Modelling neoclassical tearing modes in tokamak plasmas

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The presence of neoclassical tearing mode (NTM) magnetic islands is anticipated for the ITER standard H-mode scenario as well as advanced tokamak scenarios. They cause a loss of core pressure and might result in plasma disruptions. The NTM control technique requires an understanding of the threshold physics and associated self-healing of small magnetic islands.

A new self-consistent drift kinetic theory and associated drift island formalism to calculate the plasma response to the NTM magnetic perturbation [1] is developed. It requires small magnetic islands compared to the tokamak minor radius but accurately treats the limit of $w \sim \rho_{bi}$, where w is the island half-width and ρ_{bi} is the trapped ion banana orbit width. To implement this, two numerical codes have been developed: 4D DK-NTM [2] and 3D RDK-NTM [1], where the 3D version, being valid at low collisions, averages the particle distribution function over streamlines to reduce dimensionality and solves the 2D boundary layer problem near the trapped-passing boundary to efficiently resolve the collisional dissipation layer there. They both find the self-consistent electrostatic potential required to ensure plasma quasi-neutrality and predict the threshold island width of a few ρ_{bi} which matches the cross-machine scaling found in [3]. For the small inverse aspect ratio low beta tokamak, we find $w_c = 0.45\varepsilon^{-1/2}\rho_{bi}$, where w_c is the threshold island half-width.

References

[1] A.V. Dudkovskaia et al., Plasma Phys. Control. Fusion, accepted (2021) https://doi.org/10.1088/1361-6587/abea2e

[2] K. Imada et al., Nucl. Fusion **59** (2019) 046016

[3] R.J. La Haye et al., Nucl. Fusion **46** (2006) 451