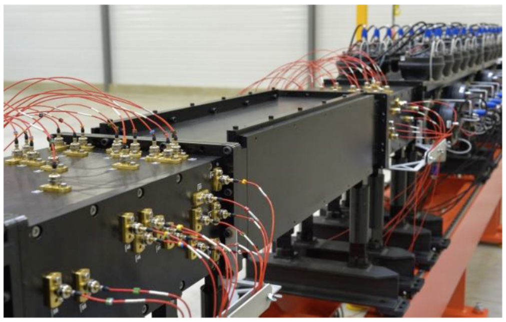
PhD funding: 3D wavefront shaping through a waveguide with disorder



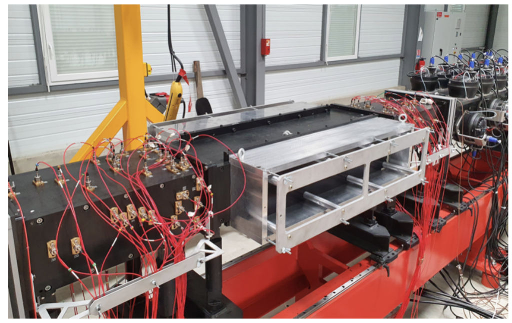


Figure 1: Pictures of the MAINE Flow experimental facility. On each side of the test section, 90 acoustic sources and 60 microphones permit the modal decomposition and the control of the multimodal sound field.

MAINE Flow is a 28×15 cm^2 rectangular duct facility recently developed at LAUM for the purpose of studying acoustic liners, which are wall treatments used to reduce the noise generated by aircraft engines [1]. The primary objective of MAINE Flow is to replicate realistic conditions for these liners, encompassing high-speed flows (up to Mach 0.6) and a multimodal incident wave field of large amplitude (up to 150 dB). One of the most interesting aspects of this experimental facility is the ability to control the modal content propagating within the duct, even at 4000 Hz where approximately 25 modes are cut-on. Additionally, two antennas of 60 microphones enable the measurement of the multimodal scattering matrix of the lined section. The fact that we control and decompose precisely the acoustic field in the duct is highly valuable for characterizing liners, and the aim of this PhD thesis is to extend this feature in order to perform wavefront shaping in presence of multiple scatterers placed inside the duct test section.

Wavefront shaping is a technique used in optics and wave physics to control and manipulate the shape and direction of waves, such as light [2] or sound waves [3]. Such a process is valuable in various applications, from improving imaging and microscopy to enhancing communication and reducing unwanted interference. However, this kind of manipulations is very rare in the framework of audible acoustic, whereas the MAINE Flow facility seem to fit perfectly with the requirements of such an experiment.

While some scattering problems will be addressed through numerical modeling, this research places significant emphasis on experimentation. Therefore, the initial months of the PhD program will enable the student to attain a level of autonomy with respect to MAINE Flow facility. During this period, she or he will acquire knowledge about the tools and concepts underpinning modal decomposition and wavefront shaping, including the Singular Value Decomposition (SVD) of the scattering matrix which establishes connections between input and output acoustic fields. It is undeniable that the implementation of these tools in MAINE Flow, which already possesses capabilities for modal control and modal decomposition, will open up exciting avenues for sound field control. Subsequently, the research will delve into one or more of the following topics, which have never been experimentally explored in the audible range:

- Anti-reflection structures that allow to improve greatly the transmission when put in front of complex arrangement of reflecting scatterers [4];
- Scattering invariant modes provided by the measurement and post-processing of transmission matrices and whose transmitted pattern is the same, irrespective of whether they scatter through a disordered sample or propagate through a homogeneous medium [5];
- Principal modes that are eigenvectors of the Wigner-Smith time-delay operator and that do not suffer from modal dispersion, such that the output-field pattern does not vary with frequency [6].

Another reason for employing MAINE Flow to investigate these issues is to determine the extent to which the SVD of the scattering matrix allows for control of the sound field in the presence of both losses (inherent to audible acoustics) and flow (precisely regulated in this facility).

Keywords: Wavefront shaping, multimodal duct acoustic, multiple scattering.

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Gross salaray: 2300 euros / month.

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