CISMMS
Center for Integrated Structure-Materials Modeling and Simulation

Civil Engineering
at JOHNS HOPKINS UNIVERSITY

CISMMS-CE Multifunctional Design Seminar

Time-Reversal and Reciprocity Breaking in Electromechanical Metamaterials and Structural Lattices

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Recent breakthroughs in condensed matter physics are opening new directions in band engineering and wave manipulation. Specifically, challenging the notions of reciprocity, time-reversal symmetry and sensitivity to defects in wave propagation may disrupt ways in which mechanical and acoustic metamaterials are designed and employed, and may enable totally new functionalities. Non-reciprocity and topologically protected wave propagation will have profound implications on how stimuli and information are transmitted within materials, or how energy can be guided and steered so that its effects may be controlled or mitigated.

The seminar will briefly introduce the state-of-the-art in this emerging field, and will present initial investigations on concepts exploiting electro-mechanical coupling and chiral and non-local interactions in mechanical lattices. Shunted piezo-electric patches are exploited to achieve time-modulated mechanical properties which lead to one-directional wave propagation in one-dimensional mechanical waveguides. A framework to realize helical edge states in two identical lattices with interlayer coupling is also presented. The methodology systematically leads to mechanical lattices that exhibit one-way, edge-bound, defect-immune, non-reciprocal wave motion. The presented concepts find potential application in vibration reduction, noise control or stress wave mitigation systems, and as part of surface acoustic wave devices capable of isolator, gyrator and circulator-like functions on compact acoustic platforms.

Massimo Ruzzene is a Professor in the Schools of Aerospace and Mechanical Engineering at Georgia Institute of Technology. He received a PhD in Mechanical Engineering from the Politecnico di Torino (Italy) in 1999. He is author of 2 books, 140 journal papers and about 180 conference papers. He has participated as a PI or co-PI in various research projects funded by the Air Force Office of Scientific Research (AFOSR), the Army Research Office (ARO), the Office of Naval Research (ONR), NASA, the US Army, US Navy, DARPA, the National Science Foundation (NSF), as well as companies such as Boeing, Eurocopter, Raytheon, Corning and TRW. Most of his current and past research work has focused on solid mechanics, structural dynamics and wave propagation with application to structural health monitoring, metamaterials, and vibration and noise control. M. Ruzzene is a Fellow of ASME, an Associate Fellow of AIAA, and a member of AHS, and ASA. He is the Program Director for the Dynamics, Control and System Diagnostics Program of CMMI at the National Science Foundation.

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JHU Homewood Campus, Latrobe Hall, Room 106