Development in the Theory of Turbulence Spreading with Self-Consistent Flows

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We present several new results on the theory of turbulence spreading with self consistent E×B shear flows. Turbulence spreading is of interest to barrier formation and to enhanced confinement, as well as to nonlocality phenomena. A simple mean field model incorporating simplified turbulence dynamics, and self-consistent shear flow has been developed. Results indicate:

i.) intensity pulses propagate at $V \sim \left(D_{GB} / \tau_c L_\perp^2\right)^{1/2} \sim \rho^* V_{Th}$, a *generic* speed for drift wave turbulence. Note that steeper local scale lengths simply faster speeds, and that the propagation speed will change for drift wave turbulence with 'mean' diffusivity $D \sim (\rho^*)^\alpha D_B$. Here ρ^* is computed with the local scale length, so pulse originating in steep gradient regimes propagate faster. $\alpha=1$ is consistent with ~ 1msec 'non-local' responses observed in HL-2A.

ii.) heat and intensity pulses can be distinct, and decouple in barriers, where diffusive neoclassical transport can persist.

iii.) intensity pulses can penetrate gaps in local turbulence excitation. Penetration depth depends on gap width, local damping and heat flux thru the gap region. In particular, *outward* heat flux can inhibit *inward* pulse propagation thru an ITB.

iv.) rapid intensity pulse propagation can produce a fast edge → core connection, since front propagation times are much slower than transport times. Such a fast connection appears to explain profile resiliency in edge + center heating experiments.

v.) turbulence generated zonal flow can both enhance (by symmetry breaking) and inhibit (by coupling to dissipation) turbulence spreading. For reasonable zonal flow damping, however, inhibition wins. We report on studies of a model with both local and non-local couplings (in k) and its implications for spreading.

Special emphasis is placed on discussion of implications for experiment. In particular, we address the important issue of how one might determine which nonlinear couplings mediate turbulence spreading.