Strong-field physics with mid-infrared lasers

by

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The strong-field picture of ionization describes the physics of how an isolated atom interacts with an intense ultra-fast laser field. The basic strong-field picture is described as tunnel ionization, which is characterized by the rapid burst of an electron wave packet into the continuum, followed by the classical motion of a quasi-free electron in a strong laser field and recollision with the parent ion. Recollision physics is at the very heart of what makes strong-field science an exciting tool for probing matter on ultrafast time scales. It offers a mechanism to create Attosecond (1 as = 10^{-18} s) laser pulses through High-Harmonic Generation and it offers a method for controlling electron-ion collisions on sub-femtosecond (1 fs = 10^{-15} s) time scales.

In my talk I will discuss how wavelength scaling has offered a more robust description of the strong-field picture. In particular, long wavelength lasers provide deep access to tunnel ionization and high energy electrons (several hundred eV) for studying electron recollision. I will discuss two separate aspects of my contributions that have helped to extend the strong-field picture. First, I will discuss inelastic laser driven scattering, or non-sequential ionization, in the long-wavelength limit of a 3.6 μm laser field. Here, large recollision energies (up to 400 eV) driven at modest field strengths result in the impact ionization of charge states up to Xe^{+6}. The multiple ionization pathways are well described by a white electron wave packet and field-free inelastic cross sections, averaged over the intensity-dependent energy distributions for *(e,ne)* electron impact ionization. Then, I will discuss how wavelength scaling has made possible extending the strong-field picture of ionization to condensed phase systems. Here, we have observed evidence of a dramatic new mechanism for High Harmonic Generation that is unique to crystals yet closely parallels the semi-classical analysis of the strong-field atomic picture.