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Multipoint mixed FEM for rotation-based poroelasticity with faults

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In this work, we present a mixed finite element formulation of the Biot problem based on the rotation and displacement for the elasticity, and Darcy velocity and pressure, for the fluid phase flow. The discretization of the problem is based on exact discrete complexes and also on a suitable choice of a quadrature rule to localize, in a multi-point fashion, and thus algebraically eliminate the rotation and flux variables. The resulting method has fewer degrees of freedom than the original one, leading to a cost-effective formulation of the poroelastic problem with a two fields formulation. Indeed, we consider lowest order Raviart-Thomas finite elements for the displacement and piece-wise constants for the fluid pressure, thus the number of degrees of freedom is equivalent to a mixed formulation of a single-phase flow. Numerical results show the expected convergence rates for the errors for all the variables, for both the four and two fields formulations. We extend this discretization strategy to account for faults, which are three-dimensional physical objects where one of the dimension (their thickness) is orders of magnitude smaller than the others, and their material properties might be very different than the surrounding porous media. To avoid excessive mesh refinement, in the discrete setting, we represent them as objects of codimension one and consider a new set of equations based on a dimensional reduction strategy. We can thus reformulate the problem as mixed-dimensional and exploit the properties of the discrete approximation to obtain reliable solutions at an affordable computational cost. The reference paper for this contribution is [1], see also references therein.

Participation

In-Person

References

[1] arXiv:2212.12448 [math.NA]

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