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Inf-sup theory and finite element discretizations for poroelasticity

ABSTRACT:
Poroelasticity models the flow of a fluid inside an elastic porous medium. Poroelastic models have a wide range of applications covering, e.g., reservoir engineering, biomechanics and medicine. These models are often quasi-static, meaning that the evolution of the elastic medium is assumed to be much slower than the one of the fluid. This gives rise to mixed-type systems, consisting of stationary equations for the solid and of evolutionary ones for the fluid.

The analysis and the discretization of poroelastic models are typically handled by the theory of implicit evolution equations or, more often, by the Faedo-Galerkin scheme. We propose a new paradigm , based on the inf-sup theory, i.e. on the Banach-Nečas theorem for the well-posedness of linear variational problems. The main advantages of this approach is the derivation of two-sided stability estimates which, in turn, are the starting point for the derivation of sharp a priori and a posteriori error bounds for a discretization.

We discuss a few results obtained by the proposed approach, both for the analysis and the dicretization of some poroelastic models, with an emphasis on the robustness with respect to the material parameters.