# NUMERICAL EVALUATION OF INTERACTION TENSORS IN HETEROGENEOUS MATERIALS

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Two-scale simulations for multiscale modeling purposes require the solution of boundary value problems for each macroscopic material point. Each macroscopic point contains a representative volume element (RVE) that exhibits the micro-structure of the material, constituted by microscopic points. When dealing with complex heterogeneous micro-structures, the computational effort to solve the boundary problems for all macroscopic points is immense. In order to make multiscale simulations utilizable for a wider range of purposes, a reduction of the computational complexity is indispensable.

A reduction of the systems internal variables can be achieved by a decomposition of the full RVE into several subdomains, where constitutive equations need to be solved for all subdomains instead of for all microscopic points. In this work, the Transformation Field Analysis (TFA) strategy [1] will be implemented, assuming uniform stress and strain fields within the subdomains. The strain inside the subdomains is affected by the present eigenstrains in all other subdomains:

$$\varepsilon_r = A_r : \bar{\varepsilon} + \sum_{s=1}^{N} D_{rs} : \varepsilon_s^{eig}. \tag{1}$$

This requires the determination of strain concentration tensors and eigenstrain – strain interaction tensors. The computation of these quantities and the domain decomposition of the RVE can be performed once for all by FE simulations in the so-called “off-line” stage.

In order to achieve a reasonable decomposition into subdomains, strain concentration tensors of all microscopic points inside the RVE, representing their mechanical behavior, are computed by the application of various boundary conditions on the RVE. Subsequently, the microscopic points are decomposed into subdomains by a clustering method based on the similarity of their mechanical behavior. The applied clustering approach for the domain decomposition may allow both for a high reduction of computational costs for the simulations and settle shortcomings due to not well captured plastic strain fields of the original TFA method.

The constitutive relations for the single clusters rely on interaction effects between the clusters. Interaction tensors can be evaluated in the “off-line” stage by analytical or numerical approaches. Analytical approaches include homogenized overall properties of the RVE, being not representative in cases of the presence of dominant heterogeneous microstructures. In this work, the eigenstrain – strain interaction tensors for the TFA approach are determined numerically by off-line FE simulations. Eigenstrains are applied on each single cluster, and a comparison with the resulting strain in all clusters allows for the complete characterization of the interaction tensors.

## References

[1] Dvorak J. Transformation Field Analysis of Inelastic Composite Materials. Proceedings: Mathematical and Physical Sciences 1992; 437:311–327.

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