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Pentamode metamaterials for acoustic wave control

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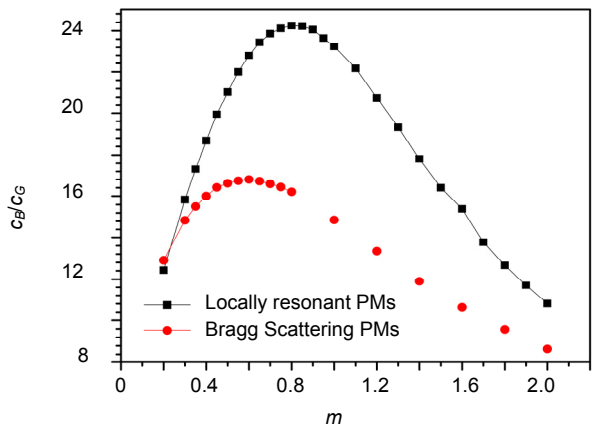

The quality factor comparing between locally resonant PMs and Bragg scattering PMs.

Abstract: Pentamode metamaterials (PMs) are one of the artificial periodic materials for which the six eigenvalues of the effective elasticity tensor only take one non-zero but five zero. Hence, PMs are also called "metafluids" by making the bulk modulus B extremely large compared to the shear modulus G. PMs with anisotropic elastic tensor have potential applications for acoustic cloaking, noise insulation, and other special acoustic devices. So it is concerned by scientists. In the review, pentamode materials and their recent progress are introduced. It includes the concept of PMs, acoustic and elastic properties of Bragg scattering PMs, locally resonant PMs, fabrications and measurement methods.

PMs with structures perturbed units not only have excellent fluid properties in the single mode region, but also have the complete phonon bandgap. Therefore, in addition to the use of acoustics clacks, but also can be widely used for vibration and noise reduction, earthquake proof construction, the protection of ancient buildings, design of large concert hall, energy collection and others acoustic devices and so on. The locally resonant PMs proposed by us have the single mode regions and the complete phonon bandgap in the low-frequency regions simultaneously. Compared with the traditional Bragg scattering PMs, the first complete phonon bandgap of locally resonant PMs can be reduced by two orders of magnitude while keeping periodic unit length of structure the same. Locally resonant PMs are a new mechanism different from Bragg scattering PMs. It has excellent low-frequency characteristics and realizes small size (periodic unit length of centimeter scale) to control large wavelength (especially below 100Hz). The locally resonant PMs also have a higher quality factor than the Bragg scattering PMs. Therefore, the locally resonant PMs provide a path to control low-frequency acoustic wave.

Although the acoustic and mechanic properties of PMs have been studied, there are still many characteristics of PMs that need to be studied extensively. It includes the building and design of the novel type PMs, such as low symmetric degree PMs, and different lattice structures PMs; the operating principles of Bragg scatting PMs, locally resonant PMs, and the Snell's law of the 2D PMs; the methods of fast and high-efficient numerical calculations of PMs, the optimization designs of coding pentamode metamaterials, and the high-precision fabrication technology of PMs.

Keywords: acoustic wave control; pentamode metamaterials; Bragg scattering; local resonance

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See page 34 for full paper.