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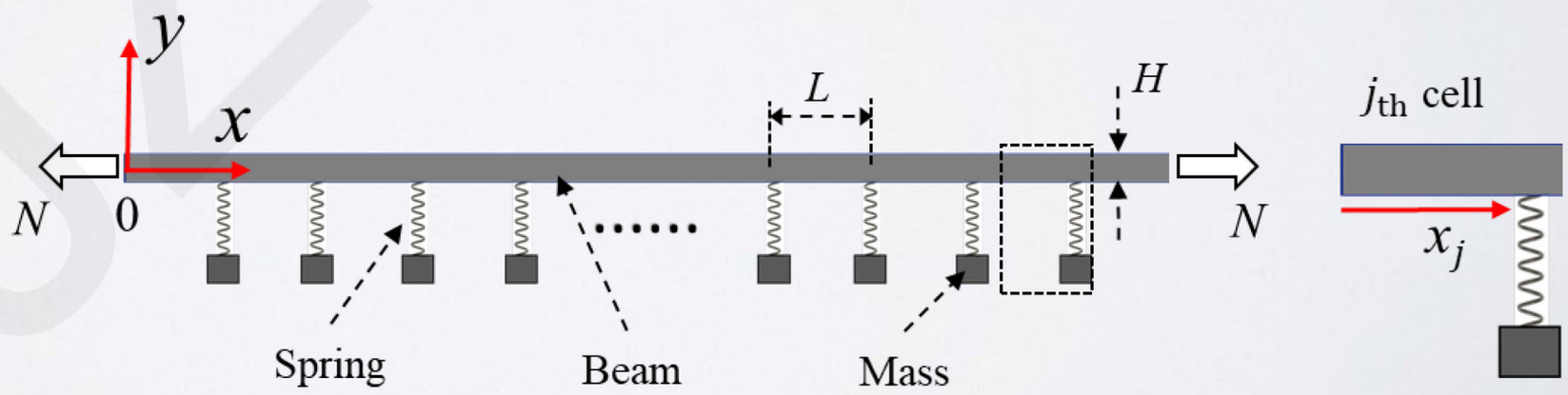
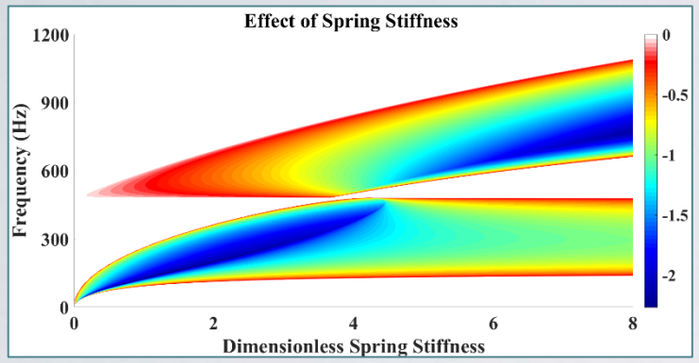
Tuning bandgaps in metastructured beams: numerical and experimental study

Key words:

