Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Contractive control design for Navier-Stokes systems with the incompressibility constraint relaxed HUAN YU, POORIYA BEYHAGHI, THOMAS BEWLEY, University of California, San Diego, FLOW CONTROL LAB TEAM — One approach to the linear stabilization of near-wall transitional channel flow is via the Orr-Sommerfeld/Squire equations. This formulation is delicate, as it reduces the three momentum equations and the divergence-free constraint of the incompressible NSE down to a highly non-normal set of two equations, one for the wall-normal velocity and one for the wall-normal vorticity, and involves inverting a Laplacian with boundary conditions embedded. A simpler formulation for the purpose of control design is given by simply dropping the divergence-free constraint from the problem considered altogether, and at the same time dropping the pressure gradient from the momentum equations, which acts to enforce this constraint. What remains is three coupled Burgers equations. In general, there is no relationship between the stability of such constrained and unconstrained systems; however, if the unconstrained system is contractive (a condition stronger than just stability), the constrained system is also contractive. We have investigated this approach to control design for NS systems. We have proved a fundamental limit: if an uncontrolled, unconstrained channel flow system is not contractive, there is no boundary control that can make it contractive.

Huan Yu
University of California, San Diego

Date submitted: 27 Jul 2015 Electronic form version 1.4