# Professor Christian Miehe

Universitat Stuttgart, Germany

## Variational principles for dissipative solids in physical and material space: implications to plasticity and fracture

The lecture outlines a variational framework for gradient–type dissipative solids in the physical and material space. Variational concepts are investigated for solids which incorporate–structural fields, whose gradients enter the energy storage and dissipation functions. In contrast to classical local continuum approaches to inelastic solids based on locally evolving internal variables, these global micro-structural fields are governed by additional balance equations including micro-structural boundary conditions. They describe changes of the substructure of the material which evolve relatively to the material as a whole. Typical examples are global slip fields in crystal plasticity accounting for geometric necessary dislocations and order parameters in recently developed phase field models of fracture. Such material models incorporate nonlocal dissipative effects which incorporate in a natural way a length scale, reflecting properties of the material micro-structure. We show that the coupled macro- and microscopic balance equations in dual physical and material space for gradient–type standard dissipative solids result naturally as the Euler equations of properly defined incremental variational statements. The multi-field variational setting is outlined in the continuous as well as in time- and space-discrete versions. The inherent symmetry of the proposed formulation with respect to the macro– and micro–structural fields is an attractive feature with regard to the computational implementation of such models. We investigate implications of the general variational framework to computational plasticity as well as brittle crack propagation, where the balances in the material space govern configurational–force–driven mesh refinement indicators in the elastic–plastic bulk and configurational–force–driven mesh– alignment indicators at the crack tip. The performance of the formulation is demonstrated by means of representative numerical simulations.

### Brief CV

Christian Miehe is internationally well known for his work on the theoretical and computational modeling of solid materials and structures. A focus is put on advanced models of finite elasticity, viscoelasticity, plasticity, damage, fracture mechanics and coupled problems towards a reliable description of dissipative effects and failure mechanisms. Among other positions he has been Dean of the Faculty of Civil and Environmental Engineering, University of Stuttgart. He is in the editorial board of several international journals in the broad area of continuum mechanics.