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On new approaches to the fixed-stress split scheme for solving flow problems in deformable porous media

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Biot's equations [1] model the time dependent interaction between the deformation of an elastic porous material and the fluid flow inside of its pore network. There is a vast number of applications of this model, making very important its numerical simulation. There are two main approaches to deal with this problem, the monolithic or fully coupled methods, which solve the linear system simultaneously for all the unknowns, and the iterative coupling schemes, which solve sequentially the equations for fluid flow and geomechanics, at each time step, until a converged solution within a prescribed tolerance is achieved. The most used iterative coupling method is the fixed stress split scheme [2, 3].

Here, we present two new approaches to the fixed-stress split algorithm. First, we propose a new version which forgets about the sequential nature of the temporal variable and considers the time direction as a further direction for parallelization [4], giving rise to a parallel-in-time iterative solution method. Second, we consider an inexact version of the fixed-stress split scheme as smoother in a geometric multigrid framework [5], giving rise to a very efficient monolithic solver for Biot's problem.

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