About the ambiguity of noise source localization based on the causality correlation technique

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Samples of typical causality correlation results for synchronized PIV and acoustic measurements on a rod-airfoil configuration and a cold jet are presented. The difficulties in interpreting the resulting correlation coefficients between turbulent flow quantities and the far-field pressure fluctuations are illustrated. An approach for the interpretation of the space time resolved coefficient matrix is demonstrated, with special attention to the influence of coherent structures in the flow topology. Two simplified models of the coherent structures in subsonic jets are analyzed in order to contribute to the understanding and a meaningful interpretation of causality correlation results. The first model is simulating a distribution of correlated monopoles on the axis of a jet. The second is based on a jittering wave-packet along the jet-axis. The radiated sound from these modelled sources is calculated and correlated with the source signal. The dependency of the resulting coefficient matrix on the temporal and spatial extend of the source distribution is studied. Truncation effects and the influences of the temporally localized changes in the wave-packet are investigated. It can be shown that resulting high amplitude bursts in the far-field pressure are dominating the space-time evolution of the correlation coefficient. Supported by a comparison of recently obtained measurement results for a subsonic jet generated by a chevron nozzle and a round nozzle, it can be shown that the obtained coefficient matrix indeed provides space time resolved information about flow regions which are subject to the same physical phenomenon as the aeroacoustic source.

Fig. 1 Jet experiment at M = 0.9: Temporal evolution of the correlation coefficient between the axial velocity component and the far-field pressure along the jet-axis for the standard-nozzle (top) and the chevron-nozzle (bottom). The dashed line marks the end of the potential core and the solid line shows the points in time the noise travels from the respective position to the microphone.

Fig. 2 Jittering wave-packet model for a free jet at M = 0.9 with temporal and spatial localized envelope truncation. Top: Resulting space-time distribution of the Lighthill’s stress tensor aligned with the jet axis. Middle: Resulting pressure signal in the far-field, calculated by numerical integration of the stress tensor. Bottom: Resulting space-time distribution of the correlation coefficient between the stress tensor and the pressure fluctuations in the far field. The magenta cross marks the position of the maximum value. The dashed line depicts the time delay based on the convection velocity of the coherent structures in the flow field.