

Underwater sound control with bubble metascreens

Applications to field synthesis and bioacoustics

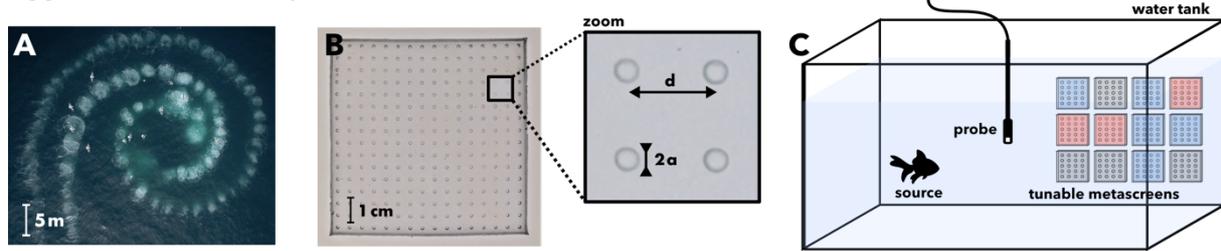


Figure 1. Acoustics of bubble curtains – (A) A bubble net created by two humpback whales to trap their prey (source: BBC NHU). (B) Photograph of a bubble metascreen consisting of air cavities embedded in a soft silicone matrix. (C) Schematic of an experimental setup where multiple bubble patches are used to passively shape the soundscape inside the water tank.

Context. Sound plays a central role underwater — it is a primary means of perception, navigation, and communication for many marine species. One striking example comes from humpback whales, which produce spiral curtains of bubbles to trap their prey [1] (see Fig.1A). These bubble nets act as acoustic walls, reflecting the surrounding sound field to confuse the targeted fish. In recent years, engineers have drawn inspiration from these natural processes, for different kinds of applications. Nowadays, bubble curtains are deployed around underwater construction sites to mitigate noise pollution and protect marine wildlife. In research laboratories, the scattering of waterborne sound wave by a bubble curtain has been studied to understand its exceptional acoustic performance [2]. In the recent years, progresses in this field led to the development of bubble-based metamaterials (see Fig.1B)— usually soft rubber matrices embedding air cavities — which appear to be highly promising choices for wave control and absorption [3,4].

Objectives. This PhD project aims to develop a new generation of tunable bubble metascreens for real-time underwater sound shaping. The work will start by designing tunable bubble screens, whose acoustic response can be modified mechanically — for instance, by stretching the elastic matrix or applying a controlled overpressure. Such smart metascreens will then be assembled into multi-layered structures to explore coherent perfect absorption [5] and exceptional points [6]. At a later stage, large arrays of such screens could be implemented on the walls of an instrumented water tank to act on the cavity modes. One track will consist in developing the underwater analogue of an anechoic room. This configuration will also enable the manipulation of the sound fields through the modulation of reflecting panels, following approaches developed in the electromagnetic cavity community [7], a strong objective would be to demonstrate the shaping of underwater sound fields, ultimately enabling the creation of synthetic acoustic landscapes in real time.

Scientific and Societal Impact. This project stands at the intersection of wave physics and bioacoustics. From a physical perspective, it will advance the design of soft metamaterials capable of absorbing, manipulating, and imaging underwater sound. By exploring reconfigurable coherent perfect absorbers and tunable exceptional points, it will open new routes for real-time acoustic wavefront control. In parallel, the outcomes of this PhD will provide an interesting tool for bioacoustics: enabling controlled soundscapes to study how aquatic organisms produce, perceive, and respond to sound. Beyond these fundamental aspects, the project addresses the issue of underwater noise pollution [8], offering practical solutions for quieter laboratory tanks and marine environments.

Methodology. The PhD will combine experiments, modeling, and numerical simulations. The experimental work will involve the design and fabrication of bubble metascreens using 3D

printing, laser cutting, and microfabrication, followed by acoustic measurements in instrumented water tanks. The propagation, scattering, and coupling phenomena will also be approached using analytical methods and simulations.

Candidate Profile. Applicants should hold (or be completing) a Master's degree in Physics, Acoustics, Mechanical Engineering, or Applied Mathematics. The position requires motivation for experimental research in fundamental physics, curiosity, autonomy, and initiative. Proficiency in English and programming skills (MATLAB or Python) are important.

Environment. The PhD will be conducted at the Laboratory of Acoustics of Le Mans University (LAUM), an international research center in acoustics and wave physics. The candidate will join the Materials team, which studies the propagation of acoustic and elastic waves in heterogeneous media, metamaterials, and nonlinear structures. They will benefit from LAUM's multidisciplinary environment and state-of-the-art facilities, developing expertise in acoustic metamaterials, wave manipulation, and soft matter. The project will provide both theoretical and experimental training in a dynamic field at the crossroads of physics, materials science, and biology. The candidate will also be expected to write scientific articles and engage with the research community through participation in national and international conferences.

Duration. 36 months

Starting date. The contract is expected to start by the end of 2026, with some flexibility depending on the candidate's availability.

Application deadline. April 2026

Location. LAUM, Le Mans University, France

Funding. Agence Nationale de la Recherche

Supervision. The PhD project will be supervised by Maxime Lanoy, Antonin Novak, and Pierrick Lotton. It will involve a collaboration with Laurent Simon and Valentin Leroy (MSC, Paris). Please feel free to contact us for any questions or to express your interest:

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