Ion temperature gradient mode mitigation by energetic particles, mediated by forced-driven zonal flows

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Drift wave turbulence and its associated heat and particle transport have been intensively studied due to the role they play in deteriorating plasma confinement, which is a concern for future fusion plasma reactors. The ion-temperature gradient modes (ITG) [1] are drift waves driven unstable by the ion-temperature gradient. The spontaneous non-linear excitation of zonal flows by ITG modes [2], is believed to be one of their major saturation mechanisms. Recently, global simulations with the gyro-kinetic particle-in-cell code ORB5 [3] have been performed, where the self-consistent interaction of ITG turbulence, zonal flows, and Alfven modes has been studied. As a result, it has been conjectured that zonal flows forced-driven by Alfven instabilities might be used to reduce the level of ITG turbulence [4]. This would represent an indirect way of interaction of energetic particles (driving Alfven modes unstable) and turbulence.

In this work, we isolate this mechanism in the self-consistent nonlinear simulations and prove that it is indeed effective. To this aim, we measure the amplitude and radial structure of the forced-driven zonal flows and we impose them on electrostatic ITG simulations. Imposing this self-consistent zonal flow leads to a significant mitigation of the ITG instability, which induces a significant drop of the ITG growth rates. A scan of the zonal flow amplitude shows an inverse relation between the ITG growth rate and the zonal flow amplitude (figure 1 a)

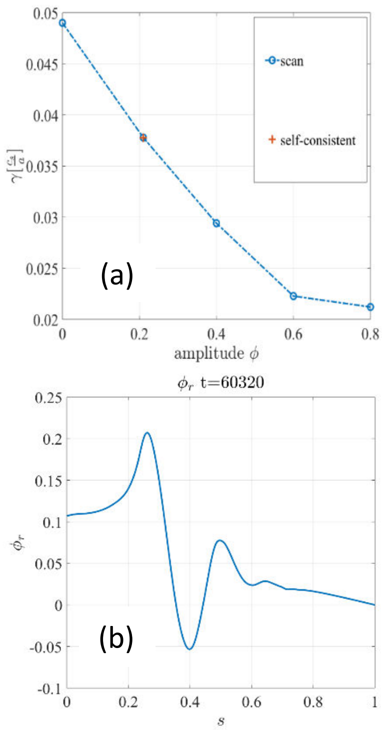

Figure 1: (a) ITG growth rate vs zonal flow amplitude, (b) mode structure of self–consistent zonal flow.

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