Workshop on Experimental and Computational Fracture Mechanics
March 4-6, 2024, Baton Rouge, LA

PHASE-FIELD MODELING OF FRACTURE: NUCLEATION, DISSIPATION, LARGE DEFORMATION, AND COMPLEX STRESS STATES

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ABSTRACT

The growth of cracks is challenging for numerical methods due to the numerous singular surfaces that must be tracked. Phase-field modeling provides an attractive alternative: by smearing out the singularities appropriately, it is possible to use standard numerical techniques, such as the finite element method, to model cracks that grow in complex ways. While current phase-field models of fracture are widely applied to various types of engineering problems, they have some critical shortcomings. Specifically, the model parameters that govern the nucleation of cracks is unclear; the behavior of fast moving cracks is unphysical near the sonic velocity; and the material response is unphysical in the large-deformation setting when the crack closes under compressive loading. To address these issues, we present results on a conservation law structure for the phase-field that enables us to transparently incorporate nucleation and stick-slip kinetics; the role of viscous stresses that, while small, are essential to provide regularity near the sonic velocity; and the formulation of a crack strain energy density that appropriately mimics the behavior of a crack under compression and other complex stress states.

This is joint work with Janel Chua (Los Alamos National Lab), Maryam Hakimzadeh (Carnegie Mellon University), Balaji Sridhar (Carnegie Mellon University), Carlos Mora-Corral (Universidad Autonoma Madrid), David Rounce (Carnegie Mellon University), George Gazonas (Army Research Lab), and Noel Walkington (Carnegie Mellon University).