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Domain Decomposition Methods for Coupling Stokes and Darcy Equations

Marco Discacciati

Abstract: This presentation concerns the study of mathematical and numerical models for simulating incompressible fluid flows through heterogeneous media. In particular, we consider the case of free fluids which can filtrate through a porous medium occupying a domain neighbouring the free fluid itself. This topic has many important applications, among which we recall the hydrological environmental ones and mass transfer in biomechanics.
In this talk we outline the mathematical and numerical analysis of a coupled Stokes/Darcy problem. In particular, by adopting the Beavers and Joseph interface conditions, we will assess the well-posedness of the global problem, and we will introduce a suitable Galerkin finite element approximation.
Then, we will focus our attention on effective iterative substructuring methods, which allow to solve the global problem through the independent solution of both Stokes and Darcy problem in each subdomain. Through the analysis of suitable Steklov-Poincaré interface operators, we can characterize an optimal preconditioner to solve the discrete algebraic problem, which can be applied in the framework of Krylov type methods.
The effectiveness of the computational methods we have introduced, will be shown on some test cases.

[1] M. Discacciati, E. Miglio and A. Quarteroni. *Mathematical and numerical models for coupling surface and groundwater flows.* Appl. Num. Math., 43:57-74, 2002.

[2] M. Discacciati and A. Quarteroni. *Analysis of a domain decomposition method for coupling Stokes and Darcy equations.* In Numerical Analysis and Advanced Applications, Brezzi Ed., Springer-Verlag, Milan, to appear (2003)

[3] M. Discacciati and A. Quarteroni. *Convergence analysis of a subdomain iterative method for the finite element approximation of the coupling of Stokes and Darcy equations.* Comput. Visual. Sci., to appear.

[4] W. Jäger and A. Mikelić. *On the interface boundary condition of Beavers, Joseph and Saffman.* SIAM J. Appl. Math., 60(4):1111-1127, 2000.

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Marco Discacciati (Speaker)
Ecole Polytechnique Federale de Lausanne
Institut d'Analyse et Calcul Scientifique
MA-Ecublens
1015 Lausanne
Switzerland
mailto:marco.discacciati@epfl.ch