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CAA based study of spectral broadening of turbine tones

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ABSTRACT

It is well known that the far-field noise spectra of jet engines show for certain jet configurations and turbine tones a characteristic spectral broadening (haystacking) effect, causing a reduction of a tone peak in favour of a more distributed spectral hump around the tone frequency. This haystacking effect likely occurs due to the interaction of acoustic waves with unsteady turbulent jet shear layers. The modified tonal noise components influence the perceived noise levels considerably such that a better understanding of this effect may help to utilise it for the purpose of noise reduction. This paper introduces a CAA prediction method for spectral broadening. A novel stochastic method **Fehler! Verweisquelle konnte nicht gefunden werden.** is applied to generate an unsteady turbulent flow field from a steady RANS simulation of the jet flow. Spectral broadening is simulated with the CAA solver PIANO of DLR by computing tone propagation through the unsteady flow field. Hot and cold jets are considered in this study and the results are compared with measurements. As a first computational problem the experimental set up of Candel et.al. **Fehler! Verweisquelle konnte nicht gefunden werden.** is considered. In these experiments a round jet was used with a sound source embedded in the cold jet, such that the tone is scattered in a single shear layer. Measured and simulated noise spectra are juxtaposed for three different velocities (U=20m/sec, 40m/sec, 60m/sec) and different microphone positions above the source. Second, a more realistic problem is computed, which is based on the scattering of a first radial spinning duct mode in a coaxial hot jet (u=117.66 m/sec; T=692.84°K) with bypass flow (u=155.2 m/sec; T=300.01°K) and outer medium at rest (u=0 m/sec; T=288°K). Figure 1 shows the scattered field due to the incident turbine tone as well as the modelled turbulent velocities. The spectra, figure 2, clearly show the spectral broadening effect and the characteristic side lobes around the centre frequency of the pure tone, which were found in the measurements **Fehler! Verweisquelle konnte nicht gefunden werden.**. Furthermore, by comparison of the computations with unsteady base-flow and steady mean-flow (with turbulence generation turned off) a

reduction of the tone peak can be identified, highlighting the effect of energy scattering from one single frequency to a broader spectrum.

REFERENCES

[1] R. Ewert "Broadband slat noise prediction based on CAA and stochastic sound sources from a fast random particle-mesh (RPM) method ", *Computers & Fluids*, 37(4), pp. 369–387, 2008.

[2] S.M. Candel, A. Guedel and A. Juliennne, "Radiation, refraction and scattering of acoustic waves in a free shear flow." 3rd AIAA Aero-Acoustics Conference, No. 76-544, CA, USA, 1976.

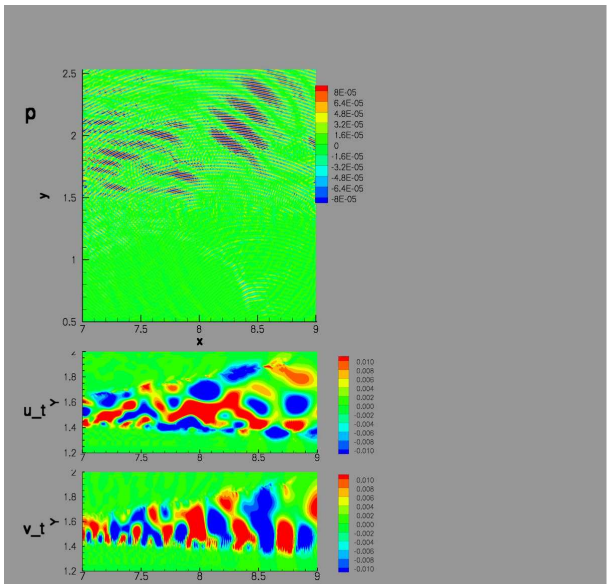

Figure 1: scattered field and modeled turbulent velocities

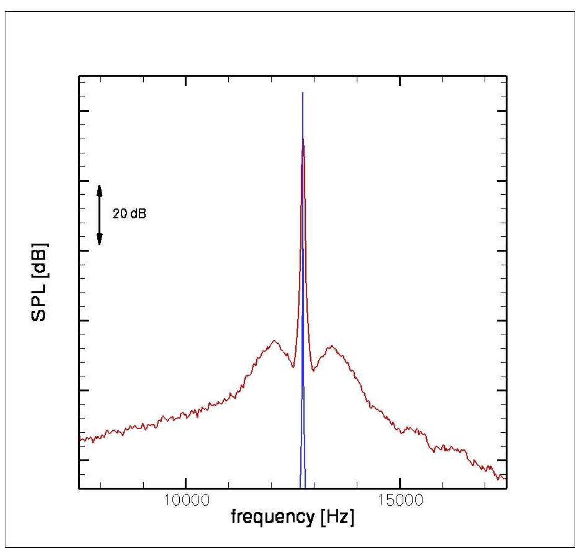

Figure 2 : spectra of scattered and un-scattered turbine tones