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Robust H_2 Feedback Control of a Prototypical Fluid Flow System

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Our ability to design efficient technologies involving complex fluid flows strongly depends on our ability to actively control these flows in real-time in an autonomous fashion, according to our needs. In this talk, we will describe the challenges one face in feedback control of multi-scale fluid flows, with wide range of spatial and temporal scales that are tightly coupled, using a spatially distributed network of sensors, actuators and controllers. A prototype system governed by partial differential equations with strong nonlinearity and solutions exhibiting saturating, periodic and soliton behavior will be considered in the talk. A H_2 optimal controller that works effectively in the presence of a class of disturbance uncertainty is designed and tested in the direct numerical simulations (DNS). Collocation spectral methods based on Fourier modes are used for the numerical computations. The solution of the resulting nonlinear matrix Riccati equations are obtained using the Eigenvalue and Schur decompositions, with and without balancing. H_2 norm is computed numerically using its time domain characterization in terms of gramians and avoiding costly improper integrals. H_∞ norm is computed using an iteration procedure involving Hamiltonian matrix. The open and closed loop DNS results indicate various surprising things and nicely illustrate the intricacies involved in dealing with the full Navier-Stokes equations.

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