Development of the Time-Resolved Electron Momentum Spectrometer

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Synopsis The recent development of our time-resolved electron momentum spectrometer is reported.

Electron momentum spectroscopy (EMS) [1], a technique based on high energy electron impact (e, 2e) reaction, is well-known for its unique ability in directly detecting electron density in momentum space for individual orbitals. On the other hand, the understanding of the structures and the dynamics of molecular excited states are significant due to its unique properties and potential applications [2]. The employment of the pump-probe technique has led to many wonderful types of experiments on the investigation of the nature of molecular excited states, exhibiting extensive application in chemical physics and material science. The combination of EMS and optical pules in the pump-probe scheme can help people image molecular orbitals in excited states directly in principle. The direct observation of the electron density distributions and its evolution in exited states of molecules will present more direct information on molecular excited states.

A new time-resolved EMS (TRMS) apparatus (Figure 1) has been built in our group for visualizing molecular excited state dynamics. In our design, molecules are pumped by ultraviolet laser pulses produced by the ultrafast laser system. The energy and time resolution of the pump laser can be 160 μJ@264 nm and 1.4 ps at a repetition frequency of 5 kHz. After adjustable time delay, the pulsed electron beam is generated by deflection chopping synchronously. The time resolution of the electron pulse is sacrificed to be nanosecond at first to improve the beam current to reduce the large statistical error of TREMS results. The molecules in excited states are detected through the measured binding energy spectra and electron momentum distributions using the double toroidal analyzer and position sensitive detector. Figure 1 shows the elastic scattering image recording by the detector. Figure 2 shows the time difference between the MCP signal and laser signal from photodiode (subtracting the fly time of the electron from reaction center to MCP), exhibiting the time width of the electron pulse and the time delay between the electron pulse and laser pulse. Other detailed results will be shown in the poster.

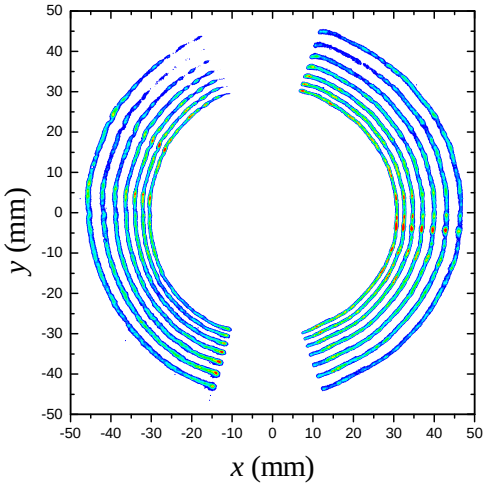

Figure 1. Contour plot of an image of elastically scattered electrons at incident electron energy from 585 to 615 eV in intervals of 5 eV.

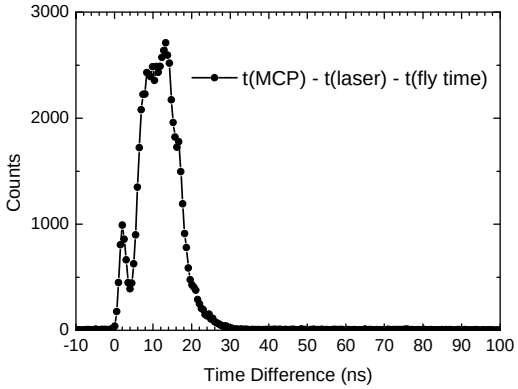

Figure 2. The time spectrum exhibiting the difference in arrive time between the electron pulse and laser pulse.

References

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[2] Altucci C et al., J. Mol. Opt. 57, 916(2010)

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