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Improving the Monte Carlo algorithm for pore-network simulations of immiscible two-phase flow in porous media

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Pore-network modeling provides a platform to study the upscaling problems in two-phase flow in porous media by representing the pore structure with a network of links and linking the pore-scale physics to the larger network. However, the bottleneck in this approach is the necessity to solve the pore-pressure field at each time step which makes it more and more computationally expensive with the increase of the network size. Moreover, when interested only on the steady-state properties, the advancing of interfaces using the time integration provides too much information about the transients. In order to improve the computational limitations inherent to the network models, we proposed a Markov Chain Monte Carlo algorithm [1] based on the Metropolis algorithm for the pore-network simulation of two-phase flow under macroscopic steady-state conditions. The algorithm generates steady-state configurations of fluids based on configuration probability, and improves the computational time significantly compared to the time stepping. The results obtained with Monte Carlo are found in agreement with the time stepping, however, it uses a rectangular sub-system to generate trial the configurations which breaks the long range correlation at high saturation. A rectangular sub-system also limits the usability of the algorithm for a irregular networks, for example in case of the three dimensional networks reconstructed from real core samples. We will address this problem here, by replacing the rectangular sub-system with an irregular sub-network of flow highways, which can preserve the long range correlations of the flow and can improve the quality of the algorithm.

References

[1] I. Savani, S. Sinha, A. Hansen, D. Bedeaux, S. Kjelstrup and M. Vassvik, Transp. Porous Med. 116, 869 (2017).

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