
Discontinuous mechanical metamaterials with controllable Poisson's ratios

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Abstract

Mechanical metamaterials were designed with internal discontinuities to enable the judicious control of Poisson's ratio as a function of compressive loading. Two different unit cells, inspired by face-centred crystalline and re-entrant honeycomb structures, were parametrically designed, optimising the internal geometries to maximise the difference between lateral and longitudinal deformation when compressed. The discontinuities utilise a combination of free movement of internal structures and geometrical interlocking to enable control over deformational behaviours and consequently their Poisson's ratios. Various interfacial geometries were investigated to couple mass reduction to the ease of manufacture. The local Poisson's ratios of individual unit cells and their corresponding arrays were analysed through static compression testing and FEA. We report the deformational behaviours and Poisson's ratio outputs to validate our design objectives. The arrays were homogenised with micropolar assumptions, and bulk properties determined to map their mechanical properties. Elastic instabilities alongside strain-dependent interlocking are found to affect the local trajectories of deformation, which in turn influence the Poisson's ratios of the metamaterials.

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