Swelling and Growth of Thin Structures

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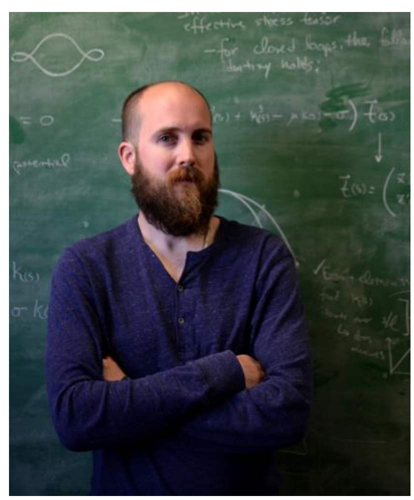
Abstract

Swelling-induced deformations of slender structures occur in many biological and industrial environments, and the shapes and patterns that emerge can vary across many length scales. The dynamics of fluid movement within elastic networks, and the interplay between a structure's geometry and its boundary conditions, play a crucial role in the morphology of growing tissues, the shrinkage of mud and moss, and the curling of cartilage, leaves, and pine cones. We aim to utilize swelling-induced deformations of soft mechanical structures to dynamically shape materials. Adaptive structures that can bend and fold in an origami-like manner provide advanced engineering opportunities for deployable structures, soft robotic arms, mechanical sensors, and rapid-prototyping of 3D elastomers. Swelling is a robust approach to structural change as it occurs naturally in humid environments and can easily be adapted into industrial design. Small volumes of fluid that interact favorably with a material can induce large, dramatic, and geometrically nonlinear deformations. This talk will examine the geometric nonlinearities that occur as slender structures are swollen – surfaces will crease, beams will bend and snap, circular plates will warp and twist, and fibers will coalesce and detach. I will describe the intricate connection between materials and geometry, and present a straightforward means to permanently morph 2D sheets into 3D shapes.

Bio



Douglas Holmes is an Assistant Professor in the Department of Mechanical Engineering at Boston University. He received degrees in Chemistry from the University of New Hampshire (B.S. 2004), Polymer Science & Engineering from the University of Massachusetts, Amherst (M.S. 2005, Ph.D. 2009), and was a postdoctoral researcher in Mechanical & Aerospace Engineering at Princeton University. Prior to joining Boston University, he was an Assistant Professor of Engineering Science and Mechanics at Virginia Tech. His group’ s research specializes on the mechanics of slender structures, with a focus on understanding and controlling shape change. He received the NSF CAREER Award and the ASEE Ferdinand P. Beer and E. Russell Johnston Jr. Outstanding New Mechanics Educator award.