

Variational phase-field modeling of cohesive fracture in elastodynamics

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Abstract

Modeling of dynamic fracture is essential to understand failure mechanisms in structures subjected to high strain rates, e.g. due to impact loading or seismic events. Phase-field modeling of brittle fracture is by now a well-established approach to reproduce the fracture behavior of brittle materials, which was originally proposed in the quasi-static regime. The approach is based on the regularized representation of a crack through a spatially varying damage variable that locally degrades the elastic properties of the material. Extensions of the phase-field approach to the dynamic framework are available and demonstrate potential to realistically predict various aspects of dynamic fracture, including crack branching phenomena, mode-I crack propagation at velocities below or approaching the Rayleigh wave speed, and the emergence of crack-tip instabilities related to competing intrinsic length scales. However, in the dynamic context, the spatial degradation of the elastic parameters at a crack introduces undesired effects. Namely, spurious wave reflections, transmissions and oscillations can be observed if an elastic wave interacts with a regularized crack. In the first part of this presentation, we explain in detail where these effects stem from and how they lead to the widening of the phase-field profile typically observed in dynamic fracture computations. These limitations motivate the need for alternative formulations for dynamic fracture. To address these shortcomings, we extend the recently proposed phase-field regularization of cohesive

fracture to the dynamic setting. In this new approach, the elastic properties of the material remain intact, while the damage variable exclusively governs the degradation of the material strength. As a result, the model avoids spurious wave interactions and is able to reproduce the expected elastodynamic response under certain conditions, which we analyze in detail. We further investigate the cohesive law in the dynamic regime, demonstrating the potential of this approach as a robust framework for dynamic fracture modeling.

Keywords:

Cohesive fracture Dynamic fracture Phase-field modeling Variational fracture