HAL open science

Rotational and anisotropic metasolids: A generalized analytical model

Elie Favier, Navid Nemati, Camille Perrot, Qi-Chang He

► **To cite this version:**

Elie Favier, Navid Nemati, Camille Perrot, Qi-Chang He. Rotational and anisotropic metasolids: A generalized analytical model. IUTAM Symposium on the acoustic/elastic metamaterials, their design and applications, Jun 2018, Beijing, China. hal-01818214

HAL Id: hal-01818214

https://hal.science/hal-01818214

Submitted on 18 Jun 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

ROTATIONAL AND ANISTROPIC METASOLIDS: A GENERALIZED ANALYTIC MODEL

Elie Favier, Navid Nemati, Camille Perrot, Qi-Chang He

Université Paris-Est, Laboratoire Modélisation et Simulation Multi Echelle, MSME
UMR 8208 CNRS, 5 bd Descartes, 77454 Marne-la-Vallée, France, elie.favier@u-pem.fr

Abstract

In this talk, an analytical approach will be presented to model a metasolid accounting for anisotropic effects and rotational motions. Based on the initial experiences reported in [1], the aim of this study is to give a generalization of the method introduced by the same group [2] to describe the physics of this metasolid. This structure, made of either cylindrical or spherical hard inclusions embedded in a stiff matrix via soft claddings, exhibits negative mass densities near the translational-mode resonances (local resonance for translational motions). Within the large wavelength limit, in micro level hypothesis of rigid solid behavior has been made for both the inclusion and the matrix in this three-component medium. This assumption simplifies the analytical study of the problem, while yielding the physical dynamics of the medium.

In this work, firstly we give the frequency-dependent components of the effective mass density that appears to be anisotropic considering the cylindrical inclusions. Figure 1 (left) shows this result for cylindrical or spherical inclusions, obtained by continuum model, as well as those from the discrete model based on an analogy with mass-spring system. The latter, which can be easily derived from quasi-static homogenization of the soft cladding [3], may be useful to tune effective metasolids with desired acoustic properties. We systematically investigate the limit of the validity of this discrete model, which gives a very accurate estimation of the first local-resonance frequencies of the structure.

The second extension concerns the rotational modes, which exhibit similar properties at different frequencies: a negative density of moment of inertia near the rotational resonances is observed and well-estimated by a simple discrete model based on inertia-

torsional spring. As such, the effective density of moment of inertia, shown in Figure 1 (right), is introduced to characterize the homogenized material with respect to its rotational mode. This kinematics is different from those found in [4] or [5].

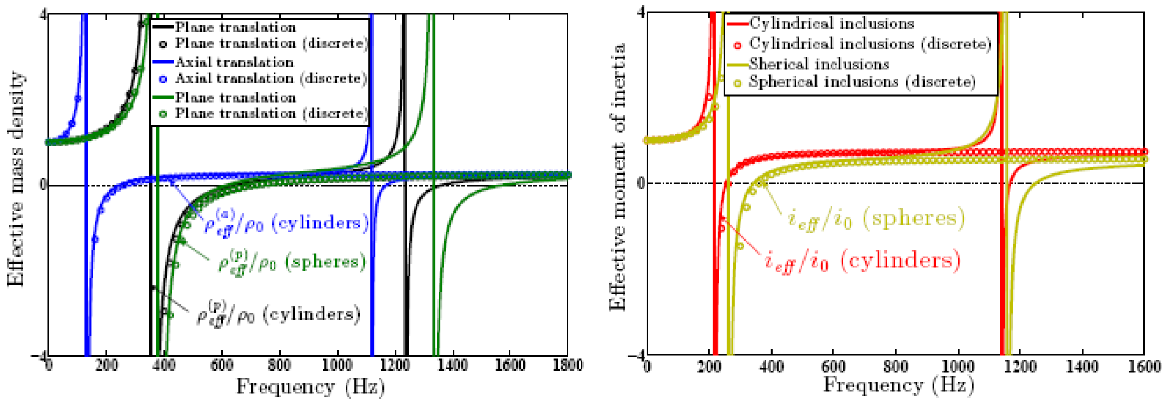

Figure 1. Effective mass densities (left), and effective moment of inertia (right).

References

[1] Liu Z., Zhang X., Mao Y., Zhu Y., Yang Z., Chan C. and Sheng P., 2000, “Locally Resonant Sonic Materials,” Science, **289**, pp. 1734-1736.

[2] Liu Z., Chan C. and Sheng P., 2000, “Analytical Model of Phononic Crystals with Local Resonances,” Phys. Rev. B, **71**, pp. 014103-8.

[3] See for example, Bonnet G. and Monchiet V., 2015, “Low Frequency Locally Resonant Metamaterials Containing Composite Inclusions,” J. Acoust. Soc. Am., **137**, pp. 3263- 3271.

[4] Peng P., Mei J., and Wu Y., 2012, “Lumped Model for Rotational Modes in Phononic Crystals,” Phys. Rev. B, **86**, pp. 134304-6.

[5] Bigoni D., Guenneau S., Movchan A. B. and Brun M., 2013, “Elastic Metamaterials with Inertial Locally Resonant Structures: Application to Lensing and Localization,” Phys. Rev. B, **87**, pp. 174303-6.