Intermittent oscillations generated by ITG-driven turbulence

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In order to understand the mechanisms of anomalous transport due to micro-instabilities and transport barrier formation related to generation of sheared plasma flows, we have studied transport regimes of ion-temperature gradient (ITG)-driven turbulence using a low degree-of-freedom model composed of 18 ODEs [1]. When the system is close to the threshold of ITG instability, an L-H-like transition and periodic oscillations are observed in the kinetic energy and convective flux fluctuations. As the ion temperature gradient 'Ki' is increased further, the system bifurcates to turbulent regimes. In the strongly turbulent regime, intermittent bursts (so-called avalanches) are observed, which contrasts with the report that no such intermittency was observed in simulations of the previously proposed low degree-of-freedom model based on 11 ODEs [2]. This intermittency is caused by the competition of the following 3 factors; (1) generation of sheared flows due to nonlinear coupling among higher harmonics and suppression of ITG turbulence by the sheared flows, (2) gradual reduction of the sheared flows due to viscosity, and (3) rapid re-growth of ITG modes due to the reduction of stabilizing effects by the sheared flows. We also obtained a scaling law between time average of the Nusselt number and the ion pressure gradient Ki. The obtained scaling law shows that, in the case of large Ki where sheared flows become dominant and intermittency occurs, the Nusselt number is significantly lower than its value that we would expect if it were not for intermittency. We have demonstrated that essential nonlinear behaviour of the ITG turbulence can be at least qualitatively accounted for by nonlinear interaction of several low order harmonics.

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