Thesis Seminar

Thursday September 26, 2013

9:00 a.m. in Lees Kubota (Guggenheim)

Landry Fokoua Djodom

"Optimal Scaling in Ductile Fracture"

We derive optimal scaling laws, in the sense of matching upper and lower energy bounds, for a material undergoing ductile fracture. The material is assumed to undergo power-law hardening and large deformations in the finite kinematics range. For the physical range of hardening exponents, the bulk energy is unstable due to geometrical instabilities such as necking. However, the energy is assumed to additionally depend on the deformation gradient, which introduces a competing stabilizing effect. For definiteness, we assume the nonlocal energy to have linear growth for large deformation gradients. Under these conditions, we show that the material has a well-defined fracture energy per unit area and that the fracture energy obeys optimal upper and lower bounds of the power-law form in the opening displacement and in the characteristic internal length. The upper bound is attained through a void-sheet construction, which in particular shows that fracture in the materials under consideration occurs on well-defined rectifiable surfaces and does not have a fractal character. The optimal scaling laws are also indicative of power-law cohesive behavior at the macroscale, representing a gradual decrease of bearing capacity across the fracture plane with increasing opening displacement. In this manner, the optimal scaling laws effectively upscale microscale material properties, such as length scale and surface energies, into macroscopic properties such as the specific energy of fracture. We present comparisons with experiment, including Charpy test data, that verify and validate the predictions of the theory.