Abstract Submitted
for the DFD11 Meeting of
The American Physical Society

The global nonlinear stability of a swirling flow in a pipe ZVI RUSAK, RPI, SHIXIAO WANG, Auckland University, LEI XU, RPI, STEVE TAYLOR, Auckland University — The dynamics of a perturbed axisymmetric, near-critical swirling flow in a long, finite-length, straight, circular pipe is studied through a weakly nonlinear analysis. The flow is subjected to non-periodic inlet and outlet conditions. Examples of flow dynamics at various near-critical swirl levels in response to different initial perturbations demonstrate the important role of the nonlinear steepening terms in perturbations' dynamics. Results reveal the evolution of explosive, faster-than-exponential, shape-changing modes as perturbations grow into a vortex breakdown process. Further analysis of the model problem shows the important role of the nonlinear evolution in (i) the transfer of perturbation's kinetic energy between the boundaries and flow bulk, (ii) the evolution of perturbations in practical concentrated vortices, and (iii) the design of control methods to stabilize vortex flows. A robust feedback control method to stabilize a solid-body rotation flow in a pipe at a wide range of swirl levels above critical is developed. Applicability of this method to stabilize medium and small core-size vortices is also discussed.

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Date submitted: 11 Aug 2011 Electronic form version 1.4