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Vibroacoustic response of lattices: Opportunities and Challenges

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Architectured lattice materials [1,2] hold significant promise to realize multifunctional “meta” materials and structures, with wide ranging practical applications from transportation to energy and health areas [3,4]. This is possible due to the our ability to manipulate wave transport by changing the scattering geometry, specifically by engineering the topological architecture and material hierarchy [2,3,4]. Lattices exhibit unique wave transmission phenomena both in bulk [5] and edge wave propagations [6]. Rapid developments in advanced manufacturing technologies [7] enabled the fabrication of architected materials with exotic geometries and have galvanized research on many fronts from phononic crystals to acoustic metamaterials [3,4]. We consider the problem of vibroacoustic transport in one and two-dimensional lattices in this presentation. While passive vibration isolation through band-gaps has been well studied [4,5], the coupled vibroacoustic transport problem poses fundamental design challenges due to the coupling between waves in the solid and the surrounding fluid. The phenomenon of coincidence arising from the fluid structure coupling works against the ideal of light weight structures [8].

We seek to address two fundamental questions within the context of linear wave transmission in passive lattices: (a) Are there limits on the frequency interval over which passive wave control can be achieved through band-gaps tailored by material architecture? (b) Can lattice architectured sandwich panels out-perform monolithic sandwich panels in terms of vibroacoustic transmission loss as quantified by diffuse field sound transmission loss and yet remain stiff?

The presentation will describe recent progress made in answering the above two questions using computation and experiments. We consider the first question by examining the band-gap formation mechanisms, and their bounds using receptance technique [9]. It will be shown that, regardless of the mechanisms underpinning the formation of band-gaps, trade-offs exists for vibration attenuation in a one dimensional lattice. The second question on the sandwich panel transmission loss will be addressed using coupled fluid-structure finite element calculations. We show that lattice sandwich cores demonstrate superior diffuse field sound transmission loss characteristics compared to their monolithic counterparts under equal mass constraint [8]. We conclude these two studies by outlining the opportunities and challenges that lattices present in multifunctional structural design.

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