

## MULTISCALE COMPUTATIONAL HOMOGENIZATION FOR BRIDGING SCALES IN THE MECHANICS AND PHYSICS OF COMPLEX MATERIALS

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### MINISYMPOSIUM

Multiscale computational homogenization methods refer to a class of numerical homogenization techniques for determining the effective behavior of complex and highly heterogeneous materials, and for computing the response of structures composed of these materials. The main added value of computational homogenization consists in surpassing limitations of analytical approaches, e.g. incorporating realistic multi-phase morphologies and complex nonlinear material behavior.

This minisymposium focuses on the developments and applications of either multiscale computational homogenization methods, including all pending challenges in this area, or on modeling and simulation methods at the scale of heterogeneous microstructures with an implicit or explicit connection to another scale. Particular emphasis is given on complex models to incorporate specific phenomena at a given scale and related simulation challenges (complex morphologies, large models, lack of deterministic description of constituents, presence of interfaces...) and emergent behavior (effective behavior not described by individual constituents).

The topics covered include (but not limited to):

- FE<sup>2</sup> methods and alternatives (e.g. FExFFT, FExDiscrete Elements...);
- Machine-learning/artificial intelligence techniques and surrogate modeling for multiscale analysis
- Advanced algorithms for reduction of computational costs associated with multiscale algorithms (model reduction, parallel computing...)
- Data-driven multi-scale mechanics
- Numerical or virtual material testing across the scales;
- Emergent behavior through upscaling
- Scientific computing and large data in multiscale materials modeling
- Coarse-graining of nano- and micromechanics
  - Numerical modeling of materials based on realistic microstructures, e.g. provided by high resolution 3D imaging techniques;
- Computational homogenization of heterogeneous, linear, time-dependent and nonlinear heterogeneous materials, including material dynamics and metamaterials;

- Heterogeneous materials with coupled multi-physics behavior (phase change, chemo-mechanics, nonlinear thermo-mechanics...), including extended homogenization schemes;
- Multiscale damage modeling, capturing the transition from homogenization to localization;
- Computational homogenization including size effects, higher-order gradients or lack of scale separation;
- Numerical modelling of the macroscopic behavior of microstructures with complex interfaces, microcracking, instabilities or shear bands;
- Integration of stochastic microscopic models and its multiscale treatment