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Growth and upscaling of viscous fingers in immiscible two-phase flow

Monday, 31 May 2021 18:00 (15 minutes)

A less viscous fluid invading into a more viscous immiscible fluid produces fingering patterns due to instabilities at the interfaces between them. In the space between two closely spaced parallel plates, the fingers appear to be smooth as there is essentially only one interface separating the fluids. In case of a porous medium, e.g. by filling the space between the plates with fixed glass beads, the fingers show fractal structures where many microscopic fluid-fluid interfaces exist. These patterns are fractal in nature and characterized by different fractal dimensions depending on whether they are dominated by viscous or capillary forces [1].

In the large-scale continuum limit where the pores are vanishingly small compared to the dimensions of the porous medium, the relative density of invading fluid in the fractal patterns approaches zero. Rather, it is the structures giving rise to non-zero saturation which will dominate. The local saturation is the proper quantity to characterize the fingers in this limit.

We now ask the following question: Is it possible to use the fractal structures on the pore scale to infer the saturation distribution in the continuum limit? We follow the experimental work of Løvoll et al. [1] and Toussaint et al. [2], using an averaging technique to map out a probability distribution for the position of the fingers. That is, each point is given a probability density for being part of a viscous finger. This creates a density profile and we conjecture that this density profile reproduces the saturation profile in the continuum limit. This conjecture is built upon the work of Arnéodo et al. [3] that demonstrated that averaging over DLA patterns reproduces the smooth fingers that Saffman-Taylor found analytically.

We perform our study with dynamical pore-network modeling [4] and analytical derivations [5], and compare them with experimental observations.

Time Block Preference

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

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[4] S. Sinha, M. Aa. Gjennestad, M. Vassvik and A. Hansen, Front. Phys. 2021 (to appear), ArXiv:1907.12842.
[5] A. Hansen, S. Sinha, D. Bedeaux, S. Kjelstrup, M. A. Gjennestad and M. Vassvik, Transp. Porous Med. 125, 565 (2018).

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