Hybrid numerical model of diamagnetic confinent in an axisymmetric mirror machine

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The recently proposed method of diamagnetic plasma confinement [1] makes it possible to radically improve plasma parameters in linear magnetic systems for thermonuclear fusion in the case of successful experimental implementation. The magnetic field is completely displaced from the area occupied by the plasma, which significantly increases the effective mirror ratio and essentially increases confinement times of particles and energy [1].

Analytical and numerical models describing the equilibrium in diamagnetic trap in the MHD-approximation in the one-dimensional [1] and two-dimensional cases [2] are currently constructed. The MHD models predict that in the regime of the diamagnetic confinement an area occupied by dense plasma is formed in the trap, from which the magnetic field is completely displaced (diamagnetic “bubble”). Width of the transition layer on the “bubble” margin and confinement times is inversely to diffusion velocity of magnetic field which is determined by plasma conductivity.

The mean free path of ions is much larger than trap length at thermonuclear parameters. Moreover the Larmor radius of ions exceeds the width of transition layer calculated in the MHD approximation. So the kinetic effects are important for description of dynamic of ions and models based on the Vlasov equation are needed. Due to the complexity of the system, analytical methods are hardly applicable and it is necessary to create numerical models that are adequate to the processes under study.

The report presents a two-dimensional axially symmetric hybrid numerical model for the formation of a diamagnetic “bubble” in a mirror trap based on the kinetic approximation for the ion component of the plasma and the MHD approximation for electrons. To solve the Vlasov equations, the author's modification of PIC method is used [3]. The issues of accuracy and convergence of the created algorithms and the possibility of their implementation on the computing systems of modern architecture are discussed. Preliminary results have been obtained of the dependence of the plasma flow dynamics in the diamagnetic regime of open traps on the plasma and magnetic system parameters.

This work is supported by RFBR grant N 18-29-21025 mk.

References

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