Dimensional analysis adapted to scaled experiments

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Résumé :

Les auteurs s'intéressent ici à l'étude d'une expérimentation à échelle réduite. L'objectif in fine est de reproduire les effets de fluctuations du milieu sur la propagation des ondes acoustiques en milieu marin. Pour cela, l'adaptation du calcul des paramètres adimensionnels utilisés en général pour définir les régimes de fluctuations est proposée. Le but du présent article est de présenter les calculs menant à l'évaluation de ces paramètres. Le procédé repose sur le calcul analytique du champ acoustique propagé au travers d'une lentille acoustique présentant une face d'entrée plane et une face de sortie aléatoirement rugueuse. Des statistiques sur le champ acoustique (moments du premier et du second ordre) et les noyaux de sensibilité ont permis l'évaluation des paramètres "strength" et "diffraction", et le rapport entre la longueur de corrélation du champ acoustique et la longueur d'onde. Une continuité entre notre protocole expérimental à échelle réduite et des configurations océaniques réalistes est ainsi assurée.

Abstract :

The authors focus here on the study of a scaled experiment. The intrinsic objective is to reproduce the effects of medium fluctuations on underwater acoustic propagation. To do so, an adaptation of the derivation of the dimensionless parameters generally used to define the regimes of fluctuations is proposed. The aim of the present paper is to present of the calculations leading to the evaluation of these parameters. The procedure is based on the analytical calculation of the sound field propagated through an acoustic lens presenting a plane input face and a randomly rough output face. Statistics on the sound field (first and second-order moments) and sensitivity kernels lead to the evaluation of the so-called strength and diffraction parameters, as well as the ratio of acoustic correlation length to the wavelength. Continuity between our scaled experimental protocol and realistic oceanic configurations is therefore ensured.

Mots clefs : Medium fluctuation, dimensional analysis, coherence.

This paper addresses the topic of wave distortions when they travel through a fluctuating medium. An original experimental protocol is proposed: we propagate a ultrasonic signal (f=2.25MHz) through a Random Faced Acoustic Lens (or RAFAL), whose characteristics are given in the present paper (see fig. 1). This induces refraction and diffraction of the acoustic wave. The measurement of the acoustic pressure field throughout specific regions of the three-dimensional space is conducted using motorized rails controlled by a computer [1].

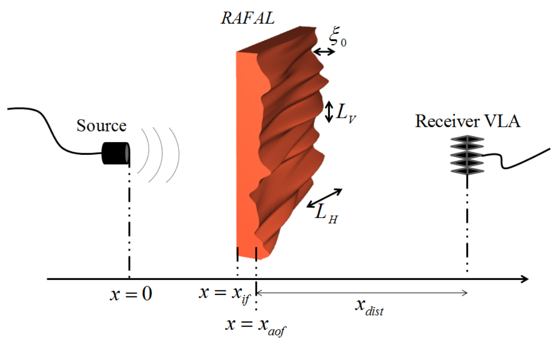

Figure 1: Experimental protocol.

In order to ensure the representativity of our scaled experiment, a dimensional analysis is used. The regimes of fluctuations defined by Wolf [2] and Flatté [3] are explored using adapted calculations of the "strength" Φ, and "diffraction", Λ, parameters. First, the sound field propagated through the RAFAL, denoted p, is calculated analytically. The small slope (SSA [4]) and the parabolic approximations were used.
Φ is obtained with the phase of the average sound field $< p >$, since $< p > \approx e^{-\frac{1}{2}\Phi^2}$ [3].
Λ is calculated using the Fresnel radius R_F, obtained with the phase sensitivity kernel (PSK). Indeed, R_F corresponds to the first maximum of the PSK [5]. The Fréchet derivative of the sound field was used to evaluate the PSK.
Furthermore, the calculation of the intercorrelation (second-order moment) of the sound field leads to the evaluation of the ratio of acoustic correlation length to the wavelength L_V/λ. The radius of curvature of the intercorrelation function of p was used to evaluate L_V/λ [6]. The concurrent evaluation of these parameters in our scaled experiment configuration and in an oceanic context allows us to ensure continuity in terms of regimes of fluctuations and coherence in both configurations. A direct comparison between our tank experiment and *at-sea* configuraitons can therefore be made.

The accuracy of our experimental scheme and of our scaling process is evaluated through the analysis of the second and fourth-order moments (respectively known as mutual coherence function and intensity). Especially, the radius of coherence normalized with the wavelength is supposed to match to L_V/λ. Satisfying results are obtained throughout the considered configurations.

References

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