Metastructured beam; Prestress; Tunable bandgap; Pseudo-gap; Arrangement



Research Methods



Bandgap feature

Simplification: Euler-Bernoulli beam, Ignoring gravity…

Prediction: bandgap feature, pseudo gap…

Theory

FEM

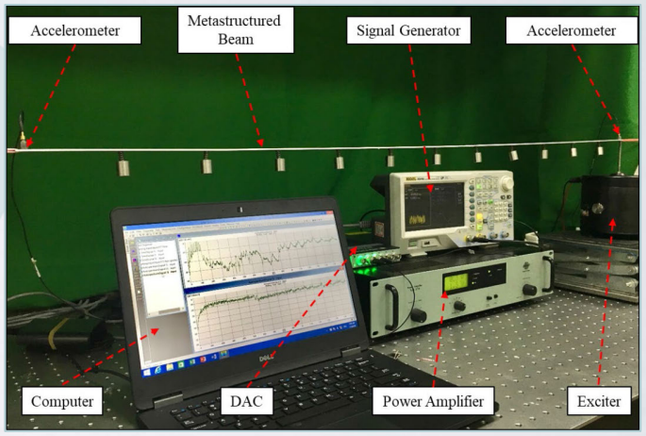
Experiment

Visualization: modal, vibration process…

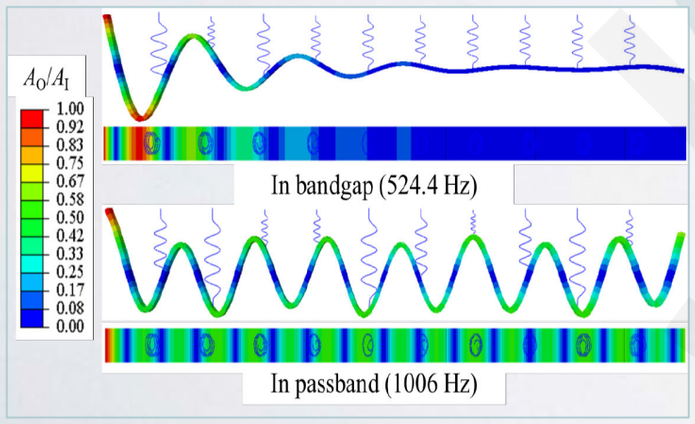
Optimization: cheap, fast, powerful, competent complexity…

