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Bio-inspired phononic crystals and elastic metamaterials

M. Miniaci[1], A. Bergamini[2], N. Kherraz[1], F. Bosia[3], A. S. Gliozzi[3], N. M. Pugno[4]
[1]*CNRS, Univ. Lille, Centrale Lille, Univ. Polytechnique Hauts-de-France, Junia, UMR 8520 -IEMN, F-59000 Lille, France*
E-mail: marco.miniaci@gmail.com
[2]*Empa, Laboratory for Acoustics/Noise Control, Uberlandstrasse 129, 8600, Duubendorf, Switzerland*
[2]*Politecnico di Torino, Department of Applied Science and Technology, Corso Duca degli Abruzzi 24, 10124, Torino, Italy*
[4]*University of Trento, Department of Civil, Environmental and Mechanical Engineering, Via Mesiano 77, 38123 Trento, Italy*

Abstract: Phononic crystals and acoustic metamaterials can be considered as composites with ad-hoc designed architectures made of periodic, quasi-periodic or even randomly disposed building blocks (unit cells) exhibiting extraordinary dynamic properties, such as frequency-dependent directionality and band gap (BG) behavior. Since their introduction a few decades ago, researchers have tried to explore more and more configurations exhibiting low and broad-band frequency effects without recurring to unpractical increases of the unit cell size or stiffness decreases [1].
On the other hand, Nature has always represented a formidable source of inspiration to solve mankind's scientific challenges and engineering tasks. For instance, it has been shown that a hierarchical organization over multiple length scales allows enhanced quasi-static mechanical properties, while the relative orientation of adjacent chiral centers strongly affects the physical properties of a polymer, to cite a few examples [2]. In this talk, we discuss how bio-inspiration may be used to enhance the potential of phononic crystals and acoustic metamaterials [3, 4]. Specifically, a comparison of the dynamic behavior of conventional and bio-inspired phononic crystals / metamaterials is presented through the evaluation of the corresponding dispersion diagrams and / or transmission properties.

References

[1] Hussein, M. I., Leamy, M. J. and Ruzzene, M. (2014). Dynamics of Phononic Materials and Structures: Historical Origins, Recent Progress, and Future Outlook. *Applied Mechanics Reviews*, 66(4), 040802.

[2] Meyers, M., Chen, P., Lin, A. and Seki Y. (2008). Biological materials: Structure and mechanical properties. *Progress in Materials Science*, 53, 1–206.

[3] Miniaci, M., Krushynska, A., Gliozzi, A. S., Kherraz, N., Bosia, F. and Pugno N. M. (2018). Design and Fabrication of Bioinspired Hierarchical Dissipative Elastic Metamaterials. *Physical Review Applied*, 10, 024012.

[4] Bergamini, A., Miniaci, M., Delpero, T., Tallarico, D., Van Damme, B., Hannema, G., Leibacher, I. and Zemp A. (2019). Tacticity in chiral phononic crystals. *Nature Communications*, 10, 4525.