Nichols, Joseph W.; **Lele, Sanjiva K.**

Global modes and transient response of a cold supersonic jet. (English) Zbl 1225.76116

J. Fluid Mech. 669, 225-241 (2011).

Summary: Global-mode analysis is applied to a cold, $M = 2.5$ laminar jet. Global modes of the non-parallel jet capture directly both near-field dynamics and far-field acoustics which, in this case, are coupled by Mach wave radiation. In addition to type (a) modes corresponding to Kelvin-Helmholtz instability, it is found that the jet also supports upstream-propagating type (b) modes which could not be resolved by previous analyses of the parabolized stability equations. The locally neutrally propagating part of a type (a) mode consists of the growth and decay of an aerodynamic wavepacket attached to the jet, coupled with a beam of acoustic radiation at a low angle to the jet downstream axis. Type (b) modes are shown to be related to the subsonic family of modes predicted by *C. K. W. Tam* and *F. Q. Hu* [J. Fluid Mech. 201, 447–483 (1989; Zbl 0672.76054)]. Finally, significant transient growth is recovered by superposing damped, but non-normal, global modes, leading to a novel interpretation of jet noise production. The mechanism of optimal transient growth is identified with a propagating aerodynamic wavepacket which emits an acoustic wavepacket to the far field at an axial location consistent with the peaks of the locally neutrally propagating parts of type (a) modes.

MSC:

76E15 Absolute and convective instability and stability in hydrodynamic stability
76J20 Supersonic flows

Cited in **22** Documents

Keywords:

absolute/convective instability; jet noise; jets

Software:

SuperLU-DIST; ARPACK

Full Text: DOI

References:

[1] DOI: 10.1016/0376-0421(84)90005-8· doi:10.1016/0376-0421(84)90005-8
[2] Nichols, Annual Research Briefs, Center for Turbulence Research pp 3– (2009)
[3] DOI: 10.1016/S0045-7930(99)00013-4 · Zbl 0978.76030 · doi:10.1016/S0045-7930(99)00013-4
[4] DOI: 10.1017/S0022112007005654 · Zbl 1115.76028 · doi:10.1017/S0022112007005654
[5] DOI: 10.1017/S0022112005005112 · Zbl 1073.76027 · doi:10.1017/S0022112005005112
[6] DOI: 10.1145/779359.779361 · Zbl 1068.90591 · doi:10.1145/779359.779361
[7] DOI: 10.1017/S0022112090003299 · Zbl 0708.76116 · doi:10.1017/S0022112090003299
[8] Lehoucq, ARPACK Users' Guide: Solution of Large-Scale Eigenvalue Problems with Implicitly Restarted Arnoldi Methods (1998) · Zbl 0901.65021 · doi:10.1137/1.9780898719628
[9] DOI: 10.1007/BFb0012619· doi:10.1007/BFb0012619
[10] DOI: 10.1017/S0022112009006399 · Zbl 1181.76068 · doi:10.1017/S0022112009006399
[11] DOI: 10.1103/PhysRevLett.78.4387· doi:10.1103/PhysRevLett.78.4387
[12] DOI: 10.1063/1.868864 · Zbl 1025.76536 · doi:10.1063/1.868864
[13] DOI: 10.1007/BF01387235· doi:10.1007/BF01387235
[14] DOI: 10.1146/annurev.fluid.37.061903.175810 · Zbl 1117.76027 · doi:10.1146/annurev.fluid.37.061903.175810
[15] DOI: 10.1017/S0022112007005496 · Zbl 1175.76049 · doi:10.1017/S0022112007005496
[16] Tumin, Global Flow Instability and Control IV, Creta Maris, Hersonissos, Crete (2009)
[17] DOI: 10.1017/S002211208900100X · Zbl 0672.76054 · doi:10.1017/S002211208900100X

[18] DOI: 10.1017/S0022112084000124 · Zbl 0543.76109 · doi:10.1017/S0022112084000124

[19] DOI: 10.1146/annurev.fl.27.010195.000313· doi:10.1146/annurev.fl.27.010195.000313

[20] DOI: 10.2514/3.7688· doi:10.2514/3.7688

[21] Schmid, Stability and Transition in Shear Flows (2001) · Zbl 0966.76003 · doi:10.1007/978-1-4613-0185-1

[22] DOI: 10.1017/S0022112008003662 · Zbl 1165.76012 · doi:10.1017/S0022112008003662