

Optimal acoustic sensing in complex scattering media

PhD proposal, 2024-2027 (funding already secured)

Laboratory: Laboratoire Interdisciplinaire de Physique (LIPhy), Grenoble, France

Supervisors: Dr. Dorian Bouchet and Prof. Emmanuel Bossy

Project description

Medical ultrasound imaging is based on a simple principle: an array of sources emit acoustic waves into the medium to be imaged, and these waves are reflected back to a sensor by the object of interest. Acoustic waves propagate in a simple way in soft biological tissues, which allows doctors to easily examine pregnant women using ultrasound waves. However, **it remains extremely challenging to perform ultrasound imaging when acoustic waves propagate in complex media**. For instance, it is very difficult to extract information from inside the brain using ultrasounds, because the skull distorts acoustic waves in an uncontrolled way. **This challenge motivates us to get a better fundamental understanding of how acoustic waves propagate in complex media.**

In the last decades, the possibility to control many independent sources has been widely employed to maximize the acoustic energy anywhere inside complex scattering media. Instead of maximizing the acoustic energy, this PhD project will now tackle the following question: **how can we take advantage of these numerous acoustic sources in order to maximize the amount of information delivered to the observer?** On the conceptual side, the project associates tools from wave theory and information theory in order to understand how information propagates in complex scattering systems, in both space and time. On the experimental side, the project involves the development of a proof-of-principle system designed to measure the position of a target hidden inside a random scattering medium composed of acoustic scatterers. Using a state-of-the-art ultrasonic transducers array, the acoustic field will be shaped in space and time in order to measure the properties of the hidden target in the most precise way.

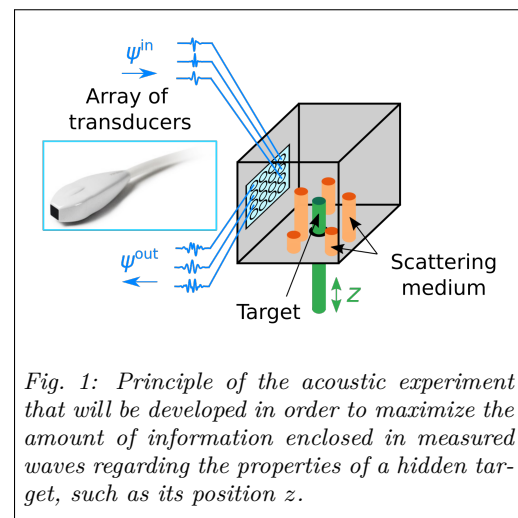


Fig. 1: Principle of the acoustic experiment that will be developed in order to maximize the amount of information enclosed in measured waves regarding the properties of a hidden target, such as its position z .

Profile of the candidate

The candidate must have a Master's degree in Physics or Engineering. He/she needs to be motivated in (i) learning new concepts in physics and (ii) applying them for the experimental development of a new kind of ultrasound imaging system.

For further information

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References:

- D. Bouchet and E. Bossy, *Phys. Rev. Res.* **5**, 013144 (2023)
- G. Godefroy, B. Arnal, and E. Bossy, *Sci. Rep.* **13**, 2961 (2023)