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The Transition to Turbulence via the Edge of Chaos in Shear Flows

Abstract:

The transition to turbulence in linearly stable shear flows is one of the most intriguing and outstanding problems in classical physics. Turbulent dynamics are readily observed at flow speeds where the laminar state remains stable under infinitesimal perturbations. Moreover, for a smaller class of shear flows, such as plane Couette and pipe flows, linear stability theory predicts that the laminar state remains stable for all Reynolds numbers. However, numerical simulations and experiments provide evidence that these flows exhibit turbulence, which can decay spontaneously, for sufficiently high Reynolds numbers and perturbations.

These observations are in agreement with a chaotic saddle coexisting with the laminar state in the system's state space. Analyzing the 'edge of chaos' between laminar and turbulent dynamics for these systems have generated additional insight into the transition mechanism. This boundary contains 'edge states' which are too weak to become turbulent and too strong to laminarize can be either dynamically simple or complex structures. To identify the edge states, we employ an iterated edge tracking algorithm which is implemented for several refinements until we find a trajectory which neither becomes turbulent or laminarizes. We show that for edge states with a stable manifold of codimension-1, the edge tracking algorithm will converge to it. We study the edge states for various channel sizes and compare their dynamics to those of edge states for other shear flows

Bio: Lina Kim received a BS in Mechanical Engineering from the University of California Riverside in 1999, an MS and PhD in Mechanical Engineering from the University of California Santa Barbara, respectively in 2003 and 2009. Her current research interests focus on investigating the transition to turbulence via edge state mechanisms in shear flows such as sinusoidal shear flow, plane Couette flow, pipe flow, and plane Poiseuille flow. Current topics of interest include the role of linear transient energy growth in the transition to turbulence, turbulence control, applying edge of chaos ideas to large-scale interconnected and biological systems. She is currently a postdoctoral researcher and lecturer at the University of California Santa Barbara.