12.00pm

Challenges and Opportunities in being Predictive for Complex Interacting Systems

Roger Ghanem
USC

Abstract

With mobility of people, information, goods and financial instruments on the rise, it is increasingly difficult to decouple the operation of any components of the complex system making up the urban environment. This interaction gains is clearly exacerbated by international protocols for managing anthropogenic factors of climate change. The stability, let alone optimality of such complex system are far from assured, and involve a coupled dynamics on a multitude of time scales. In this environment, the ability to be predictive, or even anticipative, may hold the key for resilience and even optimality. In this talk I will describe some research challenges and opportunities that are pertinent to this goal.

Biography

Roger Ghanem is Professor and the Gordon S. Marshall Professor in the Viterbi School of Engineering at the University of Southern California where he holds appointments in the Departments of Aerospace & Mechanical Engineering and Civil & Environmental Engineering. His recent research focuses on stochastic modeling, analysis, and computations for multiscale and multiphysics problems. Ghanem has received numerous recognitions for his research and teaching including awards from the US National Associated for Computational Mechanics, the International Association for Structural Safety and Reliability and ASCE. Ghanem is the founding Chair of the USACM Committee on UQ and the Programs Director for the SIAM SIAG on UQ and serves on the NRC Committee on the Mathematical Foundations of Uncertainty Quantification and V&V. He currently serves as the President of the Engineering Mechanics Institute of ASCE.

Prediction for Complex Systems

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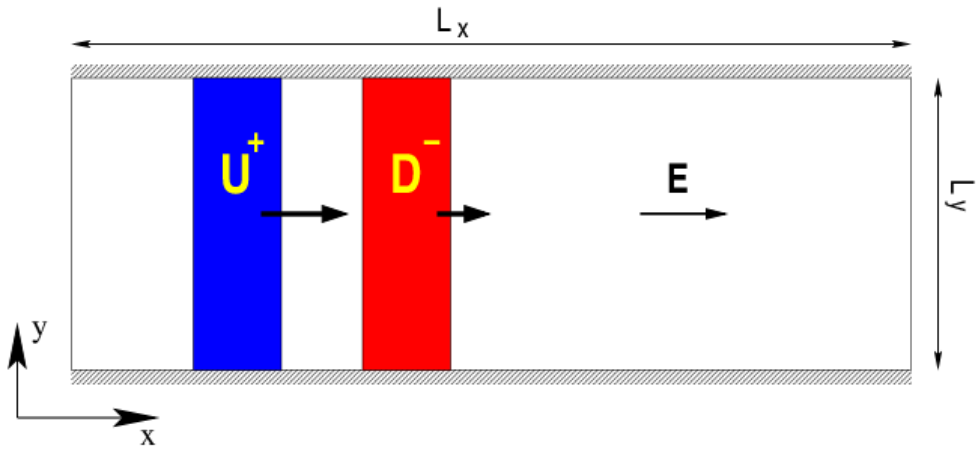
- Complex systems cannot be tested.
- Computers are big: can model phenomena at very fine resolution.
- Sensors can resolve phenomena at very fine resolution.
- Many systems are interconnected and failure in any of them can have a cascade effect: must be reliable about stating reliabilities.

