Analysis of finite-element based discretizations in nonlinear acoustics

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Nonlinear effects can be easily observed in sound waves with sufficiently large amplitudes. The nonlinearity will be apparent even sooner in high-frequency waves because these effects accumulate over the distance measured in wavelengths. This makes high-intensity ultrasonic waves inherently nonlinear. Their many applications range from non-invasive surgery to industrial welding and motivate the mathematical investigation into nonlinear acoustics.

In this talk, we will discuss the a priori analysis of finite-element-based discretizations of nonlinear acoustic equations. In particular, we will focus on the conforming and (hybrid) discontinuous Galerkin discretizations in space for acoustic equations with nonlinearities of quadratic type, such as the Westervelt and Kuznetsov equations. These are quasilinear strongly damped wave equations that serve as classical models of sound propagation through thermoviscous fluids and gases. The general approach in the a priori error analysis combines the stability and convergence analysis of their linearizations with the Banach fixed-point theorem. Numerical experiments will illustrate the theoretical results.

The talk is based on joint research with Paola F. Antonietti, Ilario Mazzieri (Politecnico di Milano), Markus Muhr, and Barbara Wohlmuth (TU Munich).