The numerical solution of the micro-scale phase-field equation and its role in a two-scale two-phase flow model.

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Porous media are complex domains involving hierarchically organized structures, where various processes take place at different scales. An example in this sense is the fluid flow through the pores of a porous medium and, in particular, the two-phase flow. Prominent real-life applications in this sense are geological CO2 sequestration or oil recovery.

In [1], a two-scale model for two-phase porous-media flow is proposed. This model includes variable surface-tension effects, depending on the concentration of a surfactant dissolved in one of the fluid phases. A phase field is employed to approximate the freely moving interfaces separating the different fluid phases. By formal homogenization techniques, a fully coupled two-scale model is derived, where the macro-scale parameters are determined by solving micro-scale cell problems, which, on their turn, depend on the macro-scale variables.

Our main challenge is to design a robust numerical scheme for the model, accounting for the coupling between the two scales. We study the macro-scale impact of the micro-scale evolution of the phase-field. Here we center the attention on the phase-field cell problems, which are Cahn-Hilliard type equations. To solve it, we propose a mixed formulation and a robustly convergent linear iterative scheme that is combined with a mesh refinement strategy, improving the efficiency of the algorithm.

References

[1] S. Sharmin, M. Bastidas, C. Bringedal, I.S. Pop, Upscaling a Navier-Stokes-Cahn-Hilliard model for two-phase porous-media flow with solute-dependent surface tension effects. (SUBMITTED), 2021.
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