# Novel continuum mechanical material models and their treatment by use of the Finite Element Method

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The system of principal physical equations is not closed for until additional equations are formulated which take the specific material behavior into account. Usually, additional, so-called internal variables are introduced that describe the time dependent microstructure and whose evolution is modeled in terms of ordinary differential equations (ODEs) or partial differential equations (PDEs), respectively. This general approach of material modeling has successfully been applied to various problems of engineering interest.

This talk aims at presenting a short overview on how the finite element method can be used to find approximate solutions to the mentioned system of coupled differential equations by focusing on novel approaches for two different problems: visco-elastic materials with stochastic properties and thermodynamic topology optimization including material nonlinearities.

After presenting a variational strategy for general material modeling, the problem of visco-elastic materials with stochastic properties is discussed. In this case, the material behavior is described by an ODE with stochastic coefficients. The recently developed time-separated stochastic mechanics allows splitting the time-independent, stochastic terms from the time-dependent deterministic terms. Thereby, both the expectation and the variance for the mechanical stresses can be computed instantly. In the end, a finite element implementation needs only negligibly more computation time than one stochastic realization hundreds of which are needed for referential Monte Carlo simulations to converge.

In the second part of the talk, the thermodynamic topology optimization is presented which makes use of a gradient-enhanced energy functional for regularization. The resultant Helmholtz equation is solved in an efficient manner which avoids increasing the number of nodal unknowns. Since the PDE for the density distribution of the topology is derived from thermodynamic concepts, it can be equipped by material models that account for material nonlinearities such as anisotropy and tension/compression asymmetry.

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