Roles of meso-scale structures on global profile relaxation and spectrum

Y. Kishimoto, K. Imadera, P. Hilsher, J.Q. Li

Graduate School of Energy Science, Kyoto Universuty, Uji, Kyoto 611-0011, Japan

kishimoto@energy.kyoto-u.ac.jp

Zonal modes, such as zonal flow, field and pressure, which are poloidally and toroidally symmetric macro-scale structures nonlinearly generated from micro-scale turbulence, play an important role in regulating turbulent structure and then transport [1]. These zonal modes are considered to be tightly linked to non-local characteristics of transport that are not explained by simple Gaussian statistics, such as intermittency, turbulent spreading [2], avalanche dynamics, etc. A self-organized critical (SOC) transport [3] is also an example in which the turbulence provides a strong constraint on relaxation, leading to a self-organized stiff temperature profile. Zonal modes are also found to lead to a non-power low spectrum, exhibiting exponential characteristics [4].

Here, we revisit these fundamental but crucial problems related to such a nonlocal transport in a simple slab geometry, but keeping global characteristics, and study the turbulent-profile interaction and resultant global profile relaxation. For this purpose, we introduce a hierarchical entropy theory retaining the radial spatial dimension and investigate the roles of zonal modes on the global profile relaxation and redistribution of plasma profiles [5]. The spatial convection of turbulent fluctuations is found to play an important role in the relaxation dynamics dominated by an avalanche process. A relaxed state characterized by a spatially corrugated short-wavelength zonal pressure is established in the ITG turbulence case, whereas a self-organized global structure subject to a strong constrained in the ETG turbulence case. Underlying physical mechanisms for these different responses in turbulent-profile interaction are discussed.

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