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► **To cite this version:**

Giuseppe Rosi, Nicolas Auffray. Wave propagation in non-centrosymmetric architected media. Forum Acusticum, Dec 2020, Lyon, France. pp.207-208, 10.48465/fa.2020.1102 . hal-03235501

HAL Id: hal-03235501

<https://hal.science/hal-03235501v1>

Submitted on 27 May 2021

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WAVE PROPAGATION IN NON-CENTROSYMMETRIC ARCHITECTURED MEDIA

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ABSTRACT

The study of elastic wave propagation is a fundamental tool in different fields, from non-destructive damage evaluation to ultrasonic imaging. Usually these techniques rely on inversion methods based on homogenised theories, that are valid only when the wavelength of the perturbation is considerably larger than the characteristic size of the heterogeneities of the materials. Heterogeneities can occur at different scales, and then it is useful to fix the scales of interest: the micro scale (i.e. the scale of the constitutive material μm), the meso scale (the scale of the architecture $\sim\text{mm}$) and the macro scale (the scale of the tissue $\sim\text{cm}$). When the wavelength approaches the characteristic size of the architecture, an upscaling occurs and mesoscopic effects can be transferred to macro-scale. In this case, classic models used in the aforementioned inversion procedures can fail to predict a the correct response and they need to be improved. In this work, we will address the case of non-centrosymmetric architectures, i.e. those for which the unit cell does not have any centre of inversion, and it will be shown that the effects on wave propagation in terms of dispersion and polarisation cannot be neglected in common applications involving elastic waves. We will also show that, in order to describe these media with a continuum model, the use of an enriched continuum theory, such as the Strain Gradient Elasticity (SGE), is mandatory. The particular example of the gyroid unit cell (Fig. 1) is detailed, following the results presented in [1].

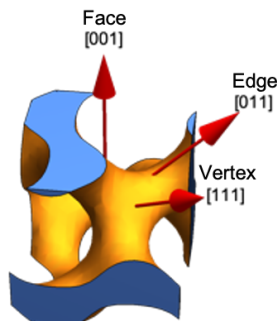


Figure 1. Gyroid unit cell.

The SGE model has been introduced in the early 1960s in the seminal works of Mindlin (see e.g. [2]). In order

to solve the elastodynamic problem, constitutive equations relating primal and dual quantities are needed. This results been already presented in [3–5]. The description of all the anisotropic strain-gradient elastic systems can be found in [3,6]. The classification detailed in this references is based on the point group of the unit cell. The most general form of the constitutive law has tensors up to the rank six. Each constitutive tensor has a precise role in defin-

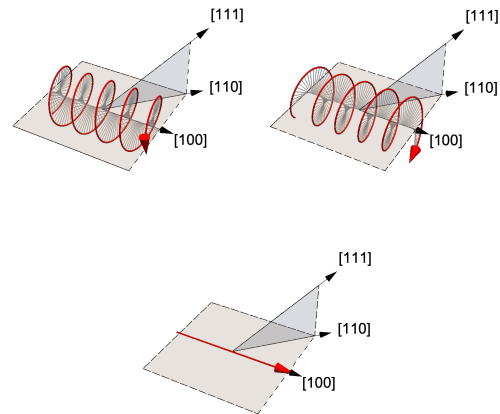


Figure 2. Wave polarisations for waves propagating towards direction [100] for the Gyroid architecture.

ing the elastodynamic properties of the system. We will show that the odd ranked tensors in the constitutive law are the direct consequence of noncentrosymmetry. Then, the way they affect wave propagation in SGE continuum model is compared to the phenomena observed in full field simulations, such as circular polarization of waves (see e.g. Figure 2) or acoustical activity.

1. REFERENCES

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