Wavefront Manipulation by Fractal Space-Coiling Acoustic Metamaterials

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Outline

➢ Aerialist & Metamaterials
➢ Wavefront Manipulation
➢ Additional Works
➢ Future Works
Aerialist

AERIALIST aims at the disclosure of the potential of metamaterials to envisage innovative devices for the mitigation of the civil aviation noise.

Scattering cancellation, hyper-focusing, and noise trapping techniques will be investigated to achieve virtual scarffing of intakes, suitable treatment of outflow ducts and enhancement of shielding effects.
Aerialist

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AdvancEd aircraft-noise-Alleviation devIceS using meTamaterials
Metamaterial

Functional Material

- Phononic Crystals
- Acoustic Metamaterials
Acoustic metamaterials
Michael R. Haberman, and Matthew D. Guild

Citation: Physics Today 69, 6, 42 (2016); doi: 10.1063/PT.3.3198
Method for retrieving effective properties of locally resonant acoustic metamaterials

Vladimir Fokin, Muralidhar Ambati, Cheng Sun, and Xiang Zhang*

Inverse program

Effective properties \((\rho, \beta)\)
Acoustic focusing by coiling up space

Yong Li, 1,2 Bin Liang, 1,2,a) Xu Tao, 1 Xue-feng Zhu, 1 Xin-ye Zou, 1 and Jian-chun Cheng 1,2,a)

Effective medium

\( n_r, Z_r \)

(a) (b) (c)
Acoustic Metamaterial With Fractal Coiling Up Space for Sound Blocking in a Deep Subwavelength Scale

Inspired by fractal photonic phononic crystals, the self-similar fractal technique is applied to design acoustic metamaterial. By replacing the straight channel of coiling up space with a smaller coiling up space, a class of topological architectures with fractal coiling up space is developed. The significant effect of the fractal-inspired hierarchy on the band structure with fractal coiling up space is systematically investigated. Furthermore, sound wave propagation in the acoustic metamaterial with the fractal coiling up space is comprehensively highlighted. Our results show that the acoustic metamaterial with higher-order fractal coiling up space exhibits deep subwavelength bandgaps, in which the sound propagation will be well blocked. Thus, this work provides insights into the role of the fractal hierarchy in regulating the dynamic behavior of the acoustic metamaterial and provides opportunities for the design of a robust filtering device in a subwavelength scale. [DOI: 10.1115/1.4057514]

Fig. 1 Schematic cross-sectional illustrations of three types of acoustic metamaterials with coiling up spaces: (a) acoustic metamaterial with the first-order coiling up space, (b) acoustic metamaterial with the second-order coiling up space, and (c) acoustic metamaterial with the third-order coiling up space.
Change of fractal dimension
Change of fractal dimension

Diameter of inner cavity

Number of edges
Diameter of inner cavity

Number of edges
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UoB

Paper
Symmetry directions

Γ

M

X
Increasing order of fractal

![Graph showing increasing order of fractal with wave vector and frequency across different regions.](image-url)
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AdvancEd aircraft-noise-Alleviation devIceS using meTamaterials
2 DoF Resonators
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Future Works

➢ Design and manufacture targeted Metamaterials
➢ Building a wave guide - experiments
➢ Experiments on neck effect
➢ Aerialist test campaign
Thanks