Phase-field fracture models for linearized and finite elasticity

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The phase-field approach to fracture simplifies sharp cracks by smooth transitions between broken and unbroken regions. The evolution of the phase-field follows an equation where the driving forces of crack growth are derived from an energy minimization principle, typically based on an Ambrosio-Tortorelli type functional. Modifications allow accounting for the no-healing irreversibility constraint of crack evolution and for the asymmetry of fracture, i.e., the fact that cracks only grow under tensile loadings but not under compression. Further modifications consider the crack evolution under pressure and at finite strains using energy densities, which are polyconvex functions of the deformation, [2, 3].

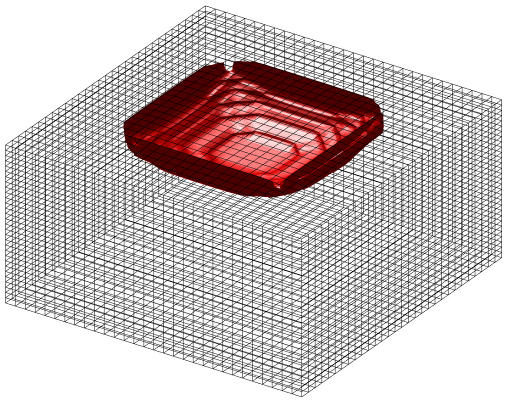

Figure 1: Crack surface in conchoidal fracture [1].

In this contribution different decompositions of the elastic energy and the pros and cons of variational and ad hoc formulations for the crack driving forces will be discussed. The latter may be based on positive principal stresses or strains for example. We compare models in linearized and in finite elasticity and present recent results on the mathematical analysis for a finite strain phase-field model. To illustrate the capability of a phase-field fracture approach, finite element simulations of brittle fracture are presented and in part compared to experimental results. The main challenge of our fracture simulations is that they require the ability of a numerical method to predict crack nucleation and fracture without stress concentration at a notch or at an initial crack.

References

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