



Mechanics of Materials

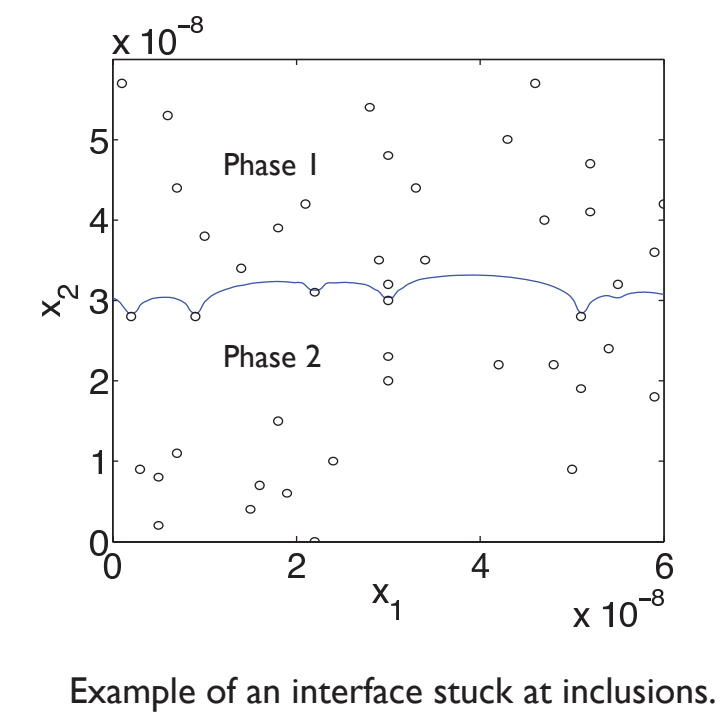
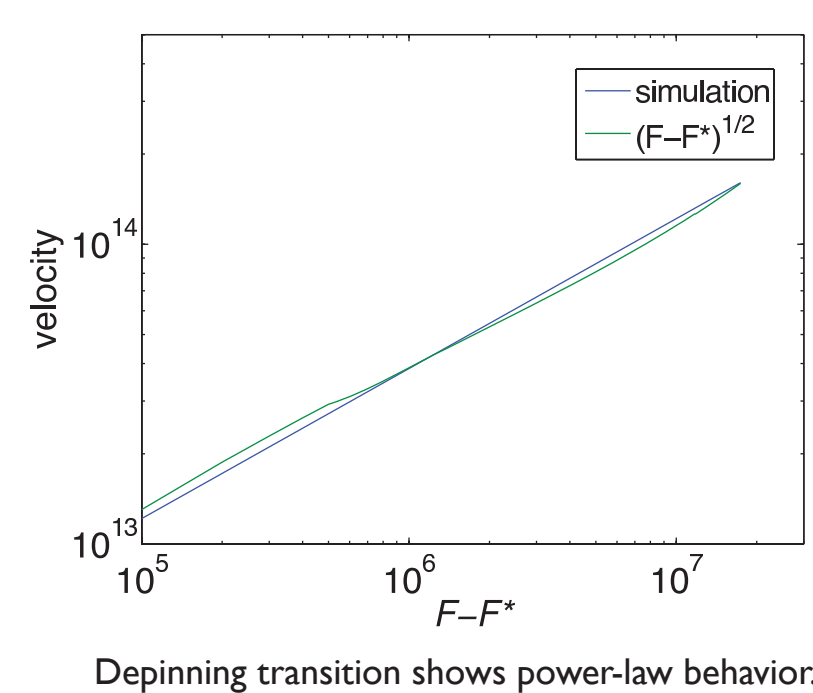
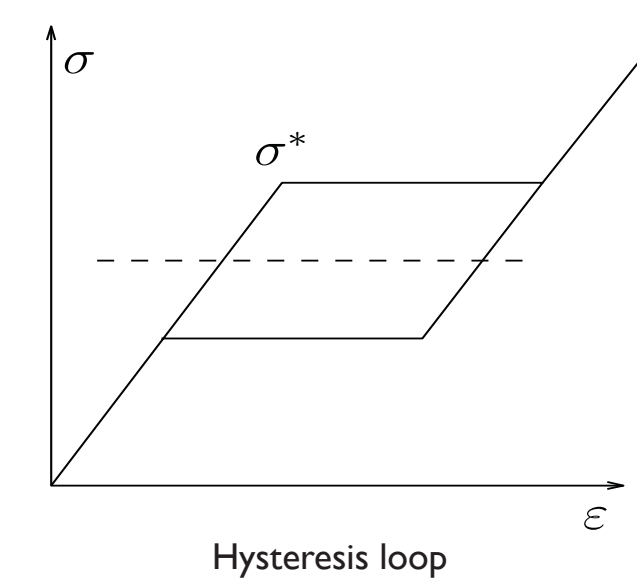
The Research Group of Kaushik Bhattacharya



