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STUDY OF THE LIMIT BEHAVIOR OF MECHANICAL METAMATERIALS WITH ELASTIC PHASE TRANSITIONS

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Abstract. The manifestation of multiple stable configurations in a structure under certain load states is often associated with a non-convex potential energy function. In the context of metamaterials, conceived as microscale structures, the multistability of the microarchitecture implies a non-convex strain energy function of the unit cell, where the elastic phases of the metamaterial correspond to the convex energy regions. At the macroscale, the observed behavior of these composites includes phenomena such as the existence of multiple equilibrium configurations, heterogeneous strain fields (referred to as microstructure formation in the context of crystals), hysteresis during loading and unloading, and the potential for repetitive extrinsic dissipation. However, it remains unclear how this type of microarchitecture with instabilities leads to a continuum model at the macroscale, particularly considering that the material response depends on the number of cells tested. Furthermore, despite their immense potential, only a few microarchitecture designs have been proposed so far, mainly consisting of simple arrangements of bistable curved beams. The purpose of this work is to propose novel topological designs and to explore the influence of these designs on the material's limit behavior. The proposed metamaterials are conceived as frames of beams, each characterized by a non-convex strain energy function. This energy function is constructed as a realistic surrogate model representing a structure with unstable behavior resulting from a geometrically nonlinear process. To advance towards a continuum description of these materials, we propose a representative analytical model of the limit behavior, based on the theory of generalized standard materials. This model involves the construction of a strain energy function and a dissipative potential based on the results obtained from the beam trusses when considering many unit cells.