Focused X-rays Reveal the Shape of Atomic Electron Clouds
Atomic, Molecular and Optical Physics Group

Using a novel technique, based on x-ray pulses focused to about a millionth of a meter ("x-ray microprobe"), the shape of an atom ionized by a strong laser pulse has now been measured. The electric field of a strong laser pulse can rip out an electron from an atom causing ionization. The resulting positively charged ion has a shape that is deformed along the direction of the laser electric field. A direct experimental proof of this fundamental effect had been lacking so far. The AMO group has developed an x-ray microprobe as a versatile tool to interrogate atoms within the focus of an intense, ultrafast laser. Making use of Argonne's Advanced Photon Source, the new methodology is employed to measure the shape of laser-generated krypton ions. This work showed that the measured shapes can be understood taking into account a relativistic effect known as spin-orbit coupling. There is great interest in compact sources of deeply penetrating radiation and this research investigating the initial step in such sources may have important implications for improving their efficiency. The x-ray microprobe methodology will also be essential in future studies with x-ray free-electron lasers and to monitor ultrafast processes in complex environments.