SmartAnswer - Non-local passive and active MDOF absorption and reflection acoustic devices

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Smart Mitigation of flow-induced Acoustic Radiation and Transmission for reduced Aircraft, surface traNSport, Workplaces and wind enERgy noise

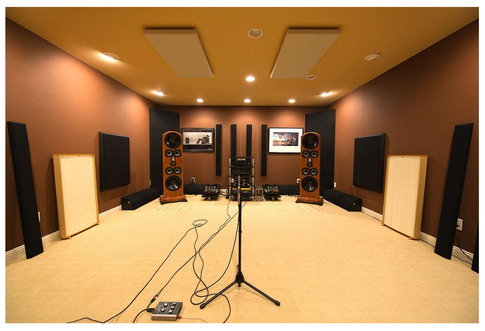
Host institution

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Motivation

In modern life, **low frequency sound** has become a strong problem, ranging from **noise radiation** by engines to **room acoustics control**.

Jet engines with absorbing liners at the intake.



Listening room with absorbent material and diffusers

Sound manipulation aims at tackling several challenges:

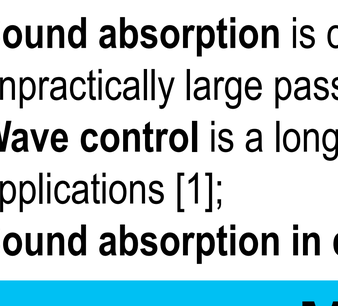
- **Sound absorption** is critical at low frequencies, because it demands unpractically large passive solutions;
- **Wave control** is a long sought-after feature, with numerous potential applications [1];
- **Sound absorption in ducts** is a sensible topic in the aviation industry

Main Objective

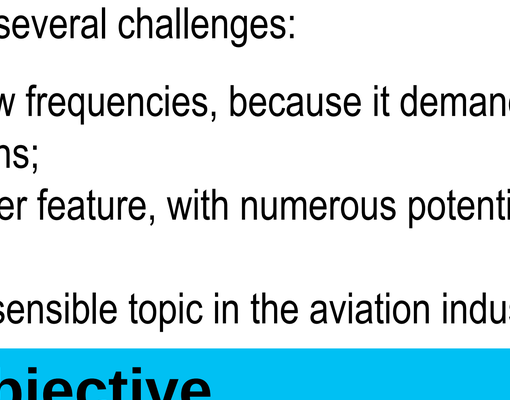
To **produce a new kind of material** for acoustic absorption or controlled reflection in order to **improve the acoustic behavior of various systems**.

Existing Background

Active impedance control via hybrid shunt was demonstrated in [2] for multiple degrees of freedom (MDOF), and proven useful in absorption.



Impedance controlled loudspeaker.



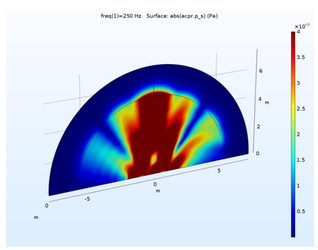
Source:[3]

Metamaterial approach.

Passive metamaterial solutions have already been investigated in previous work [3], showing several potential applications.

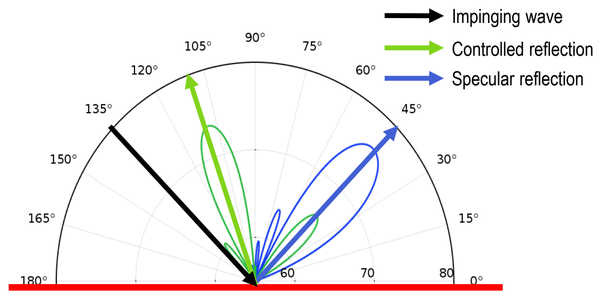
Methodology

- **FEM simulation** of the solution:



- **Anechoic measurements** and validation.

First results



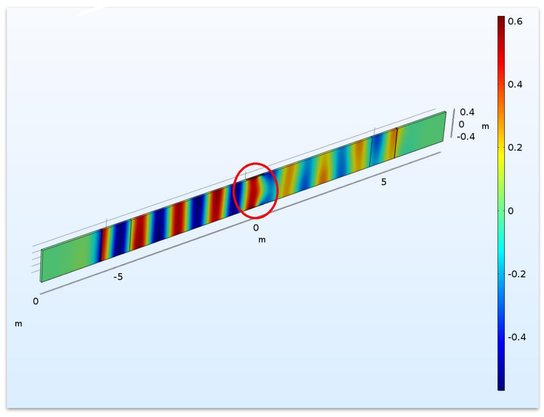
Wave redirection on a metasurface (in red)

Wave Redirection

Wave control by means of a reflectarray. The design is based on a gradient phase of the reflection coefficient along the surface, obtained with active cells.

Meta-liner

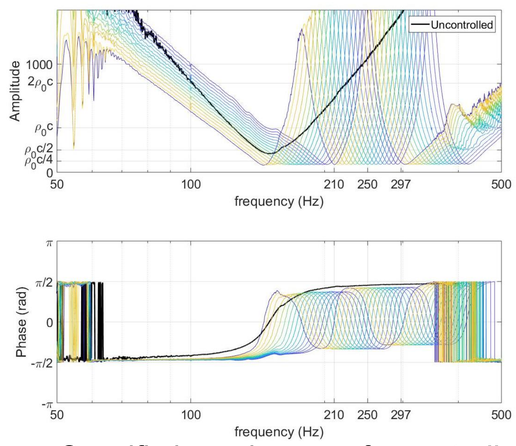
Insertion loss by treatment of a duct with a airborne to surface wave conversion on the liner, also based on a gradient phase of the reflection coefficient.



Insertion loss with a meta-liner

MDOF impedance control

Measurements of a controlled loudspeaker with an optimized 3-DOF target impedance



Specific impedances of a controlled loudspeaker array.

Elementary cell for active metamaterial:

- MDOF control strategy;
- Enabling **Generalized Snell-Descartes** (GSL) designs;
- Tailored specific impedance.

Future Work

- Expand **the control strategies**: explore **alternatives to the GSL design**
- **Apply the strategies** to concrete problems: define **objectives** for room acoustics improvement
- **Validate the performances: Compare to standard designs** and other existing solutions
- **Experimental validation:** Create a **prototype**

References

[1]H. Lissek, E. Rivet, T. Laurence, R. Fleury, “Toward wideband steerable acoustic metasurface with arras of electroacoustic resonators”, *Journal of Applied Physics*, 2018

[2] E. Rivet, “Room modal equalisation with electroacoustic absorbers”, *Thesis*, EPFL, 2016.

[3] H. Esfahlani, “Electromagnetic inspired acoustic metamaterials: studying the applications of sound-metastructures interactions based on different wave phenomena”, *Thesis*, EPFL, 2017

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