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Mechanics of Materials Department
Sandia National Laboratories
Livermore, CA

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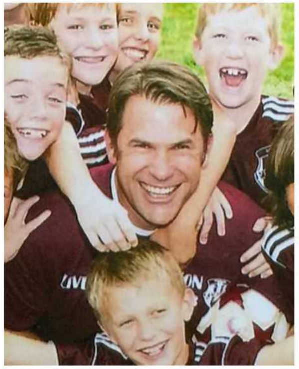
SNL CA: Mechanics of Materials Overview

- The Mechanics of Materials Dept performs experimental and analytical studies to understand the mechanical behavior of materials.
- Experimental efforts cover the entire discovery-characterization-validation spectrum
- Computational models to simulate material responses under various loading and environmental conditions, at scales from atomic to continuum.
- Development and implementation of the material models for high performance computing simulations.
- A current focus of the department is in the area of predicting material failure at various length scales.

Some of the computational solid mechanics researchers

Coleman Alleman
PhD Civil Engineering
Johns Hopkins University



Jay Foulk
PhD Mechanical Engineering
University of California Berkeley

Jake Ostien
PhD Mechanical Engineering
University of Michigan Ann Arbor

Brandon Talamini
PhD Aeronautics & Astronautics
Massachusetts Institute of Technology

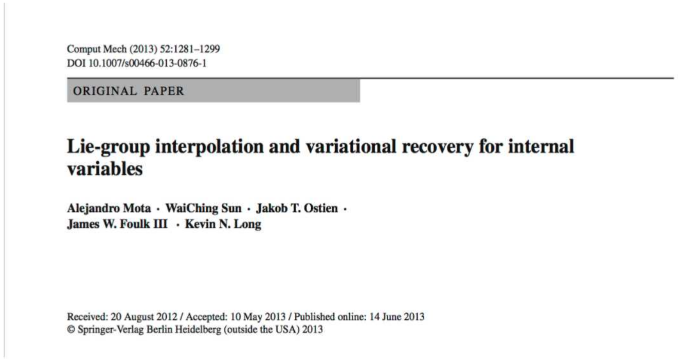
Alejandro Mota
PhD Structural Engineering
Cornell University

The problems we address

- Transient or steady state behavior of solids and structures.
- Materials and structures subjected to very large deformations.
- Damage and failure of materials and structures.
- Crack initiation and propagation.
- Fracture and fragmentation.

Our philosophy

- Use mathematics, solid mechanics and computer science to understand and predict the behavior of solids and structures.
- Start from fundamental physical principles.
- Maintain mathematical rigor.
- Acknowledgment that experiment is the ultimate arbiter.

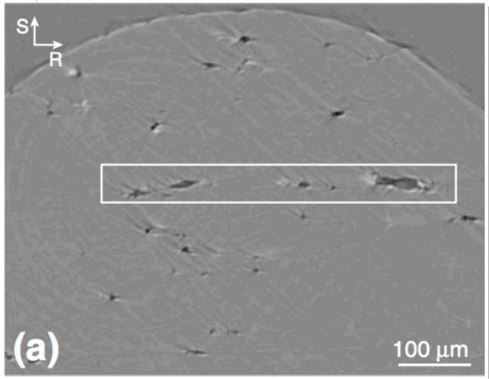

Comput Mech (2013) 52:1281–1299
DOI 10.1007/s00466-013-0876-1

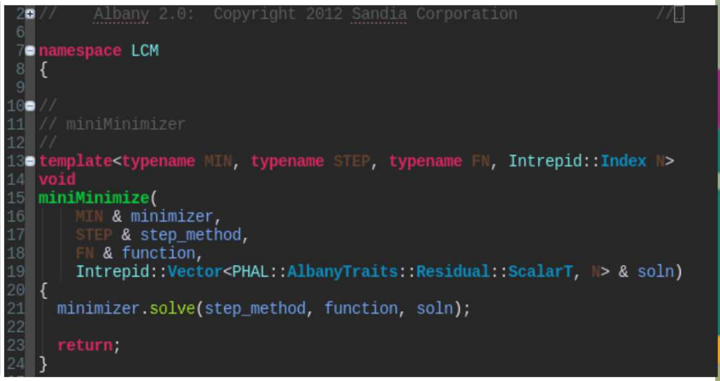
ORIGINAL PAPER

Lie-group interpolation and variational recovery for internal variables

Alejandro Mota · WaiChing Sun · Jakob T. Ostien · James W. Foulk III · Kevin N. Long

Received: 20 August 2012 / Accepted: 10 May 2013 / Published online: 14 June 2013





Research

- Finite-Deformation Solid Mechanics
- Constitutive Behavior of Materials
- Finite Element Methods
- Coupled Physics
- Multiscale Modeling and Coupling
- Remeshing and Mesh Adaptation
- Damage, Failure and Fracture Mechanics

