First Experiments on Helical Mirror Device SMOLA

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Plasma confinement in modern open magnetic traps features high relative pressure ($\beta \approx 60\%$), mean energy of hot ions of 12 keV and electron temperature ~ 1 keV [1]. At the same time, the confinement efficiency is limited by the achievable magnetic field; the mirror ratio is supposed to be 15–20 in neutron source concepts [2]. Higher fusion gain in linear plasma devices is possible with improved confinement. The existing technique of multiple-mirror suppression of the axial heat flux combined with gas-dynamic central cell [3] can provide effective mirror ratios >100, which gives feasible fusion gain appropriate for hybrid systems.

This report presents the first experimental results on the new method of active plasma flow suppression in a helical magnetic field [4]. This method renews the idea of a plasma flow control with moving mirrors. Plasma rotation in $\boldsymbol{E}\times\boldsymbol{B}$ fields can be utilized to create periodical variations of helicoidal magnetic field moving upstream in plasma's frame of reference. These variations transfer momentum to trapped particles and lead to plasma pumping towards the central trap. Theory predicts exponential dependence of the flow suppression on the magnetic structure length, that is more favorable then the power dependence in passive mirrors [5]. Plasma biasing or natural ambipolar potential can drive the rotation. The first case also leads to plasma pinching that counteracts the collisional radial diffusion.

Concept exploration device SMOLA with a helical mirror system [6] started operation in a start configuration in BINP in the end of 2017. Major aims of the first experiments were preliminary observations of plasma behaviour at changes of the magnetic configuration, regardless of the confinement efficiency. Plasma stream modification with the helical plugging was clearly shown. In this report, the main results of the experiments are discussed.

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