Johann Radon Institute for Computational and Applied Mathematics Austrian Academy of Sciences (ÖAW)

Group Seminar

Computational Methods for PDEs

Parameter-Robust Convergence Analysis of Fixed-Stress Split Iterative Method for Multiple-Permeability Poroelasticity System

Johannes Kraus, University of Duisburg-Essen

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Abstract

Poroelasticity studies the interactions between fluid motion and elastic deformation in porous media. It has many important applications including consolidation, subsidence due to fluid withdrawal, and hydraulic fracturing. One of the first and still widely used linear models is Biot's model of consolidation. Multiple-network poroelastic theory (MPET) has been introduced into geomechanics as a generalization of Biot's theory in the early 1960s. The deformable elastic matrix is assumed to be permeated by multiple fluid networks of pores and fissures with differing porosity and permeability. During the last decade, MPET has acquired many important applications in medicine and biomechanics and therefore become an active area of scientific research. The biological MPET model captures flow across scales and networks in soft tissue and can be used as an embedding platform for more specific models.

In this course, we will present different formulations of Biot's model. We will address the stability and well-posedness of the continuous model and derive norm-equivalent preconditioners in the framework of operator preconditioning. The second part of the lecture will be devoted to strongly mass conservative discretizations based on mixed discontinuous-continuous Galerkin methods. We will prove optimal error estimates and also derive fully parameter-robust precondtitioners on the discrete level. The third part of the lecture deals with generalizations of the results covered in the first two parts to multi-permeability poroelasticity problems modeled by the MPET equations. In the last part of the lecture iterative coupling schemes will be discussed as an alternative for fully implicit methods to solve the quasi-static Biot- and MPET problems.

Basic knowledge of the finite element method (FEM), in particular, discontinuous Galerkin FEM, is recommended.