Center for Fluid Mechanics, Division of Applied Mathematics
Fluids and Thermal Systems, School of Engineering
Joint Seminar Series

TUESDAY – OCTOBER 30, 2012
3:00pm
Barus & Holley, Room 190

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Low-order Models for Control of Fluids: Balanced Models and Koopman Modes

The ability to effectively control a fluid would enable many exciting technological advances, such as the design of quieter, more efficient aircraft. Model-based feedback control is a particularly attractive approach, but the equations governing the fluid, although known, are typically too complex to apply standard tools for dynamical systems analysis or control synthesis. This talk addresses model reduction techniques, which are used to simplify existing models, to obtain low-order models tractable enough to be used for analysis and control, while retaining the essential physics.

In particular, we will discuss two techniques: balanced truncation and Koopman modes. Balanced truncation is a well-known technique for model reduction of linear systems, with provable error bounds, but it is not computationally tractable for very large systems. We present an approximate version, called Balanced POD,thatis computationally tractable, and produces much better models than traditional Proper Orthogonal Decomposition (POD), at least for the examples studied. Koopman modes are based on spectral analysis of the Koopman operator, an infinite-dimensional linear operator that describes the full (nonlinear) dynamics of a nonlinear system, and we show how the associated modes can elucidate coherent structures in examples including a jet in crossflow and the wake of a flat plate.

Host: Mandre Shreyas (shreyas_mandre@brown.edu)