Asymmetric sound absorption lets in the light

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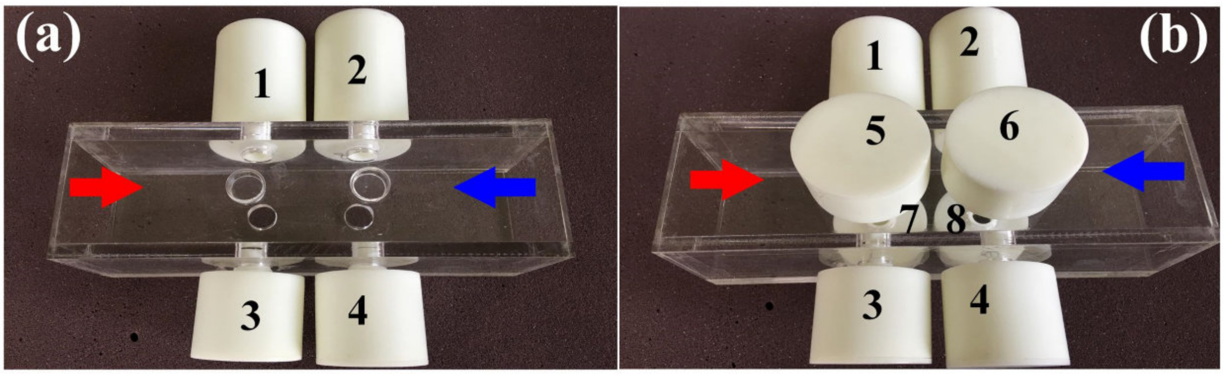

Multiband asymmetric absorptions. (a) and (b) show the photograph of structures for achieving two-band and four-band asymmetric absorptions, respectively. Credit: Long, Cheng and Liu

If you've ever lived in an apartment building or stayed in a hotel room, you are probably familiar with the inconvenience of inadequate sound absorption. Acoustic absorption refers to the absorption of sound energy by a material. Whether it's to improve acoustics or to prevent noisy neighbors, sound absorption has multiple applications in engineering and architecture, which can be improved by asymmetric acoustics.

Many asymmetric absorbers, those that only absorb sound coming in from one direction, are currently based on a single-port system, where sound enters one side and is absorbed before a rigid wall. In this design, however, light and air are unable to pass through the system. But a combined research effort from Nanjing University and the Chinese Academy of Sciences shows that asymmetric absorption can be realized within a straight transparent waveguide. The waveguide allows light transmission and air flow through the absorber and is described this week in *Applied Physics Letters*.

Ying Cheng, associate professor of physics at Nanjing University, and his colleagues developed a methodology to induce non-reciprocal absorption and reflectance for both multiband and broadband sound. They discovered that sound was almost completely absorbed, more than 96 percent, when using the multiband absorber in an asymmetric Helmholtz resonance (HR) fashion.

"Therefore, we were curious about whether there are artificial structures with the effect of 'blocking' sound waves which act as the rigid wall, but [are] transparent to light and wind," Cheng said.

Within a tube with both ends open they constructed an asymmetric sound absorber. "[T]he system can almost totally absorb the sound energy impinging on one port, but largely reflects the sound energy entering the other port," he said. "In the system, one of [the] Helmholtz resonators (located on branches to the main tube and acting as shunts) functions as an artificial soft wall which can block sound waves as if they were a rigid solid wall."

Asymmetric absorbers use a more complicated method of absorption than, say, porous metameterials that absorb from both directions. Often, nonlinear effects or highly complex structures are required to break reciprocity and allow reflection from one direction.

Here, however, the clever design of the shunted HR pairs takes advantage of natural loss mechanisms to achieve the effect. These systems could find a number of applications in architectural design, specifically in the design of acoustically isolated rooms where light and air flow is still desired.

"The researchers may [have] found an almost 100 percent absorption of the noise from outside of a room for acoustic isolation as well as high reflection of the sound waves inside the room to enhance the reverberation. And most importantly, the design allows free interchange of air between the outside and the room, which they were unable to do in previous prototypes [with only one end of the tube being open]," Cheng said.

Using the newly developed model, "we may extend asymmetric sound absorption into a two-dimensional planar system by using other types of acoustic resonators to make the asymmetric absorption more widely used," said Cheng.

More information: Houyou Long et al, Asymmetric absorber with multiband and broadband for low-frequency sound, *Applied Physics Letters* (2017). DOI: 10.1063/1.4998516

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