Contribution ID: **532** Type: **Oral Presentation**

Thermodynamics of continuum scale immiscible and incompressible two-phase flow in porous media: A statistical mechanics approach using the Color Lattice-Boltzmann model

Wednesday, 1 June 2022 11:45 (15 minutes)

Continuum scale steady-state two-phase flow in porous media can exhibit non-linear dependence on the pressure gradient, a phenomenon which is incompatible with relative permeability theory [1]. If the flow is immiscible and incompressible, it can be described in terms of a thermodynamic framework by considering averaged quantities through surfaces perpendicular to the overall direction of flow. With the assumption of Euler homogeneity on the flow, the seepage velocities can be replaced by a total flow velocity and a co-moving velocity, which consists of the difference between the two flow velocities and an additional term that depends on the saturation gradient of the total flow [2]. This function turns out to be linear in the correct choice of variables, resulting in a simple relation with only two parameters. A connection between this thermodynamic framework and statistical mechanics can be made by formulating a differential area distribution function associated with the local velocities in the slice from which the velocity distributions of the phases can be obtained. We demonstrate that only the total velocity distribution of a slice and the location and pore areas of the phases is needed to obtain the co-moving velocity, which eliminates the need to meassure the individual velocities of both fluids. This simplifies the process of obtaining macroscopic flow properties, since knowledge of the co-moving velocity and one of the saturations can be used to determine the individual flow velocities [3]. This description, as opposed to relative permeability theory, is compatible with non-linearities in the flow [4], as these can be accounted for in the co-moving velocity without issue. We investigate the co-moving velocity via the differential pore-area distributions using Lattice-Boltzmann simulations on three dimensional CT-scans of real porous materials, and show that the results are compatible with the proposed thermodynamic description.

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References

[1] Tallakstad, K. T., Knudsen, H. A., Ramstad, T., Løvoll, Grunde, Måloy, Knut Jørgen, Toussaint, R., & Flekkøy, Eirik Grude (2009). Steady-State Two-Phase Flow in Porous Media: Statistics and Transport Properties. Physical Review Letters, 102(7), 074502

[2] Hansen, A., Sinha, S., Bedeaux, D., Kjelstrup, S., Gjennestad, M. A., & Vassvik, M. (2018). Relations Between Seepage Velocities in Immiscible, Incompressible Two-Phase Flow in Porous Media. Transport in Porous Media, 125(3), 565–587

[3] Roy, S., Sinha, S., & Hansen, A. (2020). Flow-Area Relations in Immiscible Two-Phase Flow in Porous Media. Frontiers in Physics, 8(), 4

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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