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

Simulation analysis of reversed shear Alfvén eigenmode dynamics and energetic particle transport during current ramp-up

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A weakly reversed shear magnetic configuration is commonly created during the plasma current ramp-up phase of a tokamak discharge, where the frequency sweeping reversed shear Alfvén eigenmode (RSAE) can be readily excited by energetic particles (EPs) produced by, e.g., neutral beam injection. Rich phenomenology of wave-EP resonant interactions has been routinely observed. On one hand, the RSAEs often induce significant EP transport; on the other hand, the spectra of strongly driven RSAEs could consist of fast frequency chirping on top of the slow sweeping [1]. In this talk, the dynamics of strongly driven RSAEs and the associated EP transport are presented via hybrid MHD-gyrokinetic code simulation analyses [2]. A series of safety factor q profiles representing time slices of the long timescale MHD equilibrium evolution is considered, where the self-consistent RSAE-EP resonant interactions on the short timescale are analyzed in detail. Both linear and nonlinear RSAE dynamics are shown to be subject to the non-perturbative effect of EPs by maximizing the wave-EP power transfer [3,4]. In the linear stage, EPs induce evident shifts to the mode structure and frequency. In the nonlinear saturation stage, the RSAE radially decouples with the resonant EPs, and gives rise to global EP convective transport and fast frequency chirping in the non-adiabatic regime. The mechanisms of the non-adiabatic frequency chirping is interpreted as a "convective" branch via phase locking with the resonant EPs convection, and "relaxation" branches to the weakly damped MHD limit. The spatiotemporal scales of the phase space dynamics are characterized by the perpendicular wavelength and wave-particle trapping time. The simulations provide insights in the general as well as specific features of the RSAE dynamics and EP transport from experimental observations, and illustrate the fundamental physics of wave-EP resonant interaction with the interplay of the magnetic geometry, plasma non-uniformity and non-perturbative EPs [2,3,4].

References

[1] K. Shinohara, *et al.*, Nucl. Fusion **41**, 603 (2001)
[2] T. Wang, *et al.*, "Dynamics of reversed shear Alfvén eigenmode and energetic particles during current ramp-up" submitted to Nucl. Fusion (2020)
[3] F. Zonca, *et al.*, New J. Phys. **17**, 013052 (2015)
[4] L. Chen and F. Zonca, Rev. Mod. Phys. **88**, 015008 (2016)