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EX/P6-11: Study of Fast Ion Confinement in the TUMAN-3M

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Confinement of NBI produced fast ions (FI) in the TUMAN-3M tokamak was studied using neutron flux detectors (NFD) and neutral particle analyzer. Two NFDs measured flux of 2.45 MeV DD neutrons. They are calibrated to account for total radiated neutron flux I_n . Since ion temperature in the device is below 0.5 keV neutrons are produced by beam-plasma reactions and thus their flux is very sensitive to FI amount. NPA measured spectra of thermal and slowing down ions in the range of 0.2-30 keV.

In the experiments deuterium NB with $E_b=19-25$ keV was injected in co-current direction tangentially to surface with $R_{inc}=0.42$ m (plasma major radius R_0 is 0.53 m and minor radius a is 0.22 m; working gas is deuterium). Recently performed upgrade of power supply allowed to increase toroidal field B_t and plasma current I_p in the NBI phase from 0.68 to 1.0 T and from 140 to 190 kA, correspondingly. With higher B_t and I_p an improvement of target plasma performance was observed. In particular, increase in the central electron temperature $T_e(0)$ from 0.4-0.5 up to 0.65-0.75 keV and two-fold decrease of effective charge increment ΔZ_{eff} during NBI application were found. The increase of $T_e(0)$ resulted in longer FI slowing down time. Decrease of ΔZ_{eff} is clear indication of substantial reduction of first orbit losses.

Increases in B_t and I_p resulted in growth of I_n at similar E_b and n_e indicating enhanced capture of FI. Two-fold increase in I_n with increasing B_t and I_p was found. Factor of 1.2 of the I_n increase is explained by increased deuterium content in the bulk plasma due to Z_{eff} decrease. Some 20% of the I_n increase is evidently caused by enhanced capture of FI. Remaining 45% of the flux increase might be understood if longer FI slowing down time τ_s at higher B_t and I_p is assumed. The assumption is in line with the expectation of τ_s increase with T_e rise ($\tau_s \propto T_e^{-3/2}$).

To examine an existence of FI losses exceeding Coulomb deceleration the characteristic time of I_n decay after NBI switch-off τ_n was measured. Measured τ_n appeared to be by a factor of 1.1-1.2 shorter than the one calculated from classical collision theory. This was explained by charge-exchange losses and by FI redistribution induced by beam instabilities. Measured by NPA enhancement in the ion tail is in agreement with simulations of NB capture efficiency and neutron flux measurements.

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