Phononic Metamaterials:
The Big, the Small and the Nonlinear

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Phonons may be understood as elastic waves, or transmitted vibrations, that take root at the material level. Although the study of phonons is a core discipline in conventional condensed matter physics, their analysis and manipulation over multiple scales–an area that has recently been termed *phononics*–is opening up a new technological frontier with a potential impact that could match that of electronics almost half a century ago. Broadly speaking, most phononic materials exhibit some form of crystal-like periodicity–which can be in the constituent material phases, the internal geometry, or even the boundary conditions. In addition to this engineered symmetry, it is also possible to introduce local resonators within, or attached to, the body of the material to further affect intrinsic properties. Recent research has shown that local resonances are capable of giving rise to a remarkable assortment of physical phenomena and overall properties that are not possible, or even conceivable, using conventional materials. These favorable qualities include low frequency stop bands where attenuation of long waves takes place, negative effective properties, group velocity reduction, among others.

In this seminar, I will present an overview of our research in the area of phononic metamaterials. The first part of the talk will consider locally resonant elastic metamaterials at the macroscale (*the Big*) with emphasis on design and the effects of finite deformation (*the Nonlinear*) on the band structure. In the second part, I will present the concept of a nanophononic metamaterial *(the Small)* in which a novel mechanism in phonon transport is revealed that allows the thermal conductivity to be reduced without impacting the electrical conductivity–a scenario that is highly advantageous for thermoelectric energy conversion.