

Mechanics of Field-Responsive Materials and Reliable Data-Driven Prediction

Prashant K. Jha, Assistant Professor, Mechanical Engineering, South Dakota Mines, USA.

ABSTRACT

Field-responsive soft materials derive their macroscopic behavior from particle-scale interactions, material architecture, and evolving interfaces. The central modeling question is which of these features a continuum description must retain for prediction and design. Using hard-magnetic soft materials as a detailed example, I will show how particle concentration changes both stiffness and magnetic loading, why sensitivity to the constitutive model depends on where magnetic material lies relative to the dominant deformation, and how structural geometry, particle distribution, and remanent magnetization can be designed together. I will also discuss ongoing extensions to anisotropic particle architectures and particle-matrix degradation under repeated actuation.

When detailed mechanics models must be evaluated repeatedly for design or decision-making, their computational cost can become prohibitive. The challenge is not merely to replace them with faster approximations, but to determine whether an approximation is adequate for the prediction at hand. In the second part of the talk, I will briefly discuss our work toward reliable data-driven mechanics through physics-based correction of neural operators and computational-twin studies that combine error assessment and adaptation as operating conditions change. Together, these directions address two requirements for predictive mechanics: representing the mechanisms that govern material behavior and making repeated, reliable use of those models in design and decision-making.

ABOUT THE SPEAKER

Prashant K. Jha is an Assistant Professor of Mechanical Engineering at South Dakota Mines, where he leads the Computational Engineering Analysis and Design Lab. He earned his M.E. at the Indian Institute of Science and his Ph.D. at Carnegie Mellon University and subsequently held postdoctoral positions at Louisiana State University and the Oden Institute at The University of Texas at Austin. His research lies in computational mechanics, with emphasis on complex materials and interfaces, material-structural design, and reliable data-driven prediction. His work combines analytical and numerical methods with open-source research software.

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