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EPSRC Centre for Doctoral Training in Metamaterials XM²

Thin and structured acoustic metamaterial for absorption of airborne sound

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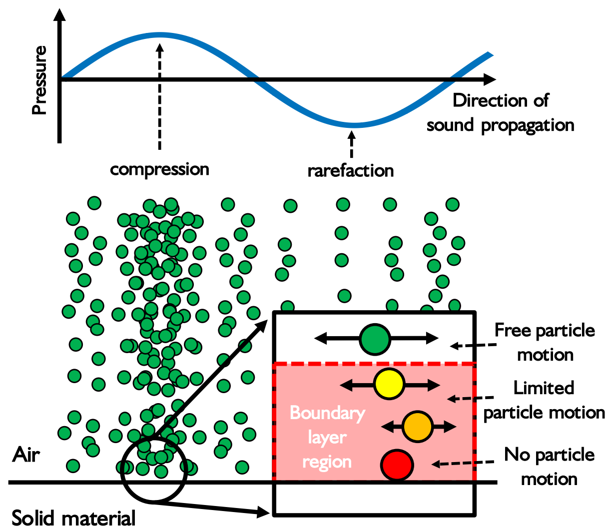
Abstract Here we demonstrate the absorption properties of an acoustic metamaterial comprising of a holey plate and a solid plate separated by a narrow air cavity. Strong attenuation of sound is observed due to the motion of air particles near the surface of plates, which causes heating due to friction in the air (thermo-viscous effects). This approach maybe used to create thin and lightweight sound absorbers.

Introduction

Sound is a longitudinal wave transmitted by compression and rarefaction of air particles. Particles oscillate about a fixed point transferring energy from one to another in the direction of sound travel.

At an air-solid boundary air particles are unable to oscillate due to a 'non-slip' condition at the surface.

This creates a region where the particle motion changes from non-slip (no motion) to maximum particle oscillation; this region is called the boundary layer, and this is where thermo-viscous heating occurs. This causes losses by transferring sound energy to mechanical/thermal energy.

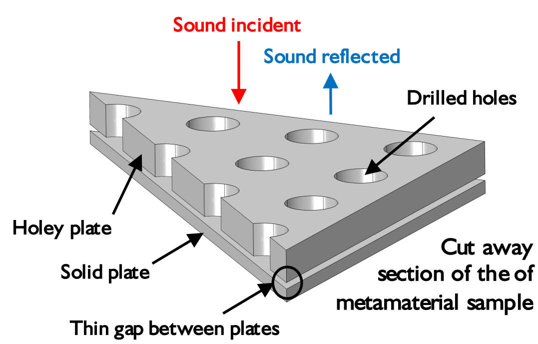


Acoustic metamaterial absorber

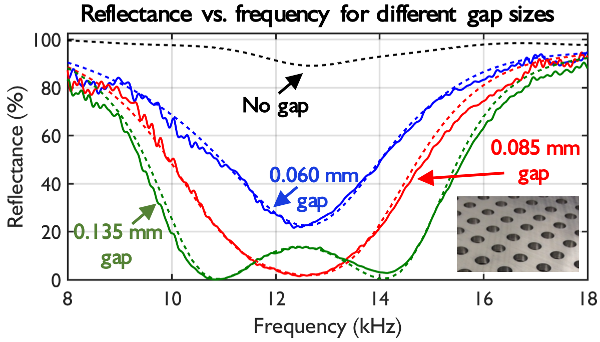
Using a solid and a holey plate we can exploit the thermo-viscous boundary layer to absorb sound.

The two plates are laid on top of each other and separated by a small gap. In the small gap region strong losses occur due to the thermo-viscous effects at certain frequencies (termed resonant frequencies).

By measuring the reflection of sound from the surface the losses are seen as minima in the spectrum.



Reflectance vs. frequency for different gap sizes



Summary

The absorption of sound radiation can be controlled by varying the gap thickness between two plates. Energy dissipation occurs due to the thermo-viscous boundary layer. This absorber is much thinner than conventional absorbers and has wide ranging applications.

Reference: Starkey *et al.* Appl. Phys. Lett. 110, 041902 (2017).

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