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Auxeticity of materials with shape preserving inclusions: studies of two-dimensional models

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Common materials exhibit a positive Poisson's ratio (PR) [1], i.e. they shrink when stretched. Mechanically stable models [2] and thermodynamically stable phases of model molecules [3] exhibiting negative Poisson's ratio, i.e. expanding laterally when stretched, have been known for more than two decades. Materials with negative Poisson's ratio, first manufactured in 1987 [4] and termed auxetics [5], have since attracted increasing interest [6].

For stable isotropic materials, PR cannot be lower than -1. Materials that satisfy this condition, further referred to as *perfect auxetics*, preserve their shape when stretched. Although such materials are not known in nature, as yet, some model structures exhibiting this unusual property have been described in the literature [2,7–10]. By applying finite pieces of these materials ('particles') as inclusions in matrices of common materials, one can obtain composites exhibiting effective auxetic behaviour.

We present results of our recent analytic investigations and computer simulations of two-dimensional model composites containing pieces of the structures described in refs. [7,10], which can be easily manufactured (at least on a macroscopic level). Such perfectly auxetic 'particles' (PAPs) can be built of circles, squares, or other rigid bodies with 'holes' in which non-bendable rods (of diameters only slightly smaller than the diameters of the holes) are placed [10]. The rods connecting the rigid bodies play the role of constraints which keep the shape of any cluster intact when its volume changes. In this presentation, our attention will be focused on composites containing small PAPs, like trimers, tetramers and hexamers. Both isotropic and anisotropic composites will be discussed.

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