

Effective interface laws for fluid flow and solute transport through thin reactive porous layers

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Abstract

We consider a coupled model for fluid flow and transport in a domain consisting of two bulk regions separated by a thin porous layer. The thickness of the layer is of order ε and the microscopic structure of the layer is periodic in the tangential direction also with period ε . The fluid flow is described by an instationary Stokes system, properly scaled in the fluid part of the thin layer. The evolution of the solute concentrations is described by a reaction-diffusion-advection equation in the fluid part of the domain and a diffusion equation (allowing different scaling in the diffusion coefficients) in the solid part of the layer. At the microscopic fluid-solid interface inside the layer nonlinear reactions take place. This system is rigorously homogenized in the limit $\varepsilon \rightarrow 0$, based on weak and strong (two-scale) compactness results for the solutions. These are based on new embedding inequalities for thin perforated layers including coupling to bulk domains. In the limit, effective interface laws for flow and transport are derived at the interface separating the two bulk regions. These interface laws enable effective mass transport through the membrane, which is also an important feature from an application point of view. This is a joint work with Markus Gahn (Universität Heidelberg).

Keywords: Stokes equations, Reaction-diffusion-advection equations, Effective interface laws, Homogenization, Two-scale convergence.

References

- [1] M. Gahn, M. Neuss-Radu, *Effective interface laws for fluid flow and solute transport through thin reactive porous layers*, Journal of Evolution Equations, 25(2):1-65, 2025.