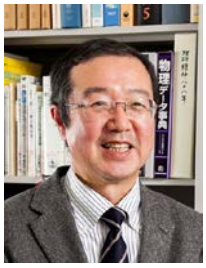
【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Interdisciplinary Science and Engineering)



Title of Project : Generation of Intense Isolated Attosecond Pulses and their Application to Attosecond Electron Dynamics Measurement

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Research Project Number : 26220606 Researcher Number : 40166070
Research Area : Applied Physics, Photon Science
Keyword : Nonlinear Optics, Attosecond Physics, Ultrafast Optics

【Purpose and Background of the Research】

Attosecond science has carved out one important research branch of ultrafast phenomena for the last decade. The success had given us many important knowledge for fundamental science of the interaction between electrons and photons. However, an output energy as well as a repetition rate is still not sufficient, though the pulse duration attained is sub-100 as. Thus, the widespread application of attosecond pulses has been limited because of the low photon flux as well as the complexity of the laser tools required to produce intense isolated attosecond pulses. To bring a breakthrough in attosecond science, we are going to tackle two research topics below.

【Research Methods】

i) Generation of intense isolated attosecond pulses
We have successfully increased an energy of isolated attosecond pulses by infrared two-color field synthesis. We are going to expand this two-color scheme into much shorter wavelength region.

Since our method has the advantage that the HH output yield can be linearly scaled up by increasing the HH emission volume, we can estimate exactly a scaled-up configuration in the soft-X-ray region. By straightforwardly upgrading the two-color scheme to a main pump energy of 50 mJ and adopting a focusing length of 5 m, we expect to achieve an isolated attosecond pulse energy grater than 0.1 μJ around 100 eV, which is almost 1000-fold higher than the energies previously reported.

ii) MHz repletion rated high harmonics
The increase of the repetition rate of high-harmonic pulses up to multi-MHz is required to explore the wide range of novel applications. In particular, photoemission spectroscopy is one of the most important applications of the multi-MHz HHG source.

We proposed a promising method for high repetition HHG inside the laser cavity of a high-power oscillator, which does not need precise control of cavity length. Energy-scalability and system flexibility of intra-cavity HHG is expected to be better than external enhancement cavity.

For realizing our concept, we design and develop a high-pulse-energy Yb:YAG thin disk mode-locked oscillator for intra-cavity HHG. In order to achieve high pulse energy at an ultrahigh repetition rate, the cavity length of 30 m which corresponds to the repetition rate of 10 MHz will be employed. Intra-cavity pulse energy of more than 100 μJ is expected with a pulse duration of 400 fs. In order to further shorten the pulse duration, we will test other thin disc media like Yb: Lu_2O_3 and Yb:KGW etc.

【Expected Research Achievements and Scientific Significance】

Here we are going to realize the MHz high-repetition HHG for ultrafast photoelectron spectroscopy and high energy attosecond pulses for attosecond-pump/attosecond-probe experiments and nonlinear science occurring on the attosecond time scale. Those are expected to bring major breakthroughs for the next attosecond frontiers.

【Publications Relevant to the Project】

・E. J. Takahashi, P. Lan, O. D. Mücke, Y. Nabekawa, and K. Midorikawa, "Attosecond nonlinear optics using gigawatt-scale isolated attosecond pulses", Nat. Commun. 4, 2691 (2013).
・E. J. Takahashi, P. Lan, O. D. Mücke, Y. Nabekawa, and K. Midorikawa, "Infrared two-color multicycle laser field synthesis for generating intense attosecond pulse, " Phys. Rev. Lett. 104, 233901 (2010).

【Term of Project】 FY2014-2018

【Budget Allocation】 134,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.riken.jp/research/labs/chief/laser_tech/