University at Buffalo
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Electronic Traps for Mechanical Waves:
A framework for piezo-enabled tunability of elastic waves

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Abstract

One of the main challenges in the design of versatile engineering devices is achieving tunability, i.e., the ability to tune a system's response to an evolving operating environment. In the context of vibration control, for example, this can lead to the design of semi-active mechanical filters. The opportunities are even broader in the realm of wave control, where one can engineer or boost the spectral and spatial wave manipulation capabilities of a mechanical system. The piezoelectric route to tunable structures relies on the use of piezoelectric elements to actively modify their inherent mechanical response. Of particular interest are methods involving shunts, whereby piezoelectric patches are passively connected to appropriately designed electric circuits, to yield a modification of the effective properties of the material and a correction of the global behavior of the host medium. This presentation focuses on the special class of resistive-inductive (RL) circuits, which de facto act as electro-mechanical resonators. When properly tuned, these resonators interact with a propagating wavefield by selectively distilling one or more frequencies from the signal and consequently attenuating and distorting the wave. Heterogeneous configurations involving multiple populations of resonators can be realized according to a plethora of (possibly random) spatial arrangements to achieve polychromatic and broadband effects, de facto behaving as tunable electromechanical rainbow materials. In two-dimensional lattice domains, the same paradigm can be used to actively manipulate the inherent frequency-selective spatial patterns exhibited by propagating wavefields. This approach ultimately results in the design of programmable structures and materials that can be used as tunable filters, mechanical signal jammers and directional actuators and sensors.

Bio Sketch

Stefano Gonella received Ph.D. and M.S. degrees in aerospace engineering from the Georgia Institute of Technology in 2007 and 2005, respectively. Previously, he received a Laurea, also in aerospace engineering, from the Politecnico di Torino, Italy, in 2003. He joined the faculty of the Department of Civil Engineering at the University of Minnesota in 2010, after 3 years of post-doctoral and teaching experience at Northwestern University. His main research interests revolve around the modeling and simulation of complex wave phenomena in unconventional structures and materials, with emphasis on cellular solids, phononic and granular crystals, and acoustic metamaterials. He is also interested in the development of new methodologies for structural and material diagnostics through the mechanistic adaptation of concepts of machine learning and computer vision.

Contact Dr. Mostafa Nouh mnouh@buffalo.edu if interested in meeting with the speaker.

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O'Brian 112
3:30-4:30 pm