Customers and Collaborators

- Center for Computing Research
- Engineering Sciences Center
- Materials Science and Engineering
- CA Weapons Systems Engineering
- Transportation Energy Center
- Computer Sciences & Info Systems
- DOE/DoD Joint Munitions Program
- DoD Army Research Laboratory

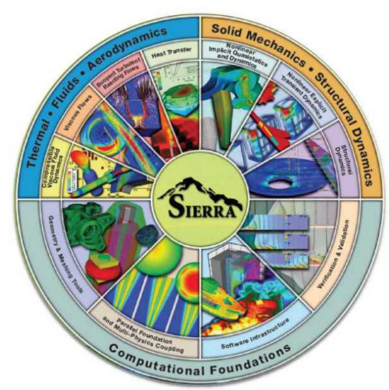
Trilinos

www.trilinos.org

Albany

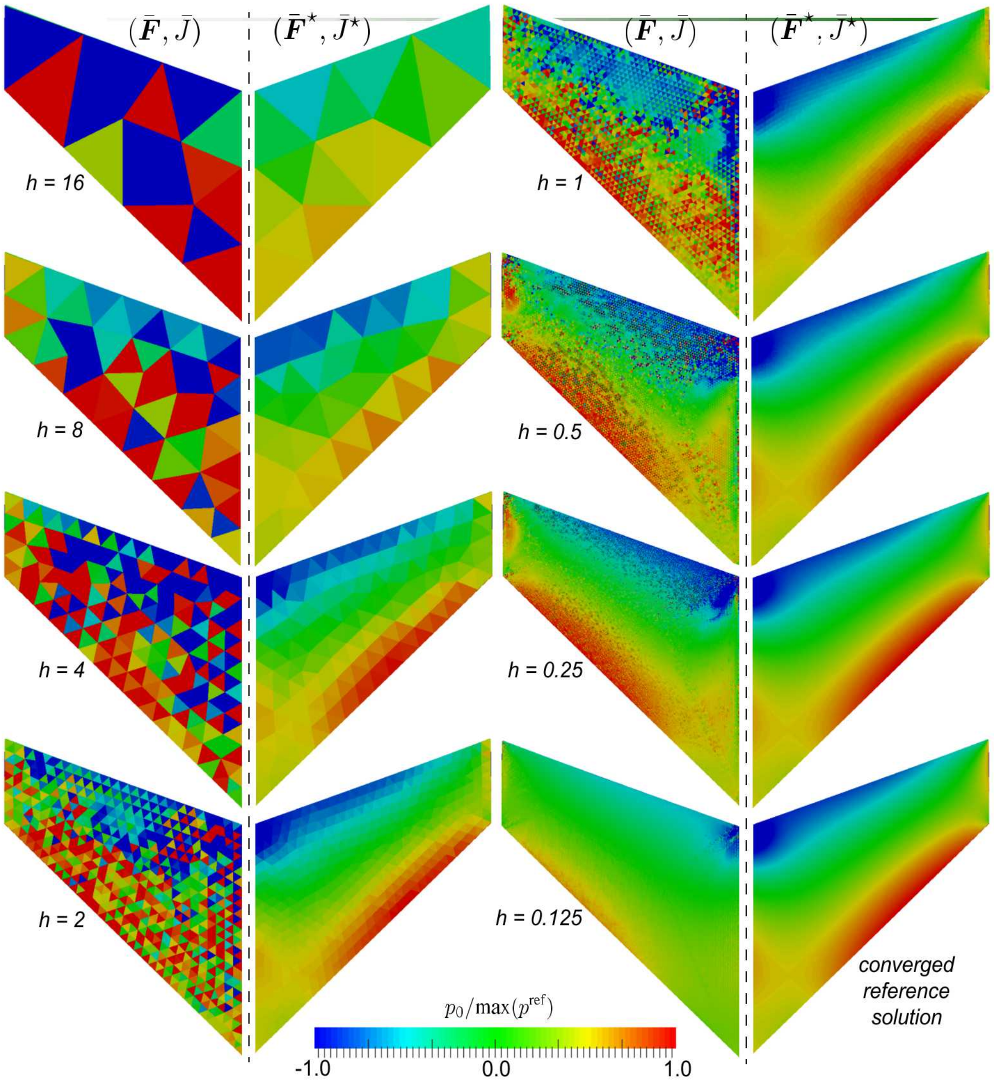
