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Effect of kinetic electron dynamics on ITB formation in flux-driven ITG/TEM turbulence

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Internal Transport barrier (ITB), which acts as the shielding layer of particle and heat transport by suppressing turbulence, has a crucial key to achieve the high-performance plasma confinement. In recent HL-2A plasma with co-NBI [1], ITB is formed in the almost flat q profile region. They found that mean flow triggered by toroidal rotation plays a dominant role in sustaining ITB, which indicates that the rotation shear effects are crucial for ITB formation.

For comprehensively studying the role of such toroidal rotation and safety factor profile, we have newly developed a 5D full-f gyrokinetic code GKNET with adiabatic electron [2-4]. This enables us to simulate flux-driven ITG turbulence consistently coupled with neoclassical transport mechanism, where mean profiles such as the ion temperature, the parallel flow, and the radial mean electric field are also evolved self-consistently under fixed momentum and power inputs as in experiments. By means of this code, we found that co-current toroidal rotation in outer region can change mean E_r shear through the radial force balance, leading to ITB formation in which the ion thermal diffusivity decreases to the neoclassical transport level [5]. We have also identified that there exists a positive feedback loop between the enhanced E_r shear and resultant momentum pinch only in the co-input case, signifying a favorite trend to ITB formation.

In this work, we have introduced kinetic electron process based on hybrid electron model [6]. In this model, only $(m,n)=(0,0)$ component of electron is assumed to be full-kinetic and the others are treated as adiabatic. Since the $k_\parallel=0$ component of the kinetic passing electron dynamics is removed from the system, we can avoid the appearance of the ω_H mode which makes the CFL condition quite severe. This model also satisfies the ambipolar condition and the GAM frequency is correctly captured.

Based on this model, we first studied flux-driven ITG turbulences with kinetic and adiabatic electrons. Although the similar ion temperature gradients with nonlinear upshift from linear critical gradients are sustained in the quasi-steady states, the radial patterns of parallel flow and radial electric field are qualitatively different. This originates from the fact that enhanced phase difference between electric potential and perturbed density in kinetic electron case can trigger turbulent particle transport.

Then we compared flux-driven ITG and TEM turbulences. Figure 1 shows the radial profiles of (A)/(C) density and (B)/(D) parallel flow in flux-driven ITG/TEM case. We can see that particle pinch becomes active in TEM case and the direction of intrinsic rotation is opposite in ITG and TEM cases. The latter is considered to originate from the ballooning angles of ITG/TEM are positive/negative, leading to the different sign of residual stress part for momentum transport [7].

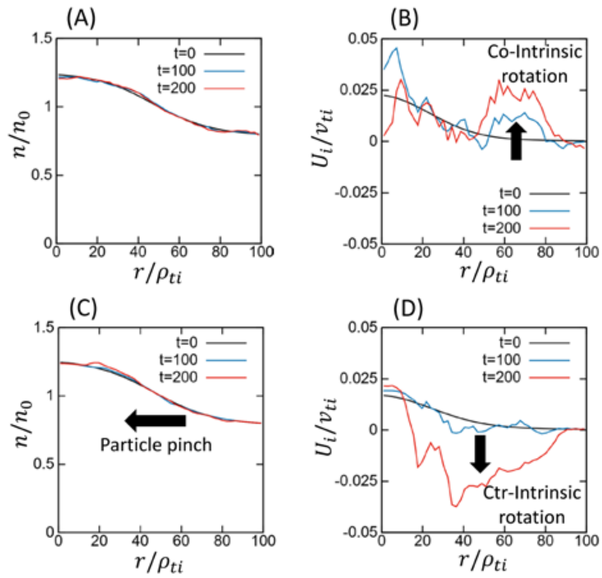

Fig. 1: Radial profiles of (A)/(C) density, (B)/(D) parallel flow in flux-driven ITG/TEM case.

In this talk, we will also address the effect of kinetic electron dynamics on ITB formation through the comparison with adiabatic electron case.

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