Aeroacoustic simulation of human phonation

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Abstract

We deal with the numerical simulation of the human phonation. The human phonation represents a coupled problem composed of three different physical fields – the deformation of the vocal folds (elastic body), the complex fluid flow and the acoustics together with all mutual couplings. Due to low Mach number regime a hybrid approach can be chosen – the fluid-structure interaction (FSI) problem can be solved separately from the aeroacoustics and the aeroacoustic simulation has the form of the FSI results postprocessing.

In order to address the effects of time-dependent computational domain the fluid flow is modelled by the viscous incompressible Navier-Stokes equations in ALE formulation. The structure motion is described by linear elasticity theory. The acoustic part is here solved with the aid of the Lighthill acoustic analogy and acoustic wave equation (AWE) benefiting from problem-specific solvers and substantial lower computation demand. On the other hand the direct computation of acoustics within compressible fluid flow simulation would have to face many problems like e.g. magnitude disparity of acoustic and hydrodynamic pressure, etc.

The all three mentioned problems are solved by finite element method (FEM). Finally, the frequency spectra of propagated acoustic signals through model of human vocal tract are shown. It is a joint work with Jaromír Horáček (Czech Academy of Sciences, Prague) and Manfred Kaltenbacher (TU Vienna, Austria).