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Transport of ultra-intense laser-driven fast electrons in dense plasmas

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Transport of ultra-intense laser-driven fast electron in over-dense plasmas has attracted great research interest because of its many potential applications, particularly in the areas of electron/ion acceleration, compact x ray or neutron sources, fast ignition scheme of inertial confinement fusion, et al. Since the fast electrons usually have large divergence due to the scattering of Weibel instability induced magnetic fields and laser transverse ponderomotive force in preplasmas, control of the fast electron propagation is crucial for these applications.

A newly developed hybrid particle-in-cell (PIC)/fluid simulation code named HEETS is applied to study the fast electron propagation in dense plasmas. It treats fast electrons by a standard, relativistic PIC method (including scattering and drag by the background plasmas), and models the background plasma as a collisional fluid.

Three of our recent works about fast electron collimation in dense plasma are presented.

（1）Mechanisms of fast electron energy deposition in dense magnetized plasma are studied. It is found that the energy deposition ratio of Ohmic heating and collisional heating can be enhanced significantly as an Al target is presented in a strongly axial magnetic field, attributed to the fast electrons rotating around the axial field. The weight of Ohmic heating is increased with laser intensity during fast electrons propagating both in magnetized and unmagnetized solid targets, which is the dominant heating mechanism as the laser intensity is greater than 1018 W/cm2 compared to the collisional heating.

（2）The influence of high-Z dopant in low-Z foam target on fast electron propagation is studied. The fast electrons are better confined in doped targets due to the increasing resistivity of the target, which induces a stronger resistive magnetic field which acts to collimate the fast electron propagation. The energy deposition of fast electrons into the background target is increased slightly in the doped target, which is beneficial for applications requiring long distance propagation of fast electrons, such as fast ignition.

（3）Criterion of fast electron collimating propagation in dense plasmas is extended by employing a more realistic magnetic field layer. The magnetic field structure obtained from the “rigid-beam” model shows that the transverse peak position of the self-generated magnetic field moves to the periphery of the focal spot with a growing tilt angle when the laser intensity increases, which greatly weakens the fast electrons collimation. A new two-pulse collimating scheme is proposed, in which the focal spot size of the guiding pulse plays a crucial role to confine the fast electrons produced by the main pulse.

References

(1) X. H. Yang, H. Xu, Y.Y. Ma, Z. Y. Ge, H. B. Zhuo, and F. Q. Shao. Phys. Plasmas 25, 063104 (2018).

(2) H. Xu, X. H. Yang, J. Liu, and M. Borghesi. Plasma Phys. Control. Fusion 61, 025010 (2019).

(3) H. Xu, H. B. Zhuo, X. H. Yang, Y. Yin, and J. Liu, Chin. J. Comput. Phys. 34, 505 (2017) (In Chinese).

(4) H. Xu, X. H. Yang, Y. Y. Ma, H. B. Zhuo, et al.. submitted.