github.com/gahansen/Albany

Research, Open Source

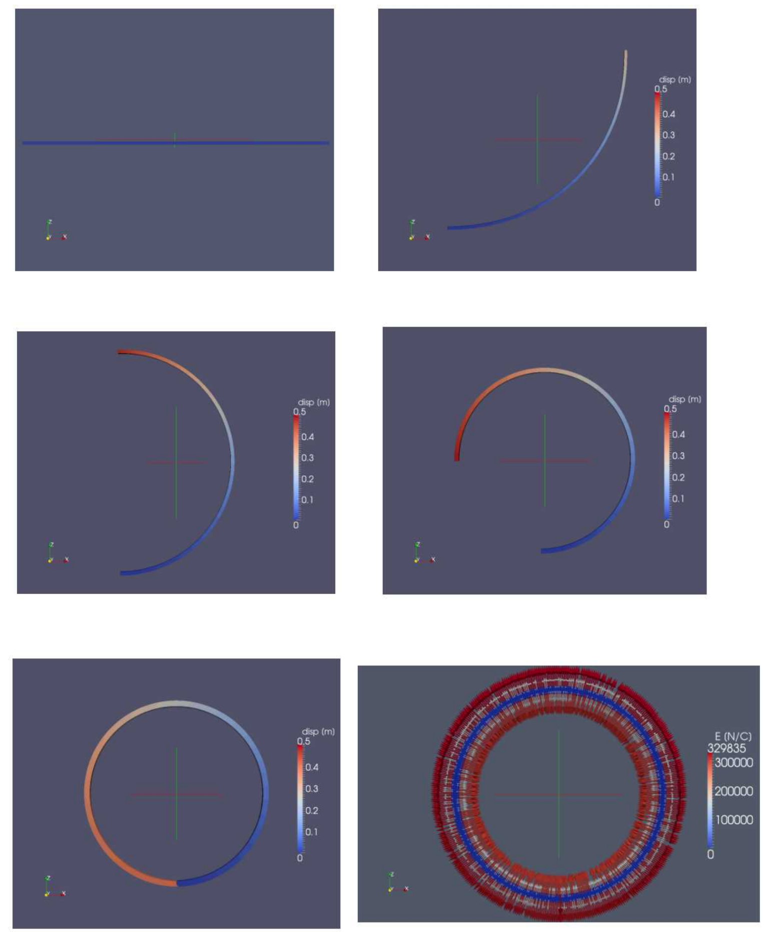


Production, Sandia Proprietary

Element Technology, Piezoelectricity



Accurate Pressure



Bending of Beam into Ring

Finite Deformation, Regularization, Schwarz Coupling

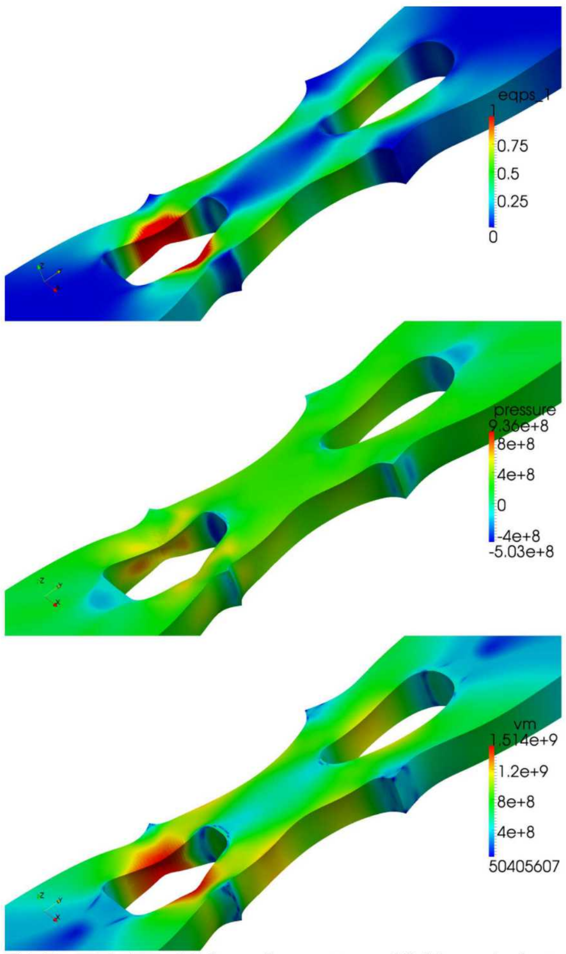
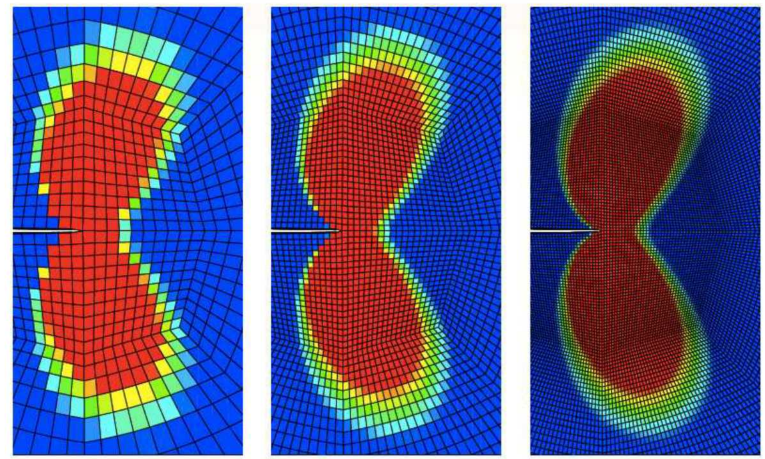
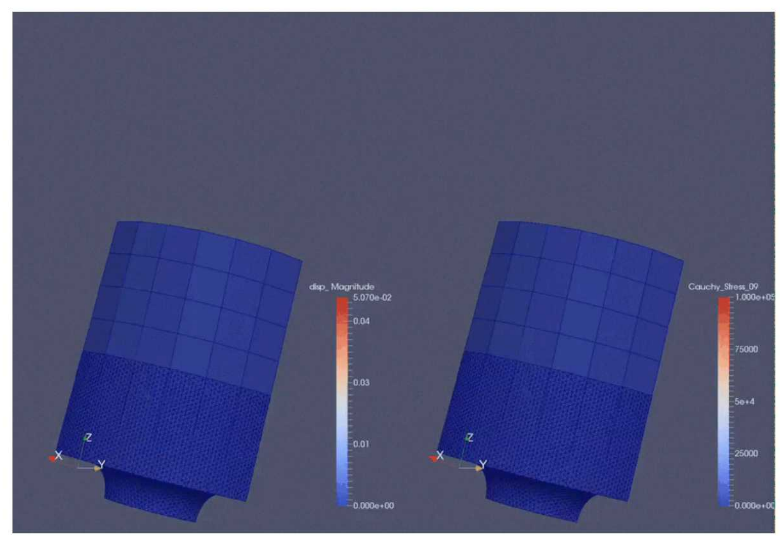