Verification: reality, persuasive…

Application: beneficial engineering practice…



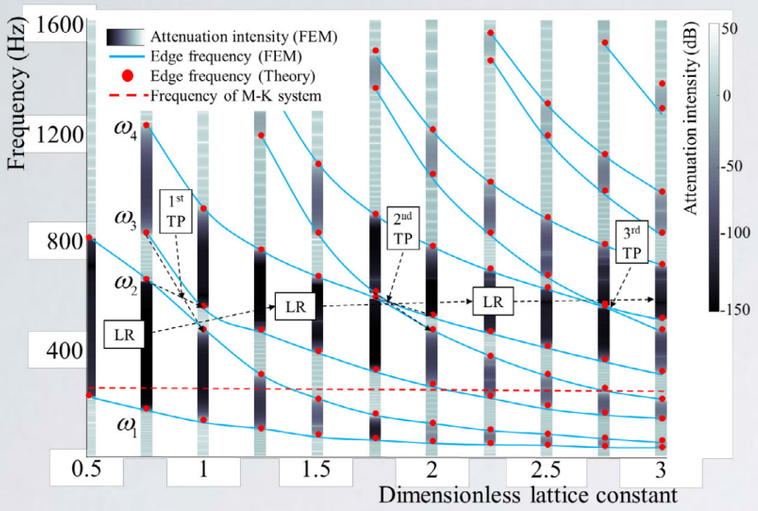
Experiment equipment



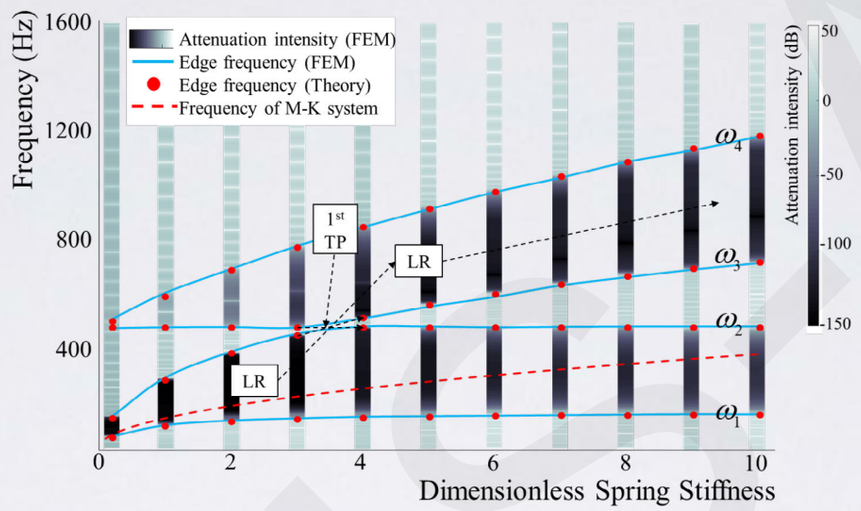
Vibration in bandgap and pass band

Research parameters & results

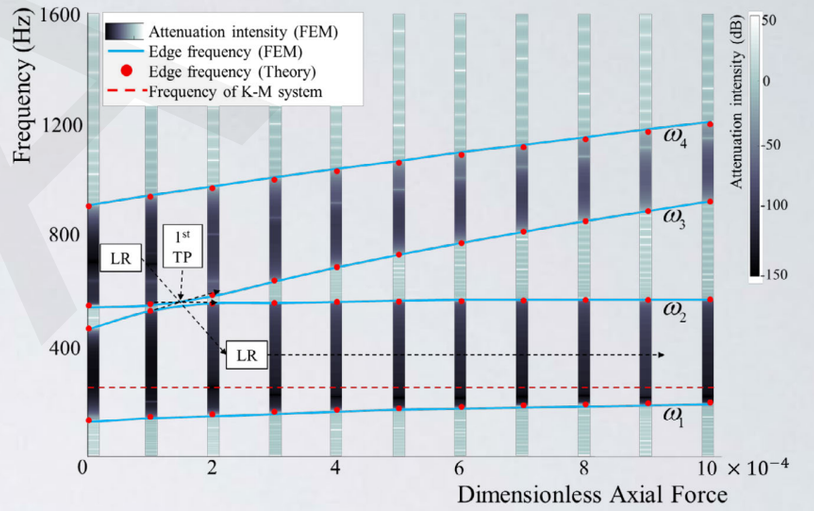
1. Lattice constant



