Gyrokinetic particle simulation of beta-induced Alfvén-acoustic eigenmode

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Due to its low frequency, the beta-induced Alfvén-acoustic eigenmode (BAAE) can be strongly damped by the thermal ions when the temperatures of ions and electrons are comparable. Therefore, it has been debated whether the BAAE as predicted by the fluid theory could exist in the collisionless plasmas where BAAE is expected to be heavily damped by ion kinetic effects. In this work, the BAAE is verified and studied through the gyrokinetic particle simulations for the first time with the electromagnetic gyrokinetic toroidal code (GTC). The existence of BAAE is first verified in the $T_i \ll T_e$ limit (where it is weakly damped) by the GTC simulations using, separately, initial perturbation, antenna excitation, and energetic particle excitation. The BAAE frequency excited by the antenna and energetic particles is almost the same as that in the initial perturbation simulation (Fig. 1). The linear BAAE properties with a more realistic $T_i = 0.5T_e$ are then studied in the GTC simulations for both reversed shear and monotonic q profiles. It is shown in the antenna excitation simulations that the damping rate of the BAAE is comparable to its real frequency. The BAAE poloidal mode structure in the monotonic q profile has opposite triangle shape compared to the reversed shear q profile. The mode structure in the reversed shear profile is similar to that observed in the DIII-D experiments. Furthermore, the frequency sweeping of the BAAE is observed in the simulations with reversed shear q profile, consistent with experimental observations.

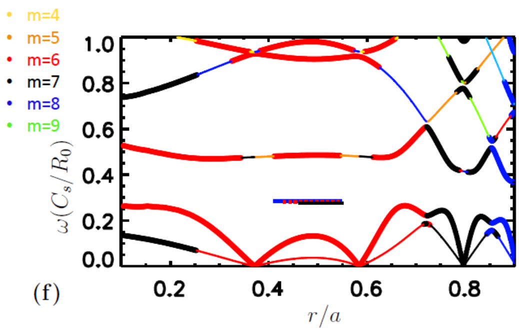

Fig. 1 The Alfvén continuum for n=3. The thick lines are the Alfvén branches and the thin lines are the sound branches. The horizontal lines indicate the BAAE frequencies and mode width from the initial perturbation (solid black), antenna excitation (dashed red), and energetic particle excitation (solid blue)