

Acoustic metamaterials for noise reduction applications

TakeAIM Winner 2017:
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Low frequency tonal acoustic noise is an everyday annoyance that disrupts quality of life. Humming fridges and overbearing washing machines are trivial examples, but excessive noise may be connected to serious conditions such as sleep disturbance and also to productivity loss. As we fill our lives with more appliances this pollutant becomes increasingly apparent. We can dramatically improve the perceived sound quality of devices by aiming to eradicate specific prominent frequencies as opposed to attempting to completely silence the device.

Metamaterials are a class of materials that have specifically engineered microstructure in order to achieve properties not currently found in nature. Examples include media with negative effective mass densities. This property implies that the medium will accelerate against an applied force in certain resonant frequency ranges, contrasting with traditional materials that accelerate in the same direction as an applied force. Although seemingly unphysical, such metamaterials have recently been realised.

In our research we utilise numerous mathematical techniques, including transformation acoustics and homogenisation theories, to design metamaterials with novel applications to sound absorption. More specifically we have designed a metamaterial that can be readily prototyped using 3D printed and effectively halves the speed of sound in air. Using this metamaterial we have been able to halve the size of an existing sound control technology, the quarter-wave resonator. Such advancements will enable manufacturers to vastly improve sound quality in the small spaces of their products available for noise control.

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The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2017 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to undergraduate and postgraduate students working in the mathematical sciences. First prize was £1,250 of Apple vouchers, second prize £500 of Apple vouchers and six runners-up each received £150 of Amazon vouchers.