Universal Photo Electron Cutoff Energy for Ionization with Intense Few Cycle Pulses: From Atoms over Clusters and Nanoplasmas to Liquids

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High order above threshold ionization leads in atoms to a well known cutoff for the photo electron energy of 10.007 Up, where Up is the ponderomotive energy. Does a similar cutoff exist in extended targets and if so, how does it evolve from the atomic limit?

We will show that this is indeed the case where for finite systems the cutoff energy is larger than the atomic one for two reasons:

(i) photo electrons can re-scatter from a different atom since (in contrast to high harmonic generation) the process is incoherent,

(ii) they impact the at recollision with a higher momentum since they are accelerated by a positive background potential (of the cluster or nanoplasma).

A very simple description gives a universal maximal cutoff energy as a function of the depth V of the background potential and the radius of the extended target R scaled to the quiver amplitude.

Comparison with new experimental data and results from molecular dynamics simulations for different parameters of cluster size (a few 10 to a few 10000 atoms) pulse intensity, pulse length (in the 10-fs range) and photon wavelength (from 2 µm to 400 nm) show good agreement with the simple prediction and underscore its universal character.