Hysteresis in Active Materials

Patrick W. Dondl

- What determines hysteresis in active materials like shape-memory alloys, ferro-electrics and piezoelectrics?
- Active behavior arises through solid-solid phase transformation.
- We investigate pinning of phase boundary by defects through mathematical theory and simulation.
- Universal power law for depinning transition: $\bar{v} \approx (F - F_{critical})^{1/2}$

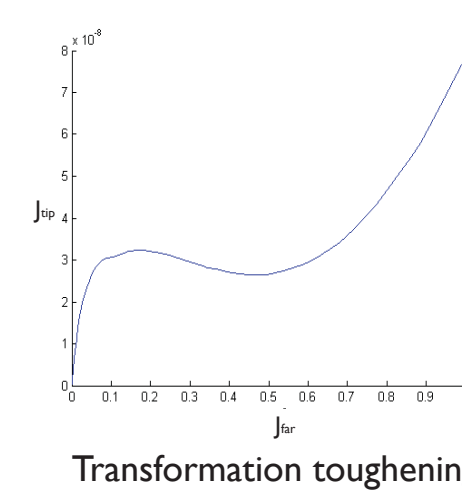
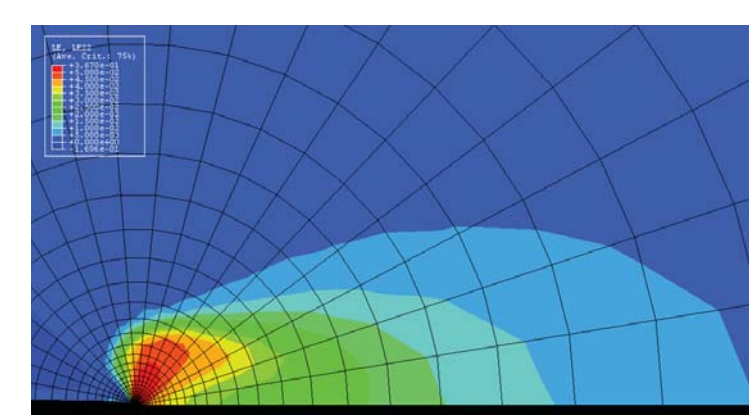
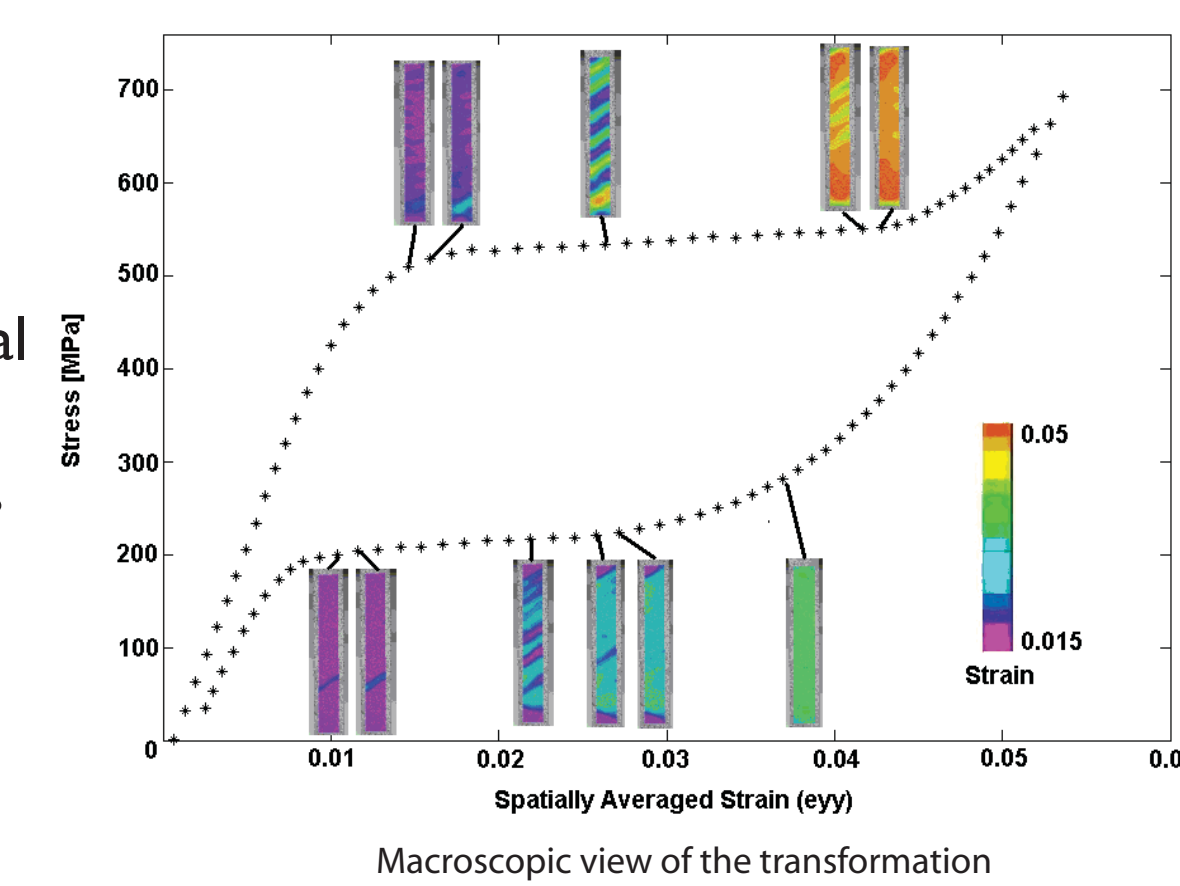


