Conformal Elastodynamics in 2D Dilational Metamaterials

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Abstract

Flexible mechanical metamaterials capable of undergoing large deformations while supporting the propagation of nonlinear waves offer interesting observable phenomena. The rotating square structure is a canonical example of a flexible mechanical metamaterial platform that, when designed strategically, can support various nonlinear dynamic phenomena such as transition waves and solitons while undergoing extremely large deformations. In this work, we consider a harmonically-driven rotating square structure consisting of rigid bodies capable of rotating at their shared corners via flexible hinges. With a Poisson ratio of nearly -1, the rotating square structure can undergo deformations based on a uniform dilation mechanism. This dilational mode introduces a conformal symmetry, in which the dynamics are approximately invariant in an infinitely periodic structure under various physical transformations. At low frequencies, we experimentally and numerically observe that the dynamic response of a finite sized sample is dominated by conformal deformations, which consist of spatially varying dilations that are largest at the edges of the sample. Furthermore, we numerically explore the effect of modifying the experimental parameters, such as hinge stiffness, sample geometry, and number of unit cells, on the dynamic response of the structure. These results offer a promising new framework to observe and study novel wave phenomena in dilational mechanical metamaterials.

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