



Professor Douglas P. Holmes

From: Douglas P. Holmes, Michal Ursiny and Alfred J. Crosby, “Crumpled surface structures”, *Soft Matter*, 2008, Vol. 4, pp. 82-85,

Engineering Science & Mechanics

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See: <http://www2.esm.vt.edu/~dpholmes/>

Education & Professional Experience:

Assistant Professor, Engineering Science & Mechanics, Virginia Tech, Blacksburg, VA (2011 – 2013)

Postdoctoral Research Associate, Princeton University, Princeton, NJ (2009 – 2011)

Ph.D. in Polymer Science & Engineering, University of Massachusetts, Amherst, MA (2009)

M.S. in Polymer Science & Engineering, University of Massachusetts, Amherst, MA (2005)

B.S. in Chemistry, University of New Hampshire, Durham, NH (2004)

Awards & Honors:

ASEE Ferdinand P. Beer and E. Russell Johnston, Jr. Outstanding New Mechanics Educator 2013

Visiting Professor, University Pierre and Marie Curie, Paris, FR 2013

Oxford University - OCCAM Visiting Scholar, Oxford, UK 2013

NSF-PACAM 2013 Travel Fellowship 2013

Oxford University - OCCAM Visiting Scholar, Oxford, UK 2011

Best Poster Prize at the WE-Heraeus Seminar, Bad Honnef, DE 2010

ICAM Scientist Travel Award: Dynamics in Soft Condensed Matter: Dynasoft 2010, Corsica, FR 2010

NSF Fellowship - Short Course on Mechanics of Soft Materials 2010

APS Padden Award Finalist 2009

Adhesion Society Peebles Award 2009

Distinguished Best Paper at the Adhesion Society 2008

UNH College of Engineering & Physical Sciences Douglas R. Woodward Award 2004

UNH College of Engineering & Physical Sciences Wilfred F. Langelier Award 2004

Summer Undergraduate Research Fellowship for Polymer Research at the University of Sydney, AU 2003

UNH Chemistry Vernon Lerch Award 2001

Research Interests:

Slender structures are ubiquitous. Commonly described by rods, plates, and shells, these thin structures are embodied by carbon nanotubes, air plane wings, blood vessels, spider silk, contact lenses, and human hair. The mechanics of these thin objects are fascinating because geometric nonlinearities will arise even as the material properties remain linear - hair will curl and tangle, skin will wrinkle, and soda cans will crumple. We are interested in understanding and controlling the mechanics, physics, and geometry of these thin structures.

Publications:

See: <http://www2.esm.vt.edu/~dpholmes/> <http://www2.esm.vt.edu/~dpholmes/dpholmes-CV.pdf>

Selected Publications (taken from <http://www2.esm.vt.edu/~dpholmes/>):

“Dynamics of Snapping Beams and Jumping Poppers”, A. Pandey, D.E. Moulton, D. Vella, and D.P. Holmes, ABSTRACT: We consider the dynamic snapping instability of elastic beams and shells. We show that the stretchability of the arch plays a critical role in determining not only the post-buckling mode of deformation, but also the timescale of snapping, and the frequency of the arch's vibrations about its final equilibrium state. We show that the growth rate of the snap-through instability, and its subsequent ringing frequency, can both be interpreted physically as the result of a sound wave in the material propagating over a distance comparable to the radius of curvature of the arch. Finally, we extend our analysis of the ringing frequency of indented arches to understand the 'pop' heard when everted shell structures snap-through to their stable state. Remarkably, we find that not only are the scaling laws for the ringing frequencies in these two scenarios identical, but also the respective prefactors are numerically close; this allows us to develop a master curve for the frequency of ringing in snapping beams and shells.

D.P. Holmes, iMechanica - Journal Club, February 2012

Welcome to February 2012's Journal club, which will include a discussion on elastic instabilities for form and function. Not long ago, the loss of structural stability through buckling generally referred to failure and disaster. It was a phenomenon to be designed around, and rarely did it provide functionality*. The increasing focus on soft materials, from rubbers and gels to biological tissues, encouraged scientists to revisit the role of elastic instabilities in the world around us and inspired their utilization in advanced materials. Now the field of elastic instabilities, or extreme mechanics, brings together the disciplines of physics, mechanics, mathematics, biology, and materials science to extend our understanding of structural instabilities for both form and function. In this journal club, we're going to look at research on the wrinkling, crumpling, and snapping of soft or slender structures.

“Bending and Twisting of Soft Materials by Non-Homogenous Swelling”, D.P. Holmes, M. Roché, T. Sinha, and H.A. Stone, *Soft Matter*, 7, 5188, 2011

ABSTRACT: Soft materials, e.g. biological tissues and gels, undergo morphological changes, motion, and instabilities when subjected to external stimuli. Tissues can exhibit residual internal stresses induced by growth, and generate elastic deformations to move in response to light or touch, curl articular cartilage, aid in seed dispersal, and actuate hygromorphs, such as pine cones. Understanding the dynamics of such osmotically driven movements, in the influence of geometry and boundary conditions, is crucial to the controlled deformation of soft materials. We examine how thin elastic plates undergo rapid bending and buckling instabilities after

exposure to a solvent that swells the network. A circular disc bends and buckles with multiple curvatures, and a large-amplitude traveling wave rotates azimuthally around the disc.

“Draping Films: A Wrinkle to Fold Transition”, D.P. Holmes and A.J. Crosby, *Physical Review Letters*, 105, 038303, 2010

ABSTRACT: A polymer film draping over a point of contact will wrinkle due to the strain imposed by the underlying substrate. The wrinkle wavelength is dictated by a balance of material properties and geometry; most directly the thickness of the draping film. At a critical strain, the stress in the film will localize, causing hundreds of wrinkles to collapse into several discrete folds. In this paper, we examine the deformation of an axisymmetric sheet and quantify the force required to generate a fold. The onset of folding, in terms of a critical force or displacement, scales as the thickness to the four-ninth power, which we predict from the energy balance of the system. The folds increase the tension in the remainder of the film causing the radial stress to increase, thereby decreasing the wavelength of the remaining wrinkles.

“Crumpled Surface Structures”, D.P. Holmes, M. Ursiny, and A.J. Crosby. *Soft Matter*, 4, 82, 2008.

ABSTRACT: The topographic control of pattern features is of great interest for a range of applications including the generation of ultrahydrophobic surfaces, microfluidic devices, and the control and tuning of adhesion. In these areas, surface patterning is achieved by a variety of techniques including: photolithography, imprint lithography, and surfaces wrinkling. In this paper, we present a scalable patterning method based on surface plate buckling, or crumpling, to generate a variety of topographies that can dynamically change shape and aspect ratio in response to stimuli.

“Snapping Surfaces”, D.P. Holmes and A.J. Crosby. *Advanced Materials*, 19, 3589, 2007

ABSTRACT: The responsive mechanism of the Venus flytrap has captured the interest of scientists for centuries. Although a complete understanding of the mechanism controlling the Venus flytrap movement has yet to be determined, a recent publication highlights the importance of geometry and material properties for this fast, stimuli-responsive movement. Specifically, the movement is attributed to a snap-through elastic instability whose sensitivity is dictated by the length scale, geometry, and materials properties of the features. Here, we use lessons from the Venus flytrap to design surfaces that dynamically modify their topography. We present a simple, biomimetic responsive surface based on an array of microlens shells that snap from one curvature to another when a critical stress develops in the shell structure.