Analysis of Single and Multi Phase Flows in Porous Media (part III)

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ABSTRACT.

Generalized Forchheimer equations are used to describe the dynamics of fluid flows in porous media when the ubiquitous Darcy's law is not adequate. A polynomial relation between the velocity and pressure gradient is used in place of the linear one. Therefore, new methods are needed to deal with such genuine nonlinearity.

For single-phase flows of slightly compressible fluids, a degenerate parabolic equation for the pressure function is derived. We study its boundary value problem with time-dependent boundary conditions. We estimate the L^∞-norm of the pressure, its gradient and time derivative, with emphasis on large time estimates. We also establish the continuous dependence of the solution on the initial and boundary data, and coefficients of the Forchheimer polynomial.

For two-phase flows of incompressible fluids with presence of the capillary pressure, we find a family of steady state solutions whose saturation and pressure are radially symmetric and velocities are rotation-invariant. Their properties are investigated based on relations between the capillary pressure, each phase's relative permeability and Forchheimer polynomial. The linearized system at those steady states is derived and reduced to a parabolic equation for the saturation. This equation has a special structure which we exploit to prove new lemmas of growth of Landis-type. These are used in studying qualitative properties of the solutions.