Nonlinear mechanisms in turbulent plane Couette flow

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The prominence of streamwise elongated structures in wall bounded shear flows motivates the use of a quasi-streamwise constant framework to investigate turbulence in plane Couette flow. This talk first presents a streamwise constant model and shows that this so-called 2D/3C model can be used to rigorously connect experimental observations of streamwise coherence to the shape of the mean velocity profile. Comparisons to DNS data confirm that this 2D/3C model accurately captures the shape of the turbulent mean velocity profile as well as the structural features associated with the well-studied streamwise elongated roll and streak structures. The basic 2D/3C model is however unable to produce self-sustaining turbulent behavior because it only contains one-way coupling from the cross-stream perturbations to the mean flow.

The second part of the talk describes a streamwise averaged (SSST) system of equations that augments the 2D/3C modeling framework through the addition of feedback from a streamwise constant mean flow to streamwise varying perturbations. The arising model not only predicts the roll/streak structures, mean profile and important momentum transfer mechanisms that are obtained by the 2D/3C model but also exhibits a bifurcation from the stable 2D/3C dynamics to a self-sustaining turbulent state that closely resembles the flow obtained through DNS. Our results imply that the statistical mean turbulent state is in large part determined by interactions between streamwise constant structures. Our investigations also indicate that the SSST framework captures fundamental aspects of the mechanisms underlying transition to and maintenance of turbulence in wall-bounded shear flows.

Biography

Dennice Gayme is an Assistant Professor in the Department of Mechanical Engineering at the Johns Hopkins University. Prior to joining Hopkins, Dr. Gayme was a Postdoctoral Scholar at the California Institute of Technology, where she also obtained her doctorate in Control and Dynamical Systems in 2010. She received a Master of Science from the University of California at Berkeley in 1998 and a Bachelor of Engineering & Society from McMaster University in 1997 both in Mechanical Engineering. Before her doctoral work she was a Senior Research Scientist in the Systems and Control Technology and Vehicle Health Monitoring Groups at Honeywell Laboratories from 1999-2003. Her research brings together computational and theoretical methods from applied mathematics, dynamics, controls and fluid mechanics to study large-scale networked and interconnected systems. Current projects include developing control oriented models for turbulent shear flows and creating algorithms and tools to facilitate large-scale integration of renewable energy sources into the electric power system.