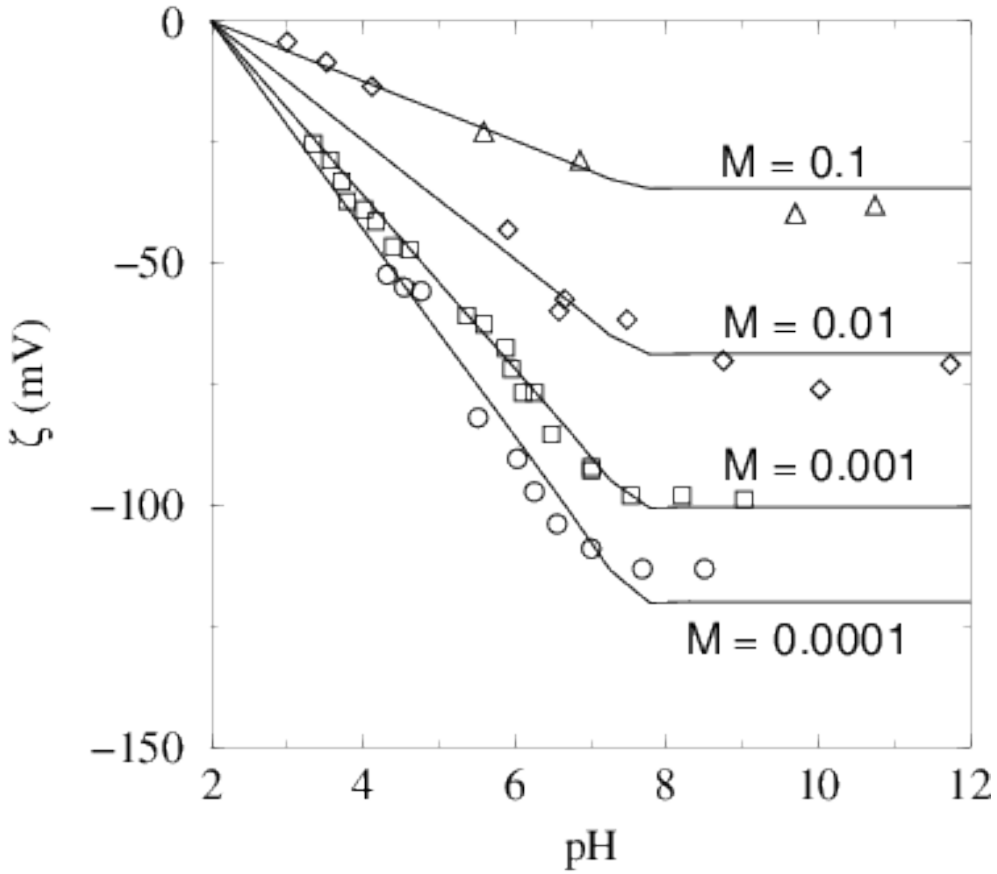
Smart Biofluidic Sensor

Unlabeled protein mixed with dye yields labeled protein:



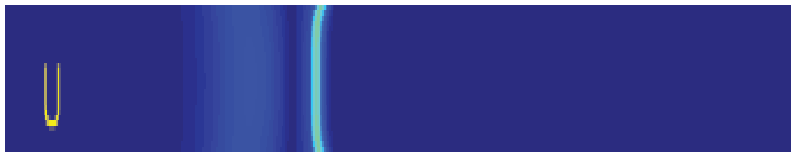
Smart Biofluidic Sensor

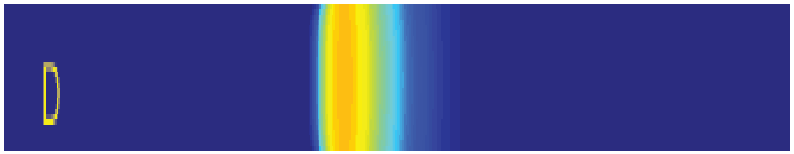
Variability (ignorance) about behavior near the wall:

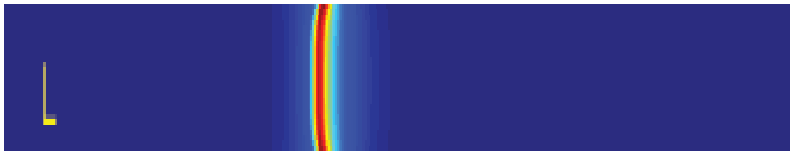


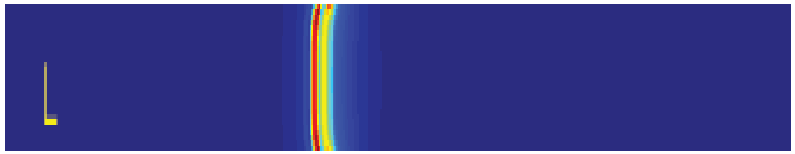
Smart Biofluidic Sensor

Uncertainty in predicted behavior: Initial conditions:



