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Nonlinear evolution of optimal transient growth modes in a vortex column FAZLE HUSSAIN, D.S. PRADEEP, University of Houston — The transient growth of optimal modes – obtained through linear analysis – is pursued via direct numerical simulation (DNS). Evolutions of both individual modes in isolation and random superpositions of several modes are studied. Increasing initial amplitude decreases both growth and growth period. Thus nonlinear effects set an "optimal" initial amplitude that maximizes energy growth. Radially outward transport of vortex filaments organized into dipoles removes radial vorticity – essential to transient growth - from regions of large strain; this nonlinear mechanism thereby diminishes production. Even a single mode's evolution reproduces the phenomena seen in a vortex interacting with fully developed ambient turbulence: (a) growth of strong core perturbations in the form of bending waves; (b) appearance of finer-scale vortex filaments (threads) wrapping around the column; and (c) accelerated vortex decay (beyond the viscous rate). Core fluctuations are seen to amplify even as the external turbulence decays (with intensities exceeding 40%); thus core breakdown (transition) appears likely in high-Re practical flows (e.g. the aircraft wake). The vortex dynamics of dipole formation and motion suggest a radial vorticity regeneration mechanism leading to sustained turbulence production at Re higher than attained by our DNS.

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