DAMOP09-2009-000109
Abstract for an Invited Paper
for the DAMOP09 Meeting of
the American Physical Society

Strong field Ionization in the Far Infrared Limit

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In the last few years, strong-field ionization has drawn considerable interest since it is the main response of atoms and molecules to a strong laser field and because of its importance in processes like high-harmonic generation. Ionization mechanisms are usually classified in terms of one of two physical processes, namely multi-photon ionization or field ionization. The Keldysh parameter $\gamma = (I_P/2U_P)^2$, with U_P the ponderomotive energy, allows to distinguish between these types of ionization. In the multi-photon regime ($\gamma > 1$) the ionization yield scales with $S \sim I^{\alpha}$, with I the laser intensity and α the minimum number of photons needed to cross the ionization threshold. In the field ionization limit ($\gamma < 1$), ionization takes place by passing over or tunnelling through the barrier that results from combining the Coulomb potential and the laser electric field. Due to technical limitations, most of experiments on strong-field ionization of atoms were performed in a relatively narrow wavelength range from the ultra-violet to the mid-infrared regime. The development of light sources like the Free Electron Laser for Intracavity Experiments (FELICE) at Rijnhuizen allows strong-field ionization experiments to be performed at previously inaccessible far-infrared wavelengths. Here, we report an experiment on strong-field ionization in Xenon and Argon using this new laser source. Starting from high-lying Rydberg states (n$>$ 7), complex photoelectron velocity distributions with resolved ATI structure characteristic of the multi-photon regime are observed which have been studied both as a function of the prepared atomic state and the wavelength of the incoming radiation. For low-lying Rydberg states (n$<$ 7), the observed ATI structure disappears, meaning that ionization takes place in the field ionization regime, involving the absorption of several hundred photons.