Gyrokinetic simulation of ion temperature gradient driven drift wave instability in the presence of magnetic island

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Abstract:

Magnetic fusion plasmas are subject to a variety of instabilities, such as the MHD modes and micro-instabilities. The micro-instability, which is scaled by the finite Larmor radius (FLR) of ions or electrons, is one of the hot topics since they are plausibly responsible for anomalous transport in plasmas. Compared with the (neo-) classical transport due to the collision diffusion in a torus, the complicated anomalous transport is still an open question even some great progresses in tokamaks such as the H mode have been achieved. Hence, the study on the multi-scale nonlinear interaction is of great importance to understand the transport mechanisms and improve plasma confinement performance.

The drift wave is one of typical micro-instabilities in tokamak plasmas. It has been extensively studied that ion temperature gradient (ITG) driven turbulence may dominate the ion transport with the regulation of the self-generated zonal flows.

Here, we investigate the ion temperature gradient mode (ITG) instability in the presence of a magnetic island using a gyro-kinetic model. We perform simplified 2d drift-kinetic simulation, where the Larmor radius effect is modeled analytically, in sheared-slab geometry. The results are compared with those observed in gyro-fluid simulation performed by Wang et. al [1].

We find that small magnetic island size causes radial and poloidal modes to couple with each other and then the fluctuating energy is transferred to stable-regions, thus playing a stabilizing role. For larger island sizes, new rational surfaces appear, which again excite destabilization. Both effects counteract with each other, where for magnetic-island sizes over w>10 the destabilization effect dominates.

Subsequently, we study more realistic plasma including full gyro-radius effects and extending the domain to the toroidal direction using a field-aligned coordinate system.

Keywords: Gyro-kinetics, Magnetic Islands, Fusion Plasma, Turbulence

[1] Z. X. Wang, Jiquan Li, Y. Kishimoto, J.Q. Dong, Magnetic-island-induced ion temperature gradient mode, Phys. Plasmas 16, 060703 (2009)