SIAM/APPLIED AND NUMERICAL ANALYSIS SEMINAR

Date: March 17, 2021

Speaker: Ying Li

Title: An artificial compressibility CNLF method for the Stokes-Darcy model and application in ensemble simulations

Abstract:

We propose and analyze an efficient, unconditionally stable, second order convergent, artificial compressibility Crank-Nicolson leap-frog (CNLFAC) method for numerically solving the Stokes-Darcy equations. The method decouples the fully coupled Stokes-Darcy system into two smaller subphysics problems, which reduces the size of the linear systems to be solved, at each time step, and allows parallel computing of the two subphysics problems. It also decouples the computation of the velocity and pressure in the free flow region. The pressure only needs to be updated at each time step without solving a Poisson equation, avoiding pressure errors in boundary layers due to imposing artifificial boundary conditions. We prove that the method is unconditionally long time stable and second order convergent. We also propose an unconditionally stable ensemble algorithm based on the CNLFAC method. The ensemble algorithm results in a common coefficient matrix for all realizations and consequently allows the use of efficient direct or iterative solvers to reduce the computational cost. Numerical experiments are provided to illustrate the second-order convergence and unconditional stability of the CNLFAC method. Moreover, the CNLFAC ensemble algorithm is demonstrated to reduce the computational time of a CNLF nonensemble algorithm by 95% in our tests.