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Simulation of incompressible two-phase flow in porous media with large timesteps DANIEL COGSWELL, MICHAEL SZULCZEWSKI, Aramco Services Company — Simulations of flow in porous media suffer from severe timestep restrictions as the permeability and viscosity contrast become increasingly heterogeneous, even when solved with a fully implicit discretization. Previous efforts to alleviate these restrictions have focused on numerical methods, but the problem persists because it originates from the shape of the fractional flow function. Here we focus on regularizing the equations themselves with the addition of an energy constraint. The equations for the flow of two immiscible, incompressible fluid phases in porous media are recast as a gradient flow using the phase-field method, a macroscopic surface tension is introduced, and a convex energy splitting scheme is applied to enable unconditionally large timesteps. Using the phase-field formulation as a homotopy map, the unmodified flow equations can be solved with large timesteps, even with high degrees of heterogeneity in permeability and viscosity. For a 2D test problem, the homotopy method allows the timestep to be increased by more than four orders of magnitude relative to the unmodified equations.

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