Homogenized phase-field equations for interfacial dynamics in strongly heterogeneous materials

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We derive effective macroscopic Cahn-Hilliard equations [1] for general homogeneous free energies which include the frequently applied double-well potential. The upscaling is done for perforated/strongly heterogeneous media. To our best knowledge, this seems to be the first attempt of homogenizing nonlinear fourth-order equations in such domains. The new upscaled formulation should have a broad range of applicability due to the well-known versatility of phase-field equations. The additionally introduced feature of systematically and reliably accounting for confined geometries by homogenization allows for new modelling and numerical perspectives in both, science and engineering. Our results for example allow to effectively describe wetting in porous media where one has a scale separation between the pore and the characteristic macroscopic length scale. Finally, we can characterize qualitatively the homogenized equations by error estimates.

References

[1] M. Schmuck, M. Pradas, G. A. Pavliotis, and S. Kalliadasis, Proc. R. Soc. A 468, pp. 3705-3724 (2012).