§10. Plasma Confinement Control Development Including Helical Field Application

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For the research of toroidal plasma confinement configurations with helical magnetic field, two small experimental machines, C-TOKASTAR and TOKASTAR-2 (Fig.1), were constructed [1]. The existence of magnetic surfaces is suggested in C-TOKASTAR, and the effects of outboard helical filed on density fluctuations are demonstrated in TOKASTAR-2.

As for theoretical analysis, we are developing toroidal transport linkage code TOTAL (Toroidal Transport Analysis Linkage) with both tokamak and helical versions including ITB and impurity transport [2].

In the analysis using the TOTAL-H (Helical version) code, magnetic field tracing code HSD is used to define vacuum magnetic surfaces, and the DESCUR code is used for Fourier mode analysis of the vacuum last closed surface. The finite-beta three-dimensional equilibrium is solved by the free-boundary VMEC code, and the effects of current-free or flux-conserving high-beta configuration are evaluated fitted to the various LHD experimental data. One-dimensional transport code HTRANS with neoclassical loss determines ambipolar radial electric field as well as anomalous transport [2].

In the TOTAL-T (Tokamak version) code the 2-D free-boundary APOLLO equilibrium code is used and the 1-D transport is solved. Related to the prediction of the ITER plasmas, the effect of the neoclassical tearing mode (NTM) on the plasma confinement has been calculated (Fig.2) [3]. The time-evolution analysis of the NTM magnetic island has been calculated in the TOTAL code using the modified Rutherford equation for a ITER normal shear plasma. The anomalous transport models used here are GLF23 model and so on.

Figure 2 shows the time evolution of central electron temperature $T_e(0)$ and magnetic island width w/a when there is no NTM (NoNTM). The NTM is introduced with m/n=3/2 mode (3/2NTM) at t= 3s. Its seed island width is assumed 0.5% The b_{2r}=1% non-resonant external helical field (3/2NTM(NRHF)) is used, to stabilize 3/2 NTM. When the stabilization method is not applied (3/2NTM), the central electron temperature $T_e(0)$ decreases to 87% of that in NoNTM case and the saturated island width W becomes 0.048. The fusion gain factor Q decreases to 74% of that in no NTM case. When the NRHF stabilization method is applied (3/2NTM(NRHF)), the NTM is stabilized and the Q value recovers to that of the case without 3/2 mode.

1) K. Yamazaki, Y. Taira, T. Oishi, H. Arimoto and T. Shoji, Journal of Plasma and Fusion Research SERIES Volume 8 (2009) 1044-1047.
2) K. Yamazaki, S. Uemura, T. Oishi, J. Garcia, H. Arimoto and T. Shoji, Nuclear Fusion 49 (2009) 055017 (6pp)
3) S. Taniguchi, K. Yamazaki, T. Oishi, H. Arimoto, T. Shoji, The 19th International Toki Conference (ITC18) on Advanced Physics in Plasma and Fusion Research (Toki, 8-11 December, 2009) P2-6.

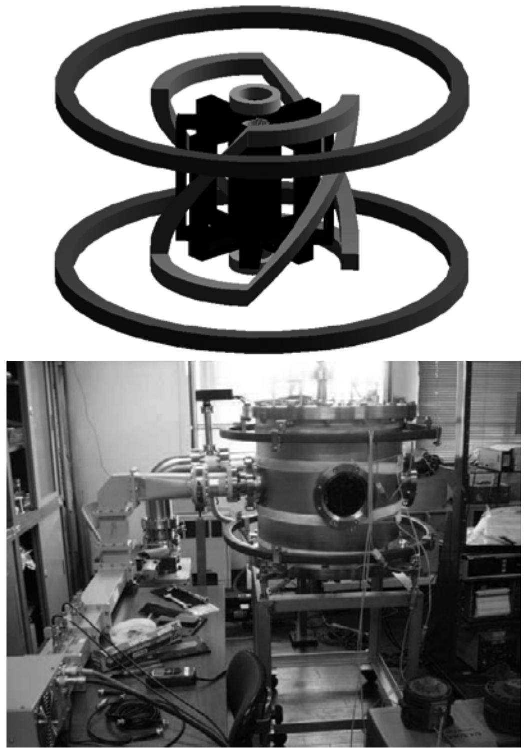

Fig.1 TOKASTAR -2 machine
(Upper) Coil configuration concept inside vacuum chamber,
(Lower) Experimental setup photo.

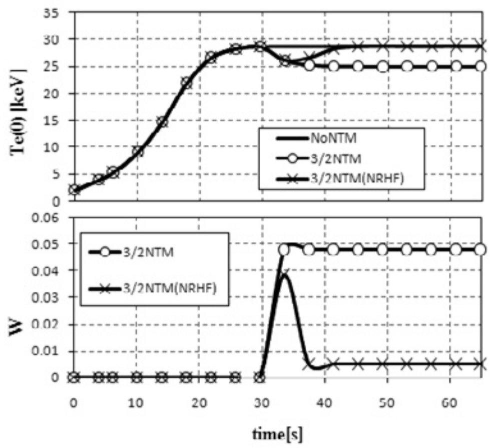

Fig. 2 Time evolution of central temperature $T_e(0)$ and the 3/2 NTM normalized island width W. The case of non-resonant external helical field application is also shown as 3/2NTM(NRHF).