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

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Magnetic fusion plasmas are subject to a variety of instabilities, such as MHD instabilities and micro-instabilities. 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 and to improve plasma confinement performance of fusion plasmas. It has been extensively studied, for example, that ion temperature gradient (ITG) driven turbulence may dominate the ion transport with the regulation of the self-generated zonal flows.

Wang *et al.*[1] used a gyro-fluid model to numerically study the linear evolution of an ITG drift wave in the presence of a static magnetic island in a two dimensional sheared slab geometry. They found that a small magnetic island reduces the total growth rate of the ITG drift wave by inducing a poloidal mode coupling, which allows unstable ITG modes to dissipate energy to stable modes and thus overall stabilizing the ITG wave. However, they also found that a magnetic island has a destabilizing effect on the ITG wave due to the formation of new rational surfaces – which is the dominant effect for large islands.

Here, we present linear simulations (using a local gyrokinetic simulation model assuming adiabatic electrons) and confirm Wang *et al.* results. However, compared to their gyro-fluid simulations, in gyro-kinetic simulations, where the FLR effects are treated to full order, the ITG drift wave inhibits a so called short-wavelength ITG mode – a second destabilization for high poloidal mode numbers, as shown by Gao *et al.*[2]. It is found that the stabilization by dissipation becomes weak compared to gyro-fluid simulations due to the appearance of this short-wavelength ITG mode. Additionally, the short-wavelength mode is also more sensitive to destabilization when the magnetic island is large enough to form new rational surfaces [3].

To study the non-linear saturation state of the ITG wave including a magnetic island, our computational code has been extended to support full-gyro-kinetic effects including an arbitrary number of species. Kinetic electrons are now included, which are essential for correctly modelling the non-linear flux-averaging term. 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 corresponding heat- and particle fluxes. Furthermore, we investigate the influence of the magnetic island on the ITG mode including profile variations, which may be helpful to understand the experimental observation of the ion temperature profile peaking inside a magnetic island.

[1] Z. X. Wang, J. Li, Y. Kishimoto and J.Q. Dong, Phys. Plasmas 16, 060703 (2009)
[2] Z. Gao, H. Sanuki, K. Itoh and J.Q. Dong, Phys. of Plasma **10**, 2831 (2003)
[3] P.P. Hilscher, K. Imadera, J. Li and Y. Kishimoto, Zero-Carbon Energy 2011 (2012)