Wave-diode effect exploiting discretely modulated phononic waveguides

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ABSTRACT

Space-time varying phononic materials have drawn great interest in the research community, due to their ability to break time reversal symmetry, therefore achieving one-way wave propagation in elastic structures. In analogy with their electric counterparts, these new devices are generally referred as acoustic diodes or mechanical diodes.

The literature about these systems is generally limited to the study of phononic cristals continuously varying their characteristics over space and time. Although interesting to represent many of the peculiarities of time-varying structures, this approach is in some way limiting when analysing practical cases, where the modulation of structure mechanical properties is typically attainable only in a discrete fashion.

In this manuscript we study discretely modulated rod and beams, whose spatiotemporal unitary cells are composed by a set of sub-cells with elastic modulus periodically varying in time. This new class of materials is able to break the mirror symmetry in the momentum space, which is necessary to achieve the acoustic wave-diode effect.

Non-reciprocal Bloch diagram is computed using a new generalized Plane Wave Expansion Method which can be applied to any generic modulation that can be written on a space-time Fourier basis. In this context, we show that the frequency spectrum is characterized by complete and directional bandgaps, that are associated to the harmonic content of the spatiotemporal unit cell.

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