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LOCALISATION OF WAVES IN A CIRCULAR MEMBRANE : EXPERIMENTAL RESULTS AND COMPARISON WITH THE LANDSCAPE THEORY

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ABSTRACT

Introduction of inhomogeneities in a vibrating structure has opened some new methods for controlling the wave propagation. When those structures present randomness, localisation phenomenon can be present and, as a consequence, the behavior of the vibrating system will be drastically changed. The localisation landscape is a new tool that predicts the localisation of vibrational modes [1]. It has been show that with one single measurement, not only we can predict wave localisation in complex structures, but also fully characterize the vibrational behavior in the low frequency spectrum [2]. We present here the methodology for measuring the localization landscape on a circular membrane (bass drum). The measurement is performed using a laser vibrometer in quasi-static regime. Localisation is induced by the blocking points in the membrane surface. Results are compared with modal analysis in vacuum conditions.

1. THE LANDSCAPE FUNCTION

The landscape function u determines if a structure will have localized modes and their geometrical placement .Is defined by the Dirichlet problem:

$$\begin{aligned} Lu &= 1, & \text{in } \Omega. \\ u &= 0, & \text{on } \partial\Omega. \end{aligned} \quad (1)$$

The operator $L = c(\vec{r})^2 \Delta$, the speed of sound $c(\vec{r}) = \sqrt{T(\vec{r})/\rho(\vec{r})}$, T is the tension and ρ , the surface density of the membrane. Lefebvre [2] proposed that an approximation of the resonant frequencies of the localized modes by the equation:

$$\omega_i \approx (4/\pi)/\sqrt{\max(u_i)}. \quad (2)$$

2. MEASUREMENT METHODOLOGY

The landscape function can be calculated given the static deformation of a structure. Taking advantage of the high precision of laser vibrometry, we can perform a quasi-static approach, by exciting the structure with a frequency very below the fundamental frequency of the structure.

For the case of a membrane, quasi static measurement

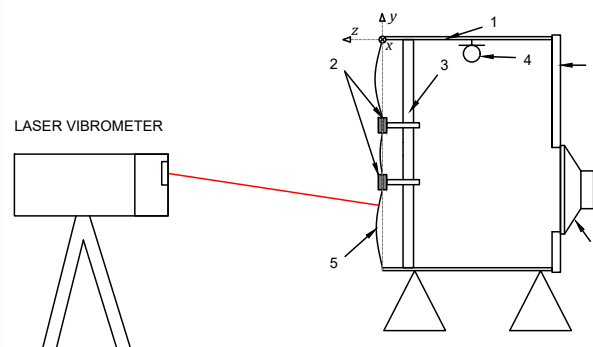


Figure 1: Side view: Configuration of the landscape measurement, 1. Bass-drum cavity, 2. Magnets used to create null displacement boundary conditions, 3. Support structure, 4. Microphone, 5. Membrane, 6. Back enclosure, 7. Loudspeaker.

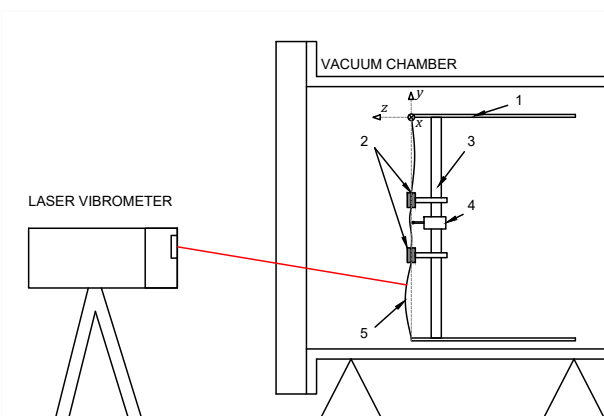


Figure 2: Side view: Configuration of the modal measurement, 1. Bass-drum cavity, 2. Magnets used to create null displacement boundary conditions, 3. Support structure, 4. Automatic hammer, 5. Membrane.

methodology was implemented and shown in Figure 1 where we placed a membrane in a fully closed bass-drum

cavity, on the rear side, a loudspeaker was installed in order to perform the quasi-static excitation inside the cavity and thus, a uniform pressure on the surface of the membrane. Then, the same structure was placed inside a vacuum chamber (Figure 2) to measure the modal deformation and resonant frequencies in vacuum conditions as illustrated in Figure 4. The measurement of the landscape function is shown in Figure 3b and the results comparing both approaches are presented in Table 1.

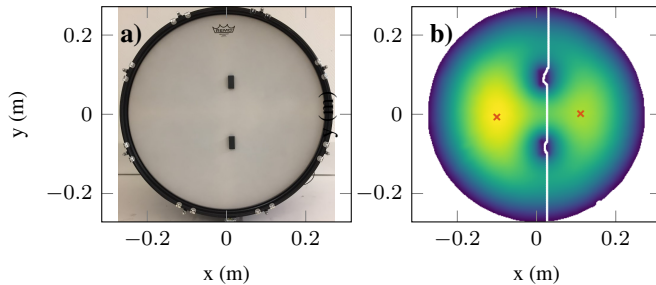


Figure 3: a) Frontal view of the membrane with the fixed points on the surface. b) Measurement of the landscape function by q quasi-static measurement. The red crosses mark the peak values in each sub-region.

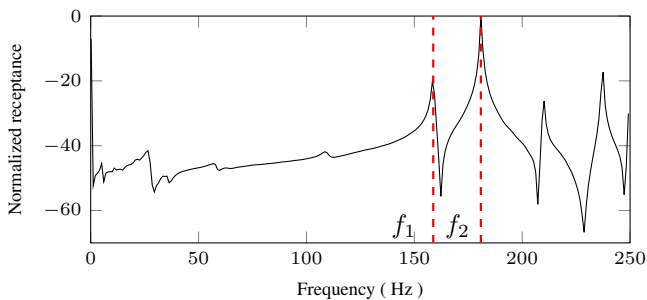


Figure 4: Measured receptance in vacuum conditions. The 2 first modes corresponds to the localized modes, predicted by the landscape theory.

3. RESULTS

A good estimation of the frequencies of the first localized modes has been found by an quasi-static measurement of the landscape function with less than 5% of difference in comparison with modal measurements. A membrane with non-uniform tension and more detailed information can be found in [3].

	Measured f.	Landscape f.	diff %
Mode 1	158.78 Hz	164.13 Hz	+3.37
Mode 2	180.85 Hz	176.05 Hz	-2.55

Table 1: Estimation of the frequency of the localized modes and comparison with modal measurements.

4. REFERENCES

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