Bifurcation in resistive drift wave turbulence

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Fusion plasmas and other turbulent flows in two dimensional (2D) geometry can undergo a spontaneous transition to a turbulence suppressed regime. In plasmas such transitions dramatically enhance the confinement and are known as L-H transitions. From theoretical and experimental work, it is now widely believed that generation of stable coherent structures such as shear flows suppresses cross-field turbulent transport and leads to the confinement improvement.

In this work we discuss bifurcation phenomena observed in numerical simulation of electrostatic resistive drift wave turbulence in 2D slab geometry. The modified Hasegawa-Wakatani (MHW) model is used to describe self-organization of zonal flows and their interactions with the drift wave turbulence.

Figure 1 shows the bifurcation diagram in a two parameter space obtained from the numerical simulations. Two parameters are the adiabaticity (α) represents the parallel electron response and the scale length of the background density ($\kappa = -\partial/\partial x(\ln n_0)$) which drives the drift wave. The system exhibits two different nonlinearly saturated states: the zonal flow dominated state ($\diamond$) and the turbulent state ($\bullet$). By controlling parameters, we observe one state suddenly jumps to the other state in a narrow transition zone ($\times$). The transition point is compared with the Kelvin-Helmholtz (KH) instability threshold of the zonal flows. The solid line in Fig. 1 shows the stability threshold of the zonal flows (tertiary instability) in the parameter space. The KH analysis explains qualitative trend of the bifurcation diagram, i.e. α is stabilizing, while κ is destabilizing. We also plot the stability boundary of the zero background (primary instability.) There is a gap between two stability boundaries where the zonal flow state is observed and the drift wave activity is suppressed. The nonlinear upshift of the onset of turbulence is one characteristic aspect of the nonlinear interaction between the zonal flows and the drift wave turbulence.

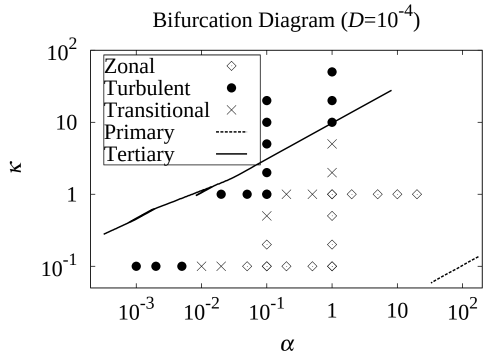

Figure 1: Bifurcation diagram in modified Hasegawa-Wakatani model.