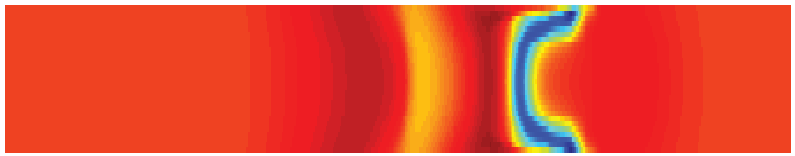






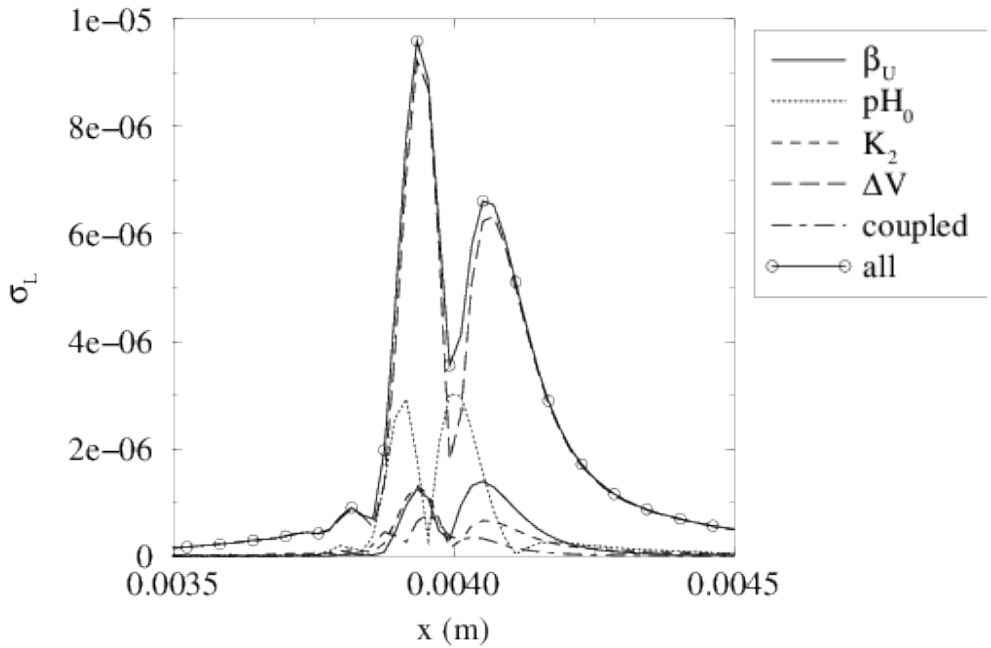
Smart Biofluidic Sensor

Uncertainty in predicted behavior: Later times:

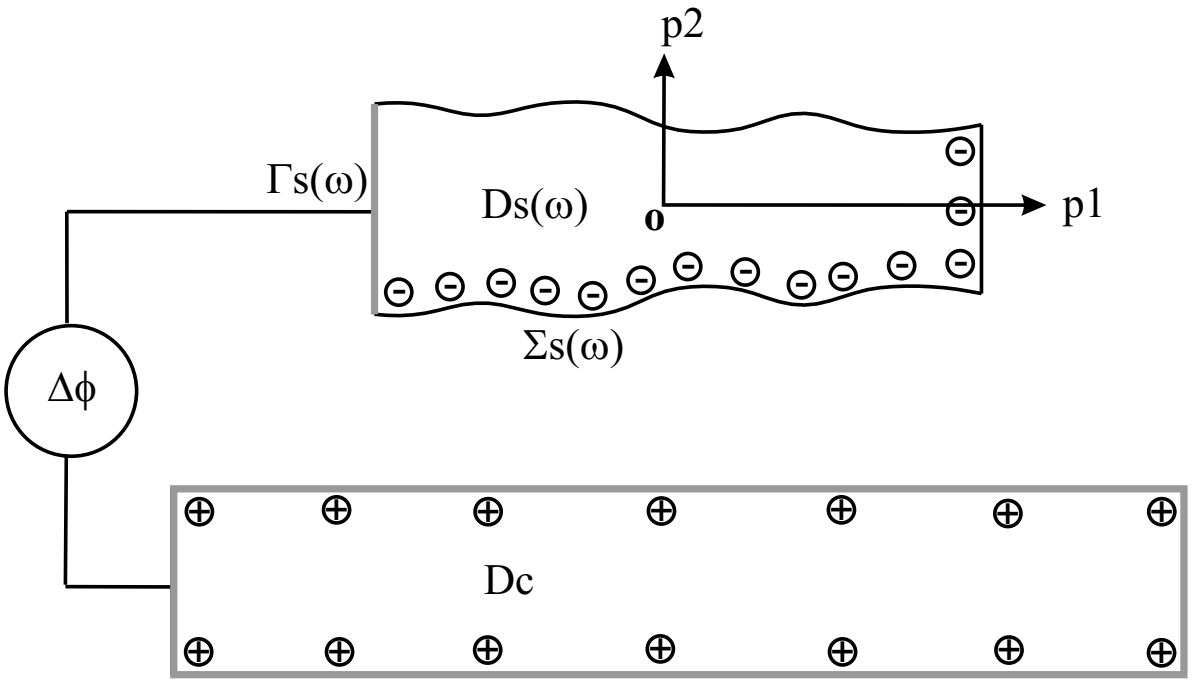
Smart Biofluidic Sensor

Reliability of prediction varies over space and time:



