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Interface conditions for Stokes–Darcy problems derived via homogenization and boundary layers

Elissa Eggenweiler[1,*] **and Iryna Rybak**[2]

[1] University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart,
elissa.eggenweiler@ians.uni-stuttgart.de
[2] University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart,
iryna.rybak@ians.uni-stuttgart.de

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Coupled systems of a free flow adjacent to a porous medium appear in many environmental settings, biological processes or technical applications. Examples are interactions of surface flow with subsurface flow, nutrient transport through human tissues or industrial filtration. In such coupled systems multiple length scales are present and the flow is highly influenced by complex exchange processes at the fluid–porous interface. Both aspects make modeling free-flow and porous-medium flow systems a challenging task.

We use the Stokes equations in the free-flow region and Darcy's law to describe the porous-medium flow. Conditions on the sharp fluid–porous interface are needed to couple the two systems of partial differential equations. Since classical interface conditions (conservation of mass, balance of normal forces, Beavers–Joseph condition) contain undetermined parameters and are unsuitable for non-parallel flows to the porous layer [1,2], effective generalized coupling conditions that account for arbitrary flow directions to the interface and do not contain any unknown coefficients are needed.

In this talk, we derive such generalized interface conditions for the Stokes–Darcy coupling via homogenization with two-scale asymptotic expansions and boundary layer correctors. These conditions extend the interface conditions derived in [2]. Besides the non-dimensional equations required for the theoretical derivation of the interface conditions we also provide the dimensional formulation of the coupled Stokes–Darcy problem needed for numerical simulations. Practical aspects on the computation of all the effective coefficients staying in the generalized interface conditions are presented.

REFERENCES

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