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Numerical Analysis of a Mixed-Dimensional Poromechanical Model with Frictionless Contact at Matrix–Fracture Interfaces

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Abstract: We present a complete numerical analysis for a general discretization of a coupled flow–mechanics model in fractured porous media, considering single-phase flows and including frictionless contact at matrix–fracture interfaces, as well as nonlinear poromechanical coupling. Fractures are described as planar surfaces, yielding the so-called mixed- or hybrid-dimensional models. Small displacements and a linear elastic behavior are considered for the matrix. The model accounts for discontinuous fluid pressures at matrix–fracture interfaces in order to cover a wide range of normal fracture conductivities.

The numerical analysis is carried out in the Gradient Discretization framework, encompassing a large family of conforming and nonconforming discretizations. The convergence result also yields, as a by-product, the existence of a weak solution to the continuous model. A numerical experiment in 2D is presented to support the obtained result, employing a Hybrid Finite Volume scheme for the flow and second-order finite elements ($\mathbb{P}_2$) for the mechanical displacement coupled with face-wise constant ($\mathbb{P}_0$) Lagrange multipliers on fractures, representing normal stresses, to discretize the contact conditions. This is a joint work with Jérôme Droniou (Monash University, Melbourne) and Roland Masson (Inria & Université Côte d'Azur, Nice).