Acknowledgement: National Science Foundation

Deformation & Failure of Shape Memory Alloys

Samantha Daly

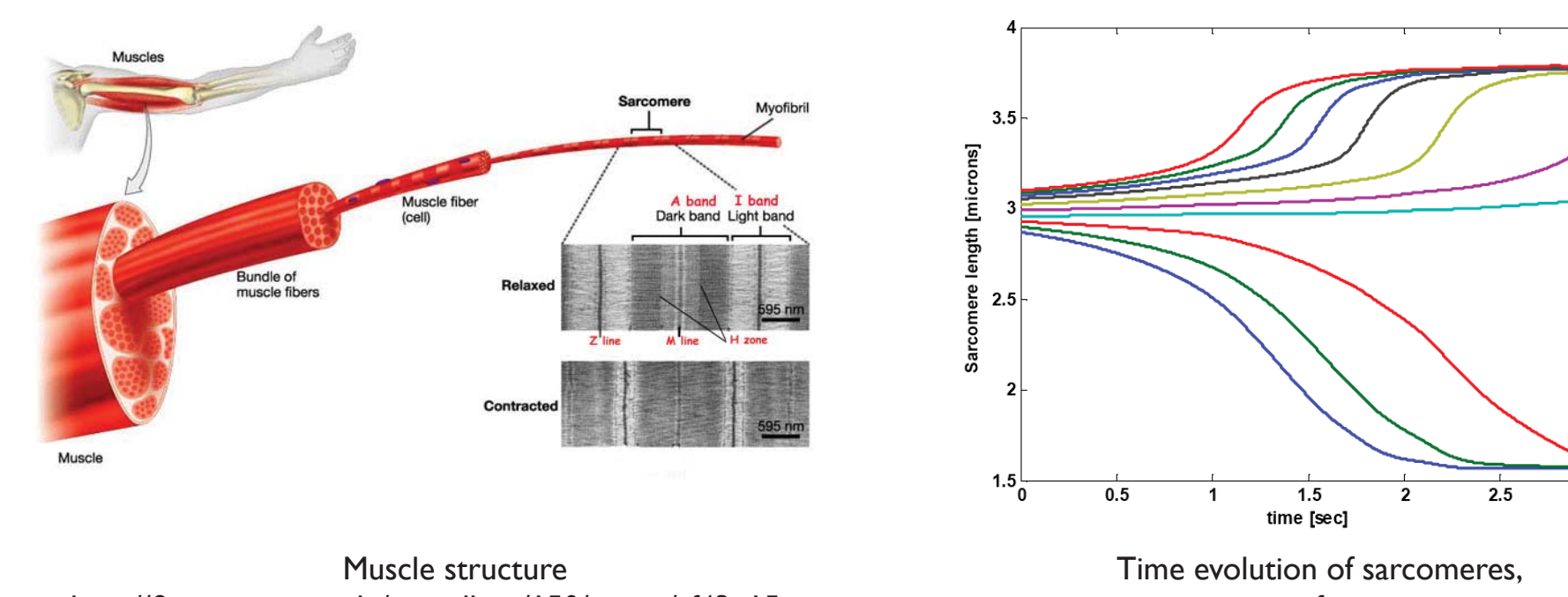
- SMAs are widely used in medical devices.
- Full-field strain measurements using Digital Image Correlation reveal onset, progress and details of localized bands.
- Measured thin sheet fracture toughness: $K_c = 51.4 \text{ MPa}\sqrt{m}$.



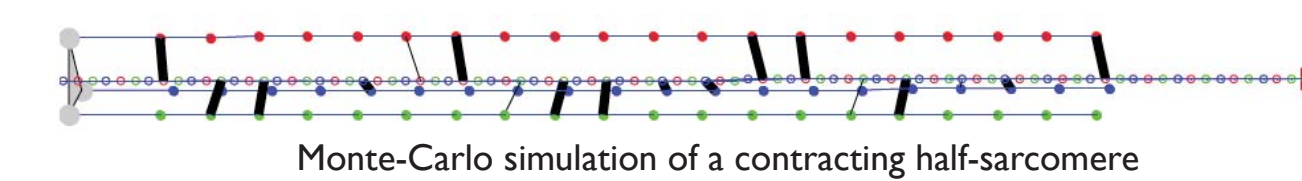
Joint work with Prof. G. Ravichandran
 Acknowledgement: National Science Foundation, Army Research Office and Powell Foundation

Muscle Mechanics

Sefi Givli



- Muscles are highly organized structures, with a hierarchical architecture that spans over several scales.
- The study aims at understanding the macroscopic behavior based on the properties of the micro-level (single sarcomere).
- Inherent instability of the single sarcomere leads to significant inhomogeneities within the myofibril.
- Monte-Carlo simulations are used for studying specialized functionalities, such as 'stretch activation.'

