6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Conservative discretizations and parameter-robust preconditioners for multiple-network poroelastic systems

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Keywords: *multiple-network poroelasticity, MPET equations, mass-conservative discretizations, uniform stability, parameter-robustness, norm-equivalent preconditioners*

Multiple-network poroelastic theory (MPET) has been introduced in geomechanics to describe the mechanical deformation and fluid flow in media permeated by pores and fissures of different porosities and permeabilities as a generalization of Biot's theory, see [1]. More recently it has also been applied successfully in the modeling of cerebral water transport [4]. The parameters in the governing system of partial differential equations typically vary over several orders of magnitude making its stable discretization and efficient solution a challenging task, see [2, 3] for the case of Biot's consolidation model.

We generalize here our approach of using pointwise mass-conservative discretizations for the classical three-field formulation of the single-network poroelastic problem, cf. [2], to a flux-based formulation of multiple-network poroelastic systems. The key to establish the uniform inf-sup stability of the continuous problem is the choice of proper parameter-dependent norms. This allows also the parameter-robust transfer of the induced norm-equivalent preconditioners to the discrete level. We further prove the corresponding optimal error estimates.

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