COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN

Mechanical Engineering Seminar Series

Topology Meet Phononics

Wave Manipulation on Edges and Interfaces

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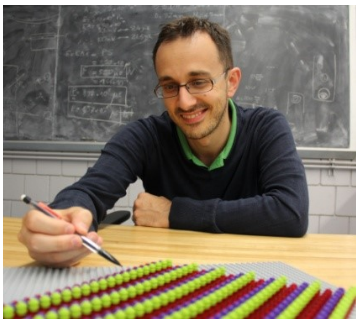

Tuesday, December 3, 2019
4:00 p.m.
2147 GG Brown

Abstract

Elastic metamaterials are structural materials that owe their unique wave manipulation capabilities to their complex internal architecture. Topological metamaterials are special metamaterials whose behavior is directly controlled by the topology of their phonon band structure. In this talk, we present two problems in topological phononics that deal with the propagation of waves at edges and interfaces.

The first problem regards a class of metamaterials known as topological Maxwell lattices. While this class of systems has been the object of extensive theoretical investigation, the classical treatment has been limited to ideal configurations and confined to the static limit. Here, we explore the dynamics of lattices in which the ideal hinges that appear in the theoretical models are replaced by ligaments capable of supporting bending deformation – a scenario practically observed in structures realized using cutting or printing fabrication techniques. Using laser vibrometry experiments, we reveal how the zero-energy floppy edge modes predicted for ideal configurations morph into finite-frequency wave modes that localize at the material boundaries. We also show that the topological polarization results in pronounced asymmetric wave transport over a broad low-frequency range.

In the second part of the presentation, we demonstrate the existence of valley-Hall edge states in the in-plane dynamics of honeycomb lattices with bi-valued strut thickness. We exploit these states to achieve non-trivial waveguiding that is immune to backscattering from sharp corners. We present how different types of interfaces can be combined into multi-branch junctions to realize a variety of structural logic designs. We illustrate this potential with two applications. The first is a direction-selective waveguide tree that endows the lattice with a strong asymmetric wave transport behavior. The second is an internal loop along which the energy can be periodically trapped and released, effectively working as a signal delayer.

Bio

Stefano Gonella received Ph.D. and M.S. in aerospace engineering from the Georgia Institute of Technology in 2007 and 2005, respectively, following a Laurea, also in aerospace engineering, from Politecnico di Torino (Italy) in 2003. He joined the faculty of the Department of Civil, Environmental and Geo- Engineering at the University of Minnesota in 2010, after 3 years of post-doctoral experience at Northwestern University. His research interests revolve around the modeling, simulation and experimental characterization of wave phenomena in architected materials, phononic crystals, and acoustic metamaterials. His latest efforts have been directed towards understanding the role of topological states of matter in the design of mechanical metamaterials and their implications for wave control. Stefano Gonella was recipient of the NSF CAREER award in 2015.

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