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Steep-gradient tokamak edge turbulence and the nonlinear instability[1] T. STOLTZFUS-DUECK, J.A. KROMMES, S.J. ZWEBEN, Princeton U. — Turbulence just inside the last closed flux surface of a toroidal fusion device is strongly affected by the steepness of the equilibrium gradients, which enhances nonadiabatic electron response. Beginning with an isothermal three-field fluid model, a simple transformation of dependent variables decomposes the electrostatic potential into adiabatic and nonadiabatic portions. Under the assumption of ideal ballooning stability, the linear behavior of the three-field model over the entire parameter space is obtained, regions of drift-like and resistive-ballooning behavior are delineated, and criteria under which the single unstable branch may be expected to be only weakly nonadiabatic are identified. Using quadratic invariants of the model as well as arguments from statistical mechanics, it is demonstrated that turbulence in the steep-gradient region is nonlinearly sustained for typical tokamak parameters. Despite net forward transfer of energy, energy return from large-k fluctuations to small-k fluctuations can effectively excite nonadiabaticity at small k, which enhances gradient drive.

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