Numerical simulation of flows in highly heterogeneous porous media

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We shall present an overview of some approximation strategies and robust solution methods for the resulting algebraic system for numerical solution of flows in highly heterogeneous porous media. Our main goal is derivation of numerical methods that work well for both, Darcy and Brinkman equations, and could be used either as (1) a stand alone numerical upscaling procedure or (2) robust (with respect to the high contrast of the porous media) iterative solvers for the finite element approximation on a fine-mesh spatial scale. The preconditioners are based on overlapping domain decomposition technique. The robustness with respect to the contrast is achieved via special construction of a coarse grid space that includes patched together eigenfunctions corresponding to the smallest eigenvalues of properly weighted local spectral problems. This approach has a natural abstract framework which we shall discuss as well.

The main target of our applications are numerical upscaling and simulation of fluid flows in highly heterogeneous media modeled by Brinkman, Darcy, and steady-state Richards' equation (with relative permeability governed by Haverkamp or van Genuchten relations).

Joint work with Y. Efendiev, J. Galvis, K. Shi and J. Willems