30E14P

ヘリカル系プラズマにおけるゾーナルフローと乱流の多階層シミュレーション・モデル

Multi-scale Simulation Model for Zonal Flows and Turbulence in Helical Plasma

渡邉智彦、洲鎌英雄、沼波政倫
T.-H. Watanabe, H. Sugama, and M. Nunami

核融合研
NIFS

A multi-scale simulation model for zonal flows and turbulence in helical systems has been developed by means of a bundle of local flux tubes, and is applied to the ion temperature gradient (ITG) turbulence in case with an equilibrium-scale radial electric field (E_r). The numerical model and the initial results are reported in the present paper.

In non-axisymmetric systems, such as the Large Helical Device (LHD), the radial electric field driving the poloidal **E**x**B** rotation is spontaneously formed by the neoclassical transport, and enhances the zonal flow response through improvement of collisionless orbit of helical ripple trapped particles. The enhancement of zonal flow response is expected to influence the ITG turbulent transport. To incorporate effects of the poloidal rotation on zonal flows, the conventional local flux tube model should be extended so that field-line-label (α) dependence of the confinement field strength is included. Then, we have considered a flux tube bundle model that consists of several flux tubes placed at different α coordinates.

The new simulation model was first applied to linear tests of the zonal flow response and the ITG instability growth, where the zonal flow enhancement by E_r and the Doppler shift of the mode frequency have been confirmed.

Nonlinear simulations of the ITG turbulence and zonal flows in the inward-shifted model LHD configuration have recently been carried out using eight flux tubes. Figure 1 shows time history of the zonal flow intensity found in the multi-scale simulations for cases with M_p=0 and 0.3, where M_p stands for the poloidal Mach number of the **E**x**B** rotation. After the initial saturation of the instability growth at t~50 L_n/v_{ti}, the zonal flow slowly grows in case with the finite poloidal rotation. This is consistent with the linear zonal flow response analysis. The time-averaged power of the zonal flow potential for M_p=0.3 is about two-times higher than that in the no poloidal rotation case.

The ion heat transport coefficient, χ_i, for different M_p cases is summarized in Fig. 2. The enhanced zonal flows for M_p>0.1 contribute to reduction of χ_i, while it is higher than that for M_p=0. This is because the zonal flows for M_p=0 can be freely generated in each flux tube, while a phase matching of zonal flows over a bundle of flux tubes makes the zonal flow growth slower. Improvement of the numerical modeling is also currently in progress and will be reported at the meeting.

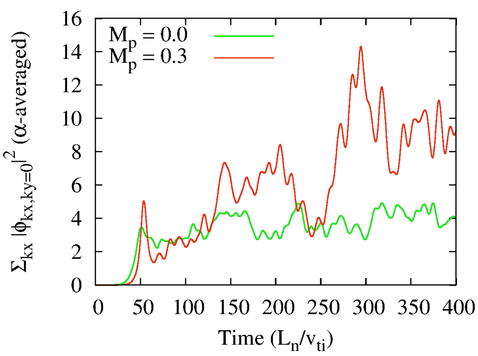

Fig.1: Time history of zonal flow intensity.

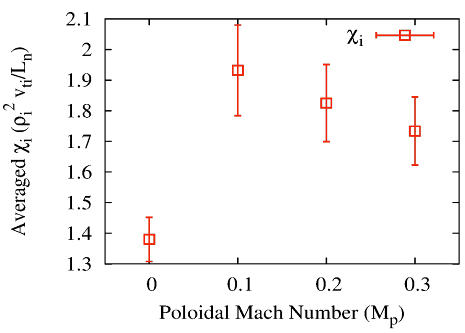

Fig. 2: Ion heat transport coefficient obtained from different M_p cases.