Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

ENGINEERING DESIGN FOR ASYMMETRIC WAVE PROPAGATION

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ABSTRACT

Elastic waves propagate in a material from one point to another in compliance with the principle of reciprocity: if the locations of the source and receiver are interchanged, the transmitted signal remains unchanged. Reciprocity has served as a powerful experimental and theoretical tool for over a century. This invariance property ensures the symmetry of small-amplitude wave propagation in materials with properties that do not change with time. As long as reciprocity holds, it is not possible for waves to have different transmission characteristics depending on the direction of travel between two fixed points. Circumventing this property can therefore enable asymmetric propagation of waves within materials, a property that can be employed for developing novel devices that isolate, steer or focus elastic waves. Recent experiments have shown the feasibility of creating such devices in the context of lattice materials and mechanical metamaterials. We review the design principles for realizing asymmetric wave propagation in these materials, with a focus on strategies that utilize nonlinear and time-dependent constitutive relations. We hope that this review encourages more research on development of advanced materials within the CSME community.

Word count: 183