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PHASE FIELD MODELLING OF FAILURE PHENOMENA IN SOLID MECHANICS

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ABSTRACT

In recent years, phase field modeling has become a very versatile and widely used approach for simulating fracture and failure phenomena within a continuum mechanical framework. The fundamental idea of those theories is to introduce an additional variable and its gradient in the constitutive modelling of the material response. This continuously distributed phase field variable interpolates smoothly between intact and broken material states and enables the characterization of complex fracture phenomena such as, e.g., kinking, merging and bifurcation of cracks.

The aim of this session is to discuss recent advances in phase field modelling of failure phenomena across different engineering applications. The basic model of phase field theories for fracture originates from a generalization of the Griffith theory for brittle materials. Nowadays, however, the method is extended to capture a large variety of materials, failure mechanisms and load histories such as ductile fracture, fatigue fracture, crack propagation in heterogeneous materials, interface cracking, cracks due to thermomechanical loading conditions and many more. Each of these extensions poses its own challenges in order to obtain physically meaningful results.
From a numerical point of view, the integration of a phase field also offers both advantages and challenges. Usually, the phase field variable is simply assumed as an additional degree of freedom within a finite element framework, enabling the use of standard solution procedures. On the other hand, the calculations are normally accompanied by high numerical effort due to the necessity of very fine meshes in the vicinity of the crack tip. This leads again to the development of new and more efficient solution strategies.

Generally, phase field modeling offers a useful tool but also poses challenges for predicting fracture behavior across many engineering applications which will be debated within this session.