A flute instability with ion finite Larmor radius effects

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A particle simulation of a flute instability was performed by taking into account the ion finite Larmor radius (FLR) effects. The linear growth rates observed in the simulation agree well with the theoretical calculation. The effects of ion FLR are usually taken in the fluid simulation through the gyroviscosity, the effects of which are verified in the particle simulation with large FLR regime. The gyroviscous cancellation observed in the particle simulation causes the drifts.

The present particle code adopts the implicit scheme to push particles and calculate the electrostatic potential by Poisson equation[1]. The unnecessary high frequency oscillations such as electron cyclotron oscillations are effectively removed in the simulation, so that the flute instability can be investigated with the help of the particle code. The effects of FLR are usually taken into account in the fluid equation through the generalized Ohm’s law and gyroviscosity[2], so that fluid simulations are performed to investigate the stabilization of flute instability with FLR. The dispersion relation of a flute instability with FLR was derived by M.N.Rosenbluth and A.Simon with the help of Vlasov equation[3]. The validity of theory and FLR effects in the fluid equation, however, has not been verified yet. Thus it is important to make clear the stabilization of a flute instability by FLR with the help of a particle code.

Figure 1 is the geometry and initial condition used in the particle simulation. The effective gravitational force $g_{eff}$ is included in the simulation instead of the centrifugal force in Fig.1. The initial condition in Fig.1 is unstable to the flute instability. Figure 2 plots the linear growth rates observed in the simulation. Here solid squares represent the case with FLR and solid circles are without FLR. The agreement between simulation and analytical calculation is very good. This is a first simulation result which verifies the analysis with FLR. There appeared the effects of gyroviscosity on a flute instability in the nonlinear stage of the particle simulation. The gyroviscous cancellation observed in the particle simulation causes the drifts in the ion diamagnetic direction.