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DESIGN OF ELASTIC METAMATERIALS WITH VOLUMETRIC PHASE TRANSITIONS

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Abstract. This work focuses on the study of metamaterials exhibiting elastic phase transitions, wherein different stable configurations of the microarchitecture emerge in response to certain load states. These phase transitions occur through geometrically non-linear deformations, while the constituent material of the microarchitecture remains within the elastic regime. Notably, despite staying elastic, the phase transitions enable the metamaterial to extrinsically dissipate energy in a repeatable manner. Traditionally, metamaterials are conceived as periodic arrays of unit cells, representing the minimum domain necessary to describe the microarchitecture. In the case of metamaterials with phase transitions, the unit cells must incorporate mechanisms or substructures capable of manifesting multiple stable configurations. The most commonly used mechanism in existing literature designs is a curved bistable beam, whose instability is driven by transverse loads, making it inherently unidirectional. Consequently, the dissipative response of metamaterials formed by arranging these beams in different directions is highly reliant on the loading direction. This dependence poses a disadvantage in scenarios where the material needs to be used without prior knowledge of the loading direction. This work contributes by introducing and analyzing novel topological designs in which the mechanism responsible for the instability or phase transition is volumetric. The analysis includes the macroscopic response of the RVE composed of many unit cells and the microstructure (pattern) formation in order to achieve lower-energy equilibrium configurations. In contrast to existing proposals, our approach ensures that the phase change is inherently three-dimensional, independent of the loading direction, resulting in a more isotropic material response. The presented designs build upon and extend to three dimensions of microarchitectures previously introduced by other authors (A. Rafsanjani and D. Pasini, *Extr Mech Lett* 9: 291-296 (2016)).