Project/Master-Thesis Language: English

Macroscopic Modeling of Large Strain Viscoelastic Composite Materials

Polymer composites find their usage in several modern engineering applications. Carbon black toughened rubbers being employed in automobile tires represent a classical use case. The effective constitutive response of such heterogeneous materials depends not only on the underlying micro-structure configuration, but also on the viscoleastic behavior of the polymer matrix. Computational homogenization techniques (see [1] for a recent review) aim at estimating the macroscopic constitutive response of such materials through averaging over building blocks, referred to as representative volume elements (RVEs).

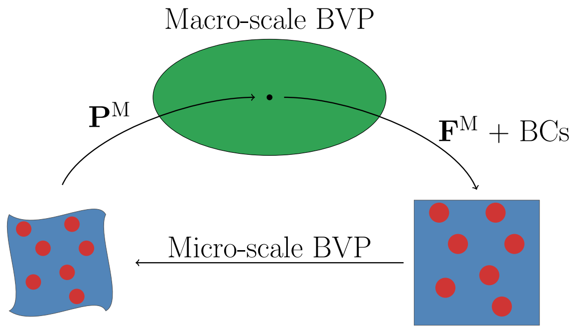

Figure 1: Schematic of the computational homogenization process.

This thesis work involves computational homogenization of particulate composites with polymer matrix exhibiting a linear viscoelastic response in a finite deformation setting [2]. The implementation shall be done in the existing `C++` source-code (based on `deal.ii` library). The student will extend the homogenization module in the existing code so as to support viscoelastic constitutive behavior at the micro-scale. Furthermore, existing *sequential* approaches for determining the macroscopic viscoelastic response (see [3] for instance) will be studied and modified to suit the current application.

References

[1] S. Saeb, P. Steinmann, and A. Javili. "Aspects of Computational Homogenization at Finite Deformations: A Unifying Review From Reuss' to Voigt's Bound". In: *Applied Mechanics Reviews* 68.5 (2016), pp. 50801–50833.

[2] P. Kumar. "Implementation of viscoelastic Ogden material model using deal.II". Project Thesis. FAU Erlangen-Nürnberg, 2018.

[3] K Terada et al. "A method of two-scale analysis with micro-macro decoupling scheme: application to hyperelastic composite materials". In: *Computational Mechanics* 52.5 (2013), pp. 1199–1219.

[4] G. A. Holzapfel. "On large strain viscoelasticity: continuum formulation and finite element applications to elastomeric structures". In: *International Journal for Numerical Methods in Engineering* 39.22 (1996), pp. 3903–3926.

Fields: Material Mechanics, Multi-Scale Mechanics

Required skills: Nonlinear Continuum Mechanics, Nonlinear Finite Elements, C++

Desirable skills: deal.ii, Micro-Mechanics

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