Axial plasma confinement in gas dynamic trap

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A key parameter of future thermonuclear systems is their energy efficiency, which rapidly increases with the increase in the electron temperature of the confined plasma. One of the factors limiting the electron temperature can be high thermal conductivity of the plasma along the magnetic field lines, which is determined by a number of complex kinetic processes in the expanders - areas of the expanding magnetic flux behind the magnetic mirrors. Therefore, it is necessary to study this loss channel in detail and determine the conditions under which it can be suppressed to levels acceptable for thermonuclear applications of open magnetic traps. Theoretical studies on this problem have been carried out earlier; however, the methods of physical processes analysis in the expanders have been oversimplified. Experimental studies aimed at solving the problem were performed only for low values ​​of the electron temperature of the scale of 20 eV. Due to the recent works on GDT facility in BINP SB RAS there is an opportunity to study in detail the longitudinal transport of plasma particles and energy with parameters closely approaching the parameters of projected neutron sources based on open magnetic traps. Stable confinement of plasma with a high relative pressure (beta = 0.6) was demonstrated; by means of additional ECR heating system, a record value of the electron temperature (about 1 keV) for quasi-stationary open magnetic traps was obtained; the associated increase in the retention time of high-energy ions and the thermonuclear neutrons yield is demonstrated. These achievements motivate the following research steps towards the development of a nuclear fusion reactor, and one of such steps should be the investigation of the longitudinal transport of particles and energy in the mirror cell.

In the first experimental series, the plasma parameters in the expander of the gas-dynamic trap were measured, namely the electric potential in the Debye layer near the surface of plasma absorber and the average electron energy as a function of the longitudinal coordinate [2]. The presence of a population of cold electrons trapped in the expander region is shown. The minimum value of the magnetic field expansion degree at still insignificant increase in longitudinal losses is determined.

To construct a complete model of longitudinal thermal conductivity in the open trap expander, a direct measurement of the density of longitudinal particle and energy fluxes dependences on number of parameters is required, namely, on the plasma temperature and density in the central part of the GDT, on the degree of magnetic flux expansion in the region of end absorbers location and on the density of the neutral gas in the expander. The results of these experiments will be presented in the report.

References

1. A.V. Anikeev, et al. Plasma Phys. Rep. 25, 10, 775-782, 1999;
2. E. Soldatkina, et al. Physics of Plasmas 24, 022505 (2017).