Identification of objects in heterogeneous media from their bistatic acoustic responses

Post-doctoral position at LMA (Marseille) in collaboration with M2P2 (Marseille), MPL and NRL (USA)
Deadline : June 15th 2022

Employer : Aix-Marseille University
Duration : 12 months starting between September 2022 and December 2022
Gross salary : 2450 euros/months to 2850 euros/months depending on qualification and experience
Location : Laboratory of Mechanics and Acoustics of Marseille UMR7031, Aix-Marseille University
Supervisors : Sandrine Rakotonarivo (LMA), Régis Cottereau (LMA)

Keywords : : Acoustic propagation, heterogeneous medium, mechanical impedance, finite elements, boundary elements, acoustic holography.

1 Context

This project seeks to develop a method for identifying an inclusion in a heterogeneous medium using acoustic measurements. One targeted application is the discrimination of objects buried in the seabed. In the case of the installation of an underwater wind farm, for example, it is necessary to first detect whether inclusions are present in the targeted bottom. Once the detection is done, it is fundamental to be able to distinguish a rock from a historical explosive device from the first two world wars, which are still very present on the French coast. The resolution of the latter inverse identification problem is based on the analysis of the diffracted echoes.The process consists of a parsimonious measurement of the response of the medium to a controlled incident field in a bistatic configuration (sources and receivers are not at the same location). Recent research has shown convincing results for *in situ* detection of inclusions in the seabed [4]. **However, the problem of identification, which is at the heart of this project, remains an open problem** [7]. This challenge is mainly related to :

- The complexity of the acoustic response of the target. The objects can be manufactured, of complex shapes and made of different materials. This diversity will induce diffraction phenomena and various resonances, and thus a complex response.
- The complexity of the environment. This complexity can be multiple reflections from the heterogeneous structure of the marine sediment, which makes its modeling difficult [3]. In addition, fluctuations and variability of the marine environment, whose influence on the response must be understood in a statistical sense .[2].
- The coupling between the target's response and its environment.

The main goal of this post-doc is to propose a robust and computationally efficient forward modeling of a target in a complex medium. In particular, challenges related to the environment complexity (heterogeneity and variability) and the coupling between the target's response and the surrounding medium will be addressed.

2 Approach/Plan of work

This project proposes to predict the response of a target immersed in a complex medium and then compare it to an in situ measurement in order to examine the identification problem. For this, we place ourselves in a formalism [1] that decouples the influence of the mechanical properties of the object and that of its medium as illustrated on figure 1, while maintaining the exactness of the solution. In this approach, the mechanical properties of the target object are first estimated. A holographic measurement methodology [6, 5] has been recently proposed to estimate the mechanical properties of an object of any geometry and shape, and then to predict its bistatic acoustic response in any infinite homogeneous environment and for any insonication conditions.

The purpose of this post-doctoral fellowship will be :

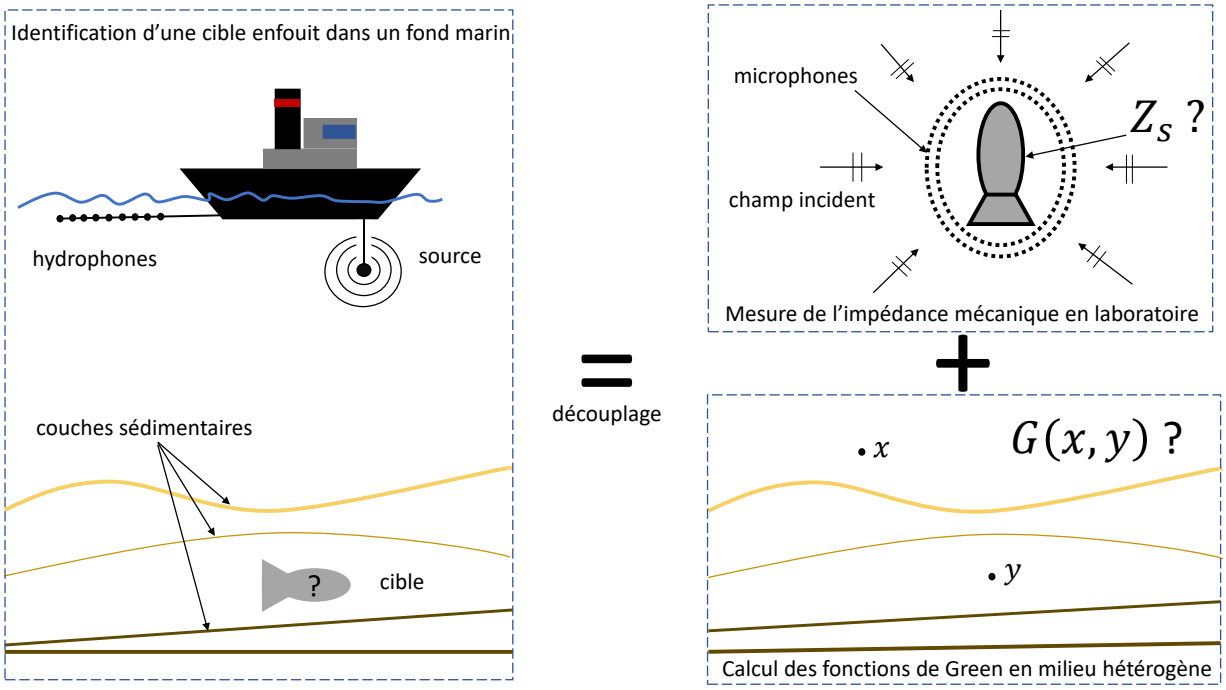

FIGURE 1 – Identification of a target in the marine environment

1. to adapt the Bobrovnitskii formalism [1] to heterogeneous and bounded media. This formalism, fundamental in the method, is for the moment only available for homogeneous infinite media. This formalism is based on the incident and diffracted fields, and will be adapted to heterogeneous finite environments [Collaboration LMA, NRL] ;
2. to couple modeling of the complex target with the existing models of propagation in heterogeneous and random media. More precisely, it will be a question of using this model with the Greens functions specific to heterogeneous media [Collaboration LMA, M2P2] ;
3. to analyze the sensitivity of the bistatic response to environmental conditions. It will be a question of characterizing the response of the target as a function of the statistics of the properties of the environment (averages, power spectral densities, ...), and not for a particular realization [LMA].

The work of the post-doc will allow to direct the experimental protocol to validate the bistatic response obtained with reference models or measurements in controlled environment [Collaboration LMA, MPL].

3 Candidate profile

Candidates must hold a Ph.D. in mechanics, acoustics or applied mathematics or related field.
Skills : Wave modeling in heterogeneous media or Structural acoustics, numerical modeling or Boundary/Finite element methods
Knowledge of Matlab or Python required
Knowledge of Comsol Multiphysics would be also appreciated

Applications Please send your application including a CV with a list of publications, a cover letter and the names/contact information of 1-2 referees who can provide a detailed account of your accomplishments and abilities to :
Sandrine Rakotonarivo (sandrine.rakotonarivo@univ-amu.fr) and Régis Cottereau (cottereau@lma.cnrs-mrs.fr)

Références

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