

## Model reduction for micromechanics of materials

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Upscaling (also known as homogenization, or change of scales) is a common practice in multiscale problems when the scales are well separated. In linear elasticity the structure of the homogenized constitutive relations is strictly preserved in the change of scales. In other words, a composite made from linear elastic constituents behaves macroscopically as a linear elastic homogeneous solid whose effective properties can be computed once for all by solving a finite number of unit-cell problems.

Unfortunately there is no exact scale-decoupling in multiscale nonlinear problems which would allow to solve only a few unit-cell problems once for all and then use them subsequently at the larger scale. The surviving coupling between the scales has led to the development of FEM2 methods which are accurate but come at a formidable cost. Another approach, involving a certain degree of approximation, is to investigate the response of representative volume elements along specific loading paths and to use them to calibrate macroscopic phenomenological models. Unfortunately most of the huge body of information generated by these micromechanical analyses is lost, or discarded, since very often only the overall response is used.

In order to derive less arbitrary constitutive relations and to reduce the formidable cost of full-field simulations, mean-field theories based on approximations of the local fields have been proposed. The crudest approximations are contradicted by experimental evidence, but recent improvements accounting for instance for intraphase field fluctuations have been proposed. This is typically the case of the Non Uniform Transformation Field Analysis ([1][2]). A new version of this model will be proposed in this talk, with the aim of preserving the underlying variational structure of the constitutive relations (similar objective in [3] [4]).

[1] J.C. Michel, P. Suquet, *Int. J. Solids Structures* 40, 6937-6955 (2003).

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[3] F. Fritzen, M. Leuschner, *Computer Methods in Applied Mechanics and Engineering* 260, 143-154 (2013).

[4] S. Lall, P. Krysl, J. E. Marsden, *Physica D* 184, 304-318 (2003).