Computational Methods for Two-Phase Flows at the Pore Scale

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ABSTRACT

Modeling multicomponent flows in porous media is important for many applications relevant to the energy and the environment. Advances in pore-scale imaging, increasing availability of computational resources, and developments in numerical algorithms have started rendering direct pore-scale numerical simulations of multiphase flow in porous structures feasible. This talk presents recent advances in the discretization of phase-field models for systems of two-phase flows in digital rocks. At the micro-meter scale, the solid rock structure is fixed and fluid flows through the connected pores. The three-dimensional domain is a convoluted non-convex domain formed by the union of voxels, obtained by micro-CT scanning of rock samples.

The phase-field models couple Cahn-Hilliard equations with the Navier-Stokes equations. Wettability on rock-fluid interfaces is accounted for via an energy-penalty based wetting (contact-angle) boundary condition. Spatial discretization is based on the interior penalty discontinuous Galerkin methods. Time discretization utilizes a decoupled splitting approach, that separates the nonlinear convection from the incompressibility constraint. Both theory and application of the proposed methods to model flows in porous structures are discussed. Extensions of the diffuse interface method for a system of two-phase flows with solute surfactant are presented.

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