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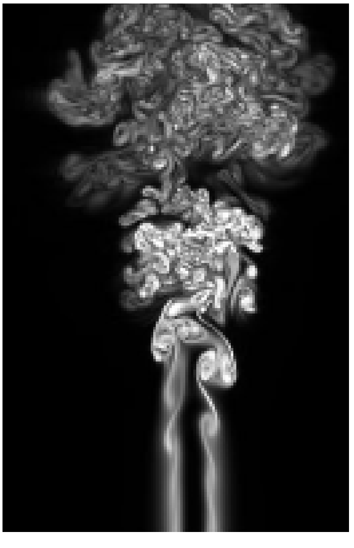
Prediction of aerodynamic sound at moderate Mach numbers is difficult due to the low amplitude of the sound waves. An acoustic wave with a Sound Pressure Level (SPL) of 100dB, which corresponds to a pressure fluctuation of only 2Pa is already damaging for the human ear. In a turbulent flow, hydrodynamic pressure fluctuations in general scale with the velocity squared. These hydrodynamic pressure fluctuations are for flows with moderate Mach numbers of order 10000-50000. Thus roughly four to five orders larges than the aerodynamic sound we want to predict.

The large range of pressure that is required in the solution of the compressible Navier-Stokes equations places a severe restriction on the accuracy of the numerical method and the numerical resolution. In this research we use a 10th order compact staggered finite difference schemes to simulate a round turbulent jet flow, with a Reynolds number of 5000 and a Mach number of 0.8 based on orifice quantities. In the figure below we show the vorticity magnitude, which is obtained from the simulation.

The observer of the sound is in general located far away from the acoustic source and an extension to the far field is necessary. In this work we make use of the porous Ffowcs Williams & Hawkings equation to obtain the far field sound. In such a method pressure data is taken from the Navier-Stokes solution and by an analytical technique the far-field pressure is computed. A typical result obtained with this approach is also shown in the figure below.

For the validation of the results an experimental setup has been build in which the simulated Reynolds and Mach could be matched exactly. The acoustic pressure fluctuations in the far-field obtained from the simulations are, in general, in good agreement with the observed experimental values.



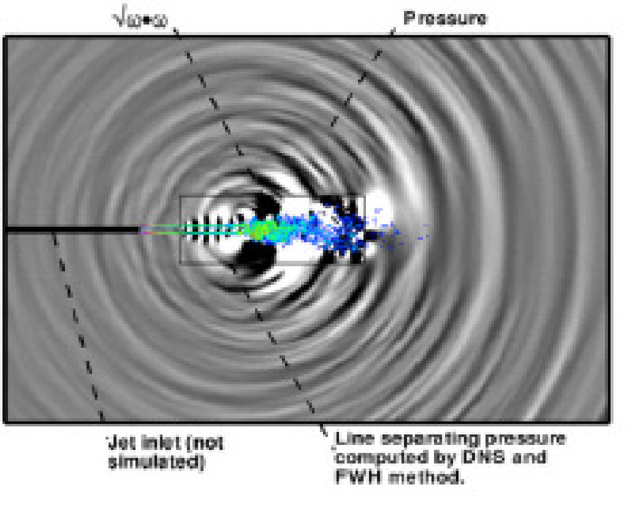


Figure Left the vorticity magnitude in a round jet with a Reynnolds number of 5000 and a Mach number of 0.8. The computational grid consisted of 768x384x384 gridpoints. The calculations have been performed on 192 nodes of a IBM-SP6 supercomputer and took roughly two weeks computing time. Right: the acoustic near and far field. The far field is computed with porous Ffowcs Williams & Hawkings equation.