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A new efficient methodology for the analysis of mechanical metamaterials with elastic instabilities

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This work approaches the problem of the design of mechanical metamaterials including, as a distinguishing feature, instabilities in the elastic regime. Among the various opportunities offered by this characteristic [1], is the manipulation of the deformation energy. In this sense, metamaterials including elastic instabilities are known to exhibit reusable energy-trapping or energy-dissipation [2].

We present a novel methodology for the analysis of microarchitectures including instabilities. The strategy largely reduces the computational effort if compared with full models of non-linear volumetric finite elements or with non-linear beam elements. As a consequence, it allows to enlarge the analysis to more unit cells within the body of the metamaterial and to evaluate efficiently a greater number of topologies, proving to be especially suitable for use in processes of optimization of the microarchitecture.

Noting that existing designs of this class of materials only achieve energy manipulation in specific predifined loading direction, in this work, we center the design aim in obtaining reusable multidirectional isotropic energy manipulation with this technique. This is in accordance with a more realistic use of the metamaterials where general boundary condition do not establish a priori the loading direction.

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