Abstract for an Invited Paper
for the DAMOP09 Meeting of
The American Physical Society

Ionization of Atoms and Small Molecules in Ultra-Strong Laser Fields

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The frontiers of ultraintense laser science stretch across an exceptional range of disciplines including plasma physics, fusion science, atomic physics, optical science, and attosecond physics. Today, ultrafast lasers have increased laboratory light intensities to 10^{20} times the intensity of sunlight on earth and there is new interest in the ultrastrong fields at "relativistic intensities." In ultrastrong fields (10^{17} W/cm^2 to 10^{20} W/cm^2) multi-electron events involving the correlation of four or more electrons have been measured and the entire valence shell along with several inner shell electrons may be ionized. Furthermore, after ionization in ultrastrong fields photoelectrons experience a tremendous acceleration, 10^{24}m/s^2 in fact at an intensity of 10^{20}W/cm^2. This acceleration can change the velocity of an electron from rest to a sizable fraction of speed of light c in less than a femtosecond. This talk will discuss recent extensions of our knowledge of atomic, molecular and optical physics from multi-photon and strong fields (10^{11} W/cm^2 to 10^{15} W/cm^2) into the new frontier of ultrastrong fields (10^{17} W/cm^2 to 10^{20} W/cm^2). The topics that will be discussed include the fundamental atomic ionization response including the role of the laser magnetic field and rescattering and Coulomb explosion and ionization of molecules in ultrastrong fields. This work is supported by the National Science Foundation (Grant No. 0757953).