§9. Development of Monte Carlo Simulation Code for Neoclassical Transport Analysis in Non-axisymmetric Configurations

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We have developed a Monte Carlo simulation code for evaluating a mono-energetic local diffusion coefficient, D. In the simulation the mono-energetic N particles are released from the initial minor radius position, r_0, where the particles are randomly distributed in the poloidal and toroidal coordinates, and in the pitch angle space.

The test particle orbits are followed solving the equations of motion in the Boozer coordinates using 50 Fourier modes of magnetic field. The Boozer coordinates are constructed based on the MHD equilibrium obtained by VMEC code. The pitch angle scatterings are taken into account applying the Monte Carlo collision operator based on the binominal distribution[1]. The pitch angle scattering after the time interval Δt is given in terms of $\lambda(= \upsilon_\parallel/\upsilon)$ by

$$\lambda_{n+1} = \lambda_n(1-\nu\Delta t)+\sigma\left[\left(1-\lambda_n^2\right)\nu\Delta t\right]^{1/2}, \quad (1)$$

where σ takes +1 or -1 with equal probabilities. ν is the deflection collision frequency.

After several characteristic collisional time, τ, the diffusion coefficient can be evaluated by taking the mean square displacement of N particles as

$$D=\frac{1}{2}\sum_{i=1}^{N}\left(r_i-\langle r\rangle\right)^2, \quad (2)$$

where r_i is the radial position of i-th particle and $\langle r\rangle=\sum_{i=1}^{N} r_i$. However, when some particles are lost from simulation region this expression does not give an accurate diffusion coefficient but smaller one. So we here employ the formula including the effects of these escaping particles from simulation region[2] as

$$D=\frac{-4L^2}{\pi^2 t}\ln\left\{\frac{1}{N}\sum_{i=1}^{N}\cos\left(\frac{\pi\left(r_i-r_0\right)}{2L}\right)\right\} \quad (3)$$

where L(= r_c-r_0) is the distance from the initial position, r_0, to the cutoff radii, r_c. This expression of D converges to eq. (2) when the distance L becomes infinity.

Figure 1 shows the normalized diffusion coefficient D^* at r/a =0.5 calculated by DCOM code (solid line) as a function of normalized collision frequency ν^* for R_{ax}=3.75m. We, here, normalize the collision frequency by $\upsilon\iota/R$, and the diffusion coefficient by the tokamak plateau value of mono-energetic case, D_p, as $D_p=(\pi/16)(\upsilon^3/\iota R\omega_c^2)$, where R, υ, ι, and ω_c are the major radius, velocity of test particle, rotational transform, and cyclotron frequency of test particle, respectively.
The open circles indicate the DKES results. We can see good agreements with DKES results from P-S regime through $1/\nu$ regime for both configuration cases. We obtain good agreements between two code results. This suggests validity of our code for the analysis of neoclassical transport in LHD.

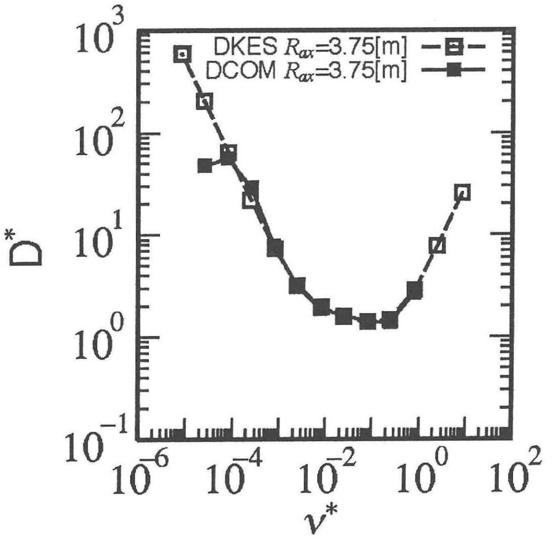

Fig. 1 Comparisons of the normalized mono-energetic diffusion coefficient obtained by DCOM and DKES codes as a function of normalized collision frequency in the standard configuration

REFERENCES

[1] Boozer, A.H. and Kuo-Petravic, G., Phys. Fluids **24**, 851 (1981).
[2] Beidler, C.D., Hitchon, W.N., and Shohet, J.L., J. Comput. Phys. **72** 220.