MFP-50 AAPPS-DPP2018

2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Effect of Kinetic Ions on the Electron Temperature Gradient Turbulence in Slab and Toroidal Geometries

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It is important to suppress the heat transport in the core region of magnetically confined plasmas for realizing fusion reactors. One of the driving mechanisms of electron heat transport is the electron temperature gradient (ETG) turbulence. In early studies of the ETG turbulence, the ion response was assumed to be adiabatic because of the large difference between ion and electron mass [1]. However, a recent gyrokinetic simulation of toroidal ETG modes, which deals with both particle species by the kinetic theory, suggests that the adiabatic ion model poorly behaves for high values of the magnetic shear [2].

In this study, we investigate effects of kinetic ions on ETG driven turbulence in a shearless slab geometry. Figure 1 shows the linear dispersion relation of shearless slab ETG. In the electrostatic case, the growth rate at the ion gyroradius scale of $k_{\perp}\rho_{ti}{\sim}1$ is enhanced by the ion polarization while reduced by a finite-β effect. We made these reasons clear in the fluid limit. Nonlinear simulations show that the zonal flow is generated in the case with adiabatic ion [see Fig. 2(a)], while in the case with kinetic ion, the ion scale eddies become dominant after saturation of the ETG instability growth in the electrostatic case [see Fig. 2(b)]. These ion-scale eddies are suppressed by the finite-β effect reducing the growth rate in the ion gyroradius scale, and then the heat transport is reduced. While in adiabatic ion case, the finite-β effect also reduces zonal flow [3], and hence the heat transport is slightly larger than that of electrostatic case.

We have also investigated the toroidal ETG turbulence to find effects of kinetic ions, and will discuss the result at the conference.

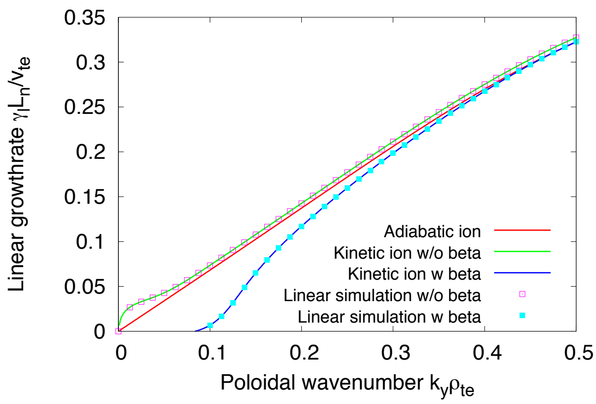

Figure 1. Linear growth rate calculated from an eigenvalue problem (solid line) and from linear simulations (square dots) for $m_i/m_e = 750$ and $\beta = \mu_0 n_0 T_e/B^2 = 0.002$.

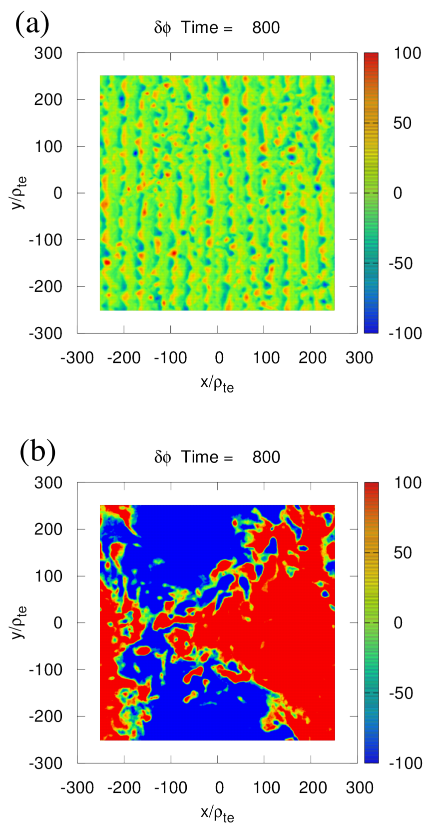

Figure 2. Contours of the normalized electrostatic potential fluctuations with (a) adiabatic ion, and (b) kinetic ion.

References

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