Solids from structures

Davide Bigoni[1]
[1]*Instabilities Lab, University of Trento, Trento, Italy*
E-mail: davide.bigoni@unitn.it

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Proper design of architected materials made up with elastic structures is believed to yield unchallenged mechanical properties in terms of stiffness, anisotropy, dynamic characteristics, and toughness. When the structure is elastic and periodic, homogenization becomes the formal procedure to obtain the response of an equivalent elastic solid. Homogenization of periodic grids of elastic rods, prestressed with axial forces and deformed incrementally under bending lead to prestressed elastic solids, which may show the emergence of material instabilities such as shear band formation [1]. A design paradigm is established for artificial materials where follower micro-forces, so far ignored in homogenization schemes, are introduced as loads prestressing an elastic two-dimensional grid made up of linear elastic rods (reacting to elongation, flexure and shear). A rigorous application of Floquet-Bloch wave asymptotics yields an unsymmetric acoustic tensor governing the incremental dynamics of the effective material [2]. The latter is therefore the incremental response of a hypo-elastic solid, which does not follow from a strain potential and thus does not belong to hyper-elasticity. The solid is shown to display flutter, a material instability corresponding to a Hopf bifurcation, which was advocated as possible in plastic solids, but never experimentally found and so far believed to be impossible in elasticity [2]. In elastic structures flutter can be originated from different loading systems [3], which can be used to architect new discrete materials. The discovery of elastic materials capable of sucking up or delivering energy in closed strain cycles through interaction with the environment paves the way to realizations involving micro and nano technologies and finds definite applications in the field of energy harvesting.

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