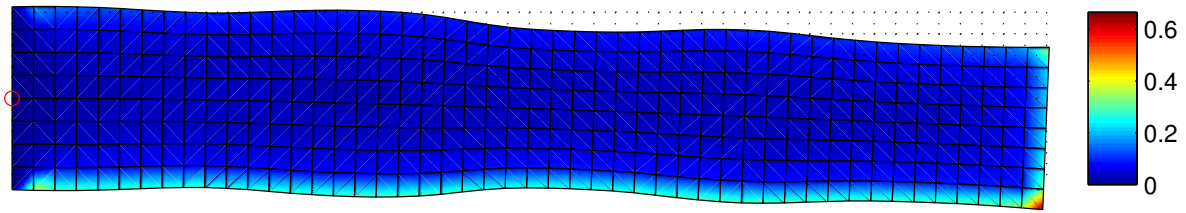
Nano Electro-Mechanical Sensor

Mechanical Deformation Induced by Electrostatic Effects



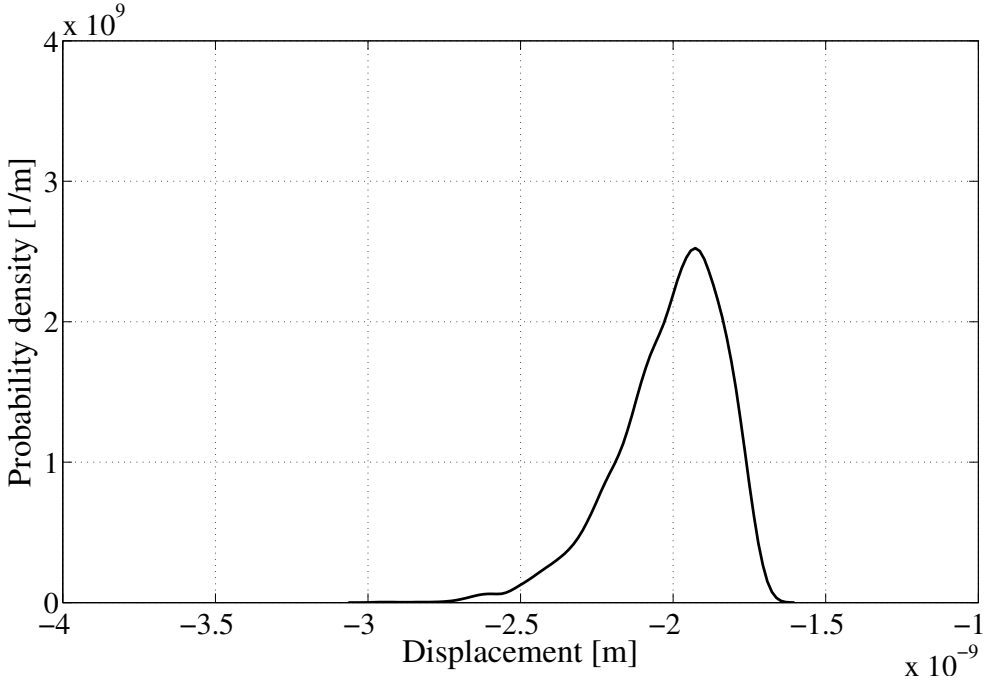
Nano Electro-Mechanical Sensor

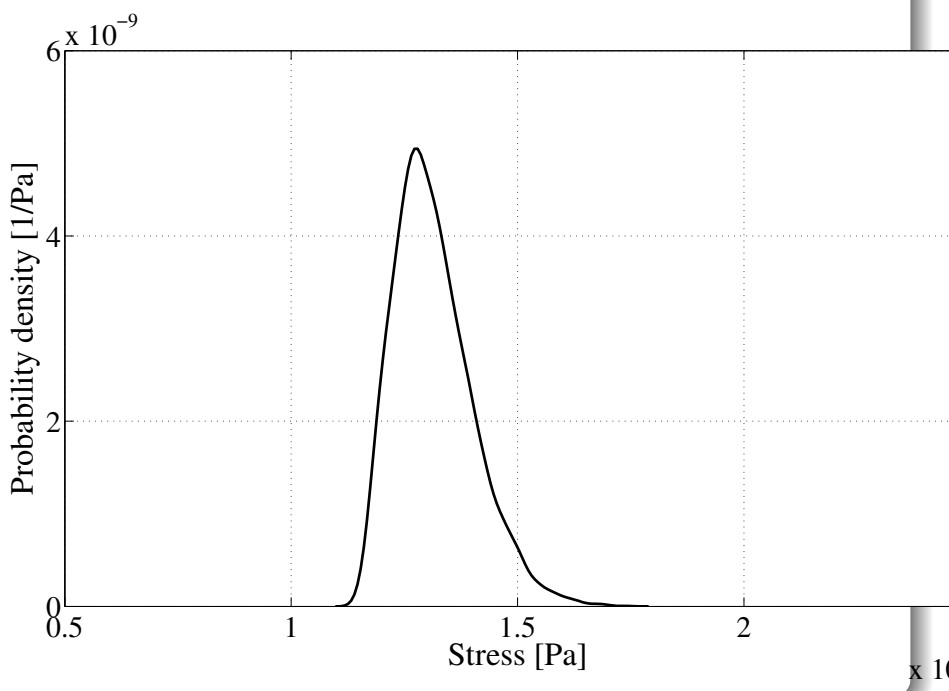
Manufacturing and Natural Variability



Nano Electro-Mechanical Sensor

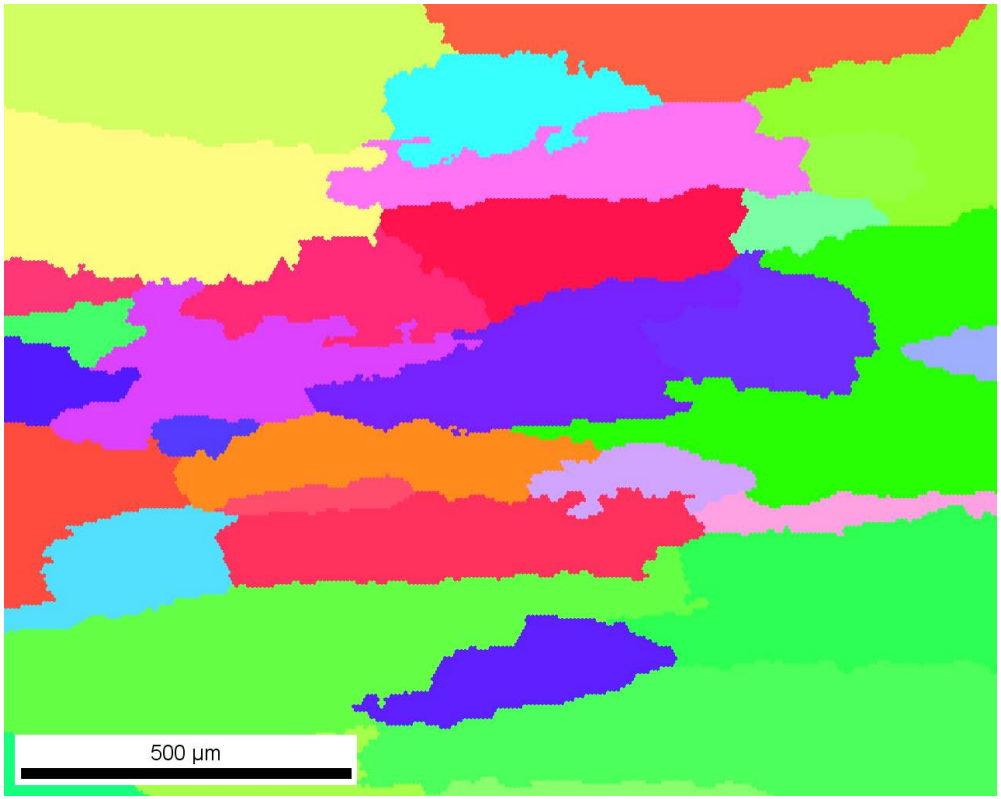
Uncertainty in Performance





