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Teaching an old foam new tricks: material design, memories and learning in aging solids

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Abstract:

Disordered solids are often out of equilibrium, evolving slowly as they age. The small incremental changes inherent in the aging process reduce the internal stresses through microscopic plastic deformations within the material. While often considered as merely a nuisance and detrimental to reliable material design, aging can, in fact, also be used as a tool to create novel functionality. Depending on the imposed deformation, the system will evolve in different manners. By imposing various strain protocols we demonstrate that non-trivial elastic responses can be trained in a generic disordered solid. These go well beyond bulk material properties allowing functionality that is more like that of a machine. We argue that training can be considered a form of learning in materials, and to that end we train a solid to classify high dimensional data that is inputted in form of imposed strains.

Our approach for material design through training contrasts traditional approaches based on computer-aided optimization of the structure, which is usually followed by careful fabrication. Functionality in our case is achieved from the self-organization of the large number of microscopic degrees of freedom, rather than the difficult task of directly manipulating the microscopic structure.

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