EFFECT OF RADIATION REACTION IN ULTRAHIGH-INTENSITY LASER INTERACTION WITH CLUSTER MEDIUMS

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With the recent development of ultrashort high power lasers, the intensity of laser light is reaching to the regime of $10^{22\text{-}24}$ W/cm^2, where materials irradiated by such lasers are ionized to high charge states by the strong laser electric field, and electrons are accelerated to relativistic velocities within a few laser cycle period. In such an ultraintense laser-plasma interaction, radiation from the accelerated electrons reaches to the energy level of gamma-ray, and accordingly, damping of electron motion by the radiation reaction becomes not negligible in the interaction dynamics. Laser-plasma interaction in such a regime has a potential to be a source of intense gamma-ray when a tailored plasma target is considered [1]. Here, in determining the interaction, the state and structure of target material is a key ingredient to be chosen properly according to the purpose.

Among various materials, cluster and cluster medium, i.e., a medium composed of multi-clusters, are interested owing to its high energy absorption and unique optical properties such as high harmonic generation and laser propagation due to the excitation of cluster dipole moment [2, 3]. Energetic ion generation using nano-size clusters are also studied intensively [4, 5]. In our previous study, we have investigated the fundamental dynamics and ion acceleration process in the interaction between cluster mediums and high intensity laser field in the regime of $10^{22\text{-}24}$ W/cm^2 based on the fully-relativistic particle-in-cell code EPIC3D [6]. It is shown that cluster ions gain relativistic energies by the Coulomb explosion associated with the radiation pressure acceleration. However, in such a strong and complex interaction between ultraintense laser and clusters, the effect of radiation reaction will be of specific importance compared to the case of simple uniform plasma targets.

Here, we study the radiation emission and the effects of radiation reaction in the interaction between laser and cluster medium in the intensity regime of $10^{22\text{-}23}$ W/cm^2 based on the PIC simulation including the radiation reaction force [7]. By carefully choosing the cluster size and spatial packing fraction, we found that the energy conversion rate from laser to high energy radiation can reach to about 35% in the cluster medium, which is increased significantly compared to the case of uniform plasma. It is also shown that the electron trajectory in the cluster medium exhibits complex motion affected by the Coulomb potential of clusters, which results in the effective radiation emission. The radiation is found to be emitted in a wide area inside of the cluster medium due to the penetration of laser field, whereas the area is limited at the peripheral of the front surface for a uniform plasma. Effect of radiation reaction to acceleration and heating of electrons and ions will be also discussed.

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