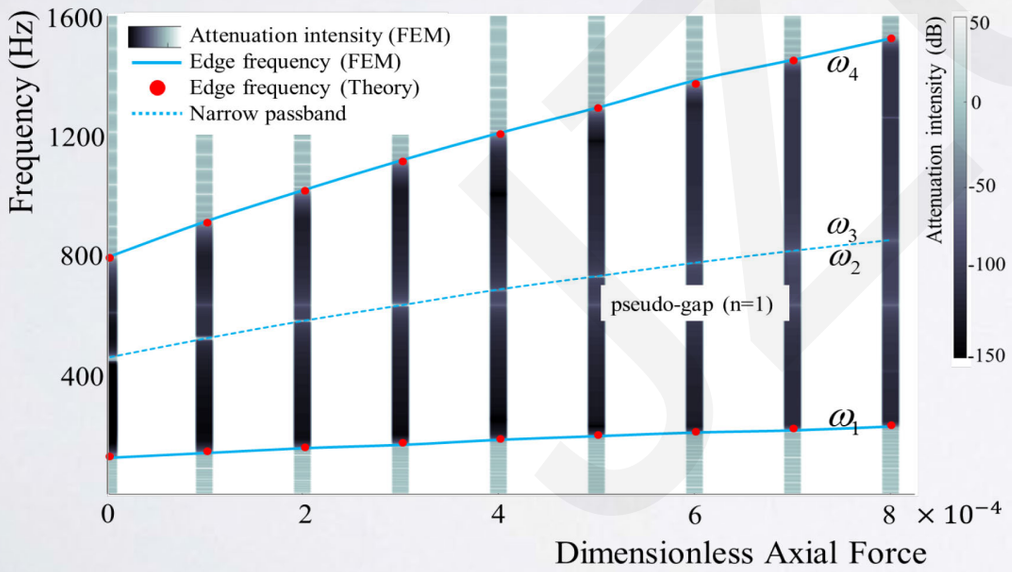
2. Spring Stiffness



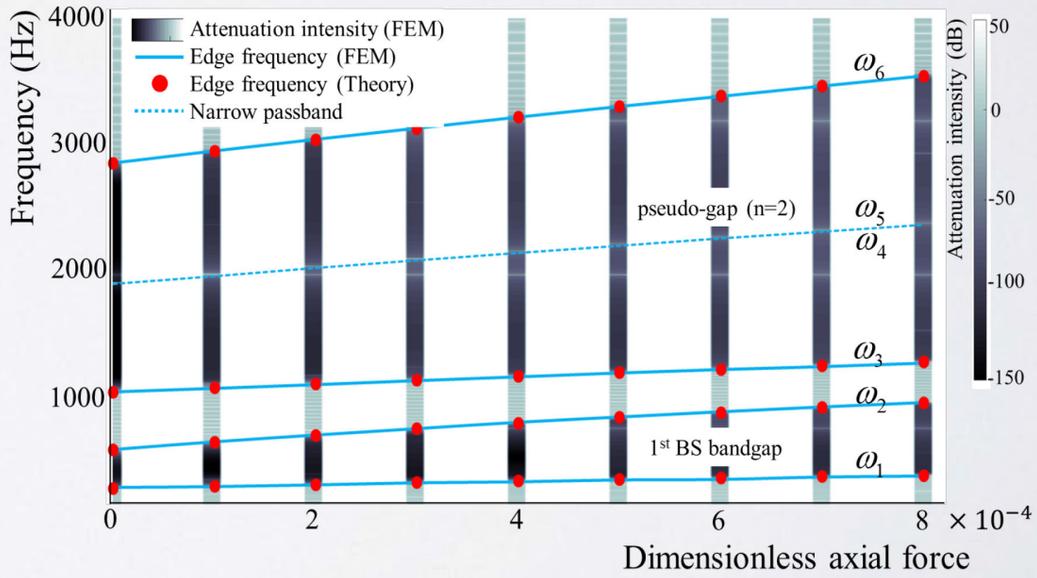
3. Axial Force



4. Pseudo-gap (n=1)

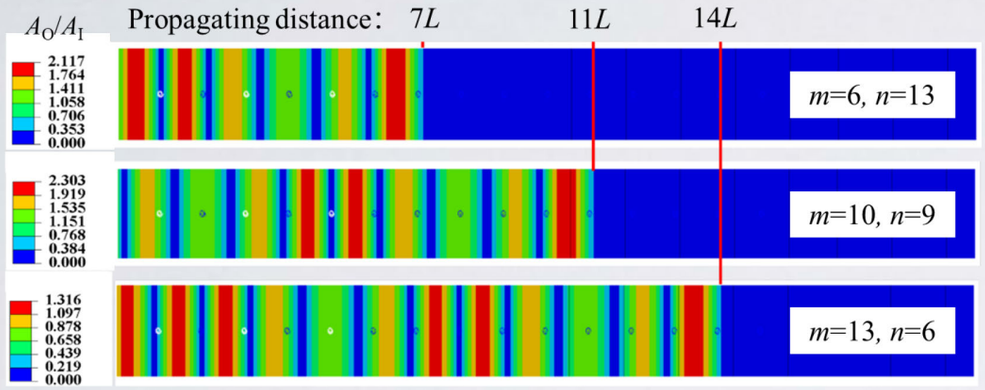


5. Pseudo-gap (n=2)

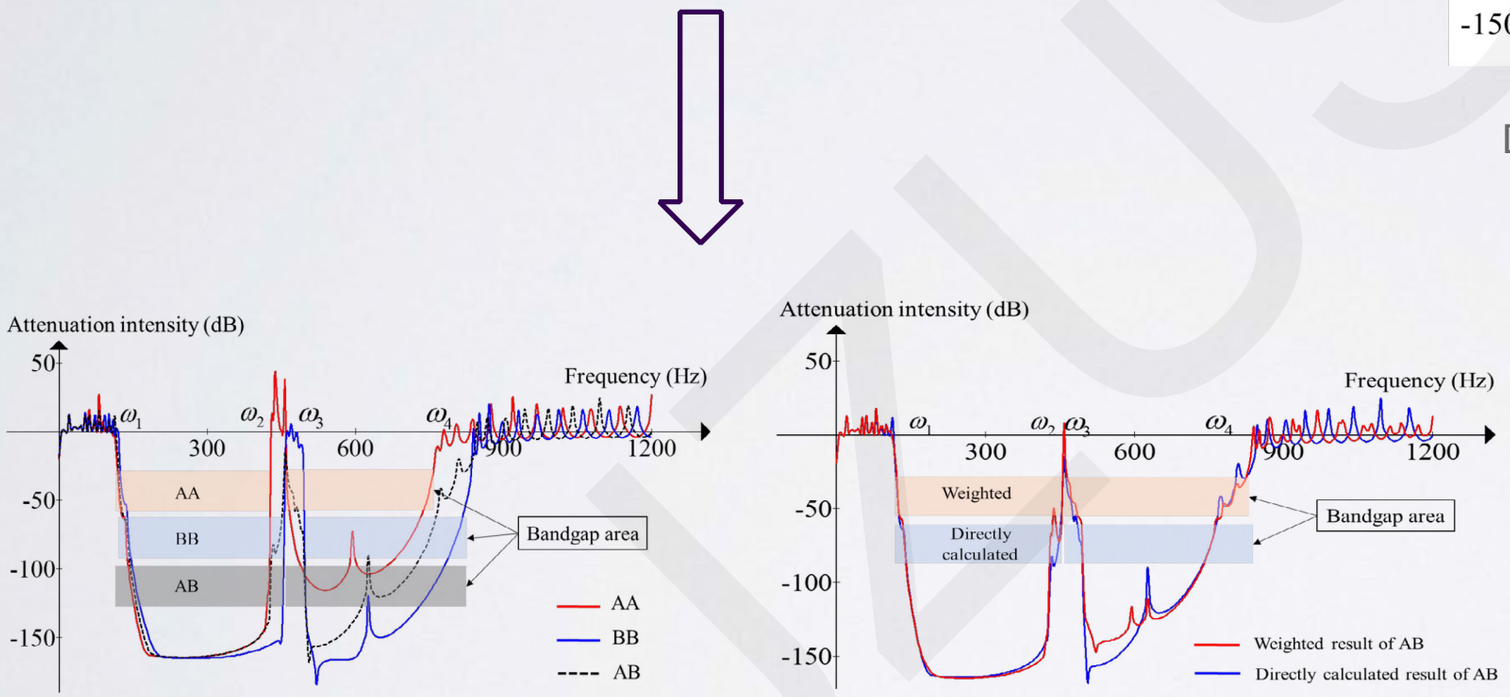


Research parameters & result

6. Arrangement

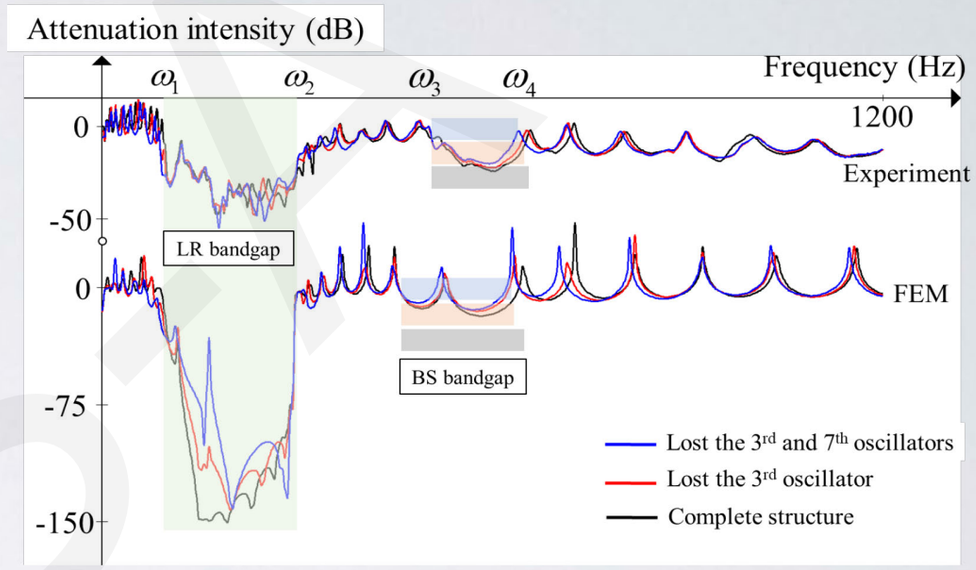


Control of wave propagation distance by changing the numbers of two different mass-spring oscillators



The synthesized metastructured beam has much wider bandgaps and an analogous super wide pseudo-gap.

7. defect



Defects have less influence on the LR bandgap but greater influence on the BS bandgaps.

