【Grant-in-Aid for Specially Promoted Research】
Science and Engineering (Mathematics/Physics)

Title of Project : Electronic stereodynamics in molecules and ultrafast molecular imaging based on molecular orientation techniques

Hirofumi Sakai
(The University of Tokyo, Graduate School of Science, Associate Professor)

Research Area : Mathematical and physical sciences

Keyword : Atom/Molecule

【Purpose and Background of the Research】

Since most molecules are anisotropic quantum systems, alignment or orientation dependence called steric effects is ubiquitous nature in various phenomena where molecules are involved.

In this project, we aim to establish "electronic stereodynamics" in molecules based on molecular alignment and orientation techniques and to develop the most advanced and sophisticated ultrafast molecular imaging techniques through the accomplishment of the following specific goals. (1) We will achieve completely field-free molecular orientation by an intense, nonresonant, two-color laser field with a slow turn on and rapid turn off. (2) With a sample of aligned or oriented molecules, studies on "electronic stereodynamics" in molecules will be performed in a direct manner.

【Research Methods】

Some specific plans are as follows:

(1) We will achieve completely field-free molecular orientation by an intense, nonresonant, two-color laser field with a slow turn on and rapid turn off. The technique is based on the combined effects of anisotropic hyperpolarizability interaction as well as anisotropic polarizability interaction. The two-color laser field with a slow turn on and rapid turn off could be shaped with a plasma shutter technique.
(2) With a sample of aligned or oriented molecules, studies on "electronic stereodynamics" in molecules such as hot above-threshold ionization (ATI), nonsequential double ionization after tunnel ionization, and high-order harmonic generation (HHG) will be performed in the most advanced and sophisticated manner. Especially, the information about photoelectron spectrum resulted from ATI will give us a good insight into the deeper understanding of the underlying physics on HHG from aligned or oriented molecules.

【Expected Research Achievements and Scientific Significance】

The accomplishment of the above goals will lead to the opening up of the physics of molecules in a new quantum phase because a sample of aligned or oriented molecules can be considered to be in a new quantum phase of an anisotropic quantum system.

The implementation of the present project will have a great impact on molecular science and the relevant fields such as "electronic stereodynamics" in molecules, ultrafast molecular imaging, attosecond science, stereodynamics in chemical reactions, surface science, and so on.

【Publications Relevant to the Project】

- Akihisa Goban, Shinichirou Minemoto, and Hirofumi Sakai, "Laser-field-free molecular orientation," Phys. Rev. Lett. **101**, 013001 (4 pages) (2008).
- Tsuneto Kanai, Shinichirou Minemoto, and Hirofumi Sakai, "Quantum interference during high-order harmonic generation from aligned molecules," Nature (London) **435**, 470-474 (2005).
- Haruka Tanji, Shinichirou Minemoto, and Hirofumi Sakai, "Three-dimensional molecular orientation with combined electrostatic and elliptically polarized laser fields," Phys. Rev. A **72**, 063401 (4 pages) (2005).
- Hirofumi Sakai, Shinichirou Minemoto, Hiroshi Nanjo, Haruka Tanji, and Takayuki Suzuki, "Controlling the orientation of polar molecules with combined electrostatic and pulsed, nonresonant laser fields," Phys. Rev. Lett. **90**, 083001 (4 pages) (2003).

【Term of Project】 FY2009-2013

【Budget Allocation】 261, 700 Thousand Yen

【Homepage Address and Other Contact Information】

http://light.phys.s.u-tokyo.ac.jp/index.html
hsakai@phys.s.u-tokyo.ac.jp