

Transformation front kinetics in deformable ferromagnets

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Materials such as magnetic shape-memory alloys possess an intrinsic coupling between material's magnetisation and mechanical deformation. These materials also undergo structural phase transitions, with phase boundaries separating different phases and the kinetics of the phase boundaries governed by the magnetic field and the mechanical stresses. There is a multiplicity of other materials revealing similar phenomena, e.g. magnetic perovskites.

To model the propagation of the phase boundaries in deformable magnetic materials at the continuum scale, three ingredients are required: a set of governing equations for the bulk behaviour with coupled magnetic and mechanical degrees of freedom, a dependency of the phase boundary velocity on the governing factors, and a reliable computational method. The expression for the phase boundary velocity is usually obtained within the continuum thermodynamics setting, where the entropy production due to phase boundary propagation is derived, which gives a thermodynamic driving force for the phase boundary kinetics. For deformable ferromagnets, all three elements (bulk behaviour, interface kinetics, and computational approaches) have been explored, but under a number of limitations.

The talk will demonstrate novel derivation of the thermodynamic driving force for transformation fronts in a general magneto-mechanical setting, adaptation of the cut-finite-element method (CutFEM) for transformation fronts in magneto-mechanics, which allows for an exceptionally efficient handling of the propagating interfaces, without modifying the finite-element mesh, and application of the developments to qualitative modelling of magneto-mechanics of magnetic shape-memory alloys.

Historically, this problem was considered in [1], but only for non-linear elasticity, magnetostatics, and absence of electric fields. The present work does not make these assumptions. The adapted CutFEM method generalises the results of [2], implementing the method for multi-physics, with the code available via GitHub [3]. The preprint of a paper summarising the results included in the talk is available at arXiv [4].

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