Ionization dynamics and structure in high power laser-matter interaction

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The development of high-intensity short-pulse lasers opens up various applications based on laser-matter interaction, such as laser fusion, compact particle accelerators, neutron sources, and high intensity short pulse X-ray[1], etc. The materials irradiated by such power lasers tend to plasmas through various ionization process. The process is fairly important since they determine the initial plasma condition from which the primary interaction takes place. Many computational works using the particle-in-cell model have been done; however, most of them made a priori assumption of ideal plasma as an initial condition. For applications utilizing relatively high-Z materials, atomic and relaxation processes play an important role in determining the interaction. In order to study such applications, we have developed a particle based integrated code (EPIC3D) which includes various atomic and relaxation processes. By using the code, we investigated the ionization dynamics in carbon film irradiated by a short-pulse high-power laser, which had not been clarified previously.

We found two types of ionization dynamics. One is a fast time scale convective propagation of ionization front triggered by the field ionization[2] due to a solitary electric field propagating with ionization front. We have identified the mechanism of trigger in driving the fast propagation. The other is a slow propagation triggered by heated high energy electrons via electron impact ionization. We have identified the mechanism of trigger in driving the fast propagation. Different ionization mechanisms thus cause multi-stage ionization dynamics, which determines transient non-equilibrium and non-stationary plasma structure irradiated high power laser. We explore the model of the trigger in deriving such ionization dynamics. We will investigate such ionization dynamics to using more high-Z materials in studying the characteristics of the high pressure materials irradiated by high power lasers in the range of 10^{21}-10^{23} W/cm^2.

[1] T.Ditmire, *et al*, "Strong X-Ray Emission from High-Temperature Plasmas Produced by Intense Irradiation of Clusters" Phys.Rev.Lett. 75, 3122 (1995)
[2] V.T. Tichonchuk, "Interaction of a beam of fast electrons with solids", Phys. Plasmas. 9, 1416 (2002)