Architected materials with tuned instabilities break the wall of hyperelasticity

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A way to implement controlled instabilities in architected materials is shown. In particular, elastic grids of axially prestressed rods are considered, to be deformed incrementally and thus involving incremental bending moment, and axial and shear forces. It is shown that tunable material instabilities can be designed, as well as the achievement of dynamical properties of wave localization and filtering. The emergence of material instabilities such as shear band formation is demonstrated both for compressive [1] and tensile axial forces [2]. Moreover, the architecture of the analyzed structures leads to the emergence of multiple band gaps, flat bands, and Dirac cones [3].
The experience gained on structural flutter [4, 5] is exploited to implement a new concept, namely, the possibility of implementing a Hopf bifurcation in a continuous medium. This possibility is proven through a rigorous application of Floquet-Bloch wave asymptotics, which yields an unsymmetric acoustic tensor governing the incremental dynamics of the effective material [6]. The latter represents the incremental response of a hypo-elastic solid, which does not follow from a strain potential and thus apparently breaks the wall of hyperelasticity, leading to non-Hermitian mechanics. The discovery of elastic materials capable of collecting or releasing energy in closed strain cycles through interactions with the environment introduces new micro and nano technologies and finds definite applications, for example, in the field of energy harvesting.

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