25th IAEA Fusion Energy Conference - IAEA CN-221

Contribution ID: **410** Type: **Poster**

Global Profile Relaxation Coupled with E×B Staircase in Toroidal Flux-Driven ITG Turbulence

Thursday, October 16, 2014 8:30 AM (4 hours)

By means of a newly developed 5D toroidal global gyrokinetic code with heat source/sink, we investigated the nonlocal characteristics of flux-driven ITG turbulence to clarify the underlying mechanism of avalanches, profile resilience and their dynamic responses in toroidal system.

We found that the turbulent transport and associated profile relaxation are dominated by two processes. One is the fast-scale intermittent bursts resulting from the instantaneous formation of radially extended potential vortices, whose size ranges from meso to even macro-scale (˜L_T) across the E×B staircase. Such potential structures are considered to trigger the non-Gaussian PDF (probability density function) tails of turbulent heat flux, which becomes longer as heat input power increases. The other is the slow-scale radial convection of temperature corrugation coupled with the meso-scale E×B staircase, which propagates from half-minor radius to edge. Ascribed to these events with long correlation lengths, a self-organized resilient profile keeping the exponential function form is found to be established even in the presence of mean flows.

We also investigated the dynamic response of such transport processes by step-up/down switching test for heat input power, P_in. A hysteresis nature in the gradient-flux relation is found to be observed, which originates from a time delay of the E×B staircase to the step-up/down event. We further found that the partition of the mean flow energy to that of the total fluctuation, i.e. eta=Eˆ(mean)/[Eˆ(mean)+Eˆ(turb)] is proportional to P_inˆ(-1/2) in a quasi-steady state. This suggests that stronger intermittent bursts due to high input power lead to weaker mean flow level, which is considered to be a reason that the profile can keep the function form even in high input power regime, while typical scale length L_T weakly depends on P_in.

Paper Number

TH/P5-8

Country or International Organisation

Japan

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Session Classification: Poster 5