Neoclassical toroidal viscous torque due to non-axisymmetric magnetic fields in tokamaks

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The toroidal plasma rotation in tokamas is influenced by the neoclassical toroidal viscous torque (NTV torque) caused by non-axisymmetric magnetic field perturbations, e.g. due to toroidal field coil ripple or magnetic perturbation coils. To determine this torque it is in general necessary to resort to numerical solution of the drift kinetic equation (DKE), e.g. using the SFINCS [1] or the NEO-2 codes [2]. The result of a recent benchmark for ASDEX between these codes [3] will be presented. The codes use slightly different methods to solve the DKE. The SFINCS code solves the 4D (poloidal angle, toroidal angle, pitch angle, speed) DKE in general 3D equilibria, and is thus suitable also for stellarator modelling. NEO-2 on the other hand makes an expansion in the closeness to axi-symmetry, and separates the contributions from different spatial Fourier modes through a quasi-linear approximation, thereby reducing the number of dimensions of the problem by one. However, the SFINCS calculations suggest that, already at the quite small amplitudes of magnetic perturbations used in experiments, the NTV torque deviates from the quasilinear approximation.

The conventional method to calculate the torque is to obtain it directly from the radial particle fluxes via the flux-force relation. In this way, any neoclassical code that can calculate radial fluxes can be used to determine the NTV torque. Alternatively, one can calculate the toroidal torque directly from the relevant moment of the distribution function, involving the divergence of the total stress tensor. In particular, one can then see that the contribution of gyrophase dependent parts of the distribution function to the viscosity tensor become important for non-zero radial electric fields.

References

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