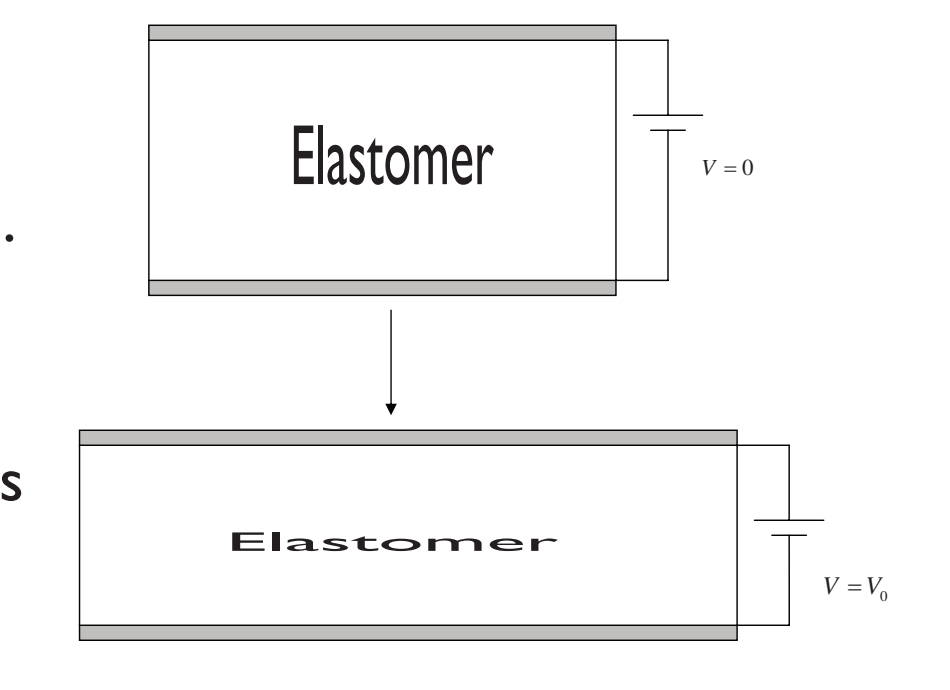


Acknowledgement: National Science Foundation and Lester Deutsch Foundation

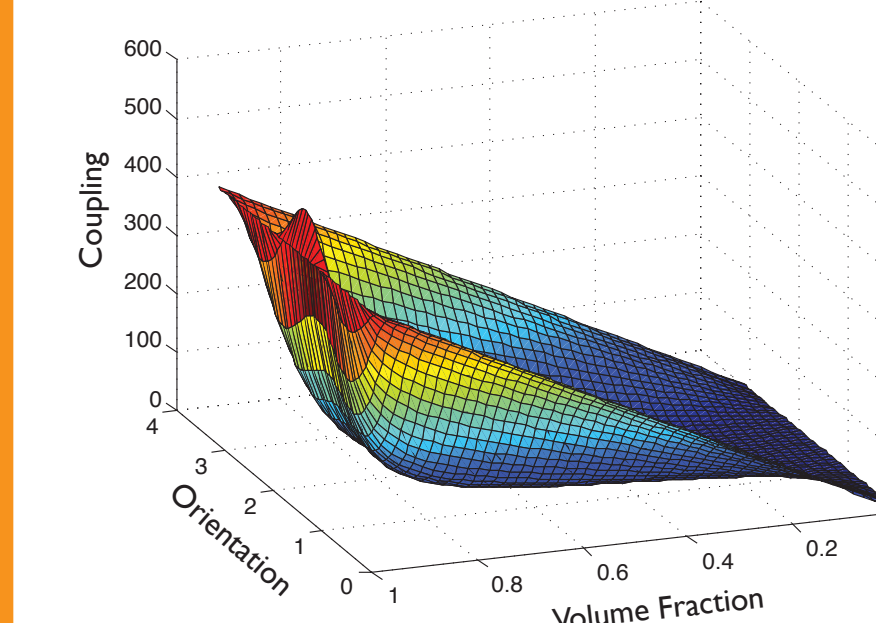
Soft Elastomer Actuators

Lixiu Tian

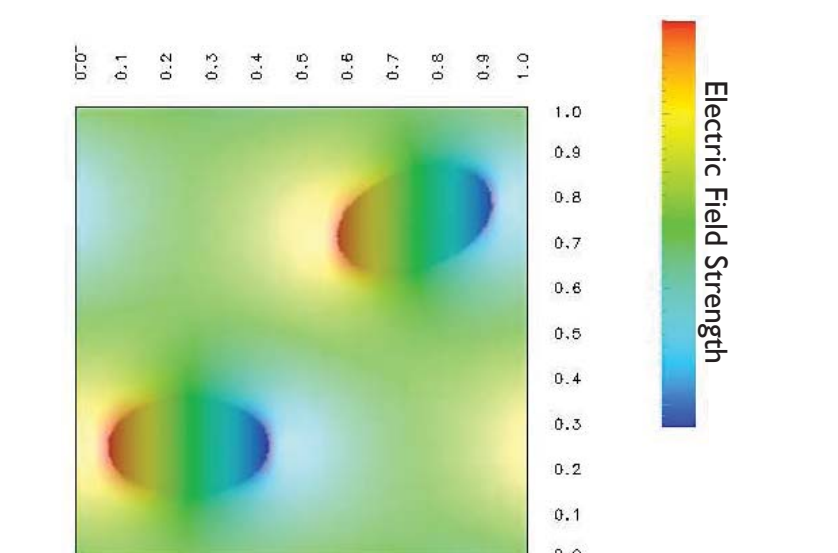
- Motivation: Improve electro-mechanical coupling through the use of a particulate composite.
- The induced (Maxwell) stress depends quadratically on the electric field. Thus field fluctuations can lead to very large electro-mechanical coupling.
