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# Topology Optimization for Pentamode Lattice Metamaterials

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Pentamode metamaterials are a new class of artificially engineered lattice metamaterials with vanishing shear modulus and able to support single mode of stress. In this research, a topological optimization method is first developed to generate pentamode lattices which will exibit effective material properties over a range of relative densities. The design of the pentamode microstructure is defined as a three-dimensional ground structure with at least orthotropic symmetry. Then, the necessary and sufficient condition for the elasticity matrices of pentamode metamaterials with at least orthotropic symmetry is proposed. This research shows that a large ratio between the bulk modulus and the shear modulus is not a sufficient condition for pentamode metamaterials that are not isotropic. After that, a range of new pentamode microstructures are created to demonstrate the effectiveness of the proposed design method. This study will supply a very solid foundation in princicple for application of pentamode applications, including cloaking devices.