A general approach for modeling interacting flow through porous media under finite deformations

Abstract:
In the last few decades modeling deformation and flow in porous media has been of great interest due to its possible application areas in various fields of engineering such as biomechanics, soil mechanics, geophysics, physical chemistry and material sciences. Due to the high complexity and in most cases also unknown geometry of porous media on the microscale, a fully resolved model is nearly impossible to obtain, but most of the times also not necessary to answer important questions. As a consequence, one switches to a macroscopic approach. Such a mathematical description of porous media on the macroscale leads to a volume-coupled multi-field problem, wherein the interface between the two phases is not resolved explicitly. In this work we propose a novel approach for modeling incompressible flow through a nearly incompressible elastic matrix under finite deformations. After a short overview of physical and mathematical fundamentals, the system equations are formulated and different representations are introduced and analyzed. Based on thermodynamic principles, a general constitutive law is derived, which allows the
integration of arbitrary strain energy functions for the skeleton. Discretization in space with
three primary variables and discretization in time using the one-step-theta method lead to a
complete discrete formulation, which is the first one including both finite deformations as well as
full coupling of structural and fluid phases. The suitability of the presented approach for
modeling two-phase saturated poroelastic media is illustrated by several numerical examples.

Stichworte:  deformable porous media, finite deformation, poroelasticity

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