Towards elastic wave manipulation in Kelvin Cell packings with controlled anisotropy

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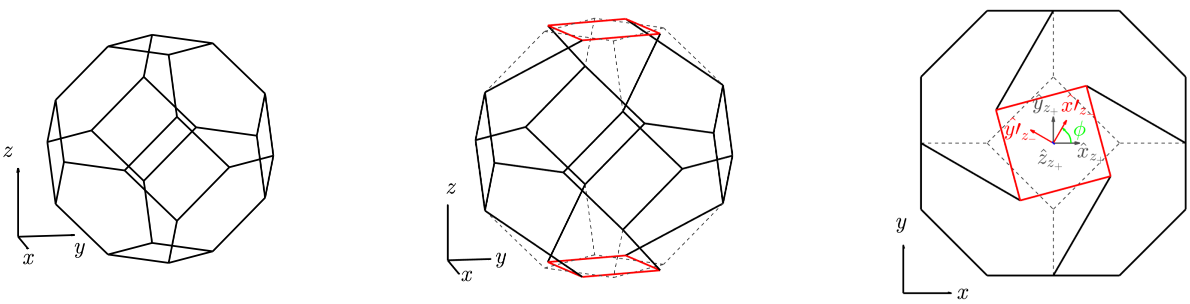
The present contribution proposes to reflect on the use of packings of distorted Kelvin Cell to create controlled anisotropic media for elastic waves. The work is still in an exploratory stage and we will present the early investigations and results. The key aspects of the proposed research is to understand how one can modify the cell geometry to alter the slowness surfaces and propagation characteristics for the resulting media. On the long run, the idea is to incite interesting effects such as wave trapping, steering and controlled compression-to-shear conversion that can find application in a number of engineering domains.

1 Context

With new manufacturing capabilities come new strategies to design and construct novel complex materials. In the context of porous media, such materials are often periodic and the recent contributions have focused primarily on media mimicking a controlled pore network. It was shown that the proposed media can then be 3D printed and that measurements and simulations for airborne propagation agree well [1].
The design of complex structures obviously goes beyond fluid acoustics applications and particularly spans over the field of elastic waves. An option to construct controlled-anisotropic lightweight media is to use arrays of distorted Kelvin cells [2, 3]. In these media, the cell to be repeated corresponds for instance to a Kelvin cell such as the one presented on Fig. 1a with some of the square faces rotated (see Fig. 1b). This kind of modifications of the cell allow to generate anisotropic media and particularly, work is ongoing to control this anisotropy. One of the key aspects today is to understand how specific types of alteration lead to different patterns in the Hooke's tensor and harness these effects. Of course, other modifications of the cell can be proposed, leading to different effects which is the scope of another contribution by the authors.



(a) Non distorted (b) Top and bottom faces rotated (c) Top view of Fig. 1b

Figure 1: The original Kelvin Cell undistorted (Fig. 1a) and distorted by rotating the top and bottom face around the z axis by 60 degrees (Figs. 1b and 1c). Reproduced from Ref. [3].

2 Proposed work

In this presentation, we will discuss the use of this new class of anisotropic media to create specific effects for elastic waves. The key aspect of the proposed research is to understand how one can modify the cell geometry to alter the slowness surfaces and propagation characteristics for the resulting media.

Being able to design groups of cells that together favour compression-to-shear conversion for instance, paves the way to a number of systems capable of trapping waves and dissipating the incoming energy within a short distance. Controlling entirely the anisotropy of a given medium also allows to target specific modes and answer precise design requirements.
The path towards such applications is arduous and this presentation aims at giving an overview of the strategy we are implementing. This includes for instance the construction of surrogate models to mitigate the computational costs of performing the numerical characterisation of the media [4] or the approach taken to identify promising alterations for a given target effect. The work is still in an exploratory stage and we intend to present the early investigations and results, hoping to foster discussions and comments.

References

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