LMS Seminar

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Predicting and optimizing wave motion in spatially graded structures

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ABSTRACT

Periodic metamaterials and architected materials have emerged as a powerful tool for, among others, controlling or suppressing elastic waves by bandgap engineering. However, wave guidance can also be achieved without bandgaps. Moreover, the manufacturable design space extends far beyond periodic structures. Spatially graded architectures with smoothly varying unit cell designs have hardly been explored for wave manipulation but offer a rich playground for wave manipulation. We here present a combined experimental-computational study into this rich design space at the example of spatially graded truss lattices. We confirm experimentally that Bloch-Floquet theory is an accurate approximation, as long as the grading in unit cell design is smooth. We further introduce ray tracing for dispersive elastic media as a convenient numerical approach to predict and optimize wave motion in graded structures. As an example, we demonstrate how conformal mappings can be exploited to create spatially graded structures which – without the need for bandgaps – are capable of low-pass wave attenuation and wave guidance, in contrast to most metamaterials that operate only on a specific (often narrow) frequency band. We finally present examples of how design optimization can lead to interesting and peculiar wave motion in graded truss lattices.

BIOGRAPHY

Dennis M. Kochmann received his education at Ruhr-University Bochum in Germany and at the University of Wisconsin-Madison. After postdoc positions at Wisconsin and Caltech, he joined the Aerospace Department at Caltech as Assistant Professor in 2011. In 2016 he was promoted to Professor of Aerospace, a position he held through 2019. Since April 2017 he has been Professor of Mechanics and Materials at ETH Zürich, where he served as Head of the Institute of Mechanical Systems and as Deputy Head of Department. His research focuses on the link between microstructure and properties of natural and architected materials, which includes the development of theoretical, computational, and experimental methods to bridge across scales from nano to macro. His research has been recognized by, among others, IUTAM's Bureau Prize in Solid Mechanics, GAMM's Richard von Mises Prize, ASME's T.J.R. Hughes Young Investigator Award, an ERC Consolidator Grant, and recently IACM's John Argyris Award. He is on the Board of Directors of the Society of Engineering Science, and serves as Associate Editor for Archive of Applied Mechanics and Applied Mechanics Reviews.