HIGH POWER LASER MATTER INTERACTION INCLUDING ATOMIC AND RELAXATION PROCESSES

Y. Kishimoto, N. Iwata, A. Sugahara, S. Nakano, T. Matsuda
Graduate School of Energy Science, Kyoto University, Uji, Kyoto 611-0011, Japan

High power laser-matter interaction leads to a complex plasma state where multiply charged ions, electrons and positrons, neutral atoms and molecules, etc. coexist. Such states are also established in fast ignition plasmas where the cone target is made by a high-Z material such as gold. Such plasmas exhibit the characteristics that are highly non-liner, non-equilibrium and non-stationary. Specifically, various complex atomic processes and relaxation processes play important roles. Lightning/discharge process, photo-ionized plasmas in inter-stellar medium and accretion disk are also categorized in the same framework. We may refer to this kind of plasma state as a *synergetic complexity* in distinction from that used in conventional ideal plasmas.

The particle-in-cell (PIC) method which treats plasmas kinetically has been widely used in simulating complex plasma dynamics. However, most of them *a priori* made an assumption that the plasma is fully ionized in the initial state and/or the charge state is fixed during the evolution. For applications utilizing relatively high-*Z* materials irradiated by high power laser, the charge state of the matter is changed rapidly in time so that various complex structures and the related dynamics are established. Here, in order to investigate such complex plasmas, we have developed a three-dimensional particle based integrated code, EPIC3D, in which complex atomic process and also relaxation processes are self-consistently included [1]. Ionization processes due to electromagnetic fields and electron impact, and also multi-photon process and Auge effect are taken into account.

Based on the EPIC3D, we performed the simulation of laser-matter (solid target, cluster, and also gas) in parameter regimes relevant to the experiment [2-4]. Specifically, we investigated the ionization dynamics of sold and cluster irradiated by intense lasers. We found several types of ionization dynamics, such as a sheath field induced ionization and that induced by the ionization driven wake field. The latter is the new mechanism for generating the wake field in solid which leads to a fast time scale propagation of ionization front comparable to the speed of light [2].

The developed EPIC3D is powerful in studying the wide range of the problems related to laser-matter interaction and complex plasmas.

[1] Y. Kishimoto, Annual Report of the Earth Simulator Center, April 2002-Marcg 2003 (ISSN 1348-5822), Chapter 4 Epoch-Making Simulation, pp.201-205.
[2] M. Masaki and Y. Kishimoto, J. Plasma Fusion Res. 81, No.9, 643 (2009).
[3] T. Nakamura, Y. Fukuda, and Y. Kishimoto, Phys. Rev A, 053202 (2009)
[4] Y. Fukuda, K. Yamakawa, et al., Phys. Rev. A67, 061201(R) (2003).