Dislocation modes and buckling in topological metamaterials

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The mechanical rigidity of frameworks -- nodes connected by springs or rigid bars -- underlies the structural integrity of bridges, the response of granular materials, and the design of metamaterials with unusual mechanical properties. Recently, a special class of topological periodic frameworks has been introduced, which exhibit localized mechanical edge modes at boundaries. Analogous to the electronic edge states of topological insulators, these mechanical modes are protected against small perturbations of the structure. I'll present two ways to exploit topological modes in metamaterials design. First, dislocation defects in such frameworks are associated with soft modes of topological origin, which do not significantly stretch or compress the constituent elements. These modes arise due to the interplay between two topological quantities: a polarization of degrees of freedom in the unit cell, and the Burgers vector of the dislocation. Second, domain walls separating different lattice orientations can be used to sculpt buckling zones in a cellular metamaterial. In both cases, the local changes to rigidity are effected without modifying the relative number of degrees of freedom and constraints in the framework. I'll show how we've realized these ideas in 2D and 3D prototypes of topological metamaterials.