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Optimal Reconstruction of Constitutive Relations for Porous Media Flows

Comprehensive full-physics models for flow in porous media typically involve convection-diffusion partial differential equations whose parameters are unknown and have to be reconstructed from experimental data. Quite often these unknown parameters are coefficients represented by space-dependent, sometimes correlated, functions, e.g. porosity, permeability, transmissibility, etc. However, special complexity is seen when the reconstructed properties are considered as state-dependent parameters, e.g. the relative permeability coefficients k_{rp}. Modern petroleum reservoir simulators still use simplified approximations of k_{rp} as single variable functions of p-phase saturation s_p given in the form of tables or simple analytical expressions. This form is hardly reliable in modern engineering applications used, e.g., for enhanced oil recovery, carbon storage, modeling thermal and capillary pressure relations. Thus, the main focus of our research is on developing a novel mathematical concept for building new models where k_{rp} are approximated by multi-variable functions of fluid parameters, namely phase saturations s_p and temperature T. Reconstruction of such complicated dependencies requires advanced mathematical and optimization tools to enhance the efficiency of existing engineering procedures with a new computational framework generalized for use in various earth science applications.