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Kirigami-Inspired Metamaterials - from Morphable Structures to Soft Robots

Katia Bertoldi

Professor of Applied Mehanics, John A.Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA

ABSTRACT:

In the search for materials with new properties, there have been great advances in recent years aimed at the construction of mechanical systems whose behaviour is governed by structure, rather than composition. Through careful design of the material's architecture, new material properties have been demonstrated, including negative Poisson's ratio, high stiffness-to-weight ratio and mechanical cloaking. While originally the field focused on achieving unusual (zero or negative) values for familiar mechanical parameters, more recently it has been shown that non-linearities can be exploited to further extend the design space. In this talk I will focus on kirigami-inspired metamaterials, which are produced by introducing arrays of cuts into thin sheets. First, I will demonstrate that instabilities triggered under uniaxial tension can be exploited to create complex 3D patterns and even to guide the formation of permanent folds. Second, I will show that such non-linear systems can be used to designs smart and flexible skins with anisotropic frictional properties that enables a single soft actuator to propel itself. Finally, I will focus on bistable kirigami metamaterials and show that they provide an ideal environment for the propagation non-linear waves.

BIOGRAPHY:

Katia Bertoldi is the William and Ami Kuan Danoff Professor of Applied Mechanics at the Harvard John A.Paulson School of Engineering and Applied Sciences. She earned master degrees from Trento University (Italy) in 2002 and from Chalmers University of Technology (Sweden) in 2003, majoring in Structural Engineering Mechanics. Upon earning a Ph.D. degree in Mechanics of Materials and Structures from Trento University, in 2006, Katia joined as a PostDoc the group of Mary Boyce at MIT. In 2008 she moved to the University of Twente (the Netherlands) where she was an Assistant Professor in the faculty of Engineering Technology. In January 2010 Katia joined the School of Engineering and Applied Sciences at Harvard University and established a group studying the mechanics of materials and structures. She is the recipient of the NSF Career Award 2011 and of the ASME's 2014 Hughes Young Investigator Award. She serves as an Associate Editor for the journal Extreme Mechanics Letters. She published over 120 peer-reviewed papers and several patents. For a complete list of publication and research information: https://bertoldi.seas.harvard.edu/ Dr Bertoldi's research contributes to the design of materials with a carefully designed meso-structure that leads to novel effective behavior at the macroscale. She investigates both mechanical and acoustic properties of such structured materials, with a particular focus on harnessing instabilities and strong geometric non-linearities to generate new modes of functionality. Since the properties of the designed architected materials are primarily governed by the geometry of the structure (as opposed to constitutive ingredients at the material level), the principles she discovers are universal and can be applied to systems over a wide range of length scales.