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Abstract

In this paper, we propose a level set-based topology optimization method for the design of hyperbolic acoustic metamaterials using a high-frequency homogenization method. To estimate the properties of acoustic metamaterials, we first introduce the high-frequency homogenization method proposed in previous work, through which the macroscopic wave behavior of periodic structures can be obtained even if the wavelength of impinging acoustic waves is comparable to the size of the unit cell. We propose a new level set-based topology optimization method based on the high-frequency homogenization method that can provide unit cell designs that exhibit hyperbolic dispersion. We compute the topological derivatives using an equation that expresses the relationship between the topological and shape derivatives. Numerical examples are provided to confirm the utility of the newly proposed optimization method. The obtained optimized unit cell designs, configurations of air and aluminum, exhibit hyperbolic dispersion by exploiting resonances induced in the unit cell.

Keywords: Acoustic metamaterial, High-frequency homogenization method, Topology optimization, Level set method, Hyperbolic metamaterial, Anisotropic metamaterial

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