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Low-rank behavior of turbulent jets: spectral analysis and resolvent model[1] OLIVER T. SCHMIDT, Department of Mechanical and Civil Engineering, California Institute of Technology, AARON TOWNE, Center for Turbulence Research, Stanford University, GEORGIOS RIGAS, TIM COLONIUS, Department of Mechanical and Civil Engineering, California Institute of Technology, GUILLAUME BRES, Cascade Technologies — We show that unforced turbulent jets exhibit a low-rank behavior that is predicted by a global resolvent analysis of the mean flow. The low-rank character of the flow is unveiled in the energy spectra of three large-eddy simulations of turbulent jets representing the incompressible, transsonic and supersonic regime. Spectral proper orthogonal decomposition (SPOD) is used to extract coherent parts of the flow in the form of orthogonal modes ranked by their energy. The low-rank behavior manifests itself in large separation between the modal energies of the leading structure from the rest. In other words, a single dominant coherent structure makes up a considerable portion of the total flow energy. This behavior is most pronounced at low azimuthal wavenumbers. Despite its limitation to optimal linear perturbations, a resolvent model accurately predicts the observed trends, and allows for the physical interpretation of the empirical results. The low-rank behavior is the result of one dominant mechanism: the Kelvin-Helmholtz (K-H) type instability of the near-nozzle shear-layer. The sub-dominant modes correspond to a second, distinct, mechanism that is active downstream of the potential core.

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