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Towards a Complete Theory of Fracture: Past, Present, and Future

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ABSTRACT:

In the first part of this talk, I will review what is that is known at present from centuries of experimental observations about the nucleation and propagation of fracture in solids. The observations will reveal that there are three basic ingredients that any attempt at a complete macroscopic theory of fracture ought to account for. Having pinpointed the basic ingredients required for a complete theory, I will then present one such theory, regularized, of phase-field type for the basic case of nominally elastic brittle materials. The theory can be viewed as a natural generalization of the phase-field approximation of the celebrated variational theory of brittle fracture of Francfort and Marigo (1998) — which is nothing more than the mathematical statement of Griffith's (1921) competition of bulk and fracture energies — to account for the material strength. In the latter part of the talk, I will illustrate the descriptive and predictive capabilities of the theory via simulations of several famously challenging experiments, including the indentation of glass, the Brazilian test on rocks, and the poker-chip experiment on rubber. I will close by discussing how exactly the same ideas behind the proposed theory may be applicable to the nucleation and propagation of fracture in dissipative solids at large.

BIOGRAPHY:

Oscar Lopez-Pamies is the Colonel Harry F. & Frankie M. Lovell Professor in the Department of Civil and Environmental Engineering at the University of Illinois Urbana-Champaign, which he joined in 2011. He received his B.A. degree in Mathematics and B.S. and M.S. degrees in Mechanical Engineering from the University of Maryland Baltimore County in 2001 and 2002, and his Ph.D. degrees in Applied Mechanics from the University of Pennsylvania and Ecole Polytechnique (France) in 2006. His research focuses on the development of mathematical theories and associated numerical methods to describe, explain, and predict the mechanical and physical behavior, stability, and failure of solids. He is the recipient of a number of academic honors, including the Young Scientist Prize from the European Mechanics Society in 2009, the NSF CAREER award in 2011, the Journal of Applied Mechanics award in 2014, and the Young Investigator Medal from the Society of Engineering Science in 2017.