Nonlinear Acoustic Non-reciprocity

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We discuss constructive utilization of intentional strong nonlinearity for passively breaking classical reciprocity in impulsively loaded acoustic waveguides. Considering first an 1D lattice with strong nonlinearity, asymmetry, and internal scale hierarchy we study targeted wave propagation and the nonlinear mechanisms that govern it. Depending on the location and intensity of the impulse, breather propagation, wave arrest or motion localization may occur; these are explained in terms of the nonlinear pass and stop bands (nPBs and nSBs) of the lattice. Then we focus on a class of 1D waveguides composed of two nonlinear component lattices, a "stiffer" and a "softer" one that are connected at an interface. Non-reciprocity in this waveguide can be achieved by tuning the nPBs of the component lattices in the frequency-energy domain, whereby, (a) at low energy wave arrest at the interface occurs; (b) at intermediate energy only waves from one side of the interface can transmit; and (c) at high energy wave transmission is blocked at both sides of the interface. Experiments validate these theoretical predictions. Passive acoustic non-reciprocity can find broad applications, e.g., for targeted energy transfer in the wavenumber/frequency domain, metamaterials, acoustic and vibration isolation, and other fields.

Bio-sketch of Alexander Vakakis

Alexander F. Vakakis has a Ph.D. from Caltech (1990), an M.Sc. from Imperial College (1984), and a Diploma in Mechanical Engineering from the University of Patras, Greece (1984). He is the Donald Biggar Willett Professor of the College of Engineering in the Department of Mechanical Science and Engineering at UIUC where he co-directs the LNDV Laboratory (http://lndvl.mechse.illinois.edu/). He received the Alexander von Humboldt Research Award (2020), the Edmond J. Safra Fellowship at Technion (2020), the ASME Thomas K. Caughey Award in nonlinear dynamics (2014), the Thomas Bernard Hall Prize (2012) and the PE Publishing Award (2009) both from the Institution of Mechanical Engineers (UK). Since 2015 he is a National High-End Foreign Expert in China. He has published over 300 archival publications, 3 patents, and 6 technical monographs. His research interests include among other topics, dynamics, vibrations and acoustics, NEMS/MEMS, and system identification and reduced-order modeling.