DOI: 10.34854/ICPAF.51.2024.1.1.022

HEAVY ION BEAM PROBE APPLICATION FOR MEASUREMENT OF RADIAL ELECTRIC FIELD AND PLASMA POTENTIAL EVOLUTION AT TUMAN-3M TOKAMAK *)

Belokurov A.A., Abdullina G.I., Askinazi L.G., Kornev V.A., Lebedev S.V., Razumenko D.V., Shergin D.A., Shuvalova L.K., Smirnov A.I., Tukachinskiy A.S., Zhubr N.A.

Ioffe Physical Technical Institute, Russian Academy of Sciences, Saint Petersburg, Russia, belokurov@mail.ioffe.ru

Neutral beam injection (NBI) is an effective method of plasma heating, generation of rotation, and fuel delivery to the plasma core.

Co-NBI (in the direction of plasma current) is more effective for fast particles capture than counter-NBI (against the direction of plasma current), but the effect of co-injection on plasma confinement is determined by the combined effect of positive Er generation due to plasma rotation and the negative Er generation due to the loss of fast particles.

As it was shown earlier [1], in the case of low plasma density (line average n < 1.2.1019 m–3), co-NBI turns out to be ineffective in terms of plasma heating, generation of rotation and initiation of the L-H transition, because of significant shine through losses. This was noticeable by the absence of evolution of plasma potential during co-NBI [1], though during co-NBI one can expect both a positive increase in the potential associated with the generation of plasma rotation by confined fast particles, and a negative increase associated with the loss of fast ions from the first orbit.

In the scenarios with line average density n > 2.1019 m–3 (at the beginning of neutral injection) measurements of the evolution of the plasma potential were carried out using heavy ion beam probe (HIBP). A beam of neutral atoms was injected into the plasma in discharges with different concentrations (2–3.1019 m–3). Measurements show that at higher plasma density during NBI, the plasma potential evolves towards more positive values, with a change in the range of 100–300 V. This indicates that additional toroidal rotation is generated in the plasma, associated with fast ions.

By means of HIBP direct measurements of the radial electric field in ohmic discharges of the TUMAN-3M tokamak were carried out in a two-point probing scheme. In this scheme, it is possible to measure the plasma potential at two adjacent points and thus locally measure the radial electric field with the spatial resolution equal to the distance between the volumes of secondary ionization (for characteristic discharges of the TUMAN-3M tokamak—1–3 mm). In ohmic discharges of the TUMAN-3M tokamak in hydrogen and deuterium with similar plasma parameters, a similar evolution of the radial electric field is observed: the values of Er = (–4)–(–8) kV/m at minor radius coordinate r = 15 cm are close to estimates for local neoclassical Er in an ohmic discharge in the stationary phase. An increase in plasma density during gas puff leads to the evolution of Er towards more negative values, which is consistent with the idea of the dependence of the neoclassical radial electric field on the density gradient.

Operation of standard diagnostics on TUMAN-3M tokamak are supported by Ioffe Institute State contract 0040-2019-0023. NBI experiments are supported by Ioffe Institute State contract 0034-2021-0001. HIBP measurements on TUMAN-3M tokamak are supported by Russian Scientific Foundation project 22-12-00062.

References

[1]. Belokurov A.A. et al // Technical Physics Letters, 2022, V. 48, No. 12.

*) abstracts of this report in Russian