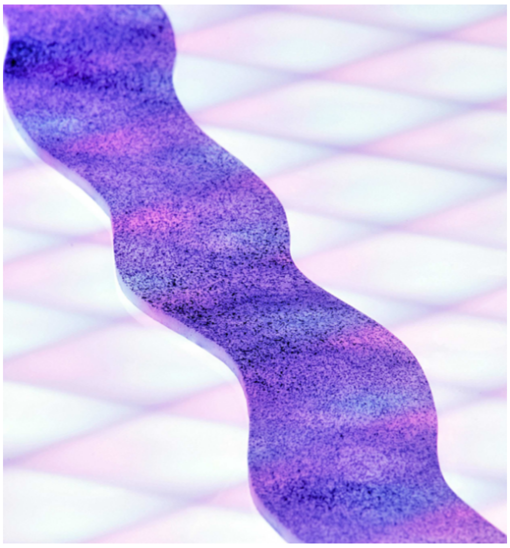
Wave propagation in active elastic structures

Waves, mechanics and active matter

M2 internship offer



Wave propagation in soft structures is a well-documented phenomenon [1].
But how does this propagation evolve when the structure exhibits a form of activity?

Context. The emergence of collective behavior in systems, such as animal groups [2-3] or mechanical models [4], has become a crucial area of study in recent years. This phenomenon relies on two key components: active individuals and the ways they interact. Typically, a change at the individual level—like a fish sensing a threat—can trigger a rapid collective response, akin to a wave in a stadium. While much research has focused on aspects like the transition to global order and spatial scales [5], the specific mechanics of how these waves propagate remain less understood. This project aims to fill that gap by using simple mechanical models made of active units connected by flexible beams. This work will serve as a foundation for further investigation at the PhD level, delving deeper into the dynamics of active elastic systems.

Objectives. This internship will provide an opportunity to explore the dynamics and the propagation of waves in active elastic structures. We aim to elucidate the role of activity and highlight how the system's spatial structure influences its final state. We will rely on very simple model systems, inspired by recent studies [6], involving flexible strings, beams, and plates. These structures will incorporate active elements, such as robots, for instance. By adjusting the local mechanical connection between these elements, and the overall geometry of the structure, we hope to explore how these changes affect wave characteristics and the system's collective behavior.

Motivations and perspectives. The systems we are interested in can be viewed as macroscopic mechanical settings that effectively mimic the dynamics of molecular and biological chains. By exploring these dynamics on a larger scale, we aim to deepen our understanding of fundamental principles and practical applications. Ultimately, this work also holds the potential to inform the design of advanced materials and soft robotic systems that leverage similar collective behaviors.

Candidate profile. The candidate must be enrolled in (or have completed) a Master's degree, ideally in Physics, but also potentially in Mechanics, Engineering, or Applied Mathematics. They should be especially motivated by the opportunity to carry out experimental research in fundamental physics. We seek curious candidates eager to acquire new knowledge across multiple disciplines. Autonomy, initiative, and fluency in English will be particularly valuable. The selected student will develop skills in both modeling and experimentation. The experimental work will involve tasks such as designing samples (molding and fabricating flexible structures), image acquisition, particle detection and tracking, as well as signal processing.

Environment. The student will conduct their research at the Laboratory of Acoustics of Le Mans University (LAUM), which specializes in acoustics and wave physics. They will join the *Elastic Waves in Complex Media* team, focusing on the propagation of elastic waves in systems with atypical behavior (such as soft metamaterials, granular media, unstable, or multi-stable systems).

Duration and starting date: 5 to 6 months from February 2025.

Location: Laboratory of Acoustics of Le Mans University (LAUM), Le Mans, France

Contacts. Feel free to contact us with any questions or to submit your application:
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References.
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