UNIVERSITY OF CALIFORNIA, IRVINE

Department of Materials Science and Engineering

Multi-Stable Metamaterials: Customizing Material Performance Post-Fabrication

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Abstract: In the first part of the presentation, as characteristics of metamaterial architectures, multi-stability and kinematic amplification are explored as a route toward a re-configurable effective property distribution and a frequency band structure of extreme tunability. Conveniently, a change in the configuration does not simultaneously alter the element dimensions and, therefore, the size/shape of the finite metamaterial structure remains constant. The dynamic performance of 1D/2D metamaterial architectures exhibiting the proposed design strategy is analytically determined via Bloch wave analysis and supported by numerical demonstration of the corresponding finite structures. In the second part, a strategy for transition wave (soliton) management is introduced which enables on-demand, post-fabrication control of the associated phase transformation kinetics and distribution. Specifically, the soliton dynamics are controlled by a small, prescribed spatio-temporal variation in the elastic potential, constituting a driving force. The stability of the wave profile under slow-propagation conditions and the characteristic spatial localization of the Hamiltonian energy supports an analogy with a Newtonian particle traversing a viscous medium under forcing. Following this prescription, two wave propagation regimes are revealed: in one, the soliton is carried by the modulation; in the other, the soliton is out-paced by the modulation. To illustrate the utility of this method, we demonstrate both the tractor and repulsor effects in multi-stable systems away from equilibrium. Finally, we conclude with on-going work and future directions.

Bio: Prof. Frazier received his B.S. in Aerospace Engineering from Embry-Riddle Aeronautical University in Prescott, Arizona (2009) after which he attended the University of Colorado, Boulder as a NSF Graduate Research Fellow and received his M.S. (2011) and Ph.D. (2015) in Aerospace Engineering Sciences. Prof. Frazier completed his postdoctoral studies in the Graduate Aerospace Laboratories at CalTech (2017) and then in the Institute for Mechanical Systems at ETH in Zürich, Switzerland (2017) before joining the faculty at the University of California, San Diego as an Assistant Professor of Mechanical and Aerospace Engineering (2017). Prof. Frazier's research focuses on understanding the mechanical and dynamic behavior of architected materials with an emphasis on multi-stability and the propagation of transition waves. In exploiting this understanding, his work aims at designing materials with unique properties and performance.