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Control of laminar wake flows using the Sum-of-Squares approach DAVIDE LASAGNA, OWEN TUTTY, University of Southampton, DE-QING HUANG, SERGEI CHERNYSHENKO, Imperial College London — A novel feedback control design methodology for finite-dimensional, reduced-order models of incompressible turbulent fluid flows, aiming at reduction of long-time averages of key quantities, is presented. The key enabler is a recent advance in control design for systems with polynomial dynamics, i.e. the discovery that the Sum-of-Squares decomposition of a non-negative polynomial, or the construction of one of such functions, can be computed via semidefinite programming techniques. Firstly, the theoretical difficulties of treating long-time averages are relaxed by abstracting the analysis to upper bounds of such averages. Then, the problems of estimation and optimisation via control design of these bounds are conveniently reformulated into constructing suitable non-negative polynomial functions, using Sum-of-Squares programming techniques. To showcase the methodology, linear and nonlinear polynomial-type state-feedback controllers are designed to reduce the fluctuations kinetic energy in the wake of a circular cylinder at $Re = 100$, using rotary oscillations. A compact, reduced-order Galerkin model of the actuated wake is first derived using Proper Orthogonal Decomposition. Controllers are then designed and implemented in direct numerical simulations of the flow.

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