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DYNAMICS OF HOT JETS: A NUMERICAL AND THEORETICAL STUDY

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Since the experiments of Monkewitz, Bechert, Barsikow & Lehmann (1990), sufficiently hot circular jets have been known to give rise to self-sustained synchronized oscillations induced by a locally absolutely unstable region. Numerical simulations (Lesshafft, Huerre, Sagaut & Terracol 2005, 2006) have been carried out in order to determine if such synchronized states correspond to a nonlinear global mode of the underlying basic flow, as predicted in the context of Ginzburg-Landau amplitude evolution equations by Couairon & Chomaz (1997, 1999), Pier, Huerre, Chomaz & Couairon (1998) and Pier, Huerre & Chomaz (2001). In the presence of a pocket of absolute instability embedded within a convectively unstable jet, global oscillations are generated by a steep nonlinear front located at the upstream station of marginal absolute instability. The global frequency is given, within 10% accuracy, by the absolute frequency at the front location. For jet flows displaying absolutely unstable inlet conditions, global instability is observed to arise if the streamwise extent of the absolutely unstable region is sufficiently large: While local absolute instability sets in for ambient-to-jet temperature ratios $S < 0.453$, global modes only appear for $S < 0.325$. In agreement with theoretical predictions, the selected frequency near the onset of global instability coincides with the absolute frequency at the inlet, provided that the ratio of jet radius R to shear layer momentum thickness θ is sufficiently small ($R/\theta \sim 10$, *thick shear layers*). For *thinner shear layers* ($R/\theta \sim 25$), the numerically determined global frequency gradually departs from the inlet absolute frequency.

References

Couairon, A. & Chomaz, J.-M. 1997 Absolute and convective instabilities, front velocities and global modes in nonlinear systems. *Physica D* **108**, 236-276

Couairon, A. & Chomaz, J.-M. 1999 Fully nonlinear global modes in slowly varying flows. *Phys. Fluids* **11**, 3688-3703.

Lesshafft, L., Huerre, P., Sagaut, P. & Terracol, M. 2005 Global modes in hot jets, absolute / convective instabilities and acoustic feedback. 10 pages *11th AIAA / CEAS Aeroacoustics Conference*, Monterey, USA, May 23-25, 2005.

Lesshaft, L., Huerre, P., Sagaut, P. & Terracol, M. 2006 Nonlinear global modes in hot jets. *J. Fluid Mech*., in press.

Monkewitz, P. A., Bechert, D. W., Barsikow, B & Lehmann, B. 1990 Self-excited oscillations and mixing in a heated round jet. *J. Fluid Mech*. **213**, 611-639.