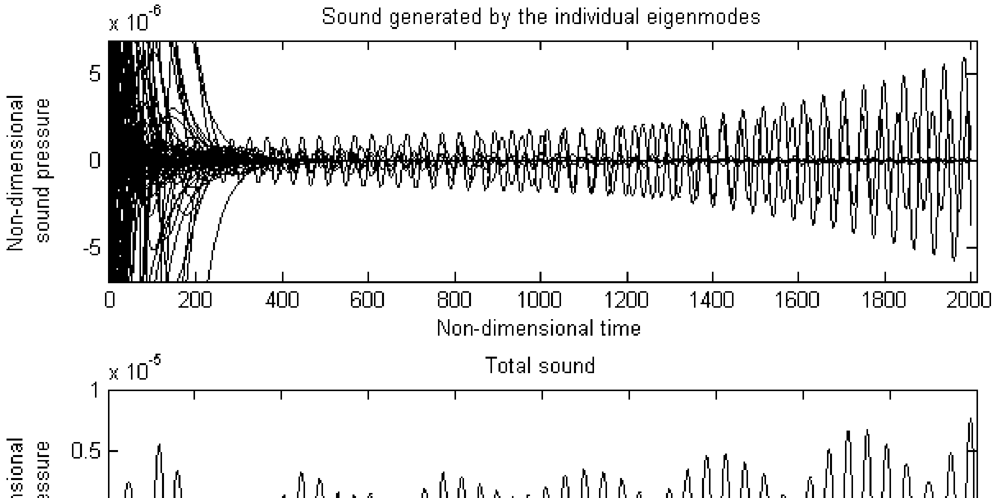
Sound prediction in conjuncture with flow control

Axel Kierkegaard and Gunilla Efraimsson

Dept of Aeronautical and Vehicle Engineering,
KTH, SE-100 44 Stockholm, Sweden

In this presentation we will discuss the use of global eigenmodes of an incompressible flow field, as a source of sound generation. The eigenmodes that are dominating the flow field are thought to dominate the sound field, and it is therefore interesting to investigate the useability of the reduced models and global modes for acoustical purposes. In this way acoustic prediction and control could be used in conjuncture with flow control to optimize acoustic performance. Another benefit of the global modes is that it is possible to distinguish between the different sound generation mechanisms in the flow, a task that is very difficult when analyzing sound from DNS data.

To predict the sound generated by a flow field, we use an acoustic analogy. The basic assumption is that the flow field generates sound, but that the sound waves don't alter the flow field. This allows for the flow field to be calculated disregarding the acoustics, and the sound to be extracted later. Here a simplified version of Curle's equation is used. This equation is formulated as an integral of the pressure fluctuations over a rigid surface.



For flow fields in a linear regime that are not exposed to time dependent external excitation such as flow control, the flow field can be expressed as a sum of eigenmodes and amplitude coefficients that are not dependent on time. This then allows for special treatment in Curle's equation to take advantage of the reduced model, and the sound can then be evaluated as a sum of constants and time-dependence terms, which yields fast and accurate calculations of the sound field. When the flow field is dynamically altered by a control process, the amplitude coefficients are varied, and this method is no longer valid. However, if the Mach number of the flow is low and the source region is acoustically compact, i.e., that the source region is much smaller than the wave length of the sound waves, it is possible to simplify the problem to take advantage of the reduced model.