§16. Development of Hierarchy-integrated Simulation Code for Toroidal Helical Plasmas, TASK3D

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For the hierarchy-integrated simulation approach, the integrated modeling code for three dimensional configurations (TASK3D) is being developed based on the integrated modeling code for tokamak plasmas, TASK (Transport Analyzing System for tokamaK) [1], being developed in Kyoto University. For helical plasmas, to take into account of the effect of E_r is important since the ambipolar condition is not satisfied intrinsically due to the non-axisymmetry of helical plasmas, and E_r is determined by the neoclassical transport. In order to extend the TASK code to be applicable to three dimensional configurations, the transport equations for the rotational transform [2] and the radial electric field (E_r) have been reformulated by taking the three-dimensional nature of configurations into account. With this new formulation, new module for E_r (ER module) has been developed and implemented. The time scale of the time evolution of E_r is much faster than for the density and the temperature. At the current stage of development of the TASK3D, E_r is determined from the ambipolar condition in order to avoid the problem of the different time scale. The estimate of neoclassical particle fluxes is required for obtaining the ambipolar E_r in the ER module. For this purpose, two approaches have been considered to be implemented in TASK3D. One is to employ simple analytic formulae [3], and the other is to utilize the database of the neoclassical diffusion coefficients being constructed by the DCOM/NNW (Diffusion Coefficient Calculator by Monte Carlo Method / Neural NetWork) [4], based on the Monte-Carlo code, DCOM.

In order to check the applicability of the ER module, test simulations have been carried out by using the combination of the TR module (originally in the TASK) and newly implemented ER module. The TASK3D has been extended to read an LHD experimental data with Ufile format. For the simulation results shown here, by utilizing this linkage to LHD experimental data, an LHD experiment data is used for initial profiles of the simulation. The characteristic parameters of this example discharge are R_{ax}=3.60m, B=2.8T, and the volume average beta value is about 0.65 % at most, where R_{ax} denotes the position of the vacuum magnetic axis. The ion temperature (T_i) is assumed to be same as the electron temperature (T_e) at initial state. The T_e, T_i and E_r are calculated by using the combination of the TR module (diffusive transport module) and the ER module. Other variables such as the density and the rotational transform are fixed. The anomalous transport coefficient is a priori assumed to be $\chi^{an}=0.6\mathrm{m}^2/\mathrm{s}$. Figures 1(a) and (b) show the radial profiles of T_e, T_i and E_r at stationary state, obtained based on (a) analytical formulae and (b) DCOM/NNW for neoclassical transport calculations. There also found a fairly reasonable agreement between both approaches. This fairly well agreement of ambipolar E_r between two approaches might be attributed to picking up a low-beta plasma in the configuration having a predominant helicity. These test simulations based on two approaches for neoclassical transport calculations have revealed the applicability and the successful linkage of TR module and ER module for an LHD experimental data. Validations of neoclassical transport models require further accumulation of these test simulations for quite large variety of parameter range achieved/expected in LHD experiments.

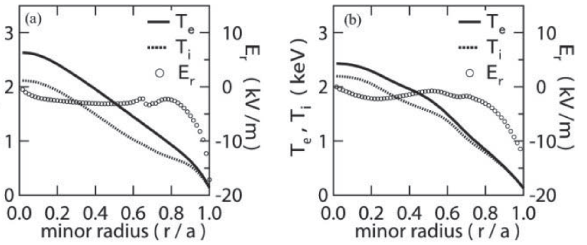

Fig. 1. Radial profiles of T_e, T_i and E_r at stationary state for cases based on (a) analytical formulae and (b) DCOM/NNW for neoclassical transport calculations.

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2) Nakamura, Y. *et al.*, Fusion Sci. and Tech. 50 (2006) pp.457-463.

3) Shaing, K. C., Phys. Fluids 27 (1984) 1567.

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