Materials Science and Engineering Department

Winter Seminar Series

Mechanism-Based 3D Mechanical Metamaterials: Design, Modeling, and Application

Prof. Yue (Luna) Zheng
Department of Mechanical Engineering and Mechanics
Drexel University

February 25, 2026
11AM-12PM | Hill Seminar Room (LeBow 240)

Mechanical metamaterials enable unprecedented control over mechanical behavior through deliberate mesoscale geometric design. While 2D architectures have been widely explored and integrated into practical systems, extending these concepts into fully three-dimensional structures remains far more challenging. The design space is constrained by geometric complexity, fabrication limitations, and predictive modeling difficulties arising from strong multiscale coupling and the computational intensity of current numerical approaches.

This work expands the 3D metamaterial design space by exploring mechanism-based architectures that leverage spatial deformation modes unavailable in 2D systems. Most importantly, we introduce a comprehensive and experimentally validated continuum modeling framework that bridges the gap between cell-level deformation mechanisms and macroscopic material response. This framework provides robust and efficient tools for predicting and designing 3D mechanical metamaterials, substantially reducing computational cost while enhancing physical insight. We further demonstrate functionalities uniquely enabled by fully 3D architectures and validate them through targeted proof-of-concept prototypes.

When integrated with advanced material platforms, these designs create new opportunities for practical implementation, including programmable actuation, reconfigurable structures, and adaptive sensing.

Yue (Luna) Zheng is a P. C. Chou Assistant Professor in Mechanical Engineering and Mechanics at Drexel University. She received her Ph.D. in Mechanical Engineering from UC San Diego and completed postdoctoral training at USC and UMass Amherst. Her research focuses on the mechanics of soft materials, soft robotics, and mechanical metamaterials, combining theory, computation, and experiments. She has published in PRL, PNAS, and JMPS, was selected as a Rising Star in Mechanical Engineering (2022).

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College of Engineering

FOR MORE INFORMATION

Contact: Dr. Caroline Schauer, cls52@drexel.edu
Keiko Nakazawa, kn52@drexel.edu
drexel.edu/materials