Ionization Dynamics for Atomic and Molecular Ions in Relativistic, Ultrastrong Laser Fields

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The discovery of laser-driven rescattering and high harmonic radiation out to a maximum photon energy of 3.17 times the ponderomotive energy laid the groundwork for attosecond pulse generation and coherent X-rays. As the laser field drives the interaction to higher energies, relativity and the Lorentz force from the laser magnetic field enter into the dynamics.

We present the results of recent studies of laser rescattering, including these effects, to give a quantitative description of rescattering dynamics in the high-energy limit, ie, recollision energies of order 1,000 hartree (27 keV). In this high-energy limit, we treat the emitted high harmonic radiation from rescattering as a bremsstrahlung process.

When the interaction of the bound state electrons with the field is included (see Fig. 1), the polarization of the bound states is of order 0.5 e-bohr with energy shifts of several hartree. We will present the polarization and energy shifts for the bound stated in species from lithium to uranium from non-relativistic intensities of 10^{14} W/cm^2 to ultraintense, relativistic fields 10^{22} W/cm^2. Ionization from the traditional 'field-free' and the interacting bound state electron wave functions will be discussed.

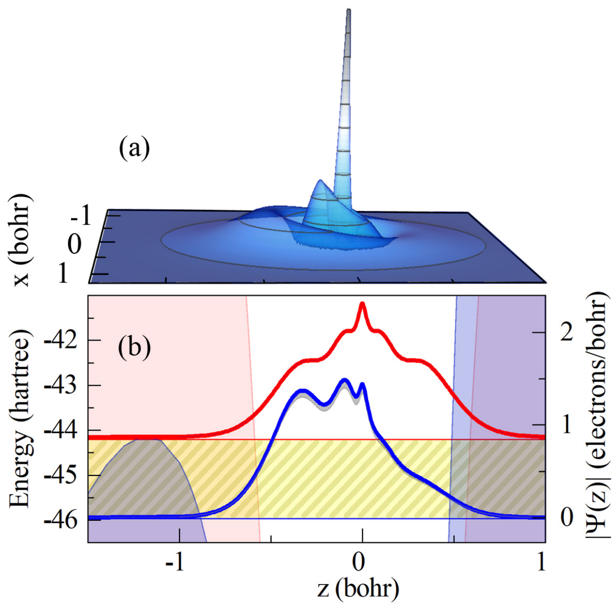

Figure 1: The wave function $|\psi(x, 0, z)|$ for the outermost electron in Kr^{25+} ionizing at an intensity of 10^{19} W/cm^2 is shown in (a). The wave function probability $\psi^*(z)\psi(z)$ for the outermost electron when field-free (red) and at 10^{19} W/cm^2 (blue) are shown in (b) superimposed with the potential energy $V(0, 0, z)$ and displayed at the Stark shifted energy