R008-10
Zoom meeting D ：11/4 AM1 (9:00-10:30)
9:45～10:00

Fluid modeling of collisionless plasmas and its range of application

#Taiki Jikei[1),]Takanobu Amano[1)]
[(1]UTokyo

Modeling of collisionless plasmas can be divided into two categories: fluid models and kinetic models. Generally speaking, fluid models require less computational resources than kinetic models, so they are suited for large-scale simulations. However, conventional fluid models such as MHD ignores wave-particle interaction. It has been pointed out that wave-particle interaction affects microscopic and macroscopic dynamics and should not be ignored even in MHD scales. This creates a demand for a fluid model of collisionless plasma that takes into account wave-particle interaction effects.

We have developed a fluid model that incorporates cyclotron resonance effects by applying non-local closure used in Landau-fluid models to the full pressure tensor equation. The model approximately reproduces the linear cyclotron resonance and linear growth of temperature anisotropy instabilities. We

have also shown that a simulation with or model can reproduce quasilinear relaxation of temperature anisotropy via resonant waves.

Another example of a kinetic fluid model is the well-known CGL(Chew-Goldberger-Low) model. The CGL model is used to analyze low-frequency waves in collisionless plasmas. With a proper FLR(finite Larmor radius) correction (and the Hall term), the Hall-CGL-FLR model predicts the growth rate of firehose instability with reasonable accuracy. However, CGL-based models cannot reproduce cyclotron resonance effects such as cyclotron damping and EMIC(electromagnetic ion cyclotron) instability because of the low-frequency assumption.

We will discuss some basic concepts of these kinetic fluid models and their range of application, especially in nonlinear simulation. Our non-local closure model is not limited by frequency (at least up to cyclotron frequency) and can reproduce both EMIC and parallel firehose instabilities but need improvement for quantitative agreement with fully kinetic models. CGL-based models can be very accurate in the low-frequency regime. Still, we found that the fact that CGL-based models do not solve gyro-motion terms in the pressure equation introduces some problems when high-frequency waves inevitably appear in nonlinear simulations. We will see these properties in the simulation of parallel firehose instabilities with different parameters.