Announcement for the course

Computational homogenization on digital image data

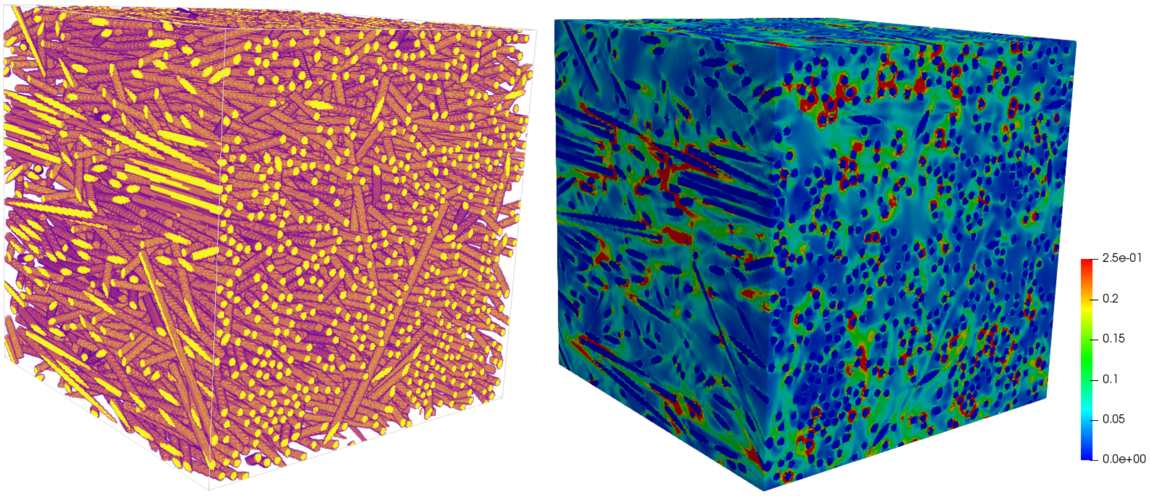

Fig.: Microstructure of a short-fiber reinforced composite (left) and the numerically computed accumulated plastic strain in % subjected to 4% applied strain in principal fiber direction (right).

Course Contents

For computing effective properties of heterogeneous materials with complex microstructures, modern computational techniques are imperative. The course provides an introduction to modern numerical discretization and solution methods which are based on the fast Fourier transform (FFT) and enable treating industrial-scale microstructures and nonlinear mechanical material behavior in an efficient manner. The course acquaints its participants to topics of current research, and is offered exclusively at KIT at master's level. The goal of the accompanying exercise sessions is implementing a prototypical FFT-based micromechanics solver.

Schedule and exams

Lecture	Tuesdays, 11:30, starting 25.10.2022
Location	20.30 SR 0.019
Exercise	Thursdays, 09:45, starting 27.10.2022
Location	10.50 HS 102
Exam	oral, on demand
Volume	Course: 2 SWS, Exercises: 2 SWS, 6 ECTS
Lecture notes	will be provided via ILIAS
Contact	JProf. Matti Schneider, M.Sc. Lennart Risthaus, M.Sc. Alok Mehta

Literature

[1] Milton, G. W.: The Theory of Composites. Springer, New York, 2002.

Target audience

This course addresses bachelor and master students with an engineering, mathematical or more general scientific background with an interest in the mechanics of heterogeneous materials. This course is complemented by other courses offered by the Institute of Engineering Mechanics (ITM).

Prerequisites

All relevant results will be developed within the course.

Syllabus

- **Basic equations for computing effective elastic material properties**
  Asymptotic homogenization of linear elasticity for periodic microstructures; the elastic cell problem to determine the effective stiffness tensor; properties of the effective stiffness tensor; Lippmann-Schwinger formulation of the cell problem of elasticity

- **The FFT-based computational homogenization method of Moulinec-Suquet**
  The Lippmann-Schwinger equation as numerical solution method (basic scheme); optimal choice of the reference material; voxel structure of micro-computed tomography images and challenges for classical finite element solvers; Fourier series representation of solution fields and the fast Fourier transform; discretization of the Lippmann-Schwinger equation by trigonometric collocation; mixed strain-stress boundary conditions for direct comparison with experiments; problems and limits of the Moulinec-Suquet method

- **Procedure for the treatment of materials with high contrast, pores or imperfections**
  Eyre-Milton formulation of the cell problem of elasticity; associated solution method; optimal choice of the reference material; the conjugate gradient method for the Lippmann-Schwinger equation; finite differences and finite element discretizations; optimal choice of discretization scheme and solution method for selected examples

- **Nonlinear and time-dependent mechanical problems**
  Formulation of time-dependent mechanical homogenization problems; time discretization; the basic scheme in the nonlinear case - interpretation as gradient descent method; the Newton-Raphson method for the Lippmann-Schwinger equation