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Programmable and Frustrated Mechanical Metamaterials

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Most metamaterials to date consist of periodic lattices of unit cells that work together in harmony. Here we demonstrate how frustration leads to new functionality. First we discuss 2D mechanical metamaterials whose response to uniaxial compression can be programmed by lateral confinement, allowing monotonic, nonmonotonic, and hysteretic behavior. These functionalities arise from a broken rotational symmetry which causes a highly nonlinear competition between two mutually incompatible modes of deformation. Second we show how to create non-periodic 3D metamaterials, leading to a wealth of novel functionalities, including mechanical pattern recognition. By perturbing the stacking order in these material we incorporate frustration which leads to multistable behavior.