Ionization and explosion dynamics of atoms in clusters irradiated by ultrashort, intense laser pulses

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Atomic clusters offer a unique area for studying high-intensity laser-matter interactions. Recently, the development of the laser-based x-ray sources using cluster targets has attracted lots of attention. This is because, compared to the solid targets, cluster targets produce less debris and are easy to handle. Although extensive studies on intense x-ray emissions from laser-cluster interactions have so far been carried out [1], the detailed physical mechanism is still ambiguous because of the highly nonlinear nature of the laser-cluster interaction. Thus, it is essential to develop the model which includes various atomic and relaxation processes as well as non-Maxwellian effects in a self-consistent manner.

In this study, short pulse laser-cluster interaction and resultant ion explosion dynamics with various charge states are investigated in detail by employing a particle based integrated code including ionization and relaxation processes. We have revealed that a formation of an enhanced electric field near a cluster surface is the key to understand complex ionization and explosion dynamics of atoms in a cluster. We have also found that a formation of an exploding ion front and a resultant sheath field affect an electron energy distribution. A combination of the non-Maxwellian electron energy distributions thus obtained and atomic kinetics rate equations will enable a more realistic modeling of the x-ray emission spectra obtained under the action of superintense laser radiation.

[1] Y. Fukuda et al., Appl. Phys. Lett. **85**, 5099 (2004).