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Physics-Based and Machine-Learning Approaches to Fracture and Fatigue in Materials

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ABSTRACT

Predicting crack development and fatigue in structural components is often challenging in the presence of defects, residual stresses, heterogeneity and coupled environmental effects. These challenges are especially relevant to increasingly complex, multiphysical material systems, including additively manufactured metals and alloys, energy-storage materials, high-performance composites and other multifunctional material systems. Computational and physics-based artificial intelligence models are increasingly utilized to provide powerful and robust predictive capabilities to capture these multiphysics phenomena and failure across multiple spatial and temporal scales.

The aim of this mini-symposium is to bring together recent advances in physics-based, data-driven and hybrid computational approaches for the modelling of fracture and fatigue in structures. Particular emphasis will be put on approaches including, but not limited to, variational and phase-field formulations for brittle, ductile, cohesive and fatigue fracture, as well as multiphysics phenomena such as hydrogen-assisted cracking, corrosion fatigue, thermal fracture and electro-chemo-mechanical degradation in energy materials. We also strongly encourage contributions at the intersection of computational fracture mechanics and machine learning approaches, such as physics-informed neural networks (PINNs), graph neural networks (GNNs), and neural operators (e.g., DeepONet), as well as their use in data-driven constitutive modeling and reduced-order or surrogate modeling of fracture processes.