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) Suppression of high-order-harmonic intensities observed in aligned CO_2 molecules with 1300-nm and 800-nm pulses [1]

High-order-harmonic generation from aligned N_2, O_2, and CO_2 molecules is investigated by 1300-nm and 800-nm pulses. The harmonic intensities of 1300-nm pulses from aligned molecules show harmonic photon energy dependence similar to those of 800-nm pulses. Suppression of harmonic intensity from aligned CO_2 molecules is observed for both 1300- and 800-nm pulses over the same harmonic photon energy range. As the dominant mechanism for the harmonic intensity suppression from aligned CO_2 molecules, the present results support the two-center interference picture rather than the dynamical interference picture.

(2) Measuring polarizability anisotropies of rare gas diatomic molecules by laser-induced molecular alignment technique [2]

The polarizability anisotropies of homonuclear rare gas diatomic molecules, Ar_2, Kr_2, and Xe_2, are investigated by utilizing the interaction of the induced electric dipole moment with a nonresonant, nanosecond laser pulse. The degree of alignment, which depends on the depth of the interaction potential created by the intense laser field, is measured, and is found to increase in order of Ar_2, Kr_2, and Xe_2 at the same peak intensity. Compared with a reference I_2 molecule, Ar_2, Kr_2, and Xe_2 are found to have the polarizability anisotropies of 0.45 ± 0.13, 0.72 ± 0.13, and 1.23 ± 0.21 Å^3, respectively, where the uncertainty (one standard deviation) in the polarizability anisotropies are carefully evaluated on the basis of the laser intensity dependence of the degree of alignment. The obtained values are compared with recent theoretical calculations and are found to agree well within the experimental uncertainties.

(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 centered 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 1sσ_g and 2pσ_u states in D_2^+ and H_2^+ molecular ions during the higher order returns of the electron wave packets.

[1] Kosaku Kato, Shinichirou Minemoto, and Hirofumi Sakai, "Suppression of high-order-harmonic intensities observed in aligned CO_2 molecules with 1300-nm and 800-nm pulses," Physical Review A **84**, 021403(R) (4 pages) (2011). Selected for Virtual Journal of Ultrafast Science Vol. 10, Iss. 9 (2011).

[2] Shinichirou Minemoto and Hirofumi Sakai, "Measuring polarizability anisotropies of rare gas diatomic molecules by laser-induced molecular alignment technique," The Journal of Chemical Physics **134**, 214305 (9 pages) (2011).

[3] Hiroki Mizutani, Shinichirou Minemoto, Yuichiro Oguchi, and Hirofumi Sakai, "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," Journal of Physics B: Atomic, Molecular and Optical Physics **44**, 081002 (5 pages) (2011) (Fast Track Communication).