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Nonlinear input-output analysis of laminar-turbulent transition for wall-bounded flows[1] GEORGIOS RIGAS, Imperial College London, DENIS SIPP, ONERA, TIM COLONIUS, Caltech — In a linear input-output analysis framework, the most amplified instabilities are typically described by considering singular vectors of the resolvent operator of the linearized Navier-Stokes equations. In this study, we extend the methodology to take into account nonlinear triadic interactions by considering a finite number of harmonics in the frequency domain using the Harmonic Balance Method. Optimal nonlinear forcing mechanisms that lead to transition and maximize the skin-friction coefficient are identified using direct-adjoint looping. We demonstrate the framework on a zero-pressure flat-plate boundary layer by considering three-dimensional perturbations triggered bya few optimal forcing modes of finite amplitude. Depending on the frequency, spanwise wavenumber, amplitude and symmetries of the perturbation, we recover all the transition stages associated with K-type and H-type transition mechanisms, oblique waves, streaks, and their breakdown. The proposed frequency-domainframeworkidentifies the worst-case frequency disturbances forwall-boundedlaminar-turbulent transition.

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