Gyrokinetic simulation of short wavelength ion temperature gradient instabilities in the ADITYA-U tokamak

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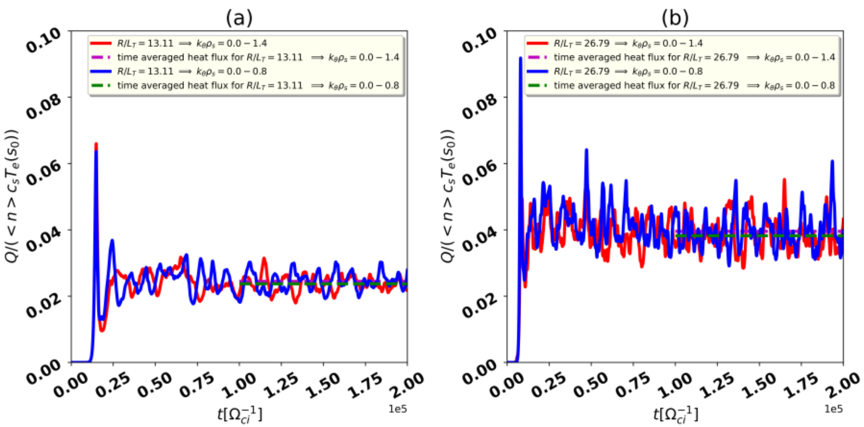

Figure 1: Temporal evolution of (a) normalized heat flux for R_0/L_T = 13.1 for poloidal wave numbers 0.0≤ $k_\theta\rho_s$≤1.4 (red solid line) and for 0.0≤$k_\theta\rho_s$≤0.8 (blue solid line) capturing only conventional ITG mode (b) normalized heat flux for R_0/L_T = 26.8 for 0.0≤$k_\theta\rho_s$≤1.4 (red solid line) and for 0.0≤$k_\theta\rho_s$≤0.8 (blue solid line) capturing only conventional ITG mode.

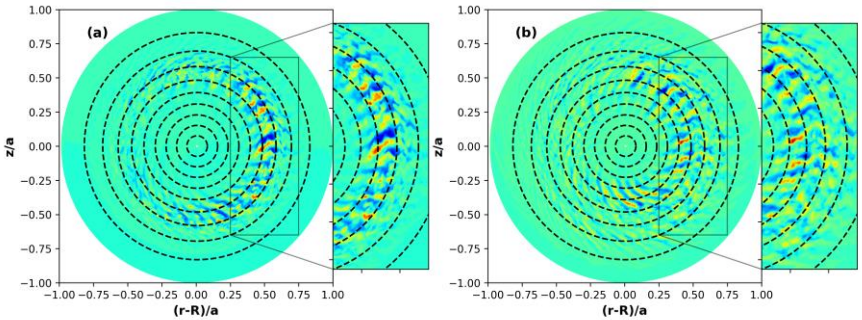

Figure 2: 2D potential structure $\varphi - \langle\varphi\rangle_{FS}$ at $t[\Omega_{ci}^{-1}]$ = 2.0e5 for R_0/L_T = 26.8 (left) and R_0/L_T = 13.1 (right) respectively.

One of the crucial concerns in current fusion research is the mitigation of anomalous transport to enable improved plasma confinement. Instabilities at frequencies lower than the ion gyro-motion frequency and with scale lengths comparable to the ion Larmor radius are thought to be the cause of degradation in plasma confinement, resulting in anomalous transport of energy and particles. The density and temperature inhomogeneities present in a magnetically confined plasma provide the free energy for these modes. It has been observed that even when wavelengths $k_\theta\rho_s$>1, the Ion Temperature Gradient mode (ITG), driven by the temperature gradient of ions, becomes unstable when the background gradients (density and temperature) are extremely sharp. These background gradients tend to drive the instability of Short-Wavelength Ion Temperature Gradient modes (SWITGs). In this work, we address the self-consistent dynamics of SWITGs in ADITYA-U, driven by sharp background gradients, their linear and nonlinear evolution, and their saturation after the onset of zonal flows. This study possibly represents very first analysis performed using a global, gyrokinetic, electrostatic solver that includes adiabatic electrons and non-adiabatic ions. To achieve this, we systematically analyze the linear and nonlinear behavior of the mode for ADITYA-U using ORB5 and GLOGYSTO codes. It is observed that the nonlinear contribution of the SWITG mode to the total thermal ion heat transport is found to be minimal due to the increased zonal flow shearing effect resulting in the suppression of transport due to the SWITG mode. Even though this mode may be linearly more unstable than the conventional long-wavelength ($k_\theta\rho_s$<1) ITG mode. This implies that the bulk part of the ion heat fluxes come from the conventional ITG mode.

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