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TH/P2-24: Drift-kinetic Simulation Studies on Neoclassical Toroidal Viscosity in Tokamaks with Small Magnetic Perturbations

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Effect of magnetic perturbations on neoclassical toroidal viscosity (NTV) in tokamaks is investigated by using a drift-kinetic delta-f simulation code, FORTEC-3D. The effect of magnetic perturbation on plasma transport and rotation is one of the important issues in recent tokamak experiments and forthcoming ITER project, in which the resonant magnetic perturbation (RMP) applied externally is a candidate to mitigate the edge localized modes. Finite NTV caused by RMPs damp the toroidal rotation, which might bring adverse effects on the other MHD instabilities such as resistive wall modes and locked modes.

We have developed the simulation code to evaluate the NTV numerically. Compared with conventional analytic formulae which adopt many approximations, FORTEC-3D solves the drift-kinetic equation by following the exact guiding-center orbits including the finite-orbit-width effect and Coulomb collisions, and the viscosity is directly evaluated from the plasma distribution function, delta-f.

In this paper, basic properties of NTV, such as the dependence of collisionality, ExB rotation speed, etc., are investigated by using the delta-f simulation. Benchmark tests of the code with analytic formulae of NTV are also reported. We have found some distinctive features which have not found in previous studies.

First, we have investigated the NTV in the limit of zero ExB rotation. Single-helicity, (m,n)=(7,3) mode small perturbation field is applied to a tokamak configuration. It is found that conventional asymptotic limit formulae for the 1/nu and super-banana plateau regimes overestimate the NTV, while the combined analytic formula by J.-K. Park agrees well with FORTEC-3D in a wide range of collision frequency.

Second, FORTEC-3D and Park's formula has been benchmarked in finite-ExB rotation cases. A reference radial electric field (E_r) was given from the force balance relation, and the dependence was studied by magnifying the reference E_r amplitude. Two calculations agree well when E_r is close to the reference value. The peak of NTV at the resonant surface shrinks in both calculations as |E_r| becomes larger. However, as |E_r| increases, there appear other twin peaks of NTV on the both sides of the original resonant surface only in the delta-f simulation. It is anticipated that the finite-orbit-width effect can cause the difference from the analytic formula.

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