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PERIDYNAMICS AND LINEAR ELASTIC FRACTURE MECHANICS

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ABSTRACT

This talk will explore the relationship between cracks as represented within the peridynamic nonlocal theory of solid mechanics and linear elastic fracture mechanics (LEFM). Peridynamics is distinguished from the standard (local) theory of solid mechanics mainly in its ability to apply the same field equations everywhere in a body, regardless of whether the deformation is continuous or singular at a point. In typical applications, a peridynamic material model contains some damage law that governs an irreversible loss of strength in the interaction between two material points. The resulting deformation of a body may or may not evolve to form cracks, as determined by the field equations, material model, and loading history.

It is well-established that global measures such as the J-integral that characterize the energy balance as a crack grows in LEFM have counterparts in peridynamics. It is known from mathematical analysis that as the nonlocal length scale, the horizon, is reduced, the peridynamic deformation converges to that of the local theory, which is the mathematical basis for LEFM. In some peridynamic material models, the critical energy release rate can be reproduced by a suitable calibration of the model parameters. However, the asymptotic fields near the tip of a crack are very different between the local and peridynamic theories. In particular, the unbounded asymptotic strain field of LEFM is not present near a peridynamic crack. Instead, a peridynamic crack tip field contains a type of process zone whose size is proportional to the nonlocal length scale. Within this process zone, energy is dissipated as the crack grows, yet the deformation measures such as bond strain remain bounded.

How can all these seemingly contradictory facts be reconciled? How can a peridynamic crack behave identically to LEFM in the global sense, yet have different asymptotic behavior near the crack tip? In this talk I will explore this seeming dissonance between the nature of cracks as characterized by LEFM and peridynamics. Recent numerical and analytical results explore the transition of a point in the path of a growing crack from being a point where the deformation is continuous to being a point of singularity. This process involves passage through an unstable part of the material response. Because these processes take place within a region of finite size, nonlocal modeling permits an explicit analysis of events that in LEFM would be considered out of the scope of the local theory. Thus, nonlocal modeling provides new opportunities to study the process of material failure.

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