PhD Offer

Non-Hermitian Topological Acoustic Metamaterials for Robust Wave Control

General information

Workplace: Institut Jean Lamour, University of Lorraine-CNRS, Nancy (France)
Desired level of education: Master's degree in Physics, Wave Physics, Mechanical Engineering, Applied Physics, Acoustics, Structural dynamics, Applied Mechanics, or equivalent.

PhD subject

The paradigm of topology has profoundly impacted condensed matter physics in recent years. This paradigm has been successfully extended to photonics and acoustics. A key outcome is the emergence of topologically protected edge, surface, and corner states, which exhibit remarkable robustness against defects and disorder.

This framework has been enabled by phononic crystals and acoustic metamaterials which are engineered structures offering unprecedented control over wave propagation. In acoustics, their macroscopic nature and experimental accessibility provide an ideal platform to explore novel wave phenomena while targeting concrete technological applications. Topological acoustic systems already enable robust waveguiding, delay lines, and offer strong potential for phononic circuits immune to fabrication imperfections. In elastodynamics, they support defect-immune guided modes relevant for optomechanics, on-chip acousto-optic modulation, and acoustic information processing. More broadly, these concepts open perspectives for high-performance sensing, vibration and noise control, energy localization and harvesting, as well as advanced biomedical ultrasound technologies where robustness and wave confinement are essential.

The topology of Hermitian systems is now well established. Introducing gain, loss, or non-reciprocity leads to non-Hermitian physics where topology is more delicate. However non-Hermitian systems exhibit phenomena that have no equivalent in Hermitian systems.

The objective of this PhD is to explore the interplay between topology and non-Hermiticity in acoustic metamaterials through the design, modeling, and experimental realization of novel structures supporting higher-order topological states and non-Hermitian skin effects. The candidate will develop active control strategies based on gain/loss engineering and non-reciprocity, and investigate generalized bulk-boundary correspondence in realistic systems. Ultimately, this work aims to establish new paradigms for manipulating sound and vibrations, with impact on phononic technologies, acoustic signal processing, computing, and next-generation ultrasound systems.

Work context

This international PhD project will be conducted jointly between the Metamaterials and Phononics group at Institut Jean Lamour (Université de Lorraine, France) and the SIMBA laboratory at Penn State University (USA), building on a strong and productive long-term collaboration.

About the Institut Jean Lamour

The Institute Jean Lamour (IJL) is a joint research unit between CNRS and Université de Lorraine. The IJL is a laboratory of fundamental and applied research in materials science and process. Its fields of investigation cover materials, metallurgy, plasmas, surfaces, nanomaterials and electronics. The workforce is composed of 183 researchers/lecturers, 91 engineers/technicians/administrative staff, 150 doctoral students and 25 post-doctoral fellows. Partnerships exist with 150 companies and research groups collaborate with more than 30 countries arround the world. Its platforms are spread over 4 sites, the main one being located at the Artem campus in Nancy.

Application

The application should be addressed to: Aurélien Merkel (aurelien.merkel@univ-lorraine.fr) & Mourad Oudich (mourad.oudich@univ-lorraine.fr).
Application should include: **CV, Cover letter**, and **M1/M2 (Master or equivalent) transcripts.**
The PhD student will be affiliated to the C2MP doctoral school (Chemistry - Mechanics - Materials – Physics, https://doctorat.univ-lorraine.fr/en/doctoral-schools/c2mp/presentation).

INSTITUT JEAN LAMOUR
Campus Artem
2 allée André Guinier - BP 50840
F-54011 Nancy Cedex
www.ijl.univ-lorraine.fr