Bounce-averaged gyrokinetic simulations of tokamak micro-turbulence

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Abstract

For the prediction and optimization of tokamak performance, it is crucial to understand the thermodynamic properties of strongly magnetized plasma, which are mainly determined by relatively low frequency turbulence occurring in the magnetized plasma. The gyrokinetic theory provides an economic way to study such low frequency turbulence and dynamics of the magnetized plasma by removing the fast periodic gyro-motions from the system, thus significantly reducing the spatio-temporal scales to describe[1]. However, even with this reduced gyrokinetic model, it is still challenging to simulate global aspects of turbulence and transport in realistic tokamak geometry. This is mainly due to the large mass ratio of ion and electron constituting the tokamak plasma, and the resulting time scale disparities in their respective motions.

In this work, we introduce the bounce-averaged kinetic model[2], which is to remove the fast periodic bounce motions of electrons, and thereby to reduce the computational cost for simulation further. We show that the bounce-averaged kinetic model can be extended and applied to study key micro-instabilities such as ITG and TEM in realistic tokamak geometry[3]. As an example, we demonstrate that the bounce-averaged model can reproduce the shaping effects on ITG-TEM micro-instabilities in quantitatively correct ways. We also discuss possible future extension of the model for nonlinear simulation of ITG-TEM turbulence in tokamak plasma.

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