Impact of non-axisymmetric magnetic field perturbations on flows

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While the achievement of High confinement regime is ensured through the formation and sustainment of transport barrier associated with sheared flows, the effect of non-axisymmetric perturbations of the magnetic field, like Resonant Magnetic Perturbations (RMPs) or ripple, on the transition remains an open issue. The underlying loss of axisymmetry is responsible for toroidal friction, sometimes called Neoclassical Toroidal Viscosity (NTV), which, as predicted by neoclassical theory, leads to magnetic braking [1]. The implementation of such perturbations in the gyrokinetic code GYSELA has been successfully benchmarked through the toroidal momentum conservation which is ensured only when accounting for the NTV. In simulated plasmas without turbulence, quantitative agreement between neoclassical theory and simulations for experimentally relevant magnetic perturbation spectra and magnitude is found for different collisionality regimes. This study relies on the NTV for which theoretical predictions are directly comparable with computed fluxes and forces. This friction constrains the toroidal rotation of the plasma, which in turn modifies the poloidal velocity and the radial electric field through the radial force balance equation. In addition turbulence competes/synergises with those neoclassical effects, generating the mean flows relevant for transport barriers. In ion temperature gradient (ITG) driven turbulent plasmas, this competition reveals that even a small perturbation amplitude (few percents of the unperturbed magnetic field magnitude) tends to change the plasma mean toroidal rotation toward the counter-current direction. This effect has already been observed experimentally in JET [2], JT-60U [3] and Tore Supra [4]. In response the mean radial electric field is significantly changed (up to +80% compared with an unperturbed plasma). The implications for the transition toward high confinement modes are discussed.

References

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