M2 internship

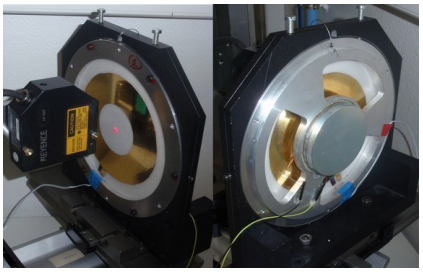
Optimization of the acoustic radiation of inflated piezoelectric plates

Institute of Mechanical Sciences and Industrial Applications

Duration : 5-6 months spring-summer 2019

Supervisor : Olivier Doaré (IMSIA ENSTA Paristech)

Context



At IMSIA researches are carried out on the dynamics and vibrations of plates or membranes used to produce sound. As an example, the figure on the right shows a flat loudspeaker prototype developed jointly with CANON. In the context of modal analysis, we can show how the radiated sound pressure level, function of the frequency and the position, depends on the geometry of the plate and on the piezoelectric patches distribution.

Objectives

During this internship, the studied system will consist of a plate partially covered by piezoelectric patches, subjected to a static pressure difference between its two faces. When imposing a time varying voltage at the electrodes, dynamical modes of the system are forced and sound is radiated. The system will be studied numerically and experimentally before performing an optimization procedure to look for the system's geometry that best satisfy various criteria (spectral equilibrium, directivity, …).

Numerical simulations will be performed will the help of the Freefem++ finite element software. An already existing code allows to compute the linear dynamics (eigenmodes and eigenfrequencies) around a nonlinear equilibrium position. Radiation is up to now calculated using the Rayleigh integral, which assumes that the plate is baffled in an infinite rigid plane.

The experimental work will consist of a small drum whose skin is a piezoelectric membrane. Different transfer functions for various values of the physical parameters of the system will be measured and compared to theoretical predictions based on the numerically computed eigenmodes.

In parallel of this experimental/numerical analyses, a numerical optimization of the system will be performed. The first optimization objective could for instance be the maximization of the modal forcing on one mode, respectively to the others, so that the radiation is dominated by a single mode. Next, various directivity objectives will be considered as well as taking into account diffraction if the plate is not baffled in an infinite plane anymore.

Profile of the student: A student interested in numerical and experimental acoustics, basic knowledge in numerical methods is sufficient, good background in structural dynamics is advised.

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