Neoclassical Toroidal Viscosity in Quasilinear Regimes

W.Kernbichler[1], S.V.Kasilov[1 2], and A.F.Martitsch[1]

[1]*Fusion@ÖAW, Institute for Theoretical and Computational Physics, TU Graz, Austria*

[2]*Institute of Plasma Physics, National Science Center "Kharkov Institute of Physics and Technology", Ukraine*

External non-axisymmetric magnetic field perturbations such as toroidal field ripples, error fields, and perturbation fields from external coils for ELM mitigation may have a significant effect on the toroidal plasma rotation in tokamaks. In contrast to resonant perturbations, which produce islands and ergodic field regions, non-resonant perturbations do not modify the magnetic field topology and are well described by ideal 3D MHD equilibria. In these equilibria neoclassical particle fluxes are not ambipolar anymore. They polarize the plasma and thus modify the radial electric field and, respectively, the toroidal plasma rotation. Formally, using the flux-force relation, this can be presented as plasma acceleration by a toroidal viscous torque. Such a perturbed field can be viewed as a particular case of a stellarator field, therefore methods for calculations of non-ambipolar particle fluxes used in stellarator theory and many stellarator relevant transport regimes apply also to tokamaks. In tokamaks, due to the smallness of the non-axisymmetric field and the rather fast plasma rotation additional regimes, which are not important in stellarators, are of relevance. A proper description of all those regimes requires an accurate collision model, which, in particular, conserves momentum. A numerical evaluation of these fluxes with such a collision model requires the solution of the linearized drift-kinetic equation, which represents a 4D integro-differential problem. Due to smallness of perturbation field amplitudes, this problem can be simplified in most of the important transport regimes using a quasilinear approximation, which reduces the problem dimension by one. Those are regimes where the effect of perturbations on particle motion within the flux surface is negligible. Based on this quasilinear approximation, a version of the drift-kinetic equation solver NEO-2 has been developed, which covers all these regimes continuously. In this report, a brief overview of the NTV problem and some illustrative results for a simple tokamak model field will be presented, where computations by NEO-2 are compared to results from a few analytical, semi-analytical and numerical models. In addition, results for realistic tokamak geometry (ASDEX Upgrade) will be shown.

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