FEM & Experiment

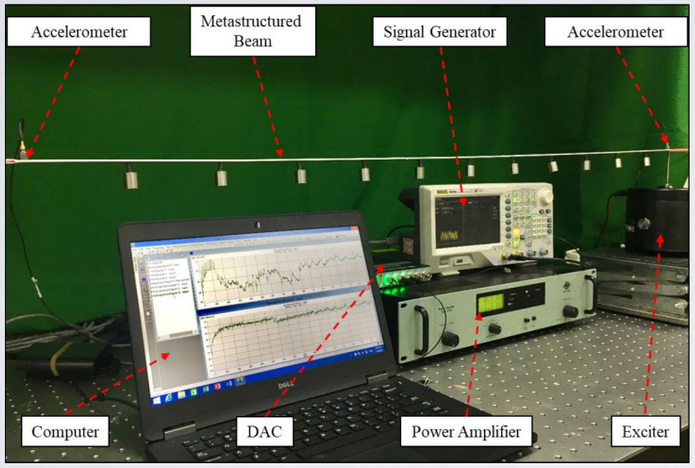
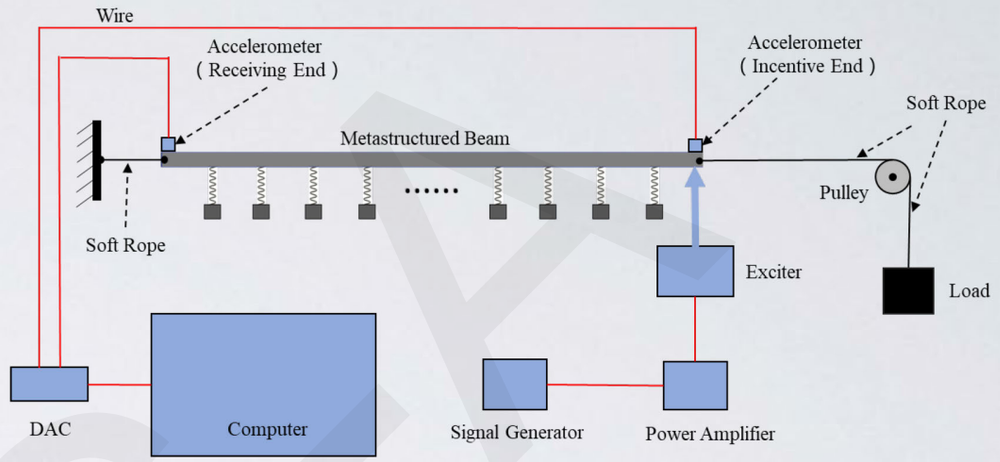
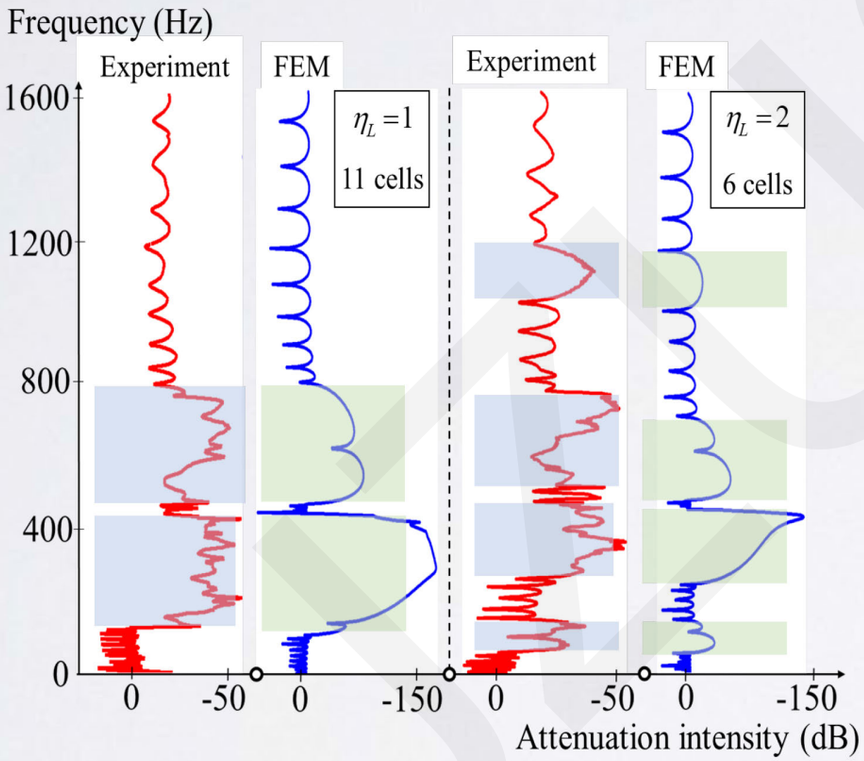


