Karlstad Applied Analysis Seminar (2021)

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Multiscale models and simulations for diffusion and interactions in heterogeneous domains

Abstract

We investigate multiscale and multiphysics models for evolution systems in heterogeneous domains. Our contributions can be grouped in two parts. First, we pose two-scale reaction-diffusion systems in domains with varying microstructures. We prove well-posedness and construct convergent and efficient finite element schemes that resolve the microscopic domain variations. Second, we investigate certain interacting particle systems and their links to a family of partial differential equations. We analyze a model of interacting populations, admitting dual descriptions from a system of ordinary differential equations and a porous media-like equation. We also construct a multiscale simulation to evaluate scenarios in population dynamics. Finally, we investigate non-equilibrium dynamics and phase transitions within a particle system extending the classical Ehrenfest model.

Our focus is two-fold: we increase the theoretical understanding of certain two-scale couplings, while on the other hand, we develop computational multiscale frameworks for a variety of scenarios known for their inherent complexity.