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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.

BIOGRAPHY:

Kaushik Dayal is Professor of Engineering at Carnegie Mellon University. He received his B.Tech. at the Indian Institute of Technology and his Ph.D. in Mechanical Engineering at Caltech. His research interests are in the area of theoretical and computational multiscale methods applied to materials in non-equilibrium settings and materials interacting with electromagnetic fields. His research has been recognized by the Eshelby and Leonardo da Vinci medals. He has held visiting appointments at the University of Bath (Parkin Professorship), University of Bonn, National Energy Technology Laboratory and Air Force Research Laboratory.