3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Directional drift and merging of focal spots in nonlinear evolution of the current filamentation instability

Xiao-Juan Wang[1], Zhang-Hu Hu[1], Yong-Tao Zhao[2] and You-Nian Wang[1]
[1] School of Physics, Dalian University of Technology, Dalian 116024, P.R. China
[2] School of Science, Xi'an Jiaotong University, Xi'an, 710049, P.R. China
e-mail (speaker): wxjcym@mail.dlut.edu.cn

The transport and energy deposition of relativistic electron beam in the non-uniform plasmas is investigated with two-dimensional electromagnetic particle-in-cell simulations. The self-consistent beam structure evolutions are shown in Fig. 1, where an electron beam with flat-top density distribution is clearly displayed. We find similar double ring structure in the edge regions when the electron beams with large radial density gradients are transported in the non-uniform plasma. For the beam with the radius much larger than the plasma skin depth, the current filamentation instability excited by the relativistic electron beam can be clearly observed, which breaks the electron beam up into a large number of filaments with a typical radius R~c/ω_{pe} and leads to the formation of strong magnetic field consequently. We can clearly observe that these beam electrons are focused to form high density focal spot under the action of the electromagnetic field, as displayed in the Fig. 1(e). Interestingly, by inspecting the Fig. 1(e) and Fig. 1(f), the focal spot obtains a transverse velocity moving to the right side of simulation region, i.e., low plasma density.

For the case that intense electron beam is transported in the non-uniform plasma, asymmetric transverse magnetic field [1], which is associated with different plasma density values, contributes to the directional drift of electron focal spot and thus enhance the merge. Furthermore, axial electric field is generated in the middle of two filaments when they merge under the action of the magnetic field. The axial electric field is responsible for the formation of plasma jet and energy deposition when two fairly large filaments begin to merge, which is significant for the fast ignition in the inertial confinement fusion.

This work was supported by the National Natural Science Foundation of China (Project Nos. 11775042, U1532263, and 11705017) and the Fundamental Research Funds for the Central Universities No. DUT17LK12.

[1] G. Shvets, O. Polomarov, V. Khudik, C. Siemon, and I. D. Kaganovich, Phys. Plasmas 16, 056303 (2009).

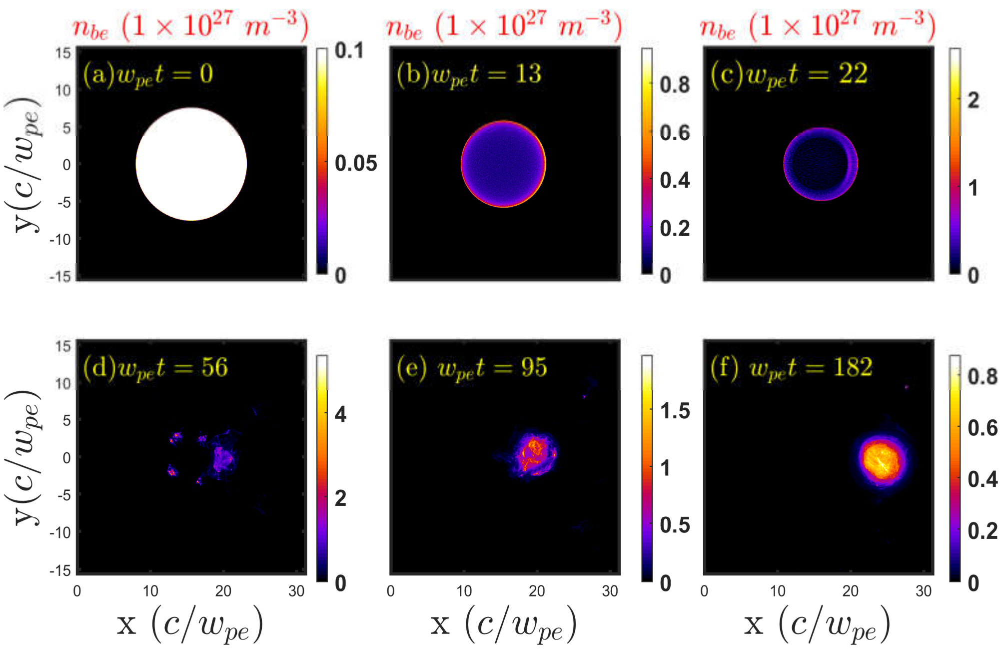

FIG. 1. The temporal density evolution of electron beam with a radius r_b = 7.6 c/ω_{pe}, much larger than the plasma skin depth. Snapshots with six different travel times are shown: (a) ω_{pe}t = 0, (b) ω_{pe}t = 13, (c) ω_{pe}t = 22, (d) ω_{pe}t = 56, (e) ω_{pe}t =95, (f) ω_{pe}t =182.