LadHyX Seminar — March 9, 10:45

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Stochastic modeling and parameter identification in aero/thermoacoustics, aerodynamics and fluid-structure interaction

Systems involving turbulent flows exhibit stochastic characteristics. For modeling and control purposes, it is essential to account for this stochastic component since it affects the system's dynamics and statistic, and leads to rich and sometimes counter-intuitive behaviors: multi-stability, bifurcation delay, extreme events and stochastic resonance.

I will show how some systems can be described with low-order stochastic models that reproduce the overall behavior and allow the identification of physical parameters. I will give examples in thermoacoustics (instabilities in gas turbines and aircraft engines), aeroacoustics (whistling of a Helmholtz resonator excited by a turbulent grazing flow), and aerodynamics / fluid-structure interaction (multi-stable turbulent wakes behind fixed / moving bluff bodies).

I will present a parameter identification method that requires measuring only one time signal of the variable(s) of interest. The Fokker-Planck equation associated with the low-order stochastic model and governing the evolution of the probability density function is derived, and its coefficients are fitted with estimates from the time signal(s). The accuracy and robustness of the method can be improved using an adjoint-based optimization procedure. In lab-scale systems, the method can be validated with a simple on / off control technique.