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The Hong Kong University of Science and Technology

Department of Mathematics

Seminar on Applied Mathematics

A Scalable Fully Implicit Framework for Bound-Preserving Reservoir Simulation on Parallel Computers

by

Prof. Shuyu Sun

King Abdullah University of Science & Technology (KAUST)

Abstract

Modeling and simulation of multiphase flow in porous media have been a major effort in reservoir engineering and in environmental study. One basic requirement for accurate modeling and simulation of multiphase flow is to have the predicted physical quantities sit within a physically meaningful range. For example, the predicated saturation should sit between 0 and 1 while the predicated molar concentration should sit between 0 and the maximum value allowed by the equation of state. Unfortunately, popular simulation methods used in petroleum industries do not preserve physical bounds. A commonly used fix to this problem is to simply apply a cut-off operator. However, this cut-off practice does not only destroy the local mass conservation but it also damages the global mass conservation, which seriously ruins the numerical accuracy and physical interpretability of the simulation results. In the talk, we will present our recent work on bound-preserving discretization and solvers for subsurface flow models based on a fully implicit framework. We reformulated a few subsurface flow models using variational inequalities that naturally ensure the physical feasibility of the physical quantities including saturations and concentrations. We applied a mixed finite element method and the implicit backward Euler scheme with adaptive time stepping. The resultant nonlinear system arising at each time step was then solved by a generalized Newton method, i.e., active-set reduced-space method, and then the ill-conditioned linear Jacobian systems were solved with a Krylov subspace method combined with a nonlinear preconditioner based on overlapping additive Schwarz type domain decomposition and nonlinear elimination. Numerical results will be presented to examine the performance of the newly developed algorithm on parallel computers. This presentation is based on the joint work [1-3] with Haijian Yang (Hunan University), Chao Yang (Beijing University), and Yiteng Li (KAUST).

[1] H. Yang, S. Sun, Y. Li, and C. Yang, CMAME, 330: 334-350, 2018. [2] Yang, S. Sun, and C. Yang, JCP, 332: 1-20, 2017. [3] H. Yang, C. Yang, and S. Sun, SISC, 38(4): B593–B618, 2016.

Date: **Friday, 7 December 2018**

Time: **11:00a.m. – 12:00noon**

Venue: **Room 4472, Academic Building, (Lifts 25, 26), HKUST**

All are welcome!