Figure 11: Zoomed view of deformed geometry and fields, equivalent plastic strain (eqps), pressure [Pa], and von Mises stress (vm) [Pa]



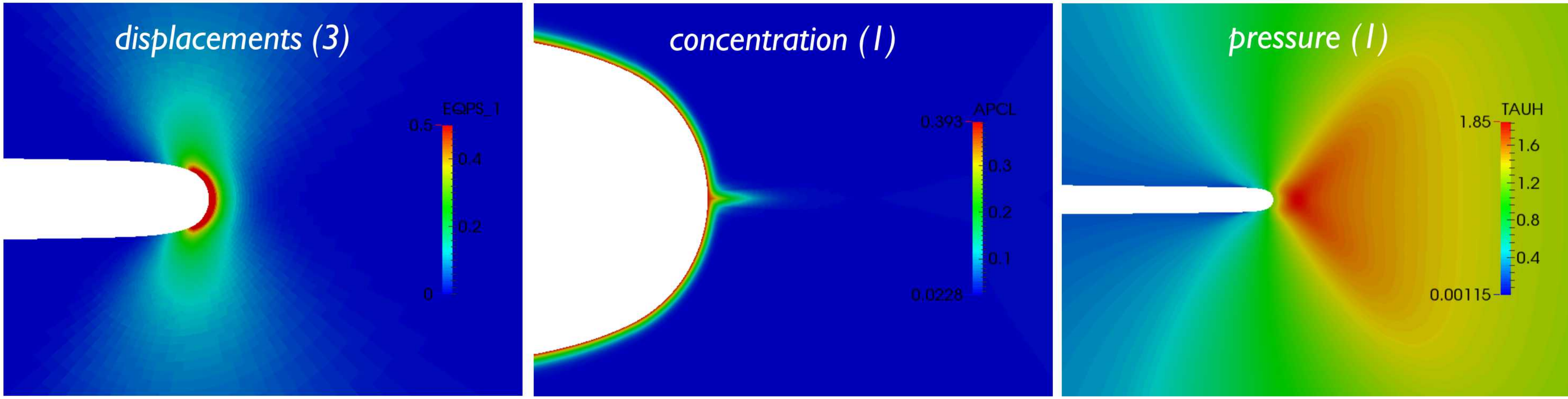
Contours of equivalent plastic strain, (0,.001), mesh sizes 60μm, 30μm, 15μm



