Mixed finite element schemes for fluid flows in fractured porous media with reduced order modeling of fractures with non-matching grids

C. D'Angelo[†], A. Fumagalli[†], A. Scotti[*,†]

[†]MOX - Department of Mathematics, Politecnico di Milano
P. L. da Vinci 32, 20133 Milano, Italy
e-mail: carlo.dangelo@polimi.it
alessio.fumagalli@mail.polimi.it
anna.scotti@polimi.it

ABSTRACT

One of the difficulties of the simulation of groundwater flows and more generally two-phase flows is related to the heterogeneous properties of the considered porous medium. Similar problems arise in the analysis of biofluids and blood perfusion [1]. In this work, we focus on the treatment of fractures and inclusions embedded in a n-dimensional porous domain Ω, in the form of a $(n-1)$-dimensional manifold Γ, to describe the coupled fluid flows in both domains [2].

Several techniques have been developed to handle this kind of fractures and to correctly impose the interface conditions, mostly in the case of conformal fracture grids, where the elements of the fracture mesh are actually faces of the grid related to the porous domain [3]. However, for large scale computations and complex fracture networks, this can easily represent a severe constraint. In this regard, the handling of nonconformal fracture grids is undoubtedly a substantial benefit of any computational scheme. Motivated by this need, we investigate specific *unfitted* finite element schemes (see for instance [4]) for coupled flows that do not require conformal grids. Specifically, we consider mixed hybrid finite elements for each of the flow problems in Ω and Γ, and derive the correct interface conditions in the case of nonconformal embedded fracture grids. The features of the resulting coupled finite element scheme are illustrated by means of several examples and applications to cases of interest in geophysical applications.

REFERENCES

[1] C. D'Angelo and A. Quarteroni, *On the coupling of 1D and 3D diffusion-reaction equations. Application to tissue perfusion problems*, Math. Models Methods Appl. Sci. **18** (2008), no. 8, 1481–1504

[2] P. Angot, F. Boyer and F. Hubert, *Asymptotic and numerical modelling of flows in fractured porous media*, M2AN Math. Model. Numer. Anal. **43** (2009), no. 2, 239–275

[3] V. Martin, J. Jaffré and J.E. Roberts, *Modeling fractures and barriers as interfaces for flow in porous media*, SIAM J. Sci. Comput. **26** (2005), no. 5, 1667–1691

[4] A. Hansbo and P. Hansbo, *An unfitted finite element method, based on Nitsche's method, for elliptic interface problems*, Comput. Methods Appl. Mech. Engrg. **191** (2002), no. 47-48, 5537–5552