Bifurcation structure in resistive drift wave turbulence

R. Numata, R. Ball, R.L. Dewar

Department of Theoretical Physics, Research School of Physical Sciences and Engineering, The Australian National University, Canberra, ACT 0200, Australia

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 2D plasmas and fluids, the net upscale energy flux from small scale turbulent modes to create large scale coherent structures can dominate the classical Kolmogorov cascade to dissipative scales. Recently, a low-dimensional dynamical model for L-H transition has been suggested and analyzed using bifurcation and singularity theories[1]. The model consists of three macroscopic energy variables and, when validated against numerical and/or real experimental data, will provide an economical tool to predict transitions over a parameter space.

The Hasegawa-Wakatani (HW) equations[2] are the model to describe the electrostatic resistive drift wave turbulence, and have been investigated to study the turbulent transport in edge plasmas. It was recently pointed out that the modification ot the HW model by subtracting the zonal components ($k_y = k_z = 0$) from the resistive coupling term is more appropriate to describe the system since the zonal modes do not contribute to the term. We have performed the direct numerical simulation of the modified HW (MHW) model in 2D slab geometry, and have revealed that the modification is crucial to generate the zonal flow[3]. It is also observed that, once the zonal flow is generated, the turbulent transport across the background magnetic field is significantly reduced. The result indicates the bifurcation of the turbulent level. In this paper, we discuss the result of systematic parameter study of the MHW model, and bifurcation structure in the parameter space.

References

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