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TOPOLOGY OPTIMIZATION OF METAMATERIALS WHICH DISSIPATE ENERGY ELASTICALLY

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Abstract. Although historically avoided in the design of materials and structures, instabilities have recently gained interest between scientists as a possibility of achieving remarkable behaviors if included as part of the design. Mechanical instabilities appear as a consequence of a non-convex potential energy scenario. This characteristic of the energy can originate, for instance, energetically equivalent deformed configurations of a body, non-equilibrium transitions such as snap-through and snap-back, local release of energy generating a hysteresis loop during an elastic loading-unloading process, and inhomogeneous strain distribution in the equilibrium of simple axial loaded systems (localization).

One of the interesting uses that can be given to these features is architected composites that can dissipate energy in an elastically, and therefore reusable, way, where there is no energy dissipation of the constituent phases of the material. The simplest type of these composites can be obtained as a chain of in-series bistable, or metastable, identical elements, where the maximum dissipation capacity of the chain depends exclusively on the force-displacement law of an individual element (G. Puglisi and L. Truskinovsky, *J Mech Phys Solids*, 48(1), 1-27 (2000)). Furthermore, different amounts of energy can be dissipated during the loading and unloading processes of the chain, if the force-displacement law is appropriately constructed (I. Benichou and S. Givli, *J Mech Phys Solids*, 61(1), 94-113 (2013)). This difference results advantageous according to the pretended use of the metamaterial.

The goal in this study is to design the microstructure of recoverable metamaterials capable of dissipating large amounts of energy through the formulation of a topology optimization problem. Different ratios between load-dissipation to unload-dissipation are imposed as constraints, and the role of the material distribution within an individual microcell to achieve the different behaviors is investigated. The inherent difficulties of this kind of problems (such as large FEM mesh distortions in low stiffness regions that interfere with the convergence of the solution, complicated force-displacements laws for intermediate designs which demand general path-following algorithms, and the need for geometrical and material non-linearities to be part of the continuum model) are appropriately tackled.