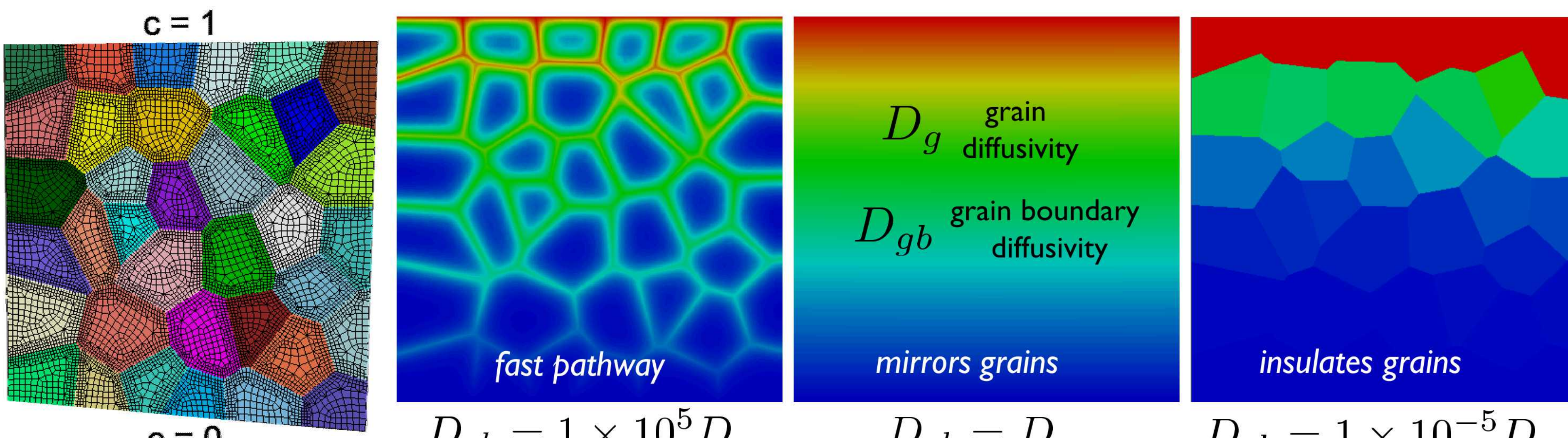
Schwarz Coupling

Strong Chemo-Mechanical Coupling

Block solve for displacement, concentration, and pressure at a crack tip

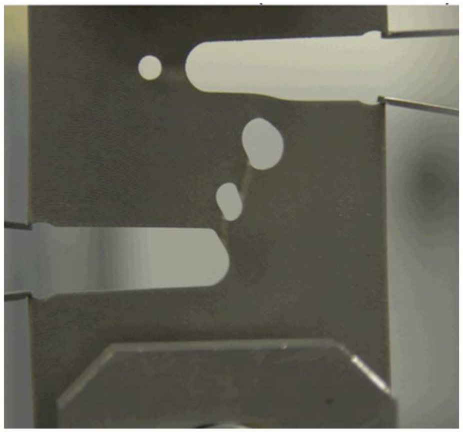


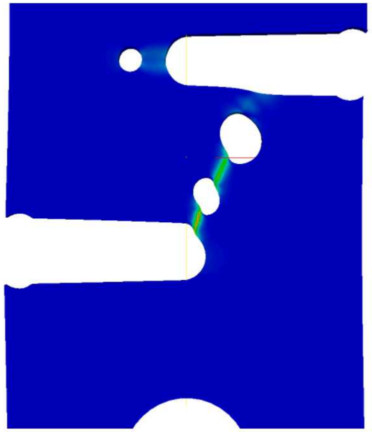
Exploring fast pathways through the inclusion of surface elements on grain boundaries

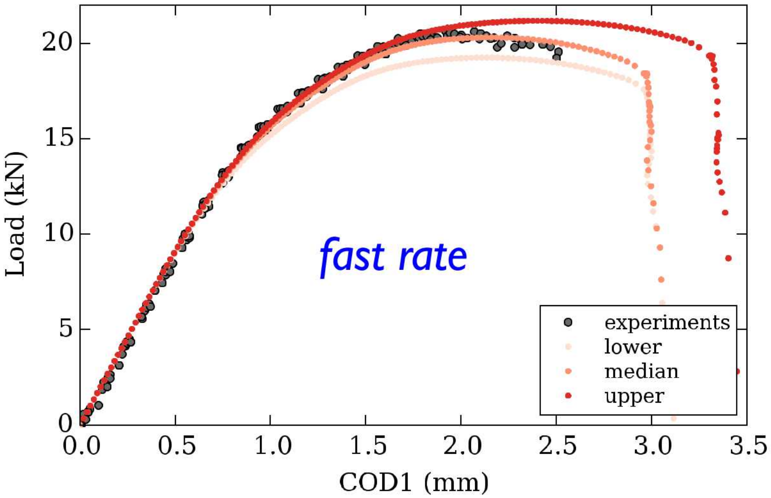


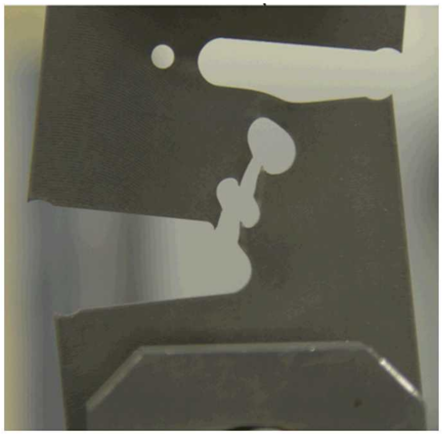
$D_{gb} = 1 \times 10^{5} D_g$ | $D_{gb} = D_g$ | $D_{gb} = 1 \times 10^{-5} D_g$

