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A comparative study of wave localization in locally resonant Thue-Morse, Rudin-Shapiro and Period-Doubling aperiodic structures

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Abstract: The localization characteristics of the in-plane elastic waves in locally resonant aperiodic phononic crystals are examined in this study. In particular, the phononic crystals generated according to the Thue-Morse, Rudin-Shapiro and Period-Doubling sequences are theoretically investigated by using the extended transfer matrix method. For comparison, the binary and ternary locally resonant systems are considered, and their band structures are characterized by using the localization factors. Moreover, the influences of structural arrangement, material combination, incidence angle, number of components, length ratio, and random disorder on the band structures are also discussed. Some novel and interesting phenomena are observed and discussed.

Keywords: phononic crystals, aperiodicity, wave localization, localization factor, transfer matrix method.

1. Introduction

Periodic phononic crystals (PNCs) have been studied intensely over the past two decades due to their potential capability of controlling acoustic/elastic wave propagation [1–13]. Moreover, there is a continuously growing scientific interest in aperiodic phononic crystals (APNCs), which are characterized by a lack of long-range periodic translational order [14–19]. Such structures exhibit anomalous properties which are of significant interest in both basic and applied sciences. For example, they do not show Bloch wave propagation characteristics, but rather exhibit unique characteristics of a mixture of acoustic/elastic wave propagation and localization. These peculiar properties are useful for the fabrication of acoustic or elastic wave filters. Although the quasi-periodic and aperiodic photonic crystals (APTCs) have been extensively investigated and reported in literature, very few theoretical studies on the localization of APNCs have been performed.

In recent years, significant research efforts have been devoted to the simulation and analysis of wave propagation in APNCs. Chen et al. [14] studied the Lamb wave transmission in Fibonacci composite plates. Sesion et al. [15] considered the acoustic-phonon transmission spectra in Fibonacci super-lattices. King et al. [16] reported experimental observations of phononic band structures in one-dimensional (1D) aperiodic waveguides. Aynaou et al. [17] studied the propagation and

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