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Electromagnetic Gyrokinetic Analysis of Turbulent Transport in Finite-Beta LHD Plasmas

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Turbulent transport in finite-beta Large Helical Device (LHD) plasmas is investigated by means of electromagnetic gyrokinetic simulations. It is found that (i) the ITG mode growth rate decreases with increasing beta, and the kinetic ballooning mode (KBM) becomes a dominant instability for local beta values larger than 2-3% in typical LHD configurations, (ii) shearing between oppositely inclined convection cells newly found in the LHD configuration leads to saturation of the KBM instability which is hardly saturated in flux tube simulations of finite-beta tokamaks because of weak zonal flow generation, and (iii) the efficiency of KBM turbulence in the transport is much smaller than that of ITG turbulence.

Whereas in low-beta torus plasmas the zonal flow shear acts to regulate ITG driven turbulence, it has often been observed by gyrokinetic simulations that instabilities continue to grow without reaching a physically relevant level of saturation at finite-beta tokamaks. The corresponding problem in finite-beta helical plasmas is an open question, and we have revealed a new saturation mechanism.

The finite beta turbulence is saturated by the new saturation mechanism that is the nonlinear interactions of oppositely inclined convection cells through mutual shearing, even when the zonal flow is weak. The new mechanism may also cause saturation of turbulence in finite-beta tokamaks in the presence of three-dimensionality such as toroidal ripples and resonant magnetic perturbation (RMP).

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