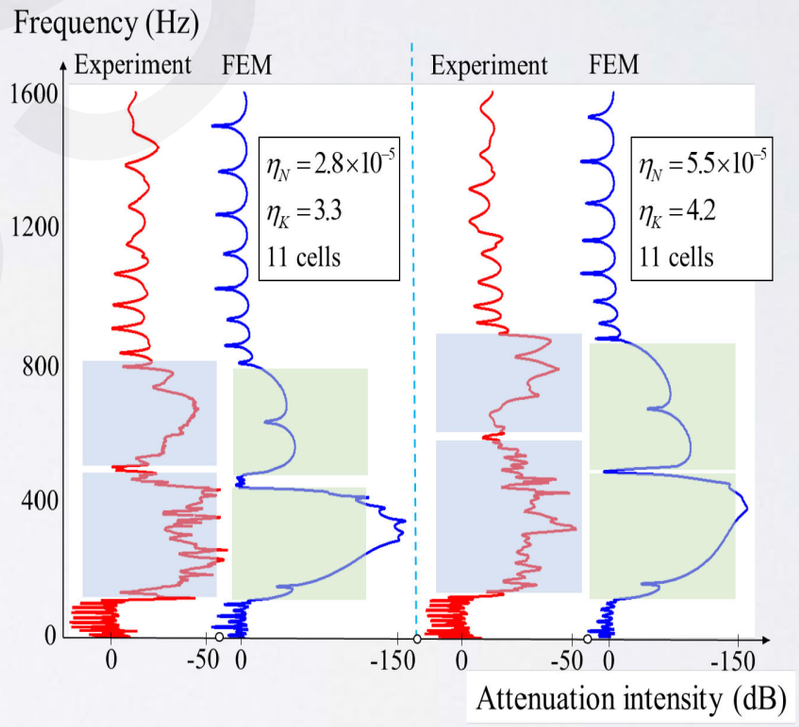
Photo of the experimental setup



Schematic diagram of the experimental setup



Effect of η_L on bandgaps.
(η_K=3.3, η_N=2.72×10^{-5})



Comparison between the experimental and numerical results (η_L=1)

Experiment results agree well with FEM results

Conclusion

- Coordinately changing the lattice constant, axial force and spring stiffness can effectively adjust the width and position of the bandgaps. Under certain conditions, a super wide pseudo-gap can be obtained and, the larger the axial force, the better the filtering effect based on the narrow passband in the pseudo-gap.

- The synthesized metastructured beam with two kinds of mass-spring oscillators selected from both sides of TP has much wider bandgaps and an analogous super wide pseudo-gap. At the same time, changing the number of different mass-spring oscillators can effectively control the wave propagation distance in the beam.

- The point defects have less influence on the LR bandgap but greater influence on the BS bandgaps. If the number of point defects increases, the BS bandgap will be narrowed and even disappear.

Related work

Zhou WJ, Wu B, Su YP, et al., 2019. Tunable flexural wave band gaps in a prestressed elastic beam with periodic smart resonators. *Mechanics of Advanced Materials and Structures*.

Wu B, Chen WQ, 2017. Tuning waves in soft phononic rods via large deformation and electromechanical coupling. International Ultrasonics Symposium.

Huang YL, Gao N, Chen WQ, et al, 2018. Extension/Compression-Controlled Complete Band Gaps in 2D Chiral Square-Lattice-Like Structures. *Acta Mechanica Solida Sinica*, 31(1):1-15.