Journal of Applied Mechanics

Guest Editorial

Special Issue Honoring Professor James R. Rice

This issue of the Journal of Applied Mechanics is dedicated, with our admiration and affection, to Professor Jim Rice of Harvard University. It serves as the proceedings of the 3 days symposium on Mechanics in Geophysical and Materials Sciences, which was held at the California Institute of Technology during Jan. 20–22, 2011 to celebrate Jim's brilliant career on the occasion of his 70th birthday.

Jim's interest in mechanics and its applications dates back to his study at Lehigh University. His undergraduate research work with Professor George Sih on cracks in dissimilar materials led to his first two papers, published in the Journal of Applied Mechanics in 1964 and 1965. Jim stayed at Lehigh to earn his M.S. and Ph.D. degrees, working with Professor Ferdinand Beer on statistical characterization of random loadings relevant to fatigue and fracture. In the process, he set a Lehigh record by completing all three degrees—B.S., M.S., and Ph.D.—in just 6 years, from 1958 to 1964. That pace was just a preview of the illustrious academic career that followed. Jim joined Brown University as a postdoctoral fellow in 1964 and faculty in 1965, becoming Professor of Engineering in 1970 and L. Herbert Ballou Professor of Theoretical and Applied Mechanics in 1973. Since 1981, Jim has been teaching at Harvard, first as the Gordon McKay Professor and then as the Mallinckrodt Professor of Engineering Sciences and Geophysics.

The depth and breadth of Jim's impact on the mechanics of materials and geophysics cannot be exaggerated. While numbers alone never tell the full story, more than 24,000 citations garnered by nearly 250 publications co-authored by Jim to date, with the current rate of more than a 1000 citations per year, provide an imperfect but objective glimpse into the lasting influence of the research accomplishments by Jim and his coworkers. Jim's contributions to both science and the scientific community have been recognized by numerous honors and awards, including membership in the US National Academy of Sciences and National Academy of Engineering; foreign/corresponding membership in the French Academy of Sciences, Royal Society of London, and Spanish Academy of Engineering; fellow status in the American Academy of Arts and Sciences, American Geophysical Union, and American Society of Mechanical Engineers (ASME); and top medals from several professional societies, such as the Timoshenko Medal from ASME and Maurice A. Biot Medal from the American Society of Civil Engineers.

Jim's contributions are so influential because they identify key issues at the heart of important problems in both engineering and geophysical sciences, and then distill them into elegant, rigorous, and broadly applicable formulations that start new fields and allow for numerous developments by others. For example, his landmark single-author paper on the *J*-integral, published in the Journal of Applied Mechanics in 1968, facilitated the creation of nonlinear fracture mechanics as a field of research for generations of young researchers. The long list of topics where Jim and his coworkers have defined or significantly advanced the research agenda includes: the *J*-integral and the HRR (Hutchinson–Rosengren–Rice) field; internal variable constitutive theories in plasticity; the ductile versus brittle transition in solids; dislocation emission and intrinsic ductility from a crack tip; inelastic deformation of single crystals and polycrystals; interfacial fracture mechanics; the stability of plastic deformation and strain localization; poroelasticity and hydraulic fracturing; ductile fracture of metals; 3D weight function theory and crack front perturbations; mechanics of subduction zones; rate and state friction laws; continuum models of earthquake cycles; stability of frictional sliding and earthquake nucleation; spatiotemporal complexity of fault slip; dilatancy and compaction of fluid-infiltrated media; rupture propagation through geometrically complex fault networks; fault weakening due to shear heating; and combined thermo-poro-mechanical processes acting at the earthquake source. In each of these subject areas, Jim's pioneering ideas serve as beacons of new directions of research for many other researchers. Recently, Jim's interests have expanded to encompass tsunamis, glaciers, and landslides, with new work on the tsunami wave analysis, subglacial hydraulic fractures, episodic glacial motions, ice stream dynamics, and landslide instabilities.

While Jim's research achievements are quite exceptional, those who know Jim are equally impressed and humbled by his personality. For all the ideas and results that bear his name, there are countless more in the literature that have been strongly influenced by him, because Jim is unusually generous in sharing ideas with students and colleagues. As a dedicated teacher and advisor, he devotes a lot of time to class preparation and mentoring his graduate students and other junior coworkers. One of the awards Jim cherishes most is the Excellence in Mentoring Award from the Graduate Student Council at Harvard. He has a very special ability to keep his students on track with well-timed advice, while patiently waiting for them to discover ideas on their own. Out of nearly 40 Ph.D. students advised by Jim, most went on to productive careers in teaching and/or research. Many more benefitted from his mentoring as graduate students at Brown or Harvard or as his junior collaborators. Together with his stimulating and supportive companion, collaborator, and spouse, Dr. Renata Dmowska, he has wide-ranging interests outside of his passion for research and teaching—in music, literature, and family. Those of us who are fortunate enough to count Jim and Renata as friends appreciate how much richer our lives have become because of that association.

Jim's 70th birthday was a perfect occasion to express appreciation and gratitude to Jim for many years of research, mentoring, teaching, and service, and to celebrate the interdisciplinary science on the boundary of mechanics, materials science, and geophysics that has been the hallmark of Jim's career. Discussions among Jim's friends, colleagues, and former students led to the idea of a symposium in Jim's honor at Caltech, with the local

organizing committee consisting of Professors Jean-Philippe Avouac, Kaushik Bhattacharya, Michael G. Gurnis, Nadia Lapusta (Chair), G. Ravichandran, and Ares J. Rosakis, and the advisory committee consisting of Professors Huajian Gao, Alan Needleman, and John Rudnicki. Three days of oral presentations, poster sessions, and discussions on future research directions were co-organized and cosponsored by Caltech's Division of Engineering and Applied Science, Seismological Laboratory, Department of Mechanical and Civil Engineering, Department of Aerospace, and Tectonics Observatory. The symposium was attended by 117 friends, colleagues, and former students of Jim as well as 40 students and postdoctoral fellows from Caltech.

The opening lecture was delivered by Jim's Harvard colleague, fellow Lehigh graduate, and long-time friend, Professor John Hutchinson, on the mechanics of wrinkling in buckled films. It was followed by 20 oral and 48 poster presentations, as well as two panel discussions, which covered a broad range of topics including: ductile fracture surface roughness and plastic deformation in nanotwinned metals; elasto-plastic modeling of shallow slip deficit in earthquakes; probabilistic theory of static and cyclic fatigue; effective properties of heterogeneous materials; rupture through branched and nonplanar faults in heterogeneous medium; molecular diffusive escape from energy wells; damage in lithium-ion batteries; super-shear versus sub-Rayleigh earthquakes and interaction with off-fault damage; multiscale modeling of granular matter; shear localization in granular media and fluid-saturated faults; poroelasticity of gels; interaction of fluids and fracture in glaciers and volcanic tremor; glacial flow modeling; constraints on global mantle flow; mechanics of slip in subduction zones and oceanic transform faults; rate and state friction and frictional aging at the nanoscale; earthquake nucleation and existence of smallest earthquakes; subduction-zone seismicity and characteristics of intermediate-depth earthquakes; determination of friction laws and properties from laboratory experiments and geodetic observations; shear-heating effects and fault weakening; brittle/ductile transition and stability of creeping faults; laboratory-based modeling of earthquake cycles; cohesive zone laws for soft adhesive materials; and active deformation of elastic sheets. The presentations and discussions were lively, inspiring, and focused. This special volume serves as a written document for some of the symposium topics and discussions, and we are grateful to the editor of the Journal of Applied Mechanics, Professor Bob McMeeking, for devoting this issue to the Symposium and inviting us to serve as guest editors.

The symposium was concluded by a closing lecture from Jim himself, on shear localization and earthquake rupture driven by strong thermal weakening. In his typical clear-yet-rigorous manner, Jim took the audience on an engaging journey through experimental measurements, field observations, mechanical theories, and numerical simulations that elucidate the effects of shear heating on thermo-poro-elasto-plastic behavior of faults and their shear strength, as well as on the resulting properties of earthquake rupture. This stimulating lecture, as well as the undiminishing stream of research publications on a variety of topics, clearly shows that Jim is as perceptive and productive as ever. We look forward to many more years of being constantly amazed with Jim's creativity, energy, intellectual curiosity, and generous personality.

Nadia Lapusta
Division of Engineering and Applied Science,
Division of Geological and Planetary Sciences,
California Institute of Technology,
Pasadena, CA 91125
e-mail: lapusta@caltech.edu

Eric Dunham
Department of Geophysics,
Stanford University,
Stanford, CA 94305-2210
e-mail: edunham@stanford.edu

Huajian Gao
School of Engineering,
Brown University,
Providence, RI 02912
e-mail: Huajian_Gao@brown.edu