
Metamaterial Sandwich Structures: Boundary Effects and Performance Optimization

Svenja Hermann^{*1}, Angela Madeo¹, Kevin Billon², and Manuel Collet²

¹Institute of Structural Mechanics, Statics and Dynamics, TU Dortmund University – Germany

²Laboratoire de Tribologie et de Dynamique des Systèmes – Ecole Centrale de Lyon – France

Abstract

Mechanical metamaterials offer unique capabilities for wave control and vibration mitigation. Modeling infinite-sized metamaterials and optimizing their dispersive behavior has become a well-established practice that is generally approached using Bloch Floquet analysis. The performance in finite-sized structures, however, which is critical for practical applications, is less explored.

In this work, we analyze a metamaterial that is embedded in a so-called sandwich structure, where it is bounded by classical Cauchy-type materials. This configuration reflects common engineering applications like structural panels or vibration isolators. Numerical simulations coupled with experimental validation provide insights into the interplay of structural boundaries and metamaterial properties.

Our study reveals that the dynamic behavior of the metamaterial in the structure is highly sensitive to boundary conditions at the interfaces with the homogeneous outer layers. The free boundaries, where the structure is in contact with air, further influence the wave propagation in the metamaterial. We present strategies to increase the absorption capacity of the metamaterial by tailoring boundary conditions and geometry. To classify the vibration reduction capability of our sandwich structures, we consider mechanical as well as vibroacoustic aspects. The findings of our research contribute to advancing the practical implementation of metamaterials in engineered systems.

^{*}Speaker