Singularity theory for the design of thermoelastic metamaterials with shape memory

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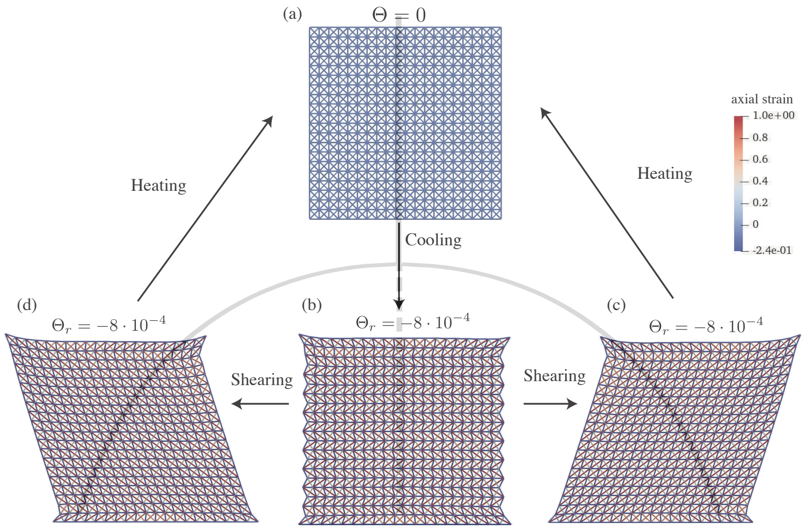
We study the possibility of designing nonlinear thermoelastic metamaterials that have a macroscopic behaviour that resembles shape-memory alloys [1]. For simple two- and three-dimensional problems, we "manufacture" lattices with an energy landscape that includes one stable energy configuration at "high" temperature and several, energetically equivalent, stable wells at low temperature. In this way, by cooling lattices down from a reference configuration, they fall onto one of the stable ones at low temperature and they can jump from one another when subject to external work. Then, a heating cycle can return the lattice to the original configuration and "heal", exhibiting a macroscopic behavior akin to that of shape memory materials [2].

The stability analyses at the unit cell level are done employing singularity theory [3], a powerful abstract technique for understanding nonlinearities behaviour, stability and bifurcations. Then, macroscopic simulations are carried out using nonlinear finite elements and dynamic relaxation [4] to simulate the whole cooling-loading-healing cycle.



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