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First Results on Ultrafast and Ultraintense X-Ray Studies of Molecular Photoabsorption using the LCLS Free Electron Laser[1]

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The study of atomic and molecular inner-shell photoionization with conventional x-ray sources is dominated by processes involving the production of single core holes. However, the unprecedented short pulses and peak power at x-ray wavelengths of the Linac Coherent Light Source (LCLS) at the SLAC National Accelerator Laboratory provides new research opportunities and opens the door to study ultra fast, nonlinear x-ray physics. We have used the LCLS to investigate fundamental questions concerning laser pulse duration dependent ionization as well as examine the creation and decay of multiple core-holes. In particular, we focused on double core-holes ionization in N_2. We measured the photoelectron, Auger and secondary electron relaxation pathways subsequent to multiple core vacancies in molecules as well as the fragmentation patterns and the charge-state distributions of the resulting ions as a function of wavelength, pulse duration and intensity. The new light source allows the characterization of the molecular ionization and dissociation dynamics and provides new insight into the interaction of matter with intense short pulses. In addition we expect our results to contribute to the foundation for future imaging experiments on molecules. The LCLS photon beam was focused to about $2\mu m^2$ area producing an intense x-ray laser beam of up to 10^{18} W/cm^2. We have used x-ray pulses with duration from about 7fs to 280 fs and a photon energy of 1.1 keV to investigate the production of multiple core holes. We have observed the multiple ionization of N_2 resulting in fragment ions of up to bare N^{7+} [1]. Furthermore, evidence for double core hole has been observed. The experiment was performed at the LCLS AMO beamline which is equipped with an ion time-of-flight spectrometer to determine the ion charge state distribution as well five angle and energy resolving electron time-of-flight spectrometers to detect the emitted photoelectrons and Auger electrons.

[1] Work done in collaboration with L. Fang, M. Hoener, O. Kornilov, M. Guehr, O. Gessner, S.T. Pratt, C. Blaga, C. Bostedt, J.D. Bozek, P. Bucksbaum, C. Buth, R. Coffee, J. Cryan, L. DiMauro, J. Glownia, E. Hosler, E. Kanter, , E. Kukk, B. Murphy and D. Rolles and N. Berrah.

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