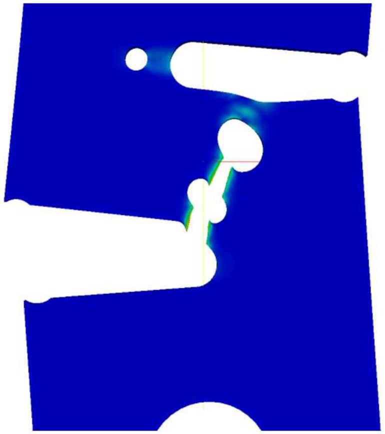
Fracture and Failure

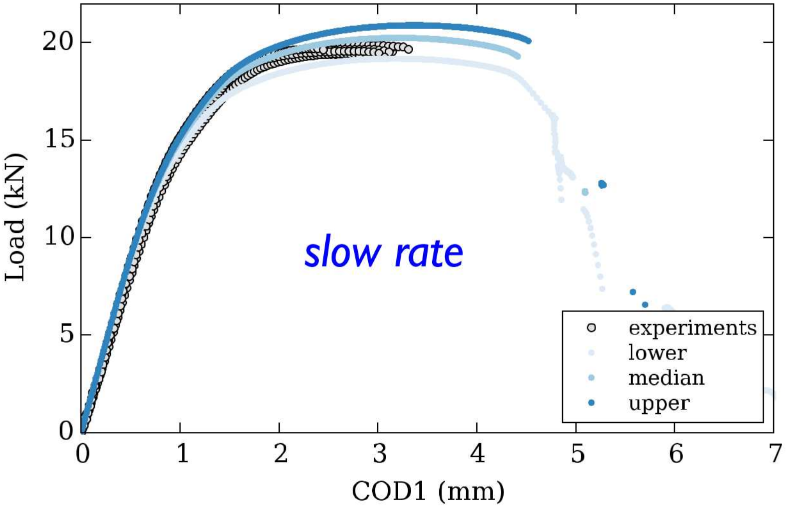




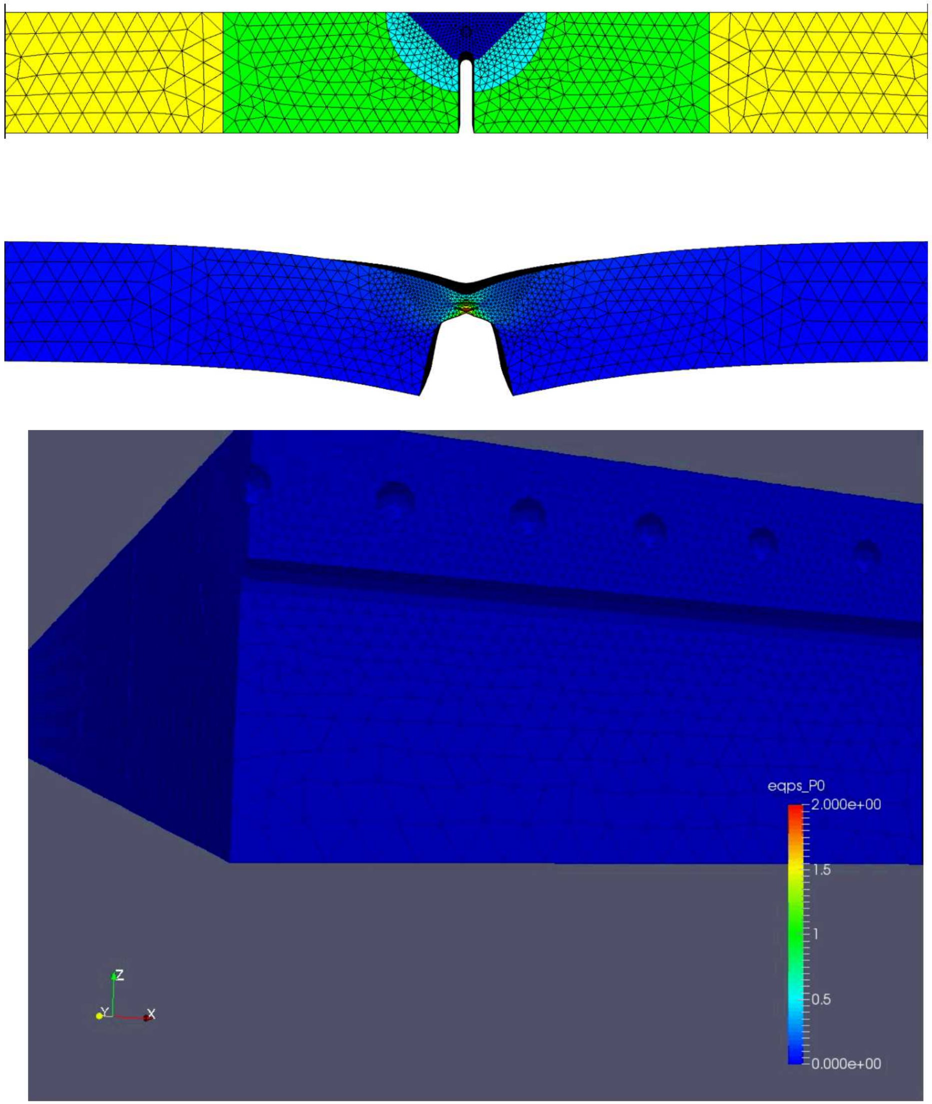




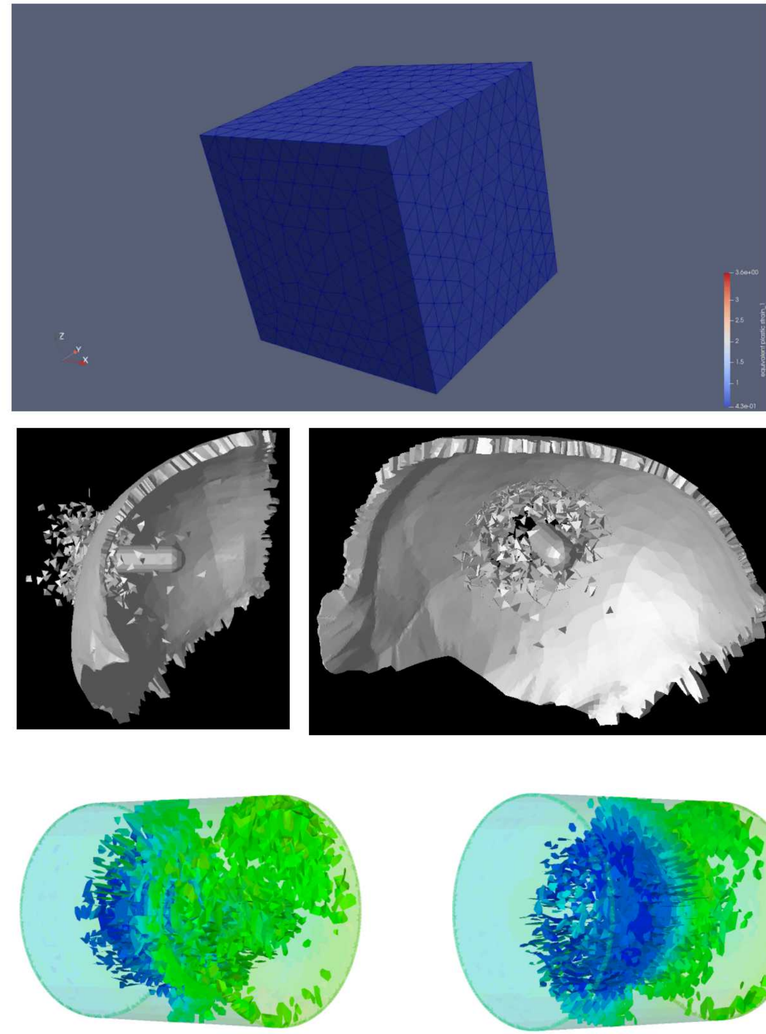




Mesh Adaptation

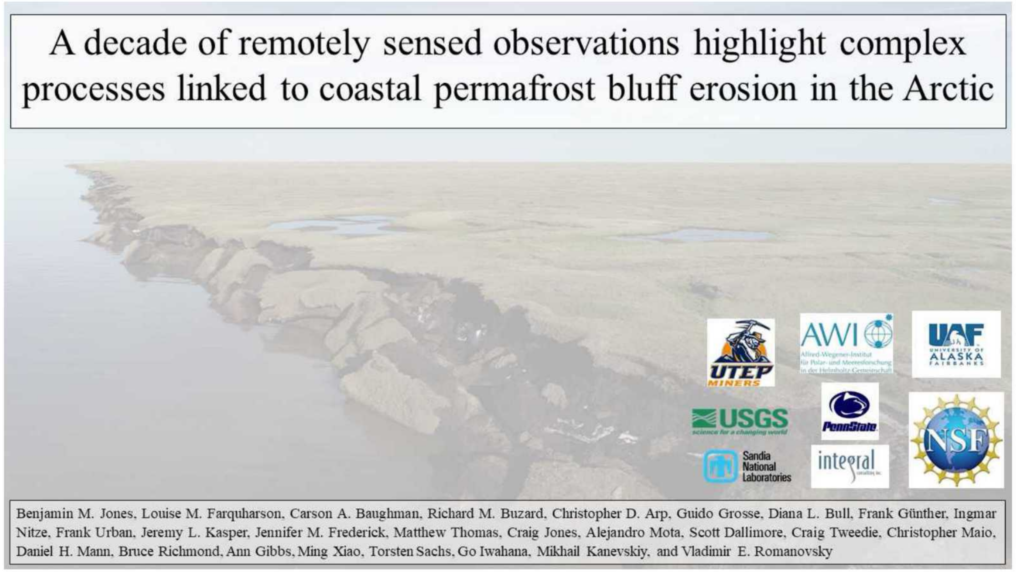