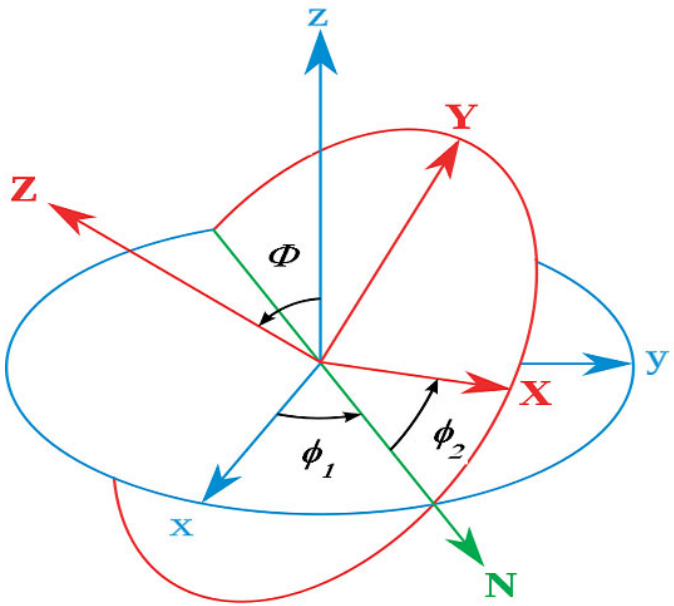
Damage Sensors in Polycrystals

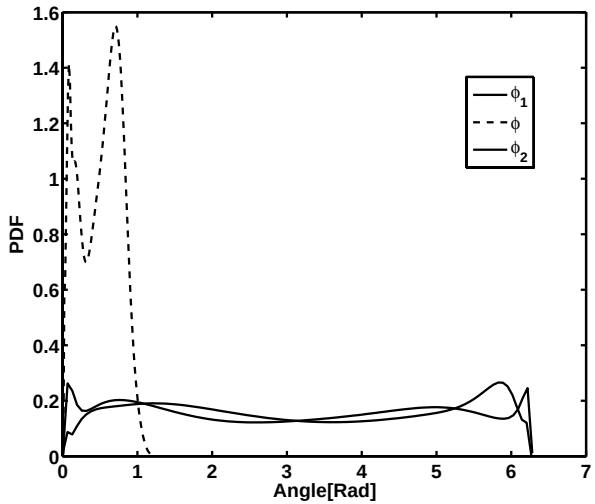
Variability in Morphology and Properties



Damage Sensors in Polycrystals

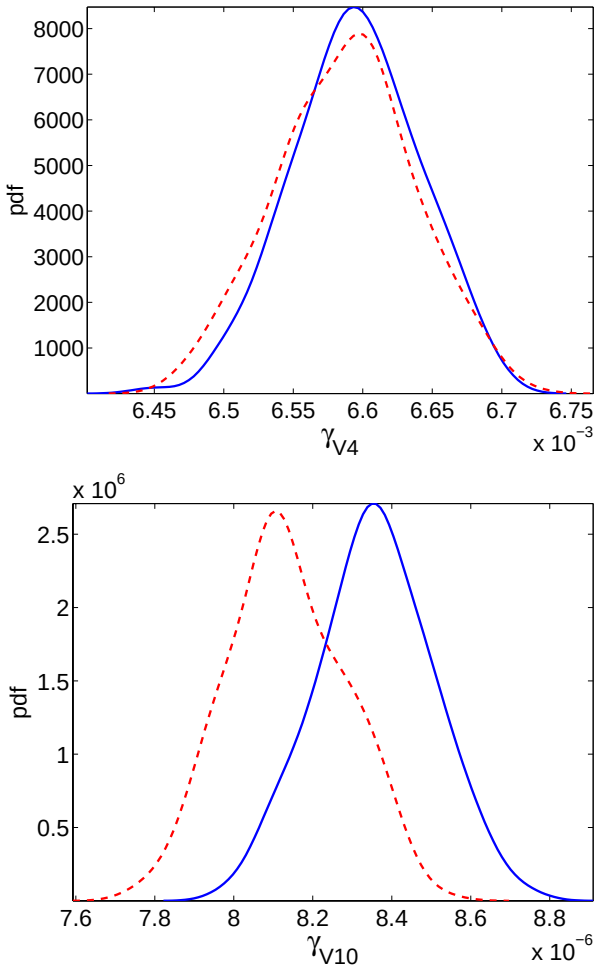
Probabilistic Models: Estimating joint pdf for fine scale





Damage Sensors in Polycrystals

If we could sense stran energy density over mm-scale



A data-driven mechanistic model of behavior on mm-scale of detecting damage at the sub-micron scale.

Concluding Thoughts

- Challenge in repackaging our understanding and observations of the pysical world to be adapted to new technologies: sensors and computers.
- Reliability is a property of information, and not of a system. For critical systems, a challenge is to understand what information is required to ensure acceptable reliability.