- Developed a model and homogenization theory.



Actuation mechanism: The electrostatic attraction between electrodes squeezes the dielectric elastomer



The effective electro-mechanical coupling coefficient can exceed the values for each individual material.



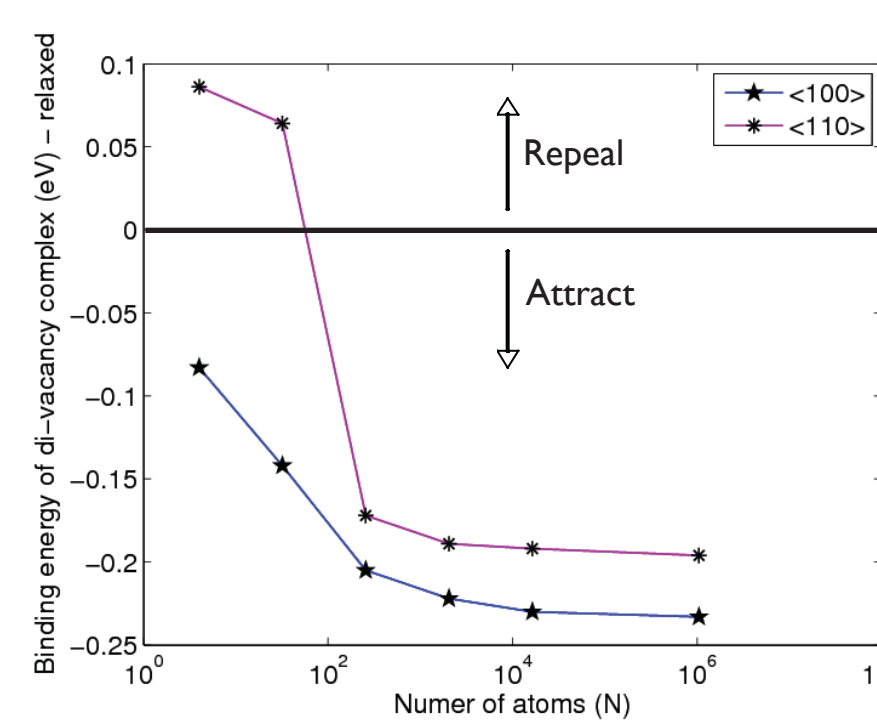
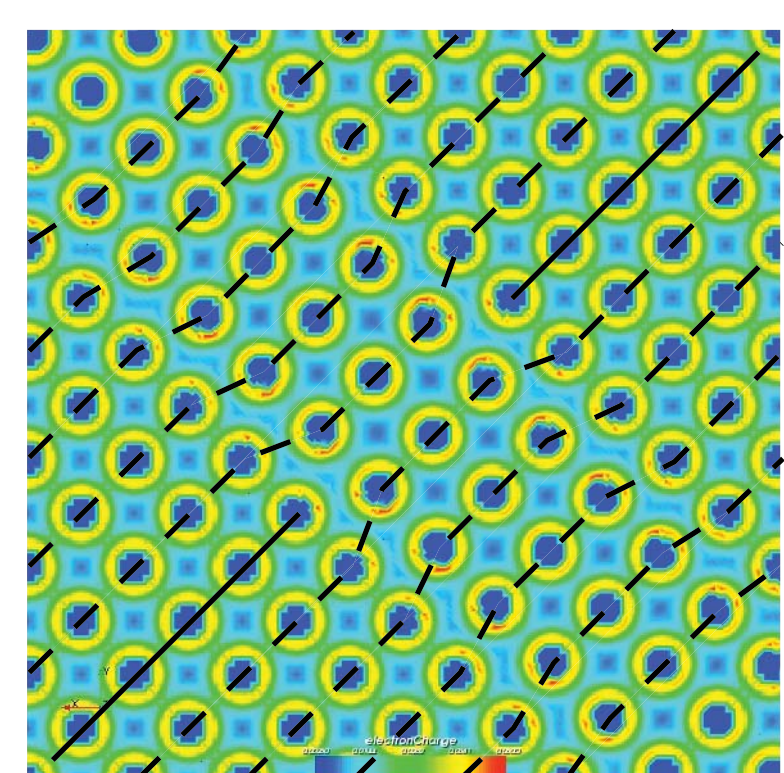
The electric field for a periodic composite in which two particles with high dielectric constant are placed randomly in a low dielectric constant matrix

