JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Weekly CEAFM Seminar: Spring 2014

Date: **Friday, March 28, 2014**

Time: 11:00 AM

Location: Gilman # 50 (Marjorie M. Fisher Hall)

Speaker: **Dr. Mihailo Jovanovic** (University of Minnesota)

Title: ***"Dynamics and Control of Wall-Bounded Shear Flows"***

Abstract

Understanding transition to turbulence is one of the most important problems in fluid mechanics. In the first part of the talk, techniques from control theory are used to examine the early stages of transition in wall-bounded shear flows. We demonstrate high sensitivity of the flow equations to modeling imperfections and show that control theory can be used not only to design flow control algorithms but also to provide valuable insights into the transition mechanisms.

In the second part of the talk, we examine the efficacy of streamwise traveling waves generated by surface blowing and suction for controlling the onset of turbulence in a channel flow. For small amplitude actuation, we utilize weakly-nonlinear analysis to determine base flow modifications and to assess the resulting net power balance. Sensitivity analysis of the velocity fluctuations around this base flow is then employed to design the traveling waves. Our simulation-free approach reveals that, relative to the flow with no control, the downstream traveling waves with properly designed speed and frequency can significantly reduce sensitivity which makes them well-suited for controlling the onset of turbulence. In contrast, the velocity fluctuations around the upstream traveling waves exhibit larger sensitivity to disturbances. Our theoretical predictions, obtained by perturbation analysis (in the wave amplitude) of the linearized Navier-Stokes equations, are verified using simulations of the nonlinear flow dynamics. These show that a positive net efficiency as large as 25% relative to the uncontrolled turbulent flow can be achieved with downstream waves. We conclude that the theory developed for the linearized flow equations with uncertainty has considerable ability to predict full-scale phenomena.