Congress on Numerical Methods in Engineering
Lisboa, June 29 to July 02, 2015

RESUMO N° 120

HYBRIDIZED MIXED FINITE ELEMENT METHODS FOR THE COUPLING STOKES-DARCY FLOW

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Keywords: Coupled Stokes-Darcy Flow, Beavers-Joseph Interface Condition, Stabilized Finite Element, Mixed-Hybrid Methods

In the last decades, numerical methods to simulate the flow of incompressible viscous fluids through permeable heterogenous media have been widely developed due to several applications in petroleum engineering (well and reservoir interaction), hydrology (coupled surface and groundwater flows), hydrogeology (flow in fractured porous medium), as examples. In particular, a well known problem is the coupling between free fluid with the porous medium governed by Stokes and Darcy equations, respectively, and a slip boundary condition, experimentally developed by Beavers-Joseph, on the interface between them. Standard finite element implementation, Lagrange multipliers imposing the interface condition and iterative procedures associated with domain decomposition techniques can be applied to solve numerically this coupled problem. Moreover, Discontinuous Galerkin (DG) methods are proposed to deal with each subdomain, but the practical utility of DG methods have been limited by their more complex formulation, computational implementation and much larger number of degrees-of-freedom. Thus, we propose a new stabilized hybrid mixed finite element formulation for the coupled problem combining the hybrid formulations for the Darcy and the Stokes problems. The Lagrange multipliers are introduced to impose weakly continuity on each side of the elements generating a global system involving only the degrees-of-freedom associated with the multipliers and the variables of interest can always be solved at the element level. This method imposes naturally the Beavers-Joseph or Beavers-Joseph-Saffman boundary conditions and preserves the main properties of the associated DG methods. To validate this methods we perform numerical experiments that illustrate the flexibility and robustness of the proposed formulations and show optimal rates of convergence.