Acknowledgements: National Science Foundation and US-Israel Binational Science Foundation

Electronic structure at continuum scales

Vikram Gavini

- Study of defects in solids requires a resolution of the electronic structure (pico-meters) with macroscopic range (micro-meters).
- Developed a completely seamless method—QC/OFDFT—to address this challenge.
- Studied vacancy clustering and prismatic loop nucleation on multi-million atom specimens.
- Scaling studies reveal the need for such calculations.

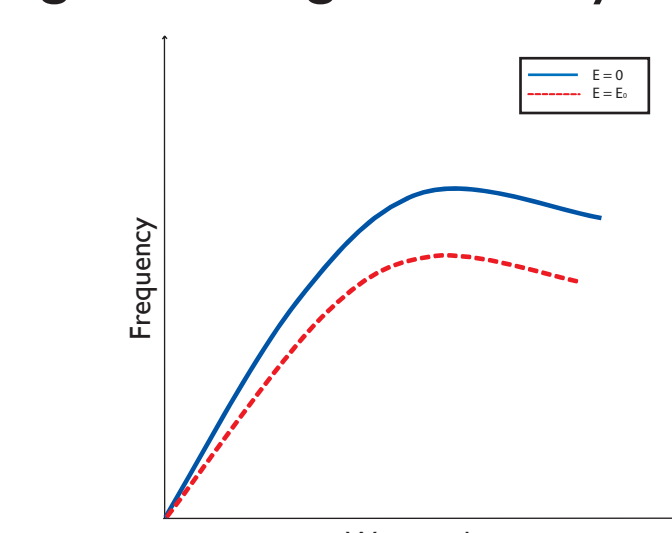
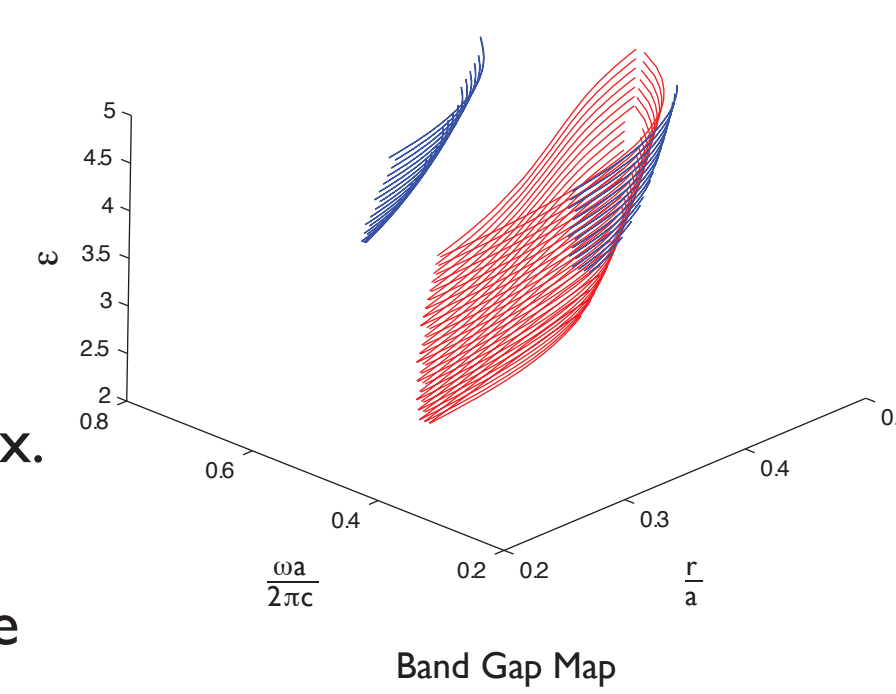


Joint work with Prof. Michael Ortiz
 Acknowledgement: Army Research Office and Department of Energy

