LMS Seminar

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Strength and Toughness of Lattice Metamaterials

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ABSTRACT

Recent advances in additive manufacturing have enabled the synthesis of lightweight architected materials, such as microlattices and stochastic foams, that can attain unique mechanical, thermal, and acoustic properties. While there has been a large volume of work focusing on the nonlinear mechanics associated with the elastic instabilities and plastic collapse of these material systems, their fracture properties under compressive and tensile loads remain relatively unexamined. The design of new materials with superior combinations of strength and toughness, by manipulating material architecture, requires a strong understanding of the connection between key microstructural characteristics and macroscopic failure. In this talk we will discuss results from our ongoing efforts to analyze the strength and toughness of strut-based metamaterials. Experiments to failure on 3D lattices are performed to measure their strength and establish the relation to the underlying microstructure and the properties of the parent solid. We will discuss different modeling strategies and their efficacy in reproducing experimental data, from critical stresses to corresponding fracture patterns. The second part of this talk will focus on the fracture mechanics and effective toughness of 2D lattices made of a brittle parent solid. In contrast to traditional fracture mechanics of monolithic solids, where the stress and displacement fields are described by the stress intensity factors, defining the corresponding fields in truss-based metamaterials remains an open challenge. We present here an energy-based technique that combines experiments, modelling, and theory, in order to define and predict the fracture properties of these complex material systems. Finally, we will talk about how we can exploit data-driven techniques for microstructure quantification and structure-property correlation for both periodic and aperiodic metamaterials. Results will be shown for 2D tessellation-based topologies and the way that key morphological characteristics contribute to the apparent macroscopic stiffness.

BIOGRAPHY

Stavros Gaitanaros received his PhD in Engineering Mechanics from the University of Texas at Austin in 2014 working at the Center for Mechanics of Solids, Structures and Materials. He then joined Massachusetts Institute of Technology as a Postdoctoral Associate in the Department of Biological Engineering. He is currently an Assistant Professor in the Department of Civil and Systems Engineering at Johns Hopkins University where he leads the Extreme Mechanics of Architected Materials group and is also affiliated with the Hopkins Extreme Materials Institute (HEMI) and the Johns Hopkins Center for Additive Manufacturing and Architected Materials (JAM2). Prof. Gaitanaros serves as the chair and co-chair respectively of the technical committees on Architected Materials (ASCE-EMI) and Instabilities in Solids and Structures (ASME-AMD). His work has received several recognitions including the IUTAM Bureau Prize in Solid Mechanics.