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Two-phase flow in porous media under the influence of external electric and magnetic field - Multiscale homogenization approach

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This work provides the derivation of a new model for immiscible flow of a wetting phase inside a non-wetting phase through the pores of a homogeneous porous medium under the effect of external electric and magnetic fields. The model assumes both fluid phases to be incompressible and Newtonian, with the solid matrix being rigid and impermeable. The
porous medium, characterized by a length □, is divided into periodically structured regions of smaller length □. For mathematical and physical understanding of two-phase flow, diffuse interface model is used. The interface between the two fluids is governed by the Cahn-Hilliard equation and the influence of electromagnetic fields is incorporated in the Stokes equation by the Lorentz force term. The research employs a two-scale asymptotic homogenization approach to upscale Stokes–Cahn–Hilliard (SCH) equation system and derive the electromagneto(EM)-permeability tensor by extending Darcy's law to account for multiple phases and incorporating the influence of external electromagnetic fields. The finite element method is utilized to solve the derived equations. The results indicate that capillary number (Ca), wetting phase saturation (□□), the intensities of external magnetic field defined by the Hartmann number (Ha) and magnitude of external electric field represented by a non-dimensional parameter (S) affect the EM-permeability.

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Primary author: MAJUMDAR, Promasree (Indian Institute of Technology Delhi)

Co-author: Dr DASGUPTA, Debabrata (Indian Institute of Technology Delhi)

Presenter: MAJUMDAR, Promasree (Indian Institute of Technology Delhi)

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