Study of non-diffusive flux-driven turbulent transport and profile stiffness/resilience

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Non-diffusive turbulent transport and profile stiffness/resilience are long standing problems, which have been observed in magnetically confined fusion plasmas. One of such dynamics is the self-organized critical transport observed in a global toroidal simulation, leading to a Bohm-like scaling [1]. Recent advanced flux-driven simulations have also reproduced similar dynamics accompanied by a $1/f$ type non-diffusive transport [2, 3]. However, the underlying physical mechanism of such dynamics has not been clarified yet.

Here, using a newly developed global gyrokinetic Vlasov code based on the multi-moment scheme [4, 5], we investigated a flux-driven ion temperature gradient (ITG) turbulence in slab geometry. Figure 1 shows the spatio-temporal evolution of heat flux observed in the simulation. Remarkable features are that the turbulent transport in a source/sink free region ($25\rho_{ti} < x < 75\rho_{ti}$) is dominated by active avalanches and the ion temperature profile in this region is tied to globally constant around $L_{Ti} \sim 60\rho_{ti}$. Such a temperature profile is found to be hardly changed in the power scan, which exhibits a strong profile stiffness/resilience. While the radial correlation length of the turbulence is $\Delta r_c \sim 5\rho_{ti}$, the propagation width of avalanches observed in the simulation shows meso-scale dynamics given by $l_A \sim 15\rho_{ti}$.

In order to clarify the underlying physics on such a non-diffusive flux-driven turbulent transport, we also investigated the energy partition between turbulence and zonal flows with different external heat flux. The partition is found to be decreased as the external heat flux is increased, indicating that the zonal flows are less generated for larger external heat flux. It can be seen that the observed strong profile stiffness/resilience and corresponding anomaly in the heat diffusivity can originate from the energy partition.

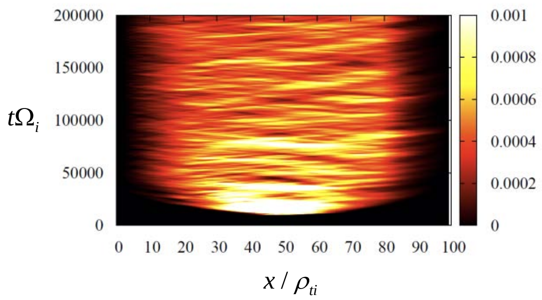

Figure 1: Spatio-temporal evolution of heat flux observed in a flux-driven ITG turbulence simulation.

We will also discuss the above conjecture by investigating the transient process of profile evolution by changing external heat flux.

Reference

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