§15. Neoclassical Transport in a Helical Torus Based on Bounce-Averaged Fokker-Planck Equation

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Numerical codes, such as the DKES code and the PFSTL code , have been developed to study neoclassical transport in helical systems. However, the computational times required by these codes are remarkably long, and the analytical and numerical results have not been completely understood, particularly when a boundary layer associated with a radial electric field is present. In the previous studies, neoclassical transport in a helical torus is reformulated on the basis of the generalized bounce-averaged orbit theory.

The transport coefficients, are evaluated for a realistic magnetic field, such as one based on the large helical device (LHD) parameters. The transport coefficients for a plasma with Maxwellian distribution are also discussed. Finally, the effect of the radial electric field on neoclassical transport is analyzed in detail.

We here study the structure of the boundary layers and evaluate the transport coefficients, such as diffusion coefficient and the bootstrap current in cases with and without a radial electric field. In these discussions, we use a realistic magnetic field which is based on the LHD parameters and is calculated by using the MAGN code. It should be noted that the present results reproduce the results based on the DKES code and the analysis is applicable to some specific resonance cases in which the DKES code is inappropriate.

Typical results for the collisionality dependences of the diffusion coefficient and the bootstrap current in the case of the LHD parameters are shown in Fig. 1 and Fig. 2, respectively, for different values of the normalized radial electric field. Figure 1 shows that, in the $1/v$ collisionality region the diffusion coefficient drastically decreases due to the radial electric field as the electric field increases. Figure 2 indicates that the bootstrap current does not monotonically increase as the collision frequency decreases and that it is very sensitive to the radial electric field. We see from Fig. 2 that as the collision frequency decreases, the bootstrap current increases in the banana region and seems to saturate at some collisionality region(at the transition); then, it decreases with decreasing collision frequency and seems to be independent of both the collisionality and the electric field strength in the very low collisionality region such as D_{11}.

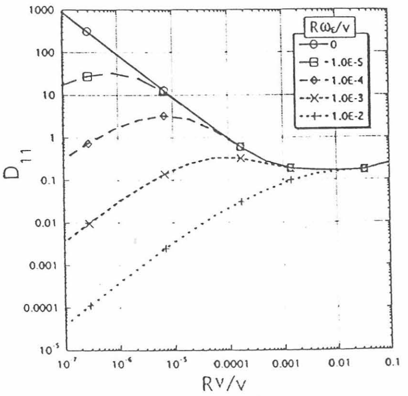

Fig.1 Collisionality dependence of D_{11}

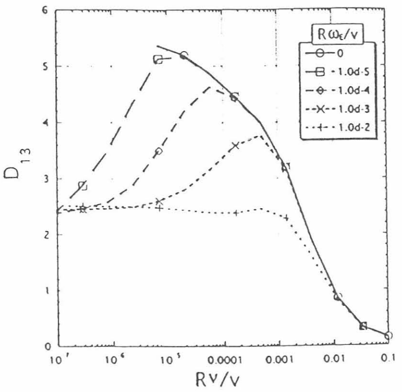

Fig.2 Collisionality dependence of D_{13}