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Mechanical Metamaterials with Negative Compressibility Transitions[1]

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When tensioned, ordinary materials expand along the direction of the applied force. In this presentation, I will explore network concepts to design metamaterials exhibiting negative compressibility transitions, during which the material undergoes contraction when tensioned (or expansion when pressured). Such transitions, which are forbidden in thermodynamic equilibrium, are possible during the decay of metastable, super-strained states. I will introduce a statistical physics theory for negative compressibility transitions, derive a first-principles model to predict these transitions, and present a validation of the model using molecular dynamics simulations. Aside from its immediate mechanical implications, our theory points to a wealth of analogous inverted responses, such as inverted susceptibility or heat-capacity transitions, allowed when considering realistic scales. References: Z.G. Nicolaou and A.E. Motter, J. Stat. Phys. 151(6), 1162 (2013); Z.G. Nicolaou and A.E. Motter, Nature Materials 11, 608 (2012).

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