DIRECT NUMERICAL SIMULATION OF MULTIPHASE FLOWS AT PORESCALE

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Analysis of the micro-flows in different natural and artificial porous materials is relevant and important problem. With the development of high performance computing and μ-CT technologies which allows to construct detailed geometrical models of material microstructure, it becomes possible to evaluate such flows using numerical experiments. In geophysical applications such techniques are called "digital rock physics" and is meant to accompany and supply regular laboratory measurements for evaluation of, e.g., transport properties of the core samples.

The talk describes numerical techniques for an analyses of single and multiphase fluid flows in the pore space of core samples with direct resolution of the pore space structure. The model and algorithms allow for simulation of dense and moderately rarefied gas flows with slipping effects and fluid flows with surface tension and fluid/solid wetting effects.

The core of the approach is quasi-hydrodynamic regularization of classical Navier–Stokes and Navier–Stokes–Cahn–Hilliard equations. The model is thermodynamically consistent and is based on diffuse interface description of the inter-phase boundaries. The regularization terms are dissipative and act as stabilizers of the numerical solution. This allows to use logically simple explicit