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A Method Based on Wavelets for Band Structure Analysis of Phononic Crystals

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Summary

The phononic crystal is a composite medium composed of periodic arrays of two or more materials with different elastic properties. Phononic crystals may exhibit complete (or absolute) band gaps in their transmission spectra where the propagation of acoustic or elastic waves is strictly forbidden in all directions. The complete band gaps could be engineered to provide a vibrationless environment for high precision mechanical systems in given frequency ranges. Understanding the full band structures (including both stop-bands and pass-bands) is expected to lead to the design of new generations of sound shields, filters, transducers, refractive devices such as acoustic lenses and acoustic interferometers, etc. By breaking the periodicity of the systems, it is possible to create highly localized defect or guided modes within the acoustic band gaps. This makes the phononic crystals potential candidates for the design of elastic or acoustic wave guides. Because of these promising applications, the propagation of elastic or acoustic waves in phononic crystals has received increasing attention in the past decade. In this paper, a numerical method based on the wavelet theory is developed for calculating band structures of 2D phononic crystals consisting of general anisotropic materials. After systematical consideration of the appropriate choice of wavelets, two types of wavelets, the Haar wavelet and Biorthogonal wavelet, are selected. Combined with the supercell technique, the developed method can be then applied to compute the band structures of phononic crystals with point or line defects. We illustrate the advantages of the method both mathematically and numerically. Particularly some representative numerical examples are presented for various material combinations (solid-solid, solid-fluid and fluid-fluid) with complex lattice structures to show the accuracy, fast convergence and wide applicability of the method.