LMS Seminar

1 February 2024 at 2:00 pm - Room Jean Mandel

Mechanics of Soft Composites:
The Interplay between Geometrical Structuring and Large Deformation to Achieve Novel Behavior

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ABSTRACT

Soft composites offer new avenues for the design and fabrication of materials and devices that exhibit novel properties and functional behavior. Engineering the interplay between the geometrical structuring of constituent materials and the large deformation behavior of the soft matrix enables structural transformations and tunable properties. Here we explore the mechanics and the design of soft composites through analytical and numerical modeling as well as through experiments on physical prototypes fabricated using multi-material 3D printing. A first exemplar set focuses on both patterned and layered structures which exhibit deformation-induced pattern transformations. These structural transformations result in concomitant changes in a multitude of behaviors: giving superelastic and multilinear elastic response, enhanced mechanisms for energy storage, and the ability to manipulate wave propagation and alter phononic band gaps. Inspired by natural material systems, we also explore soft composite materials with alternating soft/stiff layered structures. The discrete anisotropic nature of these material systems are demonstrated to provide protective yet flexible armor and are separately found to be a novel design for soft actuators, transforming local compressive loading to large scale rotational motion. Also inspired by nature, a third set presents soft matrices augmented by stiff particles which yield a material with morphable surface topologies.

BIOGRAPHY

Mary C. Boyce is Professor of Mechanical Engineering, Provost Emerita of Columbia University, and Dean Emerita of The Fu Foundation School of Engineering and Applied Science at Columbia University. Prior to joining Columbia in July 2013, Provost Boyce had served on the faculty of the Massachusetts Institute of Technology for over 25 years, leading the Mechanical Engineering Department as Department Head from 2008 to 2013. As a faculty member, Professor Boyce's education and research efforts focus on the mechanics of materials, including theoretical, computational and experimental approaches. Her research explores the nonlinear and multi-scale mechanics of polymeric materials and soft composites. Her leadership in the field of mechanics of materials has expanded the ability to model and predict the highly nonlinear time and temperature dependence of polymeric materials based on their underlying physics. Her research has expanded understanding of the interplay between micro-geometry and the inherent physical behavior of a material. Recognition for her scholarly contributions to the field include election as a fellow of the American Academy of Mechanics, the American Society of Mechanical Engineers, the American Academy of Arts and Sciences, and the National Academy of Engineering. Professor Boyce has been awarded the 2015 Engineering Science Medal by the Society of Engineering Science and the 2020 Timoshenko Medal for Advances in Applied Mechanics by the American Society of Mechanical Engineers.