PHYSICS

CRT/Unitrento/DISAT - Elastic Metamaterials for Energy-Harvesting Related Applications

Funded By	UNIVERSITA' STUDI TRENTO [P.iva/CF:00340520220] Dipartimento DISAT FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014]
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Context of the research activity	This PhD project investigates the fundamental physics of elastic metamaterials, with particular emphasis on their design, modeling, and experimental realization for the control of mechanical wave phenomena across multiple length scales.
Objectives	This PhD project investigates the fundamental physics of elastic metamaterials, with particular emphasis on their design, modeling, and experimental realization for the control of mechanical wave phenomena across multiple length scales. The central objective is to explore and engineer materials with tunable dynamic properties that enable precise manipulation of elastic and acoustic waves, leading to novel physical effects such as nonreciprocal propagation, topological edge modes, and adaptive wave localization. The research will focus on identifying and exploiting emergent behaviors arising from structured media—ranging from symmetry breaking and topological phase transitions to programmable and time-modulated responses. Such phenomena open new avenues for achieving functionalities including waveguiding, vibration suppression, dispersion engineering, mode conversion, and mechanical analogues of electronic transport. A key emphasis will be placed on topologically inspired and reconfigurable metamaterials, which exhibit robustness against disorder and environmental perturbations, as well as the potential for tunability through external fields or mechanical actuation. These systems provide a fertile platform for studying wave–matter interactions, non-Hermitian dynamics, and other frontier topics in condensed-matter-inspired acoustics. The project integrates theoretical, numerical, and experimental approaches. Analytical modeling and numerical simulations—employing tools such as finite element and Bloch wave analysis—will be used to predict and interpret the rich spectrum of wave phenomena. Experimental investigations will

	validate these predictions and reveal practical constraints and opportunities for realizing such behaviors in laboratory-scale prototypes. Ultimately, the project aims to contribute fundamental insights into the physics of structured elastic media, while also informing the design of next-generation systems for vibration control, wave-based computation, and signal manipulation. By bridging concepts from condensed matter, continuum mechanics, and acoustics, this research will advance our understanding of how geometry, topology, and nonlinearity can be harnessed to control mechanical waves in unprecedented ways

Skills and competencies for the development of the activity	The ideal candidate should have a strong background in solid mechanics, material physics, and numerical methods, with experience in FEM software (e.g., COMSOL, ANSYS) and elastic wave modeling. Experimental skills and familiarity with laboratory equipment are essential. The candidate should demonstrate analytical thinking, research autonomy, and the ability to work in an interdisciplinary environment, along with proficiency in scientific English.