Phase Field Modeling of Brittle and Ductile Fracture in Multi-Field Environments

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The lecture provides an overview of recent developments in the formulation and computational realization of evolving regularized crack discontinuities in solids, accounting for couplings with thermal, chemical or fluid transport phenomena. A characteristic approach to the phase field modeling of fracture is outlined based on the regularization of crack surfaces by first- and higher-order continuum approximations, which converge for vanishing length scales to sharp crack discontinuities. An associated minimization problem of a regularized crack surface functional provides the underlying geometric picture of the method. Crack propagation is modeled by an evolution equation of the regularized crack surface, governed by constitutive crack driving forces and transition rules related to state variables of the continuum bulk response. This methodology is accompanied by a modular concept of linking the diffusive crack modeling to any complex response of the bulk material, and favorites easy-to-implement staggered update schemes of the regularized crack surface and the state variables of the bulk. A canonical modeling approach to these scenarios is provided by variational principles for evolution problems, where all governing equations follow as the Euler equations of suitable defined rate potentials. In addition, constitutive structures with crack driving forces beyond variational principles are investigated, such as convenient stress-based functions for brittle fracture or regularized barrier functions for ductile fracture depending on internal state variables. Representative applications of the framework will cover model simulations of complex crack propagation in isotropic and anisotropic elastic and elastic-plastic solids, including diffusion-deformation-fracture couplings such as hydraulically induced fracturing of porous solids.

References

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