Acoustic streaming in a microchannel

M2 Internship proposition (5-6 months)

2026

Lab	Institut de Recherche sur les Phénomènes Hors Equilibre, IRPHE, UMR7342, Marseille, France
Duration	5 - 6 months (feb – july 2026)
Skills	Fluid mechanics, Acoustics
Key words	Acoustofluidics, acoustic streaming, microchannel
Grant	~650€/month
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Context and preliminary work

Acoustofluidics is the interplay between microscale fluid dynamics and acoustics and gains increasing interest particularly due to its potential biomedical applications.

Ultrasound stimulation (UStim) of bone regeneration based on the fascinating property of bone to be mechanosensitive was discovered in the 1950s and has been widely studied since. However, the underlying mechanotransduction mechanisms (translation of mechanical stimuli into biological response) remain poorly identified and this lack of knowledge fuels controversy, preventing the development of efficient and optimized therapeutic tools. The characterization and quantification of mechanical stresses induced by UStim on bone cells (osteocytes) is essential to understand these mechanisms. Osteocytes are known as the mechanosensors of the bone piloting the bone remodeling, they are constituted of an ellipsoidal cell body (~ 10µm) settled in lacunae and are connected to each other through hundred of dendrites circulating in canaliculi, embedded in the extracellular matrix and surrounded by a submicrometric fluid layer (Figure 1). They are supposed to be preferentially sensitive to fluid shear stress at their dendrite location.

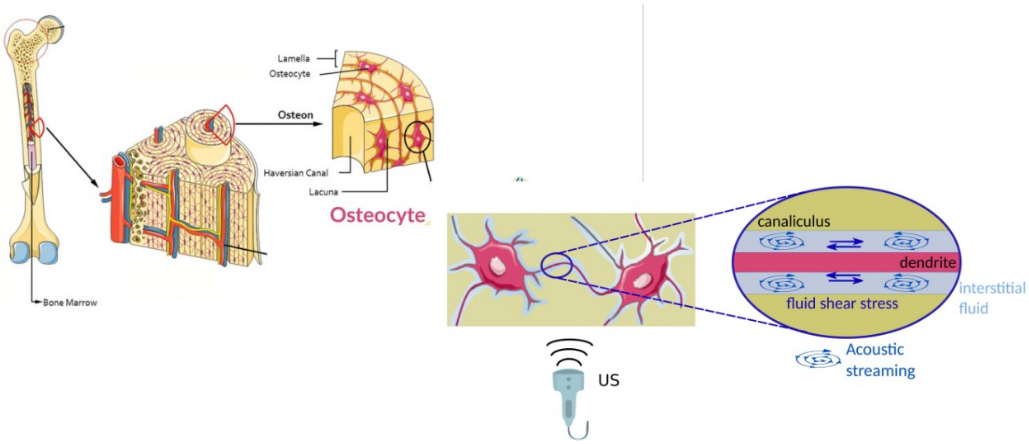

Figure 1: Multiscale structure of the bone and focus on the fluid layer surrounding the dendrite of the osteocyte embedded in the extracellular matrix.

This study investigates the hypothesis that the shear stress generated by ultrasound is caused by acoustic streaming (Figure 1).

Objectives

Acoustic streaming is a nonlinear hydrodynamic phenomenon that refers to the steady mean flow generated by the nonlinear interactions of sound waves near boundaries. Although the basic mechanism responsible for this mean flow is well understood [1,2], the properties of acoustic streaming in a microchannel excited by ultrasound waves still require further investigation.

The candidate will begin by calculating the streaming flow using a theoretical framework recently developed by the team, applied to a configuration relevant to the intended application. This theoretical prediction will then be validated using a finite-element model implemented in COMSOL Multiphysics, employing the Acoustics, CFD (Computational Fluid Dynamics), and Particle Tracing modules.

The influence of various parameters—such as channel geometry, acoustic wave characteristics, and the nature of the forcing—on the resulting streaming will then be analyzed theoretically. Finally, these results will be used to interpret recent experimental observations of acoustic streaming obtained in the laboratory using µPIV (micro-Particle Image Velocimetry) [3] in a rectangular microchannel excited by ultrasound.

[1] Nyborg. *Acoustic Streaming*, Physical Acoustics 2(Part B):265-331 (1965). DOI : 10.1007/978-3-031-58963-8_7.

[2] Hamilton et al. *Acoustic streaming generated by standing waves in two-dimensional channels of arbitrary width* JASA 113(1):153-160 (2002). DOI: 10.1121/1.1528928.

[3] Lindken et al. *Micro-Particle Image Velocimetry (PIV): Recent developments, applications, and guidelines*, Lab on a Chip 9(17):2551-67 (2009). DOI: 10.1039/b906558j

Prerequisites

The candidate should have a solid background in fluid mechanics, with particular expertise in hydrodynamics. Prior knowledge of microfluidics, acoustics or nonlinear physics phenomena would be highly beneficial.

He/she will have a strong interest in theoretical analysis, as well as in numerical simulation.

He/she should demonstrate analytical and communication skills, along with rigor, methodology and the ability to synthesize information. These qualities are essential to fully engage with the project and collaborate effectively with the internship supervisors and the broader laboratory team.

Application

Candidates must send their application by e-mail, including a Curriculum Vitae, a letter of motivation, transcripts and a letter of recommendation from a previous internship at cecile.baron@univ-amu.fr and stephane.ledizes@univ-amu.fr.

After examining the application, a video interview will be proposed.