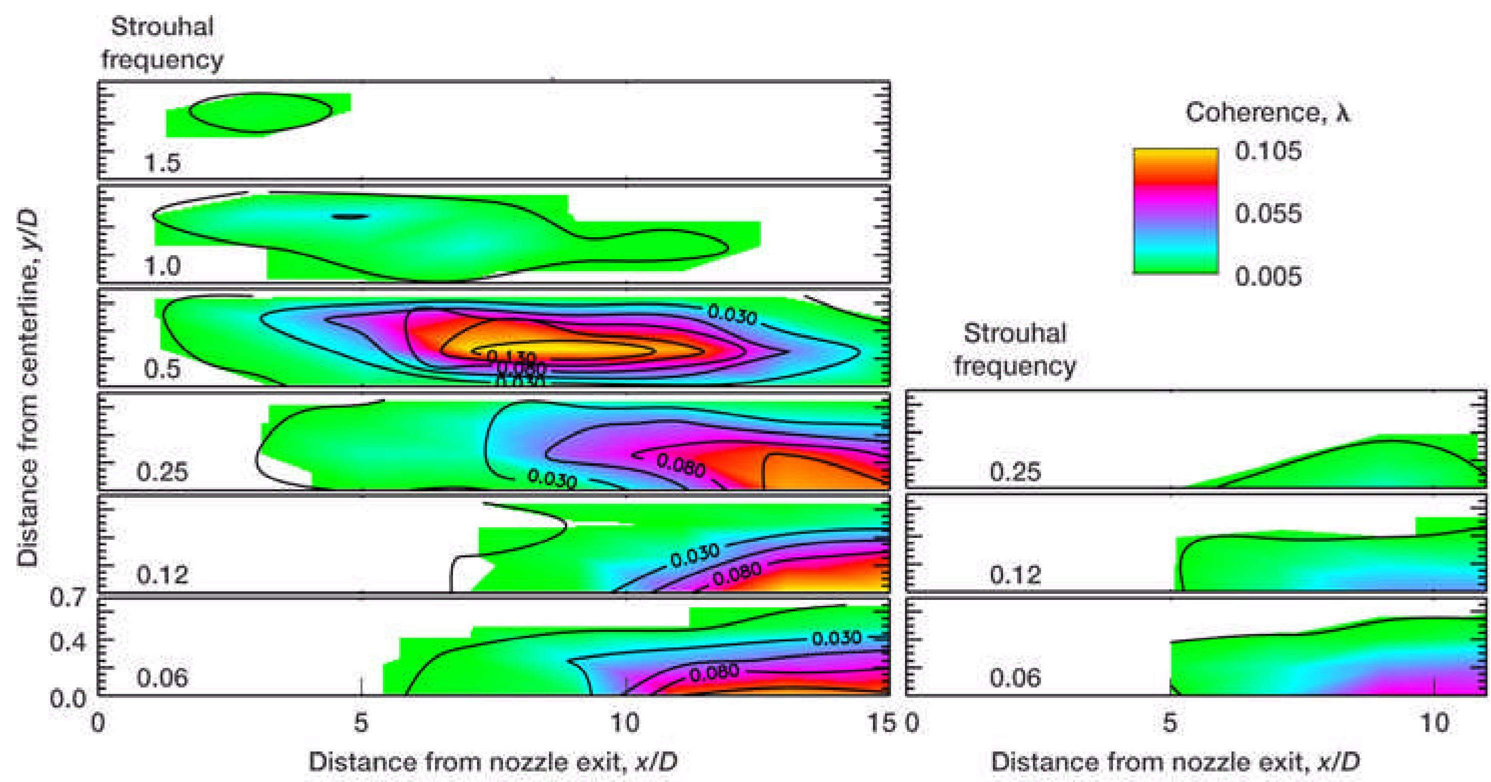
Sound Sources Identified in High-Speed Jets by Correlating Flow Density Fluctuations With Far-Field Noise

Noise sources in high-speed jets were identified by directly correlating flow density fluctuation (cause) to far-field sound pressure fluctuation (effect). The experimental study was performed in a nozzle facility at the NASA Glenn Research Center in support of NASA's initiative to reduce the noise emitted by commercial airplanes.

Previous efforts to use this correlation method have failed because the tools for measuring jet turbulence were intrusive. In the present experiment, a molecular Rayleigh-scattering technique was used that depended on laser light scattering by gas molecules in air. The technique allowed accurate measurement of air density fluctuations from different points in the plume. The study was conducted in shock-free, unheated jets of Mach numbers 0.95, 1.4, and 1.8. The turbulent motion, as evident from density fluctuation spectra was remarkably similar in all three jets, whereas the noise sources were significantly different. The correlation study was conducted by keeping a microphone at a fixed location (at the peak noise emission angle of 30° to the jet axis and 50 nozzle diameters away) while moving the laser probe volume from point to point in the flow. The following figure shows maps of the nondimensional coherence value measured at different Strouhal frequencies ([frequency × diameter]/jet speed) in the supersonic Mach 1.8 and subsonic Mach 0.95 jets. The higher the coherence, the stronger the source was.



Source distribution for sound radiation at 30° to the jet axis and at the indicated Strouhal frequencies. The plotted variable is the coherence between the flow density fluctuations and the sound pressure fluctuations at the microphone location. Left: Mach 1.8 plume. Right: Mach 0.95 plume.

The figure shows that density fluctuations from the end of the potential core (*x*/D = 7and 10 for the Mach 0.95 and 1.8 jets, respectively) is the strongest source in both jets. The higher frequency noise is emitted close to the nozzle exit in the Mach 1.8 jet. This high-frequency source, however, cannot be detected in the subsonic Mach 0.95 jet. The differences in sound sources are due to the supersonic convective speed of turbulent eddies (compared with the ambient sound speed) in the Mach 1.8 jet and subsonic speed in the Mach 0.95 jet.

Reference

1. Panda, J.; and Seasholtz, R.G.: Experimental Investigation of Density Fluctuations in High-Speed Jets and Correlation With Generated Noise. J. Fluid Mech., vol. 450, 2002, pp. 97-130.

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