diagnostics of The spatial distribution of the plasma velosity in the SMOLA helical mirror trap

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The main problem of linear open systems is suppression of the particles and energy losses. The aim of the SMOLA device is to prove the concept of helical mirror [1, 2], which is based on a dynamic system with multimirror confinement. Variations of the helical magnetic field move in the frame of the reference of the rotating plasma. Rotation is induced by the crossed radial electric and helical magnetic fields.

The determination of the spatial distribution of the plasma velocity is necessary for constructing a model describing the motion of the plasma flow in a helical trap. The measurements of the plasma velocity by observation of the Doppler shift of the emission spectral lines Hα are provided by high spatial resolution spectrometer [3]. In the spectrometric system based on the focusing spectrometer with a reciprocal linear dispersion of 0.1 nm / mm, a spatial resolution of 1.2 mm was attained. The accuracy of plasma rotation velocity determination is Δω ~ 104 s–1.

A set of experiments was carried out with the different configuration, direction and amplitude of the magnetic field. The plasma emission spectra in the vicinity of the Hα line were obtained in the 4 operation regimes of the device: plasma confinement (straight and helical magnetic field) and plasma acceleration (straight and helical magnetic field).

The radial distribution of the Doppler shift of the Hα line is used to calculate the velocity of neutral hydrogen, which gives an estimate of the plasma rotation velocity ω ≈ 106 s–1. The indicated velocity corresponds to the presence of a radial electric field ~70 V / cm. Plasma parameters in the presented experiments are as follows: plasma density ~1019 m–3, temperature ~5 eV, plasma radius ~5 cm [4].

The dependences of the plasma rotation velocity on time are determined. We observed that the plasma rotation velocity decreases with time and the maximum of rotation velocity for each regime was registered at about 50 ms after the start of plasma injection. A differential plasma rotation is detected: the central part of the plasma rotates faster than the periphery.

In the report the dependence of the plasma rotation velocity on the radial profile of the electrostatic potential which is created by the electrodes of the plasma gun, the radially segmented plasma receiver and limiters is discussed. The results of optical diagnostics and Mach probe diagnostics to determine the rotational velocity and the longitudinal directional plasma motion depending on the distribution of the radial electric field are presented.

References

1. A.D. Beklemishev, Fusion Sci. Technol. No. 63(1T) (2013) 355–357.
2. A.V. Sudnikov et al., Fusion Eng. and Design. No. 122 (2017) 86–94.
3. I.A. Ivanov et al., General Experimental Technique. No. 2 (2016) 100–105.
4. A.V. Sudnikov First Experimental Campaign on SMOLA Helical Mirror, Plasma and Fusion Research, (2018).