

# Configurational probability and glassy phase transition in two-phase flow in porous media

**Santanu Sinha**<sup>1</sup>, Humberto Carmona<sup>2</sup>, José S. Andrade Jr.<sup>2</sup>, Alex Hansen<sup>1</sup>

<sup>1</sup>PoreLab, Department of Physics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway, <sup>2</sup>Departamento de Física, Universidade Federal do Ceará, Fortaleza, Brazil

Transport of multiple immiscible fluids in porous media in steady state shows different characteristic flow patterns at the pore scale depending on the competition between viscous and capillary forces [1]. At the macroscopic scale, also called the Darcy scale, this is reflected in the effective flow properties exhibiting different regimes with linear and non-linear dependence of total flow rate on the applied pressure drop [2]. In order to predict the flow on the Darcy scale on the basis of a microscopic model, we construct a configurational probability distribution based on Jaynes maximum entropy principle. The energy function in the probability distribution resembles that of an Ising spin system. By using Boltzmann machine learning trained on the flow patterns in a dynamic pore-network model, and measuring higher order correlations, we show that the probability distribution resembles that of a spin-glass system. We measure the magnetization, the spin-glass order parameter, and the susceptibilities from the pore-scale configurations of the pore-network simulations in steady state, and construct a phase diagram for the two-phase flow system. We find that the critical line separating the paramagnetic phase from a spin-glass phase coincides with the transition where the dependence of the rate of two-phase flow on the imposed pressure gradient changes from linear to non-linear [3].

## References:

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