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Optimal perturbation growth and bypass transition in mixing layers SARAH M. IAMS, BP Institute, University of Cambridge, C.P. CAULFIELD, BP Institute & DAMTP, University of Cambridge, J.-M. CHOMAZ, LadHyX, CNRS-Ecole Polytechnique — Hyperbolic mixing layers are strongly unstable to the normal-mode Kelvin-Helmholtz instability (KHI). At finite amplitude, KHI billows are unstable to the hyperbolic instability, which becomes streamwise-aligned braid-centred rib vortices that trigger turbulence transition. However, the underlying linear operator is non-normal, and so there may be transient non-normal-mode perturbations. We use numerically-calculated power iteration of the linear Navier-Stokes operator and its adjoint to identify perturbations whose energy grows most rapidly over finite times, and also investigate the nonlinear evolution of these perturbations using nonlinear direct numerical simulations. If the energy of the perturbation is optimized over sufficiently long times, the optimal perturbation is unsurprisingly closely related to the KHI normal mode, and the nonlinear evolution of this perturbation exhibits only a slightly enhanced transient growth compared to the KHI. Furthermore, the long-time optimal perturbation of a time-evolving KHI billow is essentially the hyperbolic instability. However, if the perturbation growth is optimized over short times, an inherently three-dimensional non-normal mode is identified, which in our nonlinear simulations can trigger 'bypass' transition without any development of the primary KH instability. The growth mechanism and structure of this mode will be discussed.

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