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A study of a non-equilibrium model with relative permeability hysteresis in two-phase water-oil system

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Non-equilibrium modeling is relevant in several physics of coupled processes, flow and transport of fluids situations in homogeneous and heterogeneous porous media systems, for instance, subject to phase transitions, hysteresis and chemical reactions, among many others complex systems (see, e.g. [1,3,4,5,6] and the references cited therein). To model the dynamics of these phenomena, the corresponding system of partial differential equations typically incorporates source terms. In this work, we are interested in analytical and computational modeling of situations for which we connect states in equilibrium, but we allow that the change of physical situation presents a non-equilibrium relaxation time. We discuss the 1D-2D behavior of the wave groups of solutions in non-equilibrium situations for a two-phase water-oil model with hysteresis in relative permeability in porous media [5,6], generalizing the previous 1D results in homogeneous medium [1] for 2D flows, in heterogeneous porous medium, linked to a two-phase water-oil system [2]. This nonlinear phenomena is given by a coupled set of time-dependent partial differential equations of hyperbolic-parabolic-elliptic mixed type. We also consider synthetic spatial multiscale models of permeability and porosity that resemble the geological properties which control fluid flow. The computational 2D non-equilibrium solutions are obtained based on a sequential operator splitting approach supported by the relaxation projection method introduced in [1]. The main ingredients to obtain these solutions are shock, rarefactions and bifurcations [1,2]. We present 1D-2D solutions and discuss the nonlinearity interplay between wave structure of such solutions in non-equilibrium situations and the high-contrast heterogeneity in porous medium.

Keywords: Non-equilibrium models; Two-phase flow; Porous media; Relaxation relative permeability hysteresis; Analytical-computational methods.

Participation

In-Person

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