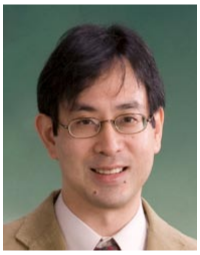

Title of Project : High Harmonic Generation in the 1-keV region and their Application to Attosecond Soft-X-ray Spectroscopy

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Research Area : Applied Physics
Keyword : Quantum electronics

【Purpose and Background of the Research】

Recent progress in intense laser technologies has realized the generation of coherent attosecond optical pulses by the process called high harmonic generation (HHG). The practical wavelength of HHG is, however, limited to about 10 nm (~ 100 eV in photon energy). This limit is set by the fact that the minimum wavelength of high harmonics is inversely proportional to the square of the driving laser's wavelength, where we usually use Ti:sapphire lasers operated at 800 nm. The purpose of this research is to break this limit by newly developed intense ultrafast light sources in infrared. If such novel light sources are realized, high harmonics can cover the spectral range down to 1 nm (or 1 keV in photon energies). Such soft X rays can interact with matters strongly and matches well with the absorption edges of light elements and transition metals. Using these absorption edges, we will aim to realize new methods to probe transiently excited states of matters on extremely short time scales. These efforts will open the field of ultrafast soft-X-ray spectroscopy.

【Research Methods】

We will develop a novel intense light source in infrared based on optical chirped pulse amplification. This concept was originally proposed by our group, and its proof-of-principle was recently demonstrated. This light source consists of a Ti:sapphire oscillator and amplifiers, whose outputs are used in parametric optical amplifiers for producing nearly-single-cycle phase-stabilized intense optical pulses at a 1-kHz repetition rate. Such high repetition rate and phase stabilization are crucial for spectroscopic applications. Using this new light source, we will produce high harmonics extended to 1-keV photon energies. Using the attosecond pulses in soft X rays, we will firstly work on the attosecond photoelectron spectroscopy in gas-phase molecules to establish time-resolved measurement techniques. We will then extend the methods to condensed matters to explore the possibilities of photo-emission spectroscopy and absorption spectroscopy on femtosecond to attosecond time scales.

【Expected Research Achievements and Scientific Significance】

Our new intense light source will realize the generation of soft X-ray pulses on femtosecond to attosecond time scales, opening the route to ultrafast soft-X-ray spectroscopy with the laboratory-scale setup. Such new instruments will allow us to probe photo-induced dynamics of atoms, molecules and condensed matters that occur on extremely-short time scales. Extension of the wavelength of intense light sources towards infrareds will also allow us to control various freedoms in matters, which will be useful to understand and control the non-equilibrium dynamics in photo-induced processes in molecular physics and condensed matter physics.

【Publications Relevant to the Project】

[1] N. Ishii, K. Kitano, T. Kanai, S. Watanabe, J. Itatani, "Carrier-envelope-phase-preserving, octave-spanning optical parametric amplification in the infrared based on BiB_3O_6 pumped by 800 nm femtosecond laser pulses," Appl. Phys. Express vol.4, p.022701-1-3 (2011),

[2] J. Itatani, J. Levesque, D. Zeidler, H. Niikura, H. Pepin, J. C. Kieffer, P. B. Corkum, "Tomographic imaging of molecular orbitals with high-harmonic generation," Nature vol. 432, p.867-871 (2011).

【Term of Project】 FY2011-2015

【Budget Allocation】 119,800 Thousand Yen

【Homepage Address and Other Contact Information】

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