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SIMULATION OF PLASMA LEAKAGE FROM AN OPEN TRAP USING A 1D DRIFT-KINETIC PIC CODE *)

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One of the most technically simple concepts of a thermonuclear reactor is based on magnetic plasma confinement in an open trap. An important step towards its implementation should be the GDMT (Gas-dynamic multiple-mirror trap) [1] installation, the design of which was proposed at the INP SB RAS. The project is designed to combine the main advantages of gas-dynamic, multiple-mirror and helical plasma confinement, which have been experimentally studied in the open traps GDL, GOL-3 and SMOLA for decades. Despite the extensive theoretical and experimental information accumulated about these modes, the question remains about the possibility of scaling the previously obtained results to the near-reactor parameters of the GDMT. To answer this question, it is necessary to thoroughly understand the physics of the phenomena occurring in the existing installations. In particular, the key issue for the future reactor is the amount of particle and energy losses along the magnetic field lines. An important role in suppressing these losses is played by a jump in the electric potential, which is formed between the plasma receivers and the center of the trap. And although the magnitude of this jump in the open trap expander was measured in experiments at the GDT, a correct interpretation of these measurements is impossible without a very detailed description of the electron kinetics.

At present, the DOL code [2] is widely used at the INP SB RAS for modeling the GDT trap. In this code, kinetic equations averaged over bounce oscillations are solved for ions, and the Boltzmann distribution is used for electrons. This code is capable of quickly calculating such a large setup as the GDT, but due to the averaged nature of the equations and a large number of external parameters it is unsuitable for problems related to the physics of expanders or the creation of a starting plasma. For a more detailed description of the electron physics, V. V. Glinsky began developing an electrostatic 1D Particle-In-Cell (PIC) code using the drift-kinetic approximation for all types of particles [3]. This work is devoted to the inclusion of the Coulomb collision algorithm [4] in this PIC model and modeling of plasma confinement in a mirror magnetic field. The simulation results of the loss rate establishment and the profile of the ambipolar potential in the problem of plasma leakage from a trap are compared with Pastukhov's formula.

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References

[1]. Skovorodin D.I. et al. Gas-dynamic multiple-mirror trap GDMT //Plasma Physics Reports. – 2023. – Т. 49. – №. 9. – С. 1039-1086.
[2]. Yurov D.V., Prikhodko V.V., Tsidulko Y.A. Nonstationary model of an axisymmetric mirror trap with nonequilibrium plasma //Plasma Physics Reports. – 2016. – Т. 42. – С. 210-225.
[3]. Glinskiy V.V., Timofeev I.V., Berendeev E.A. 1D drift-kinetic numerical model based on semi-implicit particle-in-cell method //Computer Physics Communications. – 2024. – Т. 304. – С. 109318.
[4]. Takizuka T., Abe H. A binary collision model for plasma simulation with a particle code //Journal of computational physics. – 1977. – Т. 25. – №. 3. – С. 205-219.

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