PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

An Integration Strategy for Acoustic Metamaterials to Achieve Absorption by Design*

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ABSTRACT

Even in the 21st century, noise still constitutes a major environmental problem, with the low frequency noise being especially pernicious. While resonance-based acoustic metamaterials can display many novel wave manipulation capabilities, they have the Achilles' heel of being narrow-frequency in character. It would be most desirable if a sound absorber can be designed to fit the noise spectrum, with a minimum allowed thickness. Such sound absorbing structures can now be realized through a design recipe that incorporates the *causality constraint* on the acoustic response (1, 2). We use the causality constraint to delineate what is ultimately possible for sound absorbing structures, and denote those which can attain near-equality for the causality constraint to be "optimal." Anchored by the causality relation, an integration strategy can be formulated for realizing structures with target-set absorption spectra and a sample thickness close to the minimum value as dictated by the causality constraint. By using this approach, we have realized a 10.86 cm-thick structure that exhibits a broadband, near-perfect flat absorption spectrum starting at around 400 Hz, while the minimum sample thickness from the causality constraint is 10.36 cm. To illustrate the versatility of the approach, two additional optimal structures with different target absorption spectra are presented. This "absorption by design" strategy would enable the tailoring of customized solutions to difficult room acoustic and noise remediation problems.

REFERENCES

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