Special

APPLIED MATH COLLOQUIUM

Active and architectured sheets: From nematic elastomers to rigidly-foldable origami

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ABSTRACT:

Thin and slender structures exhibit a broad range of mechanical responses as the competition between stretching and bending in these structures can result in buckling, localized deformations like folding, and tension wrinkling. Active and architectured materials also exhibit a broad range of mechanical responses as features that manifest at the micro and mesoscale in these materials result in mechanical couplings at the engineering scale (thermal/electrical/dissipative/...) with novel function (the shape memory effect/ ferroelectricity/enhanced fracture toughness/ ...). Given this richness in behaviors, my research broadly aims to address the following questions: What happens when active and architectured materials are incorporated into thin and slender structures? Do phenomena inherent to these materials compete with or enhance those inherent to these structures? Does this interplay result in entirely new and unexpected phenomena? And can all this be exploited to design new functionality in engineering systems?

In this talk, I will explore these questions in the context of thin sheets of an active material in nematic elastomer as well as architectured sheets designed to fold continuously as origami. For the latter, I will completely characterize all rigidly and flat-foldable origami, and describe an efficient algorithm to compute their designs and deformations. For the former, I will show that a material instability inherent to nematic elastomers at the micron scale is capable of suppressing a structural instability (wrinkling) at the engineering scale. These results provide novel, yet concrete, design guidance for membrane structures (where wrinkling can diminish functionality), as well as tools to efficiently investigate robust and elegant concepts for deployable space structures, reconfigurable antennas, and soft robotics using origami.

BIO.
Paul Plucinsky is a postdoctoral researcher studying the mechanics of origami, helical structures and shape memory alloys at the University of Minnesota. He attended University of Michigan, receiving a Bachelors of Science in Civil Engineering (2010) and and Masters of Science in Structural Engineering (2011). He then moved to Caltech, where he received a Ph.D in Mechanical Engineering (2017) studying the deformations of thin nematic elastomer sheets. When not folding paper—and when his Achilles in functioning properly—you can often find him on the basketball court.

MONDAY, MARCH 4, 2019
4:15 PM – 5:15 PM
Building 2, Room 190

Massachusetts Institute of Technology