Domain Decomposition Methods for Heterogeneous Materials

Engineering structures such as electrical machines consist of multiple material domains such as the housing and iron core with different physical properties. This requires different numerical treatments and spatial and temporal discretizations. Domain decomposition provides a framework for treating such multi-domain problems by solving each domain separately and coupling them at the interfaces. A Boundary Element Tearing and Interconnecting (BETI) approach is particularly promising for this purpose, but its extension from spatial to space-time coupling introduces additional challenges. Conventional coupling methods may require compatible spatial meshes and closely related time discretization.

This research aims to develop a BETI-based coupling framework for heterogeneous multi-domain problems that permits independently chosen spatial and temporal discretizations. Particular focus will be placed on mortar-type coupling strategies for transferring interface quantities between non-matching discretizations while maintaining stability and accuracy. The work will initially investigate spatial coupling for simpler elliptic problems using BEM, followed by an extension to space-time problems and different temporal discretizations. A waveform relaxation method will be applied to handle different wave speeds in domains with different material properties. In the longer term, the framework will be extended to BEM–FEM coupling for complex heterogeneous structures.