MCoMss08-003

Flexural Wave Bandgaps in 1-D Hierarchical Mechanical Metamaterial Beams

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The behavior of mechanical metamaterials under dynamic conditions is very useful for wave propagation control. Periodic structures associated with local resonance can improve the performance of elastic metamaterials, which open the possibilities of application of these kinds of systems. Additionally, hierarchical parameters are shown to influence significantly both band structure and frequency responses of metamaterials. This study explores hierarchical Euler-Bernoulli metamaterial beams composed by homogeneous material with attached single degree of freedom resonators. Different cases of hierarchies in the resonator's position and mass, following arithmetic, geometric, and Fibonacci progressions are evaluated. The bandgap formation is investigated through the dispersion diagram, obtained by plane wave expansion (PWE) and extended plane wave expansion (EPWE). Also, the frequency response of the model is computed by wave finite element method (WFEM). The bandgaps observed in the hierarchical structures presented broader frequency ranges. Thus, the combination of hierarchical features into mechanical metamaterials can contribute for the development of high performance and novel structures for dynamic purposes.