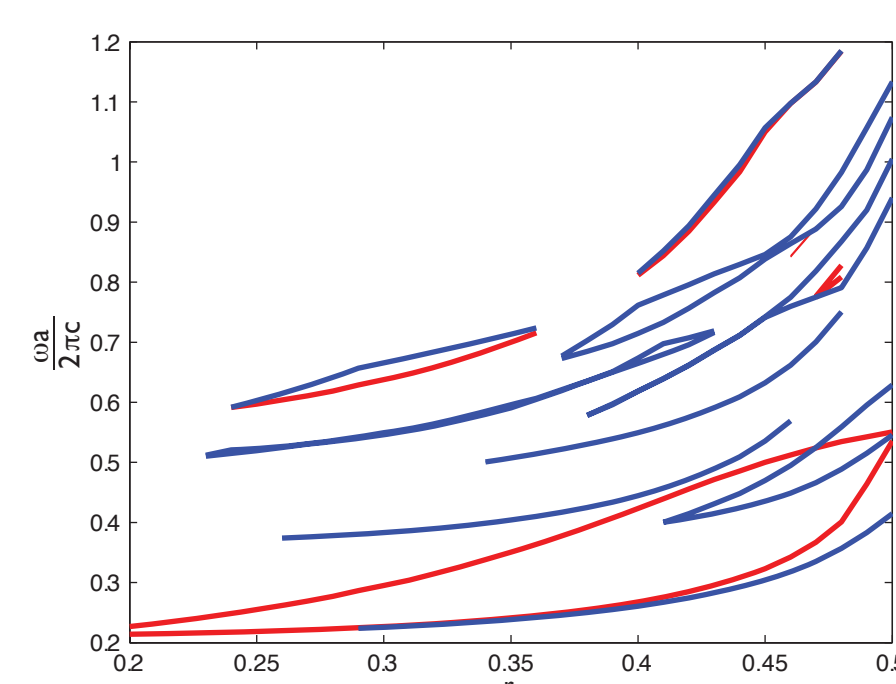
Ferroelectric Nano-Photonics

Phanish Suryanarayana

- Photonic structures are fabricated meta-material that can be used to engineer unique and nonlinear dispersion relations.
- Ferroelectric Nano Photonics = Nonlinear dispersion + tunable index.
- Use electrically modulated optical properties of ferro-electrics to make tunable photonic devices.
- Numerical studies to identify regions of high tunability.



Nonlinear dispersion can magnify small changes in index



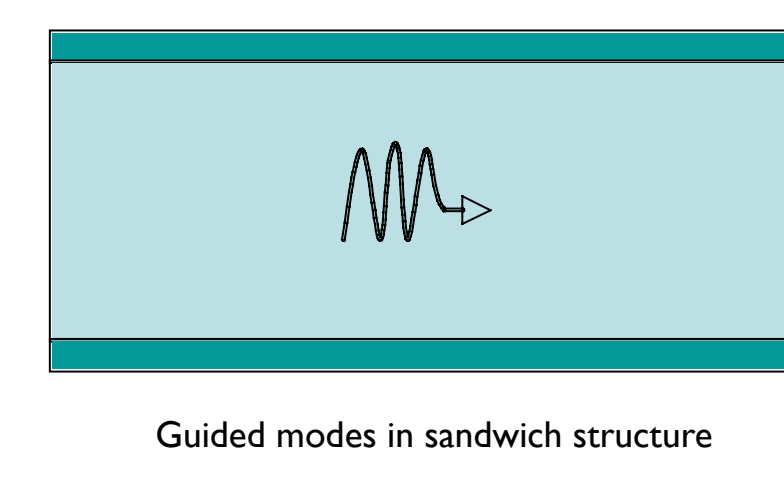
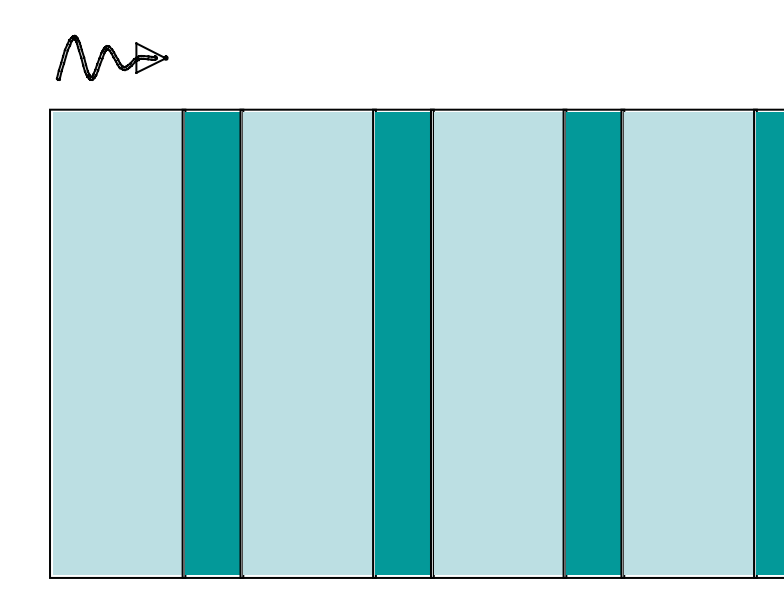
Triangular Lattice, Refractive index = 3.16

Acknowledgement: National Science Foundation

Stress Wave Propagation in Heterogeneous Media

Liping Liu

- Wave propagation in heterogeneous media leads to unusual dispersion and propagation properties.
- Investigating surface modes in heterogeneous media
- Investigating guided modes in a sandwich structure
- Coupling between the flexural modes and longitudinal modes
- Applications to high-speed boats

