

3-4 Suppression Mechanism of Turbulent Electron Heat Transport — Simulation Study of Microscopic Electron Turbulence in Tokamaks —

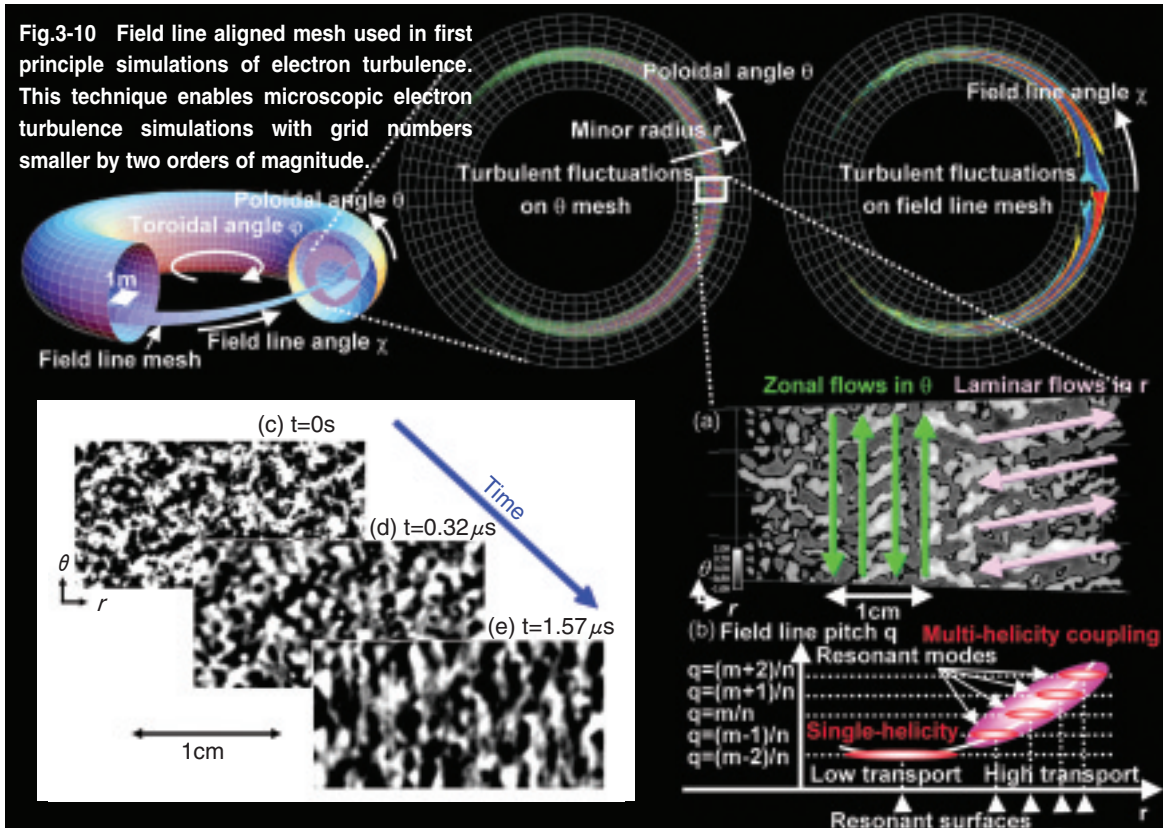


Fig.3-12 Contour plots of electric potential observed in electron turbulence simulations of self-organization processes

Single-helicity electron turbulence, which is a model for a barrier region in Fig.3-11 (a), is evolved from random turbulent fields (c). These pass through a transient state (d), and then the system is relaxed to form turbulent structures with zonal flows (e).

In tokamak research, it is one of critical issues to sustain high temperature plasmas efficiently by suppressing turbulent transport, which dissipates the heat from the reactor core. Up to now, ion turbulence (characteristic wave length $\lambda \sim 5\text{mm}$) has been studied based on first principle simulations. However, calculation of the microscopic electron turbulence ($\lambda \sim 0.1\text{mm}$) which is important especially in burning plasmas in “ITER”, where the electron heating by α -particles becomes dominant, in experimentally relevant parameters is prohibitively costly. To overcome this difficulty, we developed a new simulation technique using field line aligned mesh (Fig.3-10), and succeeded in simulating the

Fig.3-11 First principle simulations of electron transport barriers

(a) is a contour plot of the electric potential and (b) shows coupling structures of resonant modes characterized by mode numbers (m,n) in (θ, ϕ) directions. In a barrier region, zonal flows are produced by self-organization processes of single-helicity (2D-like) turbulence.

electron turbulence. By using this simulation, we studied the electron turbulence in a transport barrier region, which is often observed in recent experiments. The results show that in a barrier region, zonal flows are produced which suppress heat flux from a core (Fig.3-11 (a)), and that this effect can be expected to occur also in future large devices. Further analyses on turbulent structures clarified that they have two dimensional (2D) like character, which is similar to that found in atmospheres of planets, and that zonal flows are generated from self-organization processes similar to those of East-West zonal jets on planets (Fig.3-12).

References

- Idomura, Y. et al., Global Profile Effects and Structure Formations in Toroidal Electron Temperature Gradient Driven Turbulence, Nuclear Fusion, vol.45, no.12, 2005, p.1571-1581.
Idomura, Y., Self-Organization in Electron Temperature Gradient Driven Turbulence, Physics Plasmas, vol.13, no.8, 2006, p.080701.1-080701.4.