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Edge of chaos in the transition to turbulence

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We study the boundary of the laminar region near the onset of turbulence. Approaching the boundary from the laminar side, the lifetime of perturbations increases, diverges when the boundary is reached, and varies chaotically for larger amplitudes. In the chaotic region, lifetimes vary sensitively with amplitude, consistent with the strange saddle picture of the turbulence proposed earlier. The trajectory on the edge between the laminar and chaotic regions is asymptotic to a single well defined state, essentially independent of the type of perturbation. The edge then becomes the stable manifold of this structure. In the case of a model shear flow, the edge states are simple or period doubled or chaotic trajectories. The case of pipe flow shows less variability and the edge state seems to remain close to a state with simple vortical structure.

This is joint work with T.M. Schneider (U Marburg), J.D. Skufca (Clarkson U) and J. Yorke (U Maryland).