Kinetic-MHD numerical model of the interaction of an electron beam with the plasma

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Abstract

The research of the processes of a terahertz radiation generation is a topical for such physical problems as turbulence plasma heating on open magnetic traps, fast burning of a target in the inertial nuclear fusion and for other problems. The terahertz radiation can find implementation in the material investigation, production quality control, etc. There are many ways of obtaining terahertz radiation sources. One of such methods is getting the radiation by the interaction of an electron beam with the plasma. This process can be examined by both experiments and the numerical modeling. In the current work the numerical modeling which permits us to analyze the dependence of the radiation efficiency on different parameters has been carried out.

The most qualitative study can be carried out by a full kinetic numerical model. However the difficulties appearing at the practical implementation of such models deal with the big difference of characteristic space scales for electrons and ions. It leads to developing the hybrid (combined) models, where the kinetic Vlasov equation is used to describe the motion of one component of plasma and the magneto-hydrodynamic approach to describe the motion of another one. The decrease of requirements on the architecture and memory of computers, comparing with those of the fully kinetic models, provided the vast expansion of the hybrid models. The research based on such models is the most perspective with regard to a computational experiment.

In the present work a 3D hybrid numerical model to describe an electron plasma beam entering a plasma box surrounded by a vacuum is considered. Here to describe the motion of electrons of the beam and plasma the kinetic description in terms of guiding center is used, whether for ions the MHD approach is utilized. To solve the Vlasov equation the particle-in-cell (PIC) method is used. The comparison with a fully kinetic model will provide to determine the limits of use of the developed model and, also, will be an independent test to verify a 3D kinetic model.

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