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A linear matrix inequality based approach for efficient approximation of permissible perturbation amplitude in wall-bounded shear flows at transitional Reynolds numbers[1] CHANG LIU, DENNICE GAYME, Johns Hopkins University — The parameters governing transition to turbulence in wall-bounded shear flows have been widely studied, but a wide gap between analytically attained (provable) parametric bounds and experimental/simulation results remains. Here, we focus on one aspect of this problem, providing provable Reynolds number (Re) dependent bounds on the amplitude of perturbations a flow can sustain while maintaining the laminar state. Our analysis relies on a (Lure) partitioning of the dynamics into a feedback interconnection between the linear and nonlinear dynamics. We then derive constraints on the nonlinear term based on its known physical properties (energy conservation and bounded input-output energy). These constraints are used to formulate the computation of permissible perturbation amplitude as linear matrix inequality constrained optimization problem. Our analytically derived bounds are less conservative than those obtained through linear analysis or classical energy methods. The results are also consistent with those identified through exhaustive simulations for a range of low dimensional nonlinear shear flow models. However, they are achieved at much lower computational cost and provide a provable guarantee that a certain level of perturbation is permissible.

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