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Influences of the geometrical nonlinearity on the complex band structures of periodic lattice frame structures

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In recent years, the periodic materials and structures, such as phononic and photonic crystals, are becoming increasingly popular in the scientific community and many engineering applications. For instance, the phononic crystals (PCs) can manipulate the acoustic orelastic wave propagation characteristics [1]. In particular, it is possible to generate the so-called frequency band-gaps, which are certain frequency ranges, in which the propagation of acoustic or elastic waves is prohibited. Many numerical methods have been proposed to calculate the band structures of PCs, for example the Finite Element Method (FEM), the Boundary Element Method (BEM), the Plane Wave Expansion Method (PWE), the Layered Multiple Scattering Method (LMSM), etc. For periodic lattice frame structures, the Spectral Element Method (SEM) is another alternative numerical method and offers certain distinct advantages, such as its high accuracy and efficiency, especially in the high-frequency range.

In this study, the complex band structures of the geometrically nonlinear periodic frame structures are calculated by using the Spectral Element Method [2,3]. For this purpose, the spectral element matrix for a geometrically nonlinear beam element is derived. By solving the inverse eigenvalue problem for computing the complex dispersion curve $k(\omega)$ instead of the conventional eigenvalue problem for calculating the real dispersion curve $\omega(k)$, the complex wave vector or wave number can be obtained, whose imaginary part describes the evanescent behavior of the Bloch waves. Subsequently, the geometrically nonlinear effects on the evanescent behavior of the Bloch waves are investigated by evaluating the dispersion curves and the transmission spectra.

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