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Comprehensive Gyrokinetic Study of Eigenstate Transitions in Fast Ion-Driven Electrostatic Drift Instabilities

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Fast ion-driven drift instability is comprehensively investigated by extending the previous theory[1,2]. We have derived an eigenmode equation in the ballooning coordinate, including the non-adiabatic contribution of passing fast ions, which was neglected in Ref. [1,2]. Passing fast ions significantly affect the instability in weak negative shear or moderate positive shear plasmas. It is demonstrated that eigenstate transitions from the ground state to non-ground state, observed in ITG and TEM instability[3-5], also can widely occur for fast ion-driven drift instability under steep temperature gradient of fast ions. Eigenstate transitions to non-ground states occur more readily in weak magnetic shear, high safety factor, and long wavelength perturbations, where the linear growth rate of the instability is maximized. Linear gyrokinetic simulations using the GKV code[6] verify the theory, showing good agreement with shooting method results. The estimated quasilinear transport indicates that the net energy flux can be inward, without contradicting the second law of thermodynamics. These findings have important implications for heating efficiency and plasma confinement in the heating process, such as Ion Cyclotron Resonance Heating (ICRH) in future fusion devices.

References

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