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Fast ion driven drift instability in reversed shear burning plasmas

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It is shown that electron drift wave is destabilized by trapped fast ions produced by fusion reaction since they reverse their precession direction in reversed shear (RS) plasma to electron diamagnetic direction and can resonate with electron drift wave. We perform a local stability analysis of this new instability in fusion reactor condition and calculate consequent transport caused by drift wave turbulence developed from this new instability using gyrokinetic equations in toroidal geometry[1,2]. We consider the equilibrium distribution function of fast ions as slowing down distribution[3] and compare to the equivalent Maxwellian case for illustration. The instability occurs when the temperature gradient of fast ions peaks sufficiently compared to the density profile. The derivation in the excitation mechanism shows that the new instability has a few similarities to collisionless trapped electron mode (CTEM) instability[4]. Crucial differences include the following. Not only the electrons and the fast ions have the opposite charge, but also CTEM instability is driven by relatively high energy resonant electrons while the new instability is driven by relatively low energy resonant fast ions. Strongly negative shear plasmas are more favorable for the new instability because more number of trapped fast ions reverse their precession direction in that condition. The resulting particle flux of fast ions is outward while the particle flux of main hydrogenic ions is inward. This instability might be even beneficial for burining plasma operation since it can expel lower energy He ions preferentially while keeping the ion working gas inside.

References

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