4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Effects of radial electric field on ion-temperature gradient driven mode stability

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Drift waves (DWs) turbulence [1], driven by free energy associated with plasma pressure gradients, are considered as candidates for inducing anomalous plasma transport and degradation of confinement in magnetically-confined fusion (MCF) devices. Ion-temperature gradient driven mode (ITG) is one of the most intensively studied DWs and may cause anomalous ion thermal transport, which is much concerned in future fusion reactors. Excitation of zonal flows (ZFs), is considered as an important route for ITG self-regulation, and the regulation is achieved via nonlinear excitation of ZFs by ITG via modulation instability as ITG amplitude exceeds the threshold induced by frequency mismatch, which in turn, scatters ITG into the linearly stable short radial wavelength regime [2,3].

Besides, due to its finite frequency, GAM can resonant with, and be excited by free energy associated with energetic particles (EPs) velocity space anisotropy [4-7]. Excitation of EGAM by externally injecting energetic ions into the DW localization region is proposed as a potential active control of DW turbulences [8]. But gyrokinetic simulation in [Zarzoso et al, PRL, 2013] and [Dumont et al, PPCF, 2013] observe that after the excitation of EGAM due to EPs injection, the ITG turbulence and associated transport are excited from Dimits shift marginally stable region [9,10].

Motivated by these works, in this work, we will study the nonlinear interaction between ITG and given radial electric field by assuming the time scale separation between ITG frequency and the oscillation frequency of the electric field, and study the “linear” stability of ITG in the existence of the radial electric field. This is achieved by deriving a governing mode equation of ITG in the existence of the radial electric field induced density modulation as well as poloidal rotation, and the mode equation is solved in ballooning space for the ITG eigenmode dispersion relation.

It is found that the electrostatic potential of radial electric field contributes to the significant reduction of the growth rate of ITG turbulence, while the density fluctuation accounts for mode structure shift and has little effect on ITG “linear” stability. However, our present analysis did not provide information for understanding of [Zarzoso et al, PRL, 2013] and [Dumont et al, PPCF, 2013].

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