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Ph.D. DISSERTATION DEFENSE

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Date:	Wednesday, December 2nd, 2026 1:00 pm – 3:00 pm
Time/Location:	Edwin A. Stevens Hall (EAS), Room 229
Title:	Finite Metamaterials with Nonlinear Host Structures, Exhibiting Programmable Properties
Chairperson:	**Prof. Gizem Acar** (Charles V. Schafer School of Engineering and Science, Department of Mechanical Engineering)
Committee Members:	**Prof. Christophe Pierre** (Charles V. Schafer School of Engineering and Science, Department of Mechanical Engineering) **Prof. Christopher Sugino** (Charles V. Schafer School of Engineering and Science, Department of Mechanical Engineering) **Prof. Jia Mi** (Charles V. Schafer School of Engineering and Science, Department of Civil, Environmental and Ocean Engineering)

ABSTRACT

Locally resonant metamaterials exhibit unconventional dynamical properties through periodically distributed resonators. Existing theories mostly assume infinite periodicity and linear, small amplitude deformation. However, many engineering structures are finite and frequently operate under large deformation, where the effects of geometric nonlinearity and truncated boundaries on the dynamical behavior remain insufficiently understood. This dissertation investigates the nonlinear dynamics of finite beams equipped with local resonators and develops a programmable design framework to achieve prescribed dynamical responses.

Firstly, the influence of local resonators on geometrically nonlinear cantilever beams is investigated. The resonators suppress nonlinear resonance and bistable behavior, as well as energy localization in weakly coupled blade arrays. Geometric nonlinearity shifts the resonance frequencies but not the attenuation band, whose width remains governed by the mass ratio. Secondly, the programmability of the dynamical behavior is investigated. The frequency amplitude relationship of a targeted nonlinear response is represented through the system's effective natural frequency and effective cubic stiffness, which depend on the frequency ratio and a distribution parameter that combines resonator mass and spatial arrangement. An inverse optimization process is then used to determine resonator configurations for a prescribed target response. Distinct arrangements can realize the same response, and this nonuniqueness underlies the programmability of the

metamaterial. Finally, edge modes induced by truncation of the resonator array are investigated. The bandgap boundaries are amplitude independent, whereas the edge mode frequency increases with amplitude until the mode escapes the bandgap and loses its localized character. The escape amplitude is governed by the initial frequency separation from the upper boundary and the slenderness ratio of the host beam.

This dissertation establishes a framework to program the nonlinear dynamical response of finite locally resonant metamaterials and characterizes their edge modes in the nonlinear environment.