Frequency spectra and stop-band optimisation of generalised canonical quasicrystalline phononic waveguides

A.K. Farhat[1], Z. Chen[1], L. Morini[1], M. Gei[2]

[1]*School of Engineering, Cardiff University, UK*

E-mail: *farhatak@cardiff.ac.uk, chenz51@cardiff.ac.uk, morinil@cardiff.ac.uk*

[2]*Department of Engineering and Architecture, University of Trieste, Italy*

E-mail: *massimiliano.gei@dia.units.it*

Keywords: Floquet-Bloch technique, metamaterials, composite materials.

The dynamic properties of periodic generalised two-phase quasicrystalline phononic rods [1] are studied through the method of the toroidal manifold. The method allows all stop and pass bands featuring the frequency spectrum to be represented in a compact form with a frequency dependent flow line on the surface describing their ordered sequence. The flow lines on the torus can be either closed or open: in the former case, (i) the frequency spectrum is periodic and the elementary cell corresponds to a *canonical configuration* [2], (ii) the stop-band density depends on the lengths of the two phases; in the latter, the flow lines cover the torus and the stop-band density is independent of those lengths. It is then shown how the proposed compact description of the spectrum can be exploited to optimise the layout of the elementary cell in order to maximise the low-frequency stop band. The scaling property of the frequency spectrum, that is a distinctive feature of quasicrystalline generated phononic media, is rigorously introduced. The obtained results represent both a key to a better understanding of the properties of classical two-phase composite waveguides and an important advancement towards the realisation of composite quasicrystalline metamaterials.

Acknowledgments

AKMF acknowledges support from Embassy of Lybia (ref. no. 13556). ZC acknowledges support from China Scholarship Council (Grant No. CSC201908500111). MG is grateful to the support provided by University of Trieste through grant FRA2021 'NEO-PHONON'.

References

[1] L. Morini, M. Gei, Waves in one-dimensional quasicrystalline structures: dynamical trace mapping, scaling and self-similarity of the spectrum, J. Mech. Phys. Solids 119 (2018) 83-103.

[2] M. Gei, Z. Chen, F. Bosi, L. Morini, Phononic canonical quasicrystalline waveguides, Appl. Phys. Lett. 116 (2020) 241903.