Pump-Probe Studies of K-Shell Photoionization and Vacancy Decay of Atoms and Small Molecules

Al Belkacem

Lawrence Berkeley National Laboratory

In this presentation I will review inner-shell processes in atoms and molecules that are the most amenable to provide tools for beam diagnostics of femtosecond hard x-ray pulses. I will review the pump-probe experiments we performed at the ALS using potassium atoms as targets. I will also discuss the results of the gas phase experiment at SPPS to probe side bands of K-shell Auger electrons of neon and argon.

The binding energy of inner-shell electrons of an atom or molecule is dependent on the total electronic configuration of the system. This dependence includes the presence and configuration of valence electrons, which through correlation and core charge screening can extend their influence even to K-shell electrons. A femtosecond laser, acting on the outer electrons only, can thereby provide a handle to probe and indirectly affect properties and dynamics of inner-shell electrons.

We have used ultrafast lasers in conjunction with keV x-rays from the Advanced Light Source in Berkeley for time-domain study of electron dynamics of argon and potassium in gas phase. Removal of the potassium 4s valence electron increases the binding energies of both the valence and the 1s core levels, and induces an ultrafast change of the 1s-4p x-ray transition energy by about 2.8 eV. We simultaneously observe a 50% increase in oscillator strength of K+ over K0 for that transition. These results provide accurate experimental input for quantum mechanical calculations of many-electron atomic systems in the gas phase. The fast electron correlation makes these experiments extendible to studies on much faster time scales, and also makes them ideal candidates for ultrafast hard x-ray beam diagnostics.