**POSEIDON – Unconventional principles of underwater wave control in the sub-wavelength regime**

*PhD position in « metamaterials for underwater acoustics »*
*at the Institute of Electronic, Microelectronic and Nanotechnology (UMR CNRS 8520)*
*Laboratory of Acoustics, 41 Boulevard Vauban – Lille (FR)*

**Project Context.** Improving the nowadays wave-based technology may deeply impact our daily life. Indeed, elastic waves are ubiquitous in our life, from the propagation of sound in air (which allows us to communicate) to micro-electromechanical systems (MEMS) for sensing applications, to large-scale catastrophic events such as earthquakes and tsunamis. Although the full control of wave propagation is not possible yet, recent developments of the Solid State of Physics has proposed a new class of composite materials, generally referred as « phononic crystals (PCs) » and « metamaterials (MMs) », capable of unconventional dynamic behaviors (extraordinary transmission, negative refraction, wave focusing, cloaking, …).

PCs and MMs are periodic (or quasi-periodic) composites made of building blocks (left panel of Fig. 1), i.e., unit cells capable of performing spatial and spectral control of waves due to a frequency-dependent directionality or band gap (BG) effects. BGs are frequency regions where the propagation of waves is strongly attenuated due to the absence of dispersion curves (gray rectangle in the right panel of Fig. 1), and they are induced by nondestructive interferences created by either the scattered wave field from periodic abrupt stiffness / mass changes (Bragg BGs) or resonating inhomogeneities (locally resonant BGs). The concept of BG naturally implies applications involving vibrations, wave filtering and attenuation, which could be exploited in various frequency regimes ranging from Hz to kHz, i.e., from seismic wave abatement or water waves to noise or vibration insulation.

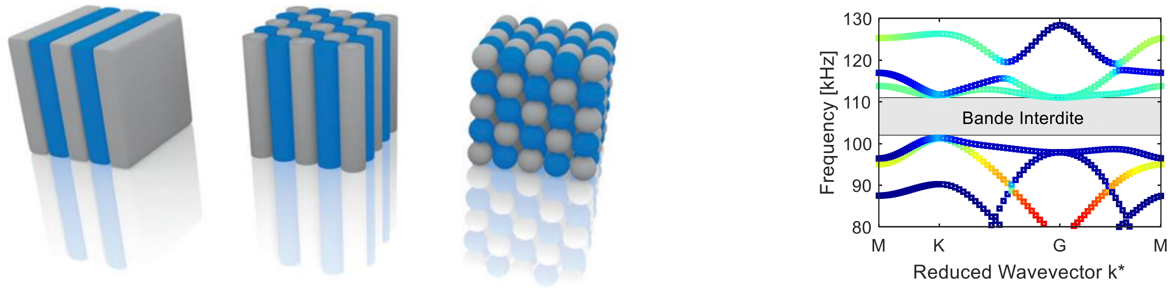


*Figure 1: Example of a metamaterial made of 1D, 2D and 3D periodic unit cells (left panel). Typical dispersion diagram describing the dynamic behavior of the metamaterial. The band gap (BG) is a region where no wave transmission is possible (right panel).*

**Objectives of the thesis.** The core objective of this PhD thesis is to investigate phononic crystals and elastic metamaterials in the context of <u>underwater acoustics</u>, where (heavy) fluid-structure interaction takes place invalidating most of the approaches used in airborne acoustics. *The design, manufacture, and experimental characterization of an innovative underwater metamaterial to create lightweight and compact underwater sound screens operating in the deep sub-wavelength regime will be the final goal of the thesis*. Due to the scalability of wave equations, other domains of applications may be explored during the thesis.

**Thesis program**. The first part of the thesis will be devoted to a bibliographic analysis on the state of the art of the subject. Afterwards, the candidate is expected to focus on the development of the necessary design

tools to deal with underwater acoustics problems (exploring, and potentially integrating, both analytical and numerical approaches). The main goal here will be to develop a tool allowing to gain understandings of the underlying physics and predict the dynamic behavior of underwater metamaterials. The unit cell and the finite structure will then be designed, optimized, and manufactured. The final phase of the thesis will be the experimental characterization of the sample. A comparison between the experimental and numerical results will be performed.
After an initial training period, the candidate is expected to contribute on the analysis and interpretation of data, manuscript preparation and dissemination of the results in the context of national and international conferences/meetings.

**Required qualifications:** The ideal candidate is a master's degree holder in engineering, physics, or similar disciplines. Candidates are expected to have a general knowledge in acoustics and mechanics, familiarity with coding (for instance MATLAB), finite element methods. Being interested into experimental research also is required.
Other desired soft skills: being a team player, proficient in English (knowledge of French and/or Italian is a plus) and having good synthesis and result reporting abilities.

**Application**: Applicants are asked to provide the following documents:
1) a motivation letter (approximately 1 page) explaining why they are applying for this position
2) a detailed CV
3) two to three reference letters
Information should be sent to Dr. Marco Miniaci (marco.miniaci@gmail.com, marco.miniaci@univ-lille.fr).
The online application procedure is also required (CNRS website).

**Location:** The Institute of Electronic, Microelectronic and Nanotechnology (UMR CNRS 8520 – https://www.iemn.fr/en/) is in Villeneuve D'Ascq, close to the city of Lille (France). With a total staff of over 500 persons, the institute has a broad area of research activity ranging from physics to materials science, acoustics, micro- and nanotechnology. The laboratory of Acoustics (where the candidate will carry on her / his research and where she / he will have her / his office) is in the city center of Lille, at 41 Boulevard Vauban, within the « Junia » buildings.

**Starting date:** January 1st, 2023.
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