Phase-field modeling of brittle fracture: an overview and a new paradigm to address multiple solutions

Laura De Lorenzis

Professor
Department of Mechanical and Process Engineering
ETH Zürich

Abstract:

The phase-field modeling approach to fracture has recently attracted a lot of attention due to its remarkable capability to naturally handle fracture phenomena with arbitrarily complex crack topologies in three dimensions. On one side, the approach can be obtained through the regularization of the variational approach to fracture introduced by Francfort and Marigo in 1998, which is conceptually related to Griffith's view of fracture; on the other side, it can be constructed as a gradient damage model with some specific properties. The functional to be minimized is not convex, so that the necessary stationarity conditions of the functional may admit multiple solutions. The solution obtained in an actual computation is typically one out of several local minimizers. Evidence of multiple solutions induced by small perturbations of numerical or physical parameters was occasionally recorded but not explicitly investigated in the literature.

In the first part of this talk, the speaker gives a brief overview of the phase-field approach to fracture and of recent related research carried out in her group. In the second part of the talk, the focus is placed on the issue of multiple solutions. Here a paradigm shift is advocated, away from the search for one particular solution towards the simultaneous description of all possible solutions (local minimizers), along with the probabilities of their occurrence. We propose the stochastic relaxation of the variational brittle fracture problem through random perturbations of the functional and introduce the concept of stochastic solution represented by random fields. In the numerical experiments, we use a simple Monte Carlo approach to compute approximations to such stochastic solutions. The final result of the computation is not a single crack pattern, but rather several possible crack patterns and their probabilities. The stochastic solution framework using evolving random fields allows additionally the interesting possibility of conditioning the probabilities of further crack paths on intermediate crack patterns.

Bio:

Laura De Lorenzis received her Engineering degree and her PhD from the University of her hometown Lecce, in southern Italy, where she first stayed as Assistant and later as Associate Professor of Solid and structural mechanics. In March 2013 she moved to the TU Braunschweig, Germany, as Professor and Director of the Institute of Applied Mechanics. There she was founding member and first Chair (2017-2020) of the Center for Mechanics, Uncertainty and Simulation in Engineering. Since February 2020 she is Professor of Computational Mechanics at the ETH Zürich. She was visiting scholar in several renowned institutions, including Chalmers University of Technology, the Hong Kong Polytechnic University, the Massachusetts Institute of Technology (as holder of a Fulbright Fellowship in 2006), the Leibniz University of Hannover (with an Alexander von Humboldt Fellowship in 2010-2011), the University of Texas at Austin and the University of Cape Town. She is the recipient of several prizes, including the RILEM L'Hermite Medal 2011, the AIMETA Junior Prize 2011, the IIFC Young Investigator Award 2012, two best paper awards and two student teaching prizes at the TU Braunschweig. In 2011 she was awarded a European Research Council Starting Researcher Grant. She has authored or co-authored more than 120 papers on international journals on different topics of computational and applied mechanics.

Monday, April 19th, 2021 12:00 – 1:00 p.m. (CDT)

Join us: https://go.cee.illinois.edu/Seminar-by-Dr-De-Lorenzis