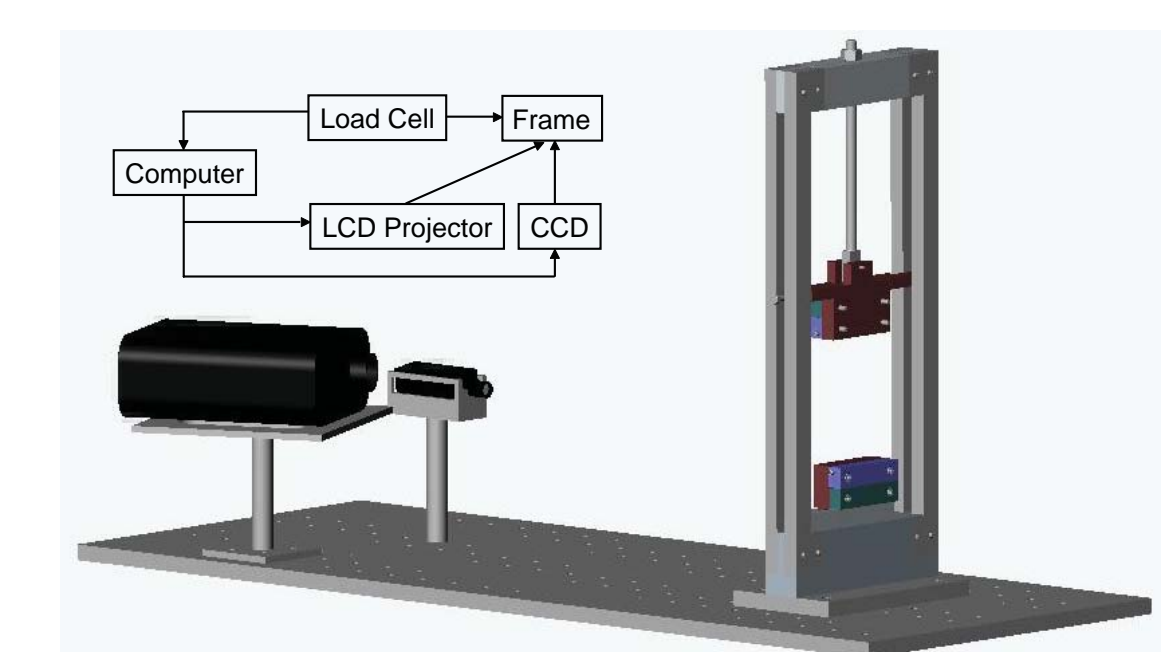
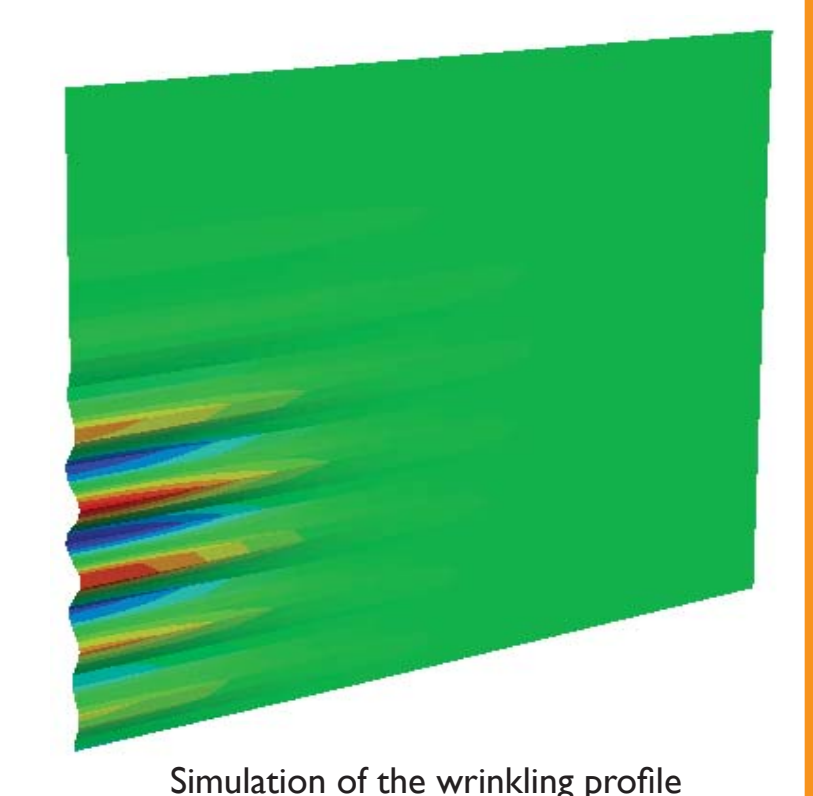


Acknowledgement: Office of Naval Research

Wrinkling on Dielectric Elastomer Membranes

Ling Zheng

- Understand the mechanism of wrinkling instability of a thin polymer membrane subjected to uniaxial tensile loading.
- Investigate the wrinkle profile and distribution experimentally and numerically.
- Suppress the wrinkling instability of dielectric elastomer membranes by means of dielectric actuation.



Joint work with Prof. G. Ravichandran
 Acknowledgement: National Aeronautics and Space Administration