COLLEGE OF ENGINEERING
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# Mechanical Engineering Seminar Series

## Non-Reciprocal Acoustics: Theory and Application to Sound Diffusion


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*Walker Department of Mechanical*
*University of Texas Austin*


Tuesday, January 25, 2022
Room 1303 EECS
4:00 p.m.

This seminar will also be streamed live at the following link

ME Seminar Zoom link (QR Code below)

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**Abstract**

The law of reciprocity in acoustics and elastodynamics codifies a relation of symmetry between action and reaction in fluids and solids. In its simplest form, it states that the frequency-response functions between any two material points remain the same after swapping source and receiver, regardless of the presence of inhomogeneities and losses. As such, reciprocity has enabled numerous applications that make use of acoustic and elastic wave propagation. A recent change in paradigm has prompted us to see reciprocity under a new light: as an obstruction to the realization of wave-bearing media in which the source and receiver are not interchangeable. Such materials may enable the creation of devices such as acoustic one-way mirrors, isolators and topological insulators. One such device of significant practical utility is the sound diffuser. Conventional sound diffuser designs for audio applications consist of a periodic arrangement of variable depth wells which result in a quasi-random spatial distribution of the reflected phase and minimal energy loss. Diffuser performance depends on geometric parameters such as well depth, number of elements per diffuser period, and in-plane dimensions. Previous work has shown that acoustic metasurfaces (AMS) can significantly reduce diffuser depth while maintaining performance when compared to classic diffusers designs. However, both conventional and AMS diffuser performance is limited due to the linear relationship between frequency, wavelength, and the diffuser geometry. Here we consider spatiotemporal modulation of an AMS impedance to control and improve sound diffusion using a technique inspired by nonreciprocal vibrations in Euler beams. A theoretical model is developed using the classical grating equation augmented with a surface impedance that is modulated as a travelling wave function. Properly selected modulation parameters lead to significant increases in diffusion performance, which is verified using finite element methods as demonstrated by the angular dependence of the scattered field magnitude.


**Bio**

Michael Haberman is an Assistant Professor in the Walker Department of Mechanical Engineering at UT Austin (UTME). Before joining UTME, he was a Research Scientist at Applied Research Laboratories at UT Austin. He received his Ph.D. degree in ME from Georgia Institute of Technology in 2007 and a Diplôme de Doctorat in Engineering Mechanics from the Université de Lorraine in Metz, France in 2006. His research is centered on elastic and acoustic wave propagation in heterogeneous media, acoustic metamaterials, new acoustic transduction materials, ultrasonic nondestructive testing, and vibro-acoustic transducers. Dr. Haberman's research finds application in technical areas that include the absorption and isolation of acoustical, vibrational, and impulsive energy using negative stiffness, acoustic cloaking, and devices that make use of non-reciprocal acoustic and elastic wave phenomena. He is an Associate Editor of the Journal of the Acoustic Society of America and the Technical Committee Chair of Engineering Acoustics for the Acoustical Society of America (ASA). He received a Young Investigator Program award from ONR in 2018, a Young Faculty Award from DARPA in 2021, and was elected Fellow of the ASA in 2020.


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