PROPOSITION DE SUJET DE THESE

Intitulé : Sound propagation in ducts with complex boundaries

Référence : **SNA-DTIS-2026-05**
(à rappeler dans toute correspondance)

Début de la thèse : septembre 2026	**Date limite de candidature :** juin 2026

Mots clés aéroacoustique ; ondes acoustiques ; guide d'ondes ; résonateurs de Helmholtz

Profil et compétences recherchées

Mathématiques appliquées, probabilités et statistiques, physique des ondes, méthodes numériques.

Présentation du projet doctoral, contexte et objectif

Air traffic is mainly concerned by the annoyances generated by turbojet engines, which exhibit multiple sources of noise: fan, turbine, combustion chamber and compressor, or jet accompanying the gas flow exhaust. Fan noise in particular represents nearly 50% of the overall noise pollution of an aircraft, both on takeoff and in the approach phase. In order to reduce this noise pollution, absorbing materials called acoustic liners are positioned along the engine nacelle (Jones 2022). These materials are subjected to very high levels of pressure (up to 160 dB) and to significant grazing flows (up to Mach 0.9). The liners currently used allow an overall attenuation of 4 to 5 dB at takeoff and 2 dB in the approach phase, still these performances must be significantly improved.

In this research, we aim to address noise mitigation in aircraft by theoretical and numerical approaches at the forefront of current researches in the field of guided wave propagation phenomena with broadband loads. We also aim to compare these approaches with experiments and relevant metrics in terms of their quantitative and qualitative acceptance for the design and implementation of innovative liner materials and architectures.

On the theoretical and numerical sides, waveguide geometries for acoustic waves will be considered at first. The classical theory of guided waves considers ideal waveguides filled with homogeneous media with straight and parallel boundaries. Reflecting, homogeneous, or constant impedance boundary conditions are usually considered to simulate acoustic liners such that, by solving the wave equation by separation of variables, the wave fields read as the superposition of non-interacting modes (Collin 1990; Magnanini-Santosa 2001). The modes get coupled in waveguides filled with heterogeneous, possibly random media, and/or with randomly fluctuating boundaries. The amplitudes of the modes are random fields accounting for the scattering phenomena arising in these situations, such as transport and diffusion (Alonso-Borcea-Garnier 2013; Borcea-Garnier 2014; Borcea-Garnier-Sølna 2019; Garnier-Papanicolaou 2007; Gomez 2015). Our first goal in this research is to address convected acoustic waves in a duct with periodic, fractal, or random boundaries for aeroacoustic applications. For relevance with the industrial applications, we shall also consider transient, broadband acoustical loads of sufficiently high amplitude to trigger nonlinear local phenomena in typical aeroacoustic liners.

The definition and implementation of optimization metrics need to take into account not only the noise performances, but also manufacturing, assembly, and constraints specific to the manufacturers, since multiphysics phenomena (dampness, dirt, aerodynamic drag, thermal gradient, fire resistance) get involved in airworthiness. In parallel, comparisons between different configurations are possible thanks to metrics such as tonal noise reduction, low-frequency noise reduction, broadband noise reduction, predictability, and linearity. Thus this research shall also investigate the practical implementation in an industrial context of the solutions developed above, considering the different constraints pertaining to aircraft.

Collaborations envisagées

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