Study on Characteristics of Turbulences in Tokamak Plasmas using Global Landau Fluid Simulation

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A complete description tokamak plasma dynamics and profile evolution requires kinetic models, such as gyrokinetics. The gyrokinetic model, though rigorous, generally need large computational resources to obtain a flux-driven steady state. Fluid models, which are obtained from a systematic reduction of kinetic equations by taking velocity moments, retain relevant physics for the study of turbulent plasma dynamics in magnetic fusion plasmas. Comparing gyrokinetics, fluid models require moderate computational capability, while keeping relevant features of nonlinear physics driving turbulence. In this work, we develop a simplified form of the so-called 3+1 Landau fluid model and perform nonlinear global gradient-driven simulations to study ion temperature gradient (ITG)-driven turbulence characteristics. This model does not take the finite Larmor radius (FLR) effects while keeping all the relevant physics of the neoclassical equilibrium. Interestingly, even though the linear growth rate obtained from the model are considerably larger that calculated from the gyrokinetic codes, the ion heat conductivity in steady states show a relatively low level, i.e., comparable to that of flux-tube gyro-fluid model. The physics of this "global stabilization" effect will be discussed in the conference. Characteristics of zonal flows and turbulent power spectra are compared in terms of Reynolds number in wave turbulence. Implications of these spectra on the turbulent transport process in tokamaks are discussed. Finally, we discuss the future perspectives of the fluid model development including the zonal flow closure to capture the Rosenbluth-Hinton residual zonal flow and the derivation of fluid moment equations in a conservative form.

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