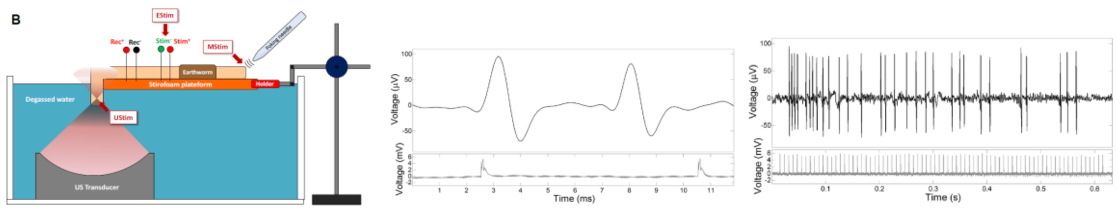
Master / Engineering student project – 6 months

# Low Energy Focused UltraSound (LEFUS) stimulation of *Ex-vivo & In-vivo giant axons*

*Understanding the biophysical mechanisms developing a hybrid* ***US-guided-LEFUS/nerve-chamber*** *platform*




## Context of the study

The only way to induce and drive brain activity artificially has long been invasive electrical stimulation. Non-invasive alternatives exist (electrical, magnetic) but have limitations (targeting / selectivity, deep region access). This past decade, an increasing number of studies have shown the ability of Low Energy Focused UltraSound (**LEFUS**) to produce or modulate neural activity without the need for invasive (needle) procedures. It is possible to stimulate the cerebral cortex *in vivo* with low frequency ultrasound (250-600 kHz), despite an extended millimetric focal zone. *In vitro* stimulation of the retina with high frequencies (40 MHz) is also feasible with an extremely fine focal spot and high spatial accuracy. Investigations from the 1980s on superficial nerve stimulations (mechanoreceptors, auditory nerves, and in the 2010s (deep brain and retina stimulations) have reported analog conclusions: while LEFUS stimulation is technically sound, no description of biophysical processes is validated for understating and controlling the phenomenon. Various mechanisms have been proposed: **1)** an effect of the LEFUS beam inducing a global radiation force compressing/shearing neural structures, then modifying the membrane electrical potential; **2)** a local mechanical action of LEFUS-induced cavitation inducing electrical current; **3)** a global absorption of LEFUS energy leading to a local temperature increase affecting the neural excitability; **4)** involvement of neuronal or glia membrane channels or neurotransmission. The exact type of cells affected is also not known (neuron, astrocyte, both?). Finally, very few evidences of neuro**stimulation** (of a new activity) have been shown compared to neuro**modulation** (of an existing activity) and mechanisms involved in both phenomena are not sufficiently understood to control their efficacy/safety. **Our main project** aims at pursuing basic research investigations on the neurostimulation mechanisms, after initial works led by LabTAU (ANR T-ERC; https://anr.fr/Projet-ANR-16-TERC-0017), with the goal to develop new brain stimulation approaches.

## Project objectives

In this project, the Master/Engineering student will continue the development of an advanced hybrid neurostimulation platform, involving **LEFUS stimulation tools, Nerve chamber electrophysiology systems, Ultrasound imaging and cavitation detection systems**. The effect of several ultrasound parameters and the role of myelin in the success rate for triggering action potentials will be studied. For doing this, LEFUS-induced neural activations will be investigated in ***2* invertebrate models of Peripheral Nervous System (PNS): the *in-vivo* Earthworm myelinated ventral axons and *ex-vivo* Lobster unmyelinated ventral axons**. To generate **LEFUS**, dedicated LEFUS prototypes will be preliminary characterized acoustically in the context of **neurostimulation**. **Opportunity to apply for a PhD scholarship.**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## Project tasks

- Invasive and non-invasive electrical stimulation/recording of action potentials in giant axons
- Mechanical stimulations
- High resolution ultrasound imaging of the ventral giant neural structures and LEFUS beam guidance
- LEFUS prototype characterization (modeling, electro-acoustical measurements)
- Comparison studies between electrical, mechanical and LEFUS stimulations

## Skills

The candidate must be an Engineering Student or a Master Student in one of the following fields: Biomedical Engineering, Electronic instrumentation, Acoustic instrumentation, Medical Imaging, System and Image

- Signal and image processing
- Medical imaging: Ultrasound, MRI
- Basic skills in electrophysiology and neurosciences
- Programming skills: Matlab, C++

## Contacts

Send a CV and a motivation letter to:


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