A Reduced Model for ITG Turbulent Transport in Helical Plasmas

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In order to improve the plasma confinement, it is important to quantitatively evaluate the transport levels due to the turbulence that is mainly caused by the micro-instabilities such as the ion temperature gradient (ITG) mode. In our work [1], for the high ion temperature LHD plasma, gyrokinetic Vlasov simulations of ITG turbulent transport were carried out by using the local flux-tube code GKV-X [2]. The simulation results reproduced the turbulent ion heat transport level and the wavenumber spectra of the density fluctuations observed in the experiment. However, since the nonlinear gyrokinetic simulation in helical plasmas requires extremely heavy computational resources, it is not practical to perform nonlinear simulations a large number of times for the purpose of parameter survey. In our recent work [3], from many GKV-X simulation data, we obtained a clear correlation between the ITG turbulent transport levels $\chi_i/\chi_{i,GB}$, and the model function of the squared turbulent potential fluctuation $T \equiv (1/2)\sum_{k_x,k_y \neq 0} \langle |\tilde{\phi}_{k_x,k_y}|^2 \rangle$ and the squared zonal-flow potential fluctuation $Z \equiv (1/2)\sum_{k_x} \langle |\tilde{\phi}_{k_x,0}|^2 \rangle$, as $\chi_i/\chi_{i,GB} \propto T^{1/2}/(C + Z^{1/2}/T)$, in spite of the fact that a wide range of conditions employed in the simulations, such as the different flux surfaces, different field configurations, and different temperature/density gradient lengths. Based on the simple relation, we propose a reduced ITG turbulent transport model [4] using only linear gyrokinetic analyses without nonlinear simulations. The model can be represented in terms of the linear growth rates of the instability and the linear responses of the zonal-flow potentials. It is confirmed that the model can reproduce the transport levels obtained from nonlinear simulations under various LHD equilibrium conditions. Furthermore, we will discuss about contribution of the model to integrated transport analysis in helical plasmas.