Particle based integrated code for the study of complex ionized medium

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All plasmas are produced from neutral medium via complex atomic and molecular processes. Such plasma production and ionization processes, where discharges and lightning are typical examples, are complex exhibiting prominent spatio-temporal structures. The sudden trigger of the event followed by the avalanche dynamics and emergence of complex fine branching structures are universal nature frequently observed, which remind us that the process is probabilistic and hardly predicted and controlled. Such a state may be referred to as *cmplex ionized medium*, where neutral atoms and molecules, multiply charged ions and free electrons, various wavelength radiations including externally applied electromagnetic field and internally generated higher harmonics, X-rays, etc. coexists. Such plasmas, which are highly non-linear, non-equilibrium and non-steady state with strong spatial inhomogeneity, can be seen not only in laboratories but also in space and universe. Many computational works using particle-in cell model, which is a powerfull tool for the study of palsma physics, have been done. However, most of them have made a priori assumption of ideal plasma.

In order to study such complex ionized medium, we have developed a particle based integrated code (EPIC) which includes key atomic processes and collision relaxation processes self-consistently in fully relativistic three dimensional configuration [1-2]. Using the EPIC, we studied the ionization dynamics and structure of solid thin film and clusters irradiated by ultra-short high power lasers, which have attracted attention in high energy ion acceleration[2]. We also investigate the interactions of x-ray free-electron laser light with a cluster target using the EPIC for the study realizing diffractive imaging of material and especially biological samples such as living cells. The target damage due to the irradiation by XFEL light is numerically evaluated, which gives an estimation of the XFEL intensity so as to suppress the target damage within a tolerable range for imaging. We also studied the discharge and lightning process using the EPIC3D in compressed gas immersed in high electric field and successfully reproduced streamer formation exhibiting fine net structure and associated avalanche dynamics [1].

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