§5. Heat Transport Analysis of High Ion Temperature Plasma in the LHD

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It is important to develop the integrated simulation code to predict the plasma performance of the future reactor. TASK3D [1] is an integrated transport code for helical plasmas and has been developed in collaboration between Kyoto University and NIFS. It has a modular structure and each module describes different physics phenomena. TR is 1D diffusive transport module, and solves the diffusive transport equation for the density, the temperature, and the toroidal angular momentum of each plasma species and the poloidal magnetic field. The neoclassical transport coefficients are calculated by DGN/LHD, which is neoclassical transport database in LHD, and the radial electric field is calculated by ER module according to ambipolar condition. The NBI power deposition is calculated by FIT3D module. The heat transport analysis has been performed for various LHD plasmas using these modules of TASK3D [2].

In order to simulate the NBI heated LHD plasmas, FIT3D code is incorporated into TASK3D. We perform self-consistent calculation of the heat transport including the change of the heat deposition profile due to the plasma shift using the experimentally observed plasma profiles.

In this paper we study the heat transport of the LHD plasma in the high ion temperature experiments using the improved TASK3D. Several turbulent transport models are considered. TR module includes a variety of turbulent models and, in this study, we assume the turbulent transport model as the gyro-Bohm model; $\chi_{\mathrm{TB\ gyro\text{-}Bohm}} = C_{\mathrm{gyro\text{-}Bohm}}(T/eB)(\rho/a)$, where $C_{\mathrm{gyro\text{-}Bohm}}$ is a constant factor determined by matching the simulation results with experimental results.

First, in order to determine the constant factor for the turbulent transport term, we simulate the reference plasmas in Table 1. We determine the constant factor C_{model} for each turbulent model which best fits the simulation results to the experimental results by minimizing the RMS.

$$\mathrm{RMS} = \sqrt{\frac{1}{\mathrm{NRMAX}}\sum_{\mathrm{NRMAX}}\left(\frac{T^{\mathrm{TASK3D}}(\rho)-T^{\mathrm{EXP}}(\rho)}{T^{\mathrm{EXP}}(\rho)}\right)^2}$$

The LHD experimental data is used for initial conditions of the simulation; density profiles are fixed at the experimental profiles; Te and Ti evolve until they reach steady state. The heating power deposition profile calculated based on experimental density and temperature profiles is used and the radial electric field is determined by the ambipolar condition.

The factor C_{model} are determined so as to minimize RMS values. We show the results in the case of assuming the gyro-Bohm model in Fig. 1. Calculating the RMS values with the various values of C_{model} in the reference shots, the C_{model} values which minimize the RMS are distributed from 22 to 27. After summing up all cases we find that the C_{model} value of 25 minimizes the summation of these RMS values. In this case, the averaged error between the experimental results and TASK3d results are about 20%. Figure 2 shows the comparisons between the experimental and simulated ion and electron temeratures.

[1] M. Sato et al., Plasma Fusion Res., 3, S1063 (2008).
[2] A. Wakasa et al., 23rd IAEA-FEC (2010).

Shot num.	time[sec]	Rax[m]	B_0[T]	T_{e0}[keV]	T_{i0}[keV]	$n_0[10^{19}m^{-3}]$
88343	1.84	3.60	2.75	1.5	1.5	1.41
the 15 cycle exp. (17 SEP 2011)						
109081	4.24	3.60	2.75	3.0	3.0	3.07
109082	4.24	3.60	2.75	3.2	3.5	2.78
109125	4.24	3.60	2.85	3.4	4.1	1.81
109129	4.24	3.60	2.85	3.4	3.8	2.63
109131	4.24	3.60	2.85	3.4	4.0	2.27
109133	4.24	3.60	2.85	3.4	3.8	2.61
109134	4.24	3.60	2.85	3.3	3.5	2.87
109135	4.24	3.60	2.85	3.3	3.4	2.99

Table 1. Reference plasma shots to determine the constant factor of turbulent transport model

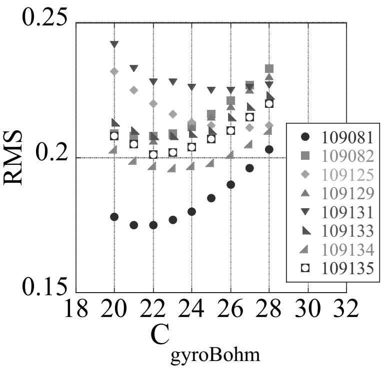

Fig. 1. RMS values assuming gyro-Bohm model.

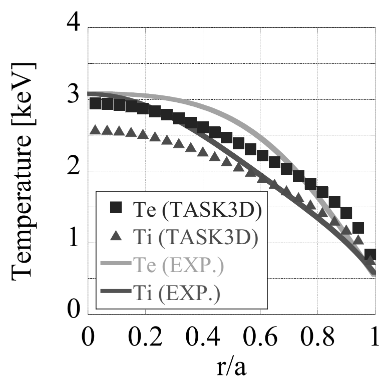

Fig. 2. Comparisons of the experimental and simulated ion and electron temperatures.