Statistics and spatio-temporal correlations of flow-induced wall pressure noise beneath an impinging round jet boundary layer

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We present here experimental results from synchronized measurements of an incompressible impinging round jet turbulent boundary layer and an hydroacoustic wall pressure array. Data was collected in 1.2m x 0.6m water tank with flow driven by a 90-gal/hr submersible circulation pump through an axisymmetric round jet with a 10:1 contraction ratio and 14° convergence angle mounted 45° normal to the impingement surface. Flow fields were obtained via particle image velocimetry (PIV) using a continuous wave 532-nm Coherent Sapphire SF green laser at 100mW and a Nikkor 105mm f/2.8 macro lens on a Nikon z6II at 120 frames per second. Simultaneous measurements of acoustic wall pressure were obtained using a linear array of five flush-mounted piezoelectric sensors spaced equally at a distance of three jet nozzle diameters D_j, covering a total range of ~14D_j from the stagnation point.

Spatio-temporal correlations between boundary layer coherent structures and signatures in the acoustic wall pressure data were computed, and convection velocities of turbulence features from the PIV data were found to be in agreement with pressure signals propagating along the sensor array. Additionally, a cross-wavelet analysis on wall pressure transient fluctuations was performed to identify dominant modes of the high- and low-frequency components. A characterization of the spectral properties of the pressure signals, including probably density functions and a statistical description of higher order moments, was computed and used to identify hydroacoustic and hydrodynamic components of the wall pressure. The results are important for future signal processing efforts to isolate flow-induced noise from a target signal, as well as for potential active flow control strategies. [Work supported by the Office of Naval Research.]

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