Kinetic behavior of electron magnetohydrodynamic structures

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The interaction between fast rising electron current pulses and plasmas is an important area of research activity. It has broad applications such as fast ignition concept of laser fusion, the physics of nondiffusive penetration of magnetic fields in astrophysical plasmas, the kinetics of electron layer in collisionless magnetic reconnection phenomena, and so on. When short electron current pulse propagates in plasma, return current is induced due to current neutrality. The combination of these forward and return currents causes well-known Weibel instability. It separates the forward and return currents spatially. As a result, cylindrical current channel is formed. The center of the channel carries the forward current that is surrounded by a cylindrical shell of return current. This current configuration produces poloidal magnetic fields. For convenience a transverse slice of the cylinder is considered. In this representation the magnetic field associated with the combination of forward and return currents forms a dipolar structure. The characteristics of this dipolar structure have been studied on previous work using electron magnetohydrodynamic (EMHD) model in 2D plane [1,2]. The consideration of immobile ion and zero temperature employed in EMHD formalism, however, is pretty restrictive. Therefore kinetic behavior of a dipolar structure that is exact solution of EMHD model has been explored in this study.

For this purpose, Particle-In-Cell (PIC) simulations that include kinetic effects are conducted. The exact dipole solution is used as initial conditions [3]. Changing the electron temperature, we perform PIC simulations to investing finite temperature effects. Furthermore effects of density inhomogeneity on dipole propagation are also studied.

[1] A. Das, Plasma Phys. Controlled Fusion **41**, A531 (1999).
[2] S. K. Yadav, A. Das, P. Kaw, and S. Sengupta, Phys. Plasmas **16**, 040701 (2009).
[3] M. B. Isichenko and A. M. Marnachev, Sov. Phys. JETP **66**, 702 (1987).