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

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A numerical code for solving the bounce-averaged Fokker-Planck equation has been developed and its applications to the transports in helical systems have been carried out. The present numerical code is much faster and more efficient compared with existing transport codes such as DKES code, which up to now gives the most useful and well-pervasive numerical tool for studying transports in toroidal systems. A comparison of the transport results based on both DKES and the present codes has been made , particularly, in detail associated with effect of radial electric field on the confinement improvement.

Although a large amount of analytical formula have been developed to study the neoclassical transport in helical systems, the greater part of these theories were originally based on a number of somehow disconnected expressions for transport coefficients which were derived in different regimes of collisional frequency and which in general do not match smoothly and correctly. Furthermore, a number of assumptions such as frequency ordering were made for deriving analytical expressions which substantially limit its validity. To study these neoclassical transport in helical systems, numerical codes such as DKES code and PFSTL code have also been developed. However, the computational time becomes remarkably long and these analytical and numerical discussions have not been completely understood, particularly, in the presence of boundary layer associated with radial electric field. When the helical torus of our interest has a large number of period N in the toroidal direction and the rotational transform of the magnetic line of force per period is small, however, the particle motion can be described in terms of the so-called longitudinal adiabatic invariant J. In the previous study, the neoclassical transport in the helical torus is reformulated on the basis of the bounce averaged orbit theory. The numerical code solving bounce averaged Fokker-Planck equation is developed. In solving the linearized Fokker-Planck equation, the function is Fourier expanded with respect to the poloidal angle and the cubic B-spline expanded with respect to the modulus y, which will be defined later, such as y=1 corresponds to the boundary of the ripple trapped and passing particles. The appearance of the boundary layer makes the Legendre polynomial expansion for the pitch angle, which is frequently used in the existing transport codes, inappropriate. The use of the variable mesh size allows to use the finer mesh in the region where the boundary layer develops.

Although a model magnetic field is frequently employed in the most neoclassical transport theories, in the present study, the magnetic fields used are calculated by MAGN code [5] for fixed coil currents. Then, transport coefficients are evaluated for the realistic magnetic field data such as the Large Helical Device(LHD) parameters. The transport coefficients for a plasma with Maxwellian distribution are also discussed. Finally, the effect of electric field on neoclassical transport is analyzed in detail. A typical result is shown in Fig.1 .

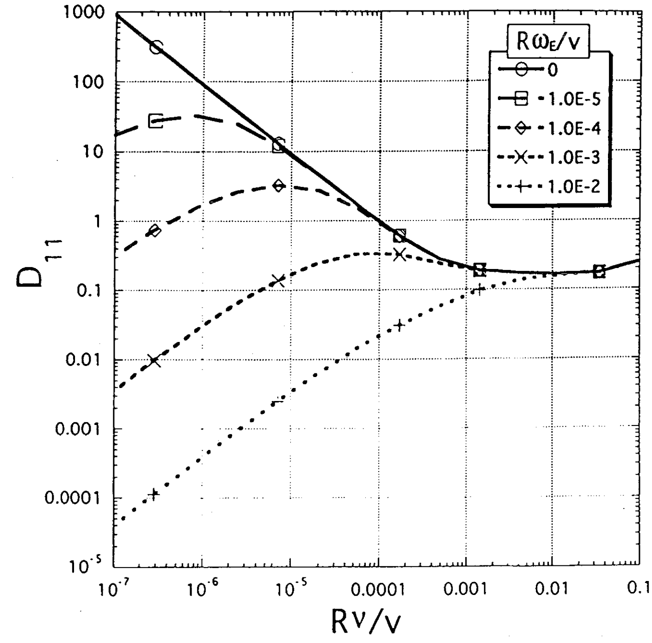

Fig.1 Reduction of diffusion coefficient D due to electric field in low collisionality region