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Nonlinear Fluid Flow Analysis Using Integral Quadratic Constraints[1] ANIKETH KALUR, PETER J. SEILER, MAZIAR S. HEMATI, University of Minnesota, Twin Cities — The exact mechanism for sub-critical transition to turbulence in shear flows is complicated and not fully understood due to the interaction between the linear and nonlinear terms in the Navier-Stokes equations (NSE). The linear operator in NSE causes a transient amplification of perturbation energy – a necessary condition for sub-critical transition. The nonlinearity in NSE acts in feedback with the linear system and mixes energy between modes. This static lossless nonlinearity is responsible for triggering transition and sustaining turbulence. In this talk, we will show that the nonlinearity in NSE can be replaced by a set of integral quadratic constraints (IQCs), which effectively represent correlations between the inputs and outputs of the nonlinearity. Thus, analysis of nonlinear flows can be cast as problems in the analysis of linear dynamics – coupling energy-based methods with corresponding IQCs. We perform our investigations on the Waleffe-Kim-Hamilton (WKH) model, which is a low-dimensional mechanistic model developed to capture the physics of transition. IQC-based stability and performance analysis of the WKH model will be presented.

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