Monte Carlo Simulation of Immiscible Two-Phase Flow in Porous Media

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Finding a set of equations describing the simultaneous flow of two immiscible fluids in a porous medium is an outstanding problem in theoretical physics. Today, it is possible to follow the fluids in detail at the pore level using e.g. micro-CT or other such techniques. However, to translate this visualization into a mathematical description at a coarse-grained level where the porous medium may be viewed as a continuum is a step that is still lacking. Finding such a description is a central theme for the Center of Excellence Porelab. Our approach is to emulate the approach of statistical mechanics leading to thermodynamics as the final continuum theory.

As part of this effort, we published in 2017 a paper presenting a Markov Chain Monte Carlo algorithm based on the Metropolis algorithm for simulation of the flow of two immiscible fluids in a porous medium under macroscopic steady-state conditions using a dynamical pore network model that tracks the motion of the fluid interfaces [1,2]. This method rests on our ideas using statistical mechanics to describe the flow problem being not only correct but also implementable.

The method as it stands has a major weakness: it requires that the underlying porous medium may be mapped onto a regular lattice. It is very important that we overcome this constraint and here is the central theme of the proposed MSc project: How to reconstruct the Monte Carlo method based on a generalized statistical mechanics so that it may be implemented on any pore network.

The project will involve extensive numerical calculations based on programs that are already in existence. It is necessary with a good understanding of statistical mechanics and a knowledge of fluid mechanics.

The PoreLab environment is highly interdisciplinary, international and dynamic.

1] I. Savani, S. Sinha, A. Hansen, D. Bedeaux, S. Kjelstrup and M. Vassvik, A Monte Carlo Algorithm for Immiscible Two-Phase Flow in Porous Media. *Transp Porous Med* **116,** 869–888 (2017). https://doi.org/10.1007/s11242-016-0804-x.

[2] I. Savani, Non-Equilibrium Statistical Mechanics of Two-Phase Flow in Porous Media, PhD Thesis, NTNU (2016), http://hdl.handle.net/11250/2432735.