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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 In. 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 Eb=19-25 keV was injected in co-current direction tangentially to surface with R_inc=0.42 m (plasma major radius Ro is 0.53 m and minor radius al is 0.22 m; working gas is deuterium). Recently performed upgrade of power supply allowed to increase toroidal field Bt and plasma current Ip in the NBI phase from 0.68 to 1.0 T and from 140 to 190 kA, correspondingly. With higher Bt&Ip an improvement of target plasma performance was observed. In particular, increase in the central electron temperature Te(0) from 0.4-0.5 up to 0.65-0.75 keV and two-fold decrease of effective charge increment delta-Z_eff during NBI application were found. The increase of Te(0) resulted in longer FI slowing down time. Decrease of delta-Z_eff is clear indication of substantial reduction of first orbit losses.
Increases in Bt&Ip resulted in growth of In at similar Eb and n_e indicating enhanced capture of FI. Two-fold increase in In with increasing Bt&Ip was found. Factor of 1.2 of the In increase is explained by increased deuterium content in the bulk plasma due to Z_eff decrease. Some 20% of the In increase is evidently caused by enhanced capture of FI. Remaining 45% of the flux increase might be understood if longer FI slowing down time tau_s at higher Bt&Ip is assumed. The assumption is in line with the expectation of tau_s increase with Te rise (˜Teˆ3/2).
To examine an existence of FI losses exceeding Coulomb deceleration the characteristic time of In decay after NBI switch-off tau_n was measured. Measured tau_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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