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Gyrokinetic simulation of ion temperature gradient driven turbulence in the presence of a magnetic island and kinetic electrons

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Micro-instabilities, which are scaled by the finite Larmor radius (FLR) of ions or electrons, are of great importance in order to understand the transport mechanisms in Tokamak plasmas. It has been extensively studied, for example, that the ion temperature gradient (ITG) driven turbulence may dominate the ion transport with the regulation of self-generated zonal flows.

Here, we are investigating the multi-scale interactions of the ITG drift-wave with a static magnetic island, a setup, which was previously studied by Wang et al. (PoP, 2009) using a gyrofluid code.

Employing gyrokinetic simulations in the two dimensional sheared slab geometry, we find that a small magnetic island reduces the linear growthrate of the ITG drift wave by inducing a poloidal mode coupling, which allows unstable ITG modes to dissipate energy through stable modes and thus overall stabilizes the ITG wave. However, we also find that a magnetic island has a destabilizing effect on the ITG wave due to the formation of new rational surfaces, which is dominant for large islands. In this case, the short-wavelength ITG mode with $ky \geq 1$ is more sensitive to the destabilization, due to its smaller radial mode structure width size and thus dominates the linear global mode.

To study the non-linear saturation state, kinetic electrons are included, which are now essential, as the flux-averaging term cannot be easily calculated due to magnetic field line perturbations from the magnetic island. We investigate the interaction between the magnetic island and ITG turbulence, focusing on the influence of the magnetic island on ITG zonal flow generation, and the corresponding heat- and particle fluxes and find that the island greatly increases the heat flux independent of the magnetic island size.