

**Visualization of electron transfer in matter
with a time-resolved reaction microscope for electron Compton scattering**

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【Outline of survey】

The purpose of this project is to develop a time-resolved reaction microscope for electron Compton scattering by gaseous molecules. It is a method to visualize the change of electron motion in a transient species, which is the driving force behind any chemical reaction, or to see in momentum space how the electron wave function would evolve as time advances. Here the inelastically scattered electron, ejected electron, and fragment ion produced by Compton scattering in the collision of a pulsed electron beam with the transient species, that is prepared beforehand with a pump pulse laser, are measured in coincidence, whilst the timing of the ionization with respect to the pump pulse is varied. The experimental data of vector correlations amongst the three charged particles are subsequently employed to construct the electron momentum distribution functions of the transient species as a function of electron binding energy in addition to the timing of the ionization. This method represents the first time that the change of electron motion in matter would become observable, thus developing previously uncharted areas of photoinduced ultrafast dynamics such as excitation-energy transfer, electron transfer and isomerisation processes. Furthermore, the method can be recognized as the first pump-and-probe approach combining electron impact ionization with the ultrafast dynamics.

【Expected results】

The time-resolved reaction microscope for electron Compton scattering can be realized by combining the latest pulsed laser techniques with the kinematically-complete electron Compton scattering experiment in the molecular frame that our group has recently pioneered. By keeping in mind that, at present, only theory has access to the electron wave function itself, the outcome of this project is expected to have a profound impact upon a wide range of fields from material science to life science. For instance, qualitative changes could be brought about eventually into the understanding of chemical bonding and chemical reactions.

【References by the principal investigator】

- M. Takahashi, N. Watanabe, Y. Khajuria, Y. Udagawa, and J. H. D. Eland, "Observation of a Molecular Frame (e , $2e$) Cross Section: An (e , $2e+M$) Triple Coincidence Study on H_2 ", *Phys. Rev. Lett.* **94**, 213202 (2005).
- M. Takahashi, "Development of Molecular Frame (e , $2e$) Spectroscopy by Means of a Triple Coincidence Technique" (in Japanese), *BUTSURI*, **61**, 90 (2006).

【Term of project】 FY2008—2012

【Budget allocation】

118,400,000 yen (direct cost)

【Homepage address】

<http://www.tagen.tohoku.ac.jp/labo/takahashi/index.html>