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Kelvin-Helmholtz Destabilization of Localized Interchange in a Slowly Rotating Tokamak

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Toroidal rotations at small fractions of the sound speed have been observed in present day neutral beam injected tokamaks. Substantial rotation shear could result from good confinement of the toroidal angular momentum. Conventional wisdom indicates that magnetohydrodynamic (MHD) modes are stabilized by a weak rotation shear yet destabilized by a strong rotation shear. In DIII–D negative central shear (NCS) discharges with a peaked central pressure, MHD bursts have been observed [1] in the central reversed shear region with good confinement. In this region, based on static MHD theory with no flow, localized MHD interchange [2] and ballooning modes have been predicted to be stable, only the resistive interchange [3] has been found to be unstable, but at reduced growth rate compared [4] to experimental observation. This work investigates the destabilizing effect of a strong rotation shear (Kelvin-Helmholtz effect) on the ideal localized interchange to attempt to resolve this discrepancy between theory and experiment.

Stability to localized MHD interchange modes is studied in a tokamak with toroidal flow and with a non-negligible shearing rate of the toroidal rotation. We use the variational principle of Frieman and Rotenberg [5] and consider localized plasma motion around a rational surface. Modification to the localized interchange stability criterion is obtained by maximizing the growth rate. The rotation shear couples to both the Alfvén and sound waves and reduces the stabilizing effect of these waves. This coupling allows the plasma motion to tap the energy associated with the flow shear. A new interchange criterion is obtained. In this new criterion, the effect of the flow shear appears through the flow mach number and the effect of sound wave appears through the plasma beta.

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