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Enriched Galerkin Approximations for Flow and Transport

We present and analyze an enriched Galerkin finite element method (EG) to solve coupled flow and transport system with jump coefficients referred as miscible displacement problems. This technique recently applied to hydraulic fracturing in porous media. Especially, we focus on the three key points for coupling flow and transport including; discrete maximum principle, discrete sum compatibility, and locally conservative flux.

The EG is formulated by enriching the conforming continuous Galerkin finite element method (CG) with piecewise constant functions. This method is shown to be locally and globally conservative while keeping fewer degrees of freedom in comparison with discontinuous Galerkin finite element methods (DG). In addition, we present and analyze a fast and effective EG solver simpler than DG and whose cost is roughly that of CG and can handle an arbitrary order of approximations for the flow problem.

Moreover, to avoid any spurious oscillations for the higher order transport system, we employ an entropy residual stabilization. Dynamic mesh adaptivity using hanging node strategy is also applied to save computational cost for large-scale three dimensional physical problems.

Number of numerical tests in two and three dimensions are presented to confirm our theoretical results as well as to demonstrate the advantages of the EG.

This is a joint work with Mary F. Wheeler (University of Texas at Austin) and Young-Ju Lee (Texas State University).

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