Regularised Fracture Models Based on Representative Crack Elements

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The energetic description of a crack dates back to GRIFFITH, who has related the required energy to create a crack increment to the available potential energy in the system. A variational formulation of the crack problem

$$\mathcal{E}(\boldsymbol{u}, \mathcal{B}^\Gamma) = \int_{\mathcal{B}\setminus\mathcal{B}^\Gamma} \psi(\nabla \boldsymbol{u}) \, \mathrm{d}V + \int_{\mathcal{B}^\Gamma} \phi([\![\boldsymbol{u}]\!]) \, \mathrm{d}A \to \min_{\boldsymbol{u}, \mathcal{B}^\Gamma}$$

is known as *free discontinuity problem*, where the size and location of the crack domain $\mathcal{B}^\Gamma$ is unknown. Two regularisations for this problem are under strong developed and are applied to brittle fracture, namely phase-field fracture [1] and eigenfracture [2].

The prediction of the crack state (opened/closed) and the forces, which can be transferred through a crack, are essential for the post-fracture behaviour but also for the calculation of the potential energy available to drive the crack. The authors have proposed to determine the deformation kinematics of a crack from discrete crack models and to couple them to the regularised fracture model by means of computational homogenisation. We have derived efficient numerical solution schemes for these *Representative Crack Models* in the context of phase-field fracture [3] and eigenfracture [4] among others. The obtained formulation is consistent to the spatial derivative, which was shown for free discontinuity problems at the discontinuities [5] and is covered by the Γ-convergence proof in [2] for linear elastic fracture problems.

In this talk, we present applications of the framework to material and geometrical nonlinearities, e.g. visco-elasticity [6], anisotropic plasticity, crack surface friction and finite deformations, as well as applications to multi-physical material models, like thermo-mechanics with heat radiation through the crack [7] and electro-mechanics with different permeability models for the crack gap [8].

References

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