Nonlinear interaction between drift wave and toroidal Alfvén eigenmode mediated by zonal structures

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Drift wave (DW) [1] and shear Alfvén wave (SAW) [2] are two fundamental instabilities in magnetically confined fusion (MCF) devices such as tokamaks, driven unstable by bulk plasma nonuniformity and energetic particles (EPs), respectively, and lead to transport loss of thermal plasma and EPs. Thus, understanding of the linear stability and, especially, nonlinear saturation of DWs and SAWs are important for assessing confinement of plasmas. In particular, the nonlinear interactions between these two major instabilities are of interest for reactor burning plasmas.

Recently, it is found that direct nonlinear scattering by ambient electron drift waves (eDWs) may lead to significant damping of TAE [3], while, for typical parameters and fluctuation intensity, direct nonlinear scatterings by TAEs have negligible net effects on the eDW stability [4]. As a natural step forward, motivated by those work, we investigated the in-direct nonlinear interaction between TAE and DW, mediated by zonal structures (ZS) [5].

In this work, the gyrokinetic theory and ballooning mode representation are used to investigated the stability of ion temperature gradient driven mode (ITG) in the presence of the ZS beat-driven by TAE [6]. The dependence of the growth rate and real frequency of ITG on the TAE amplitude is calculated analytically and numerically by solving the corresponding eigenmode equation both in the strong [7] and weak [8] coupling limit. The results in the strong limit are shown in Figure 1, with analytical and numerical results agreeing well with each other. It is found the growth rate as well as real frequency of ITG increase with increasing TAE amplitude, but the magnitudes of their changes are negligibly small for typical TAE amplitude, contrary to some existing numerical results.

References

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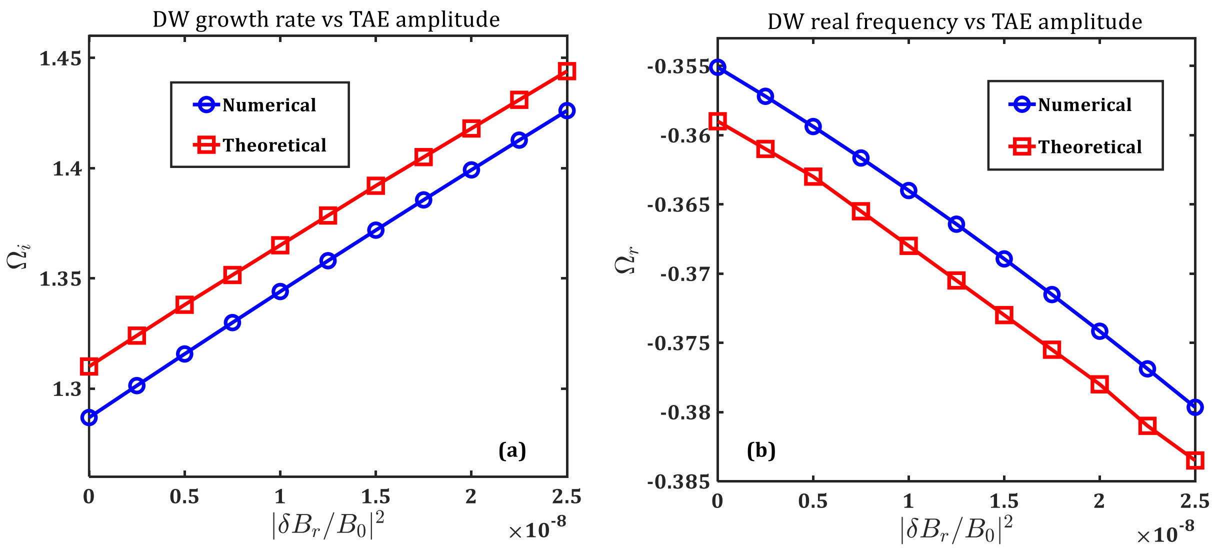

Figure 1. The dependence of normalized ITG growth rate (a) and real frequency (b) of ITG on the TAE amplitude.