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

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ABSTRACT:

Thin sheet 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 manifest at the micro and mesoscale in these materials result in mechanical couplings at the engineering scale (thermal/electrical/dissipative/...) that enable functionality (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 sheets? Do phenomena inherent to these materials compete with or enhance those inherent to sheets? 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 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 improving the efficiency of solar sails and the performance of other 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.

BIOGRAPHY:

Paul Plucinsky joins the faculty in the USC Department of Aerospace and Mechanical Engineering as an Assistant Professor in January 2020. Prior to USC, Paul was a Postdoctoral Scholar in Aerospace Engineering and Mechanics at the University of Minnesota. He received his Ph.D. in Mechanical Engineering as Caltech in 2017, and a B.S. in Civil Engineering and M.S. in Structural engineering at the University of Michigan in 2011. Paul works at the interface of solid mechanics, materials science, and applied mathematics. He applies a theory-guided approach to a range of topics, including nematic elastomers, origami design, shape memory alloys, and phase transitions in nano-structures.