Fast ion confinement in the experiments with the increased magnetic field on the Globus-M spherical tokamak

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In recent experiments on Globus-M, preceding tokamak disassembling, toroidal magnetic field $B_{\text{tor}}$ and plasma current $I_p$ were increased from 0.4 T and 200 kA up to 0.5 T and 250 kA respectively.

D-D beam-plasma neutron rate growth up to 40\% was observed after the $B_{\text{tor}}$ and $I_p$ increase in the discharges with the 26 keV D injection into D plasma. There are two main reasons for this improvement: electron temperature $T_e$ rise and fast ion losses decrease. In these experiments central $T_e$ and volume averaged $T_e$ growth were recorded by 40\% and 20\% respectively mainly due to $B_{\text{tor}}$ growth. To estimate the effect of the $T_e$ change NUBEAM code \cite{1} was used, which predicts 20\% neutron rate growth. Modeling with the fast ion tracking algorithm \cite{2} shows 30\% decrease of the first orbit losses of the main beam energy component mainly due to $I_p$ increase.

Increase of the magnetic field resulted in the change of the instabilities behaviour and their effect on fast ion confinement. Formerly in the 0.4 T experiments strong sawtooth oscillations usually suppressed other instabilities. In the 0.5 T experiments sawtooth oscillations coexisted with fishbone instabilities and TAEs. Also a new $m = 4$ $n = 1$ MHD mode was found which leads to fast ion losses and redistribution. Other experimental observations in the discharges with the increased magnetic field were made and discussed in the report.

Neutron rate growth in the experiments with the increased $B_{\text{tor}}$ and $I_p$ agrees well with the results of numerical modeling. Modeling for the conditions of Globus-M2 plasma with $B_{\text{tor}} = 1$ T, $I_p = 500$ kA and additional 1 MW 50 keV neutron beam predicts more than two orders neutron yield increase.

References: