Estimating effective parameters using direct pore-scale simulations

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For the simulation of transport processes in porous media effective parameters for the physical processes on the target scale are required. Numerical upscaling, as well as multi-scale approaches can help where experiments are not possible, or hard to conduct.

In [1] Bastian and Engwer proposed an Unfitted Discontinuous Galerkin (UDG) method for PDEs on domains with a complicated geometric shape. This method is well suited for simulations on the pore scale. The method uses finite element meshes which are significantly coarser then those required by standard conforming finite element approaches and is flexible enough to be used for elliptic, hyperbolic and parabolic problems.

We apply this method to numerical upscaling using direct simulation on the pore scale. For simple periodic porous media an analytic computation of the permeability is possible using homogenization techniques [2]. We use these periodic structures as a test setup for the numerical upscaling using an Unfitted Discontinuous Galerkin method and compare numerically computed permeability with analytic results. The method is robust with respect to computations on coarse meshes.

References

[1] C. Engwer and P. Bastian. An Unfitted Finite Element Method using Discontinuous Galerkin. *International Journal for Numerical Methods in Engineering*, 2009. in press.

[2] A. S. Sangani and A. Acrivos. Slow flow through a periodic array of spheres. *International Journal of Multiphase Flow*, 8:343–360, 1982.