakai, “High-order harmonics generation from aligned molecules with carrier-envelope-phase-stabilized 10-fs pulses,” submitted to Physical Review A.