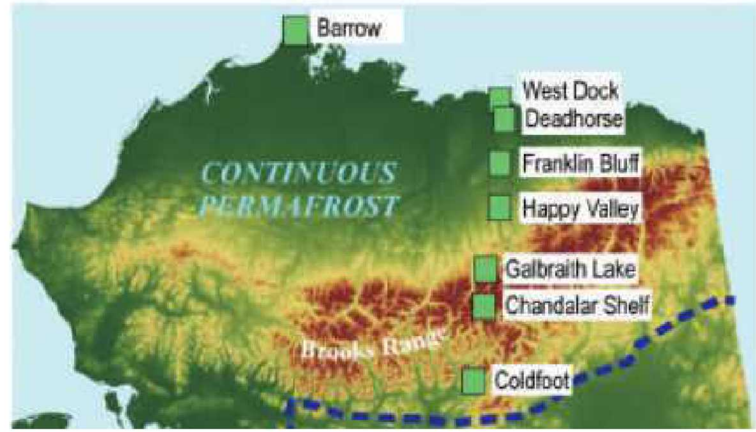
Resolving the evolution of pores in laser welds

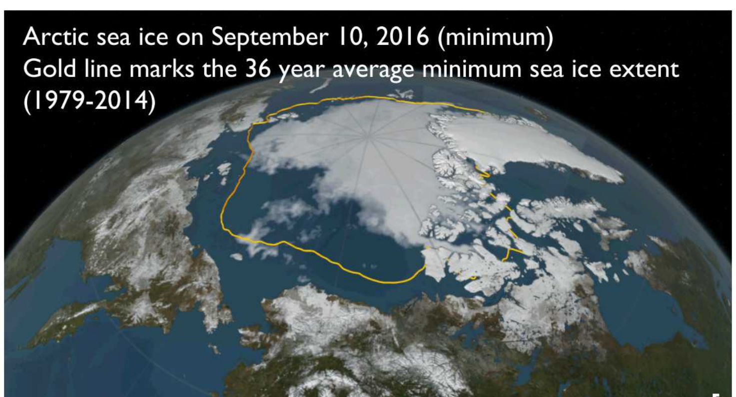


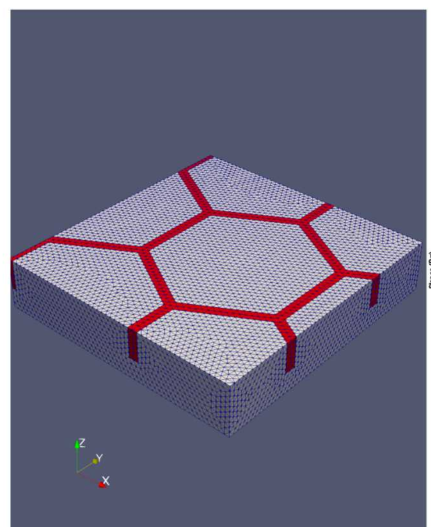
Multiple crack paths and fragmentation

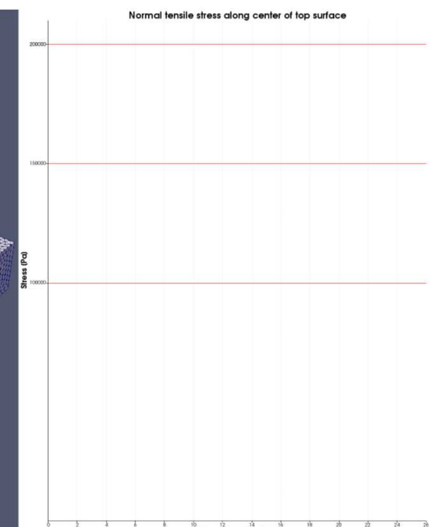
Climate Change









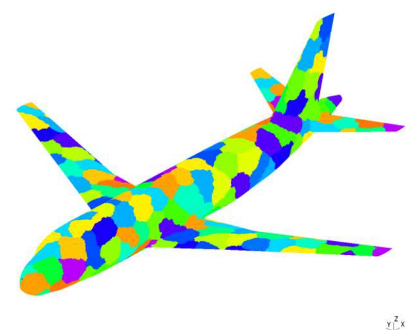


High order, discontinuous Galerkin shell elements:

Stable, accurate, locking-free

airbag inflation

Stress resultant-based cohesive zone model for shells



Parallel processor subdomains