§4. Development of Neoclassical-Diffusion-Coefficients Database for Integrated-Transport-Code Analyses of LHD Plasmas

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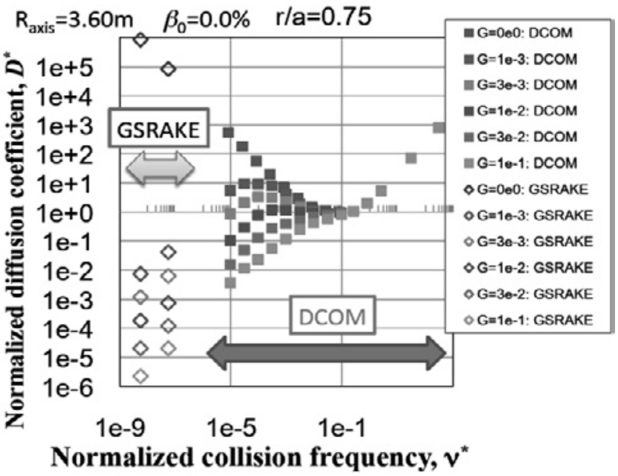
The neoclassical(NC)-diffusion-coefficients database has been prepared and extended to perform accurate and fast analyses of NC diffusion for a variety of LHD plasmas. This database has been incorporated in the NC module of the integrated transport code, TASK3D.

For this extension, the two NC transport codes have been utilized to complement advantages/disadvantages. One is DCOM[1)], and the other is GSRAKE[2)]. The DCOM employs the neural network approach based on the diffusion coefficients evaluated based on Monte-Carlo method. It can deal the three-dimensionality of the magnetic configuration with high-accuracy, but it requires time-consuming calculations especially for low-collisional regime, where recent high-temperature LHD plasmas tend to exist. On the other hand, GSRAKE is based on bounce-average approach, for which the accuracy of the three-dimensionality of magnetic configurations is a bit sacrificed (small/fine magnetic ripple cannot be taken into account). Presently, the magnetic field spectrum having the poloidal mode number of 0, 1, 2 and 3, and the toroidal mode number (normalized by the field period number) of 0, ±1 (total 10 modes) are taken into account. However, it provides diffusion coefficients in such a low-collisional regime in a short-time, and furthermore, it has been benchmarked against DCOM and other NC transport codes to prove its result to be accurate enough in several LHD vacuum magnetic configurations[3)].

Combining these two NC transport codes, the diffusion coefficients database has been extended towards low-collisional regime (as shown in Fig. 1). Since the magnetic field spectrum broadens (resultantly, the validity of GSRAKE calculations becomes weakened) as the beta value is increased in the LHD, the compatibility of DCOM and GSRAKE results should be carefully examined at certain range of collisionality.

In such a way, NC diffusion-coefficient-database has been extended as a function of (Rax, <β>, ρ, ν*, Er), where symbols denote the vacuum magnetic axis position, volume-averaged beta value, radius position, normalized collisionality and radial electric field, respectively. The parameter range (Rax, <β>) covered by prepared database are summarized in Tab. 1. It has been incorporated into the NC module of the integrated-transport-code, TASK3D, so that accurate and fast evaluation of NC diffusion for a wide range of LHD plasmas has been made possible.



$$\nu^* = \frac{R\nu}{\iota v} \qquad G = \frac{R_0}{\iota r}\frac{E_r}{v B} \qquad D^* = \frac{D}{D_{Plateau}} = \frac{\iota\pi R_0}{0.64\rho^2 v} D$$

Fig. 1. Neoclassical diffusion coefficients calculated in combination of DCOM and GSRAKE (this particular example is for ρ=0.75 of Rax=3.6 m and vacuum configuration). The normalization for collision frequency (x-axis) and the diffusion coefficients (y-axis) is also denoted in the figure.

Rax(vac)	<β>(%) (approx.)
3.5	0, 1, 2
3.53	0, 1, 2, 3
3.6	0, 1, 2, 3
3.75	0, 1, 2, 3
3.9	0, 1, 2

Tab. 1. Range of Rax and <β> values are summarized, for which the database has been already prepared.

1) A.Wakasa, S.Murakami et al., Japanese Journal of Applied Physics, 46 (2007) 1157.
2) C.D.Beidler et al., Plasma Phys. Control. Fusion 36 (1994) 317.
3) C.D.Beidler et al., TH_p8-10, 22nd IAEA Fusion Energy Conference (Geneva, Oct. 2008), http://www-pub.iaea.org/MTCD/Meetings/FEC2008/th_p8-10.pdf