§8. Analysis Code Development for ITB Formation and Impurity Control

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From the view-point of good plasma confinement and simple axisymmetric configuration, the tokamak concept seems to be better than other fusion confinement configurations. Especially internal transport barrier (ITB) operation leads to its confinement improvement. Similar transport barriers are obtained even in helical systems.

Here, we are developing toroidal transport linkage code TOTAL (Toroidal Transport Analysis Linkage) with both tokamak and helical versions including ITB and impurity transport [1].

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 [2-4].

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 [5]. 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.

Here, we will show typical results of impurity transport simulation in helical plasma [1] using TOTAL-H code. Figure 1 shows plasma density and temperature radial profile and tungsten impurity density profiles of total and typical charge-states in helical ignited helical reactor HR-1. The tungsten impurity ion density becomes peaked at the normalized minor radius of~ 0.8 and is not deeply penetrated into the plasma core, which is different from tokamak reactor TR-1 case. The operational temperature is rather low and density is rather high in this case, and the radiation loss effects are serious to keep ignition.

1) Yamazaki, K., Yamada, Y., Oishi, T., Arimoto, H., Shoji, T., "*Impurity Behavior in ITER and Helical Burning Plasmas with Internal Transport Barriers*", 14th International Congress on Plasma Physics (ICPP2008) (September 8-12, 2008, Fukuoka)
2) Oishi, T., Yamazaki, K., Arimoto, H., Shoji, T., *Pellet And Gas-Puff Fueling Simulation In ITER And Power Plant Plasmas Using "Total" Code,* 14th International Congress on Plasma Physics (ICPP2008) (September 8-12, 2008, Fukuoka)
3) Higashiyama, Y., Yamazaki, K., Garcia, J., Arimoto, H., Shoji, T., Plasma and Fusion Research: Regular Articles 3 (2008) S1048
4) Higashiyama, Y., Yamazaki, K., Garcia, J., Arimoto, H., Shoji, T., Journal of Physics: Conference Series 123 (2008) 012032
5) Takahashi, Y., Yamazaki, K., Garcia, J., Arimoto, H., Shoji, T., Journal of Physics: Conference Series 123 (2008) 012036

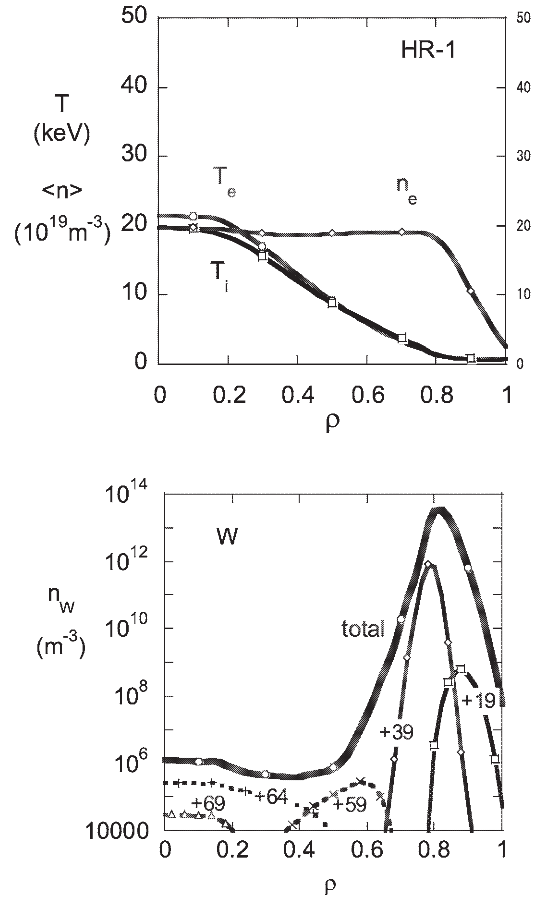

Fig. 1. Tungsten impurity profile in ignited helical reactor HR-1.
(Upper) Plasma density and temperature profiles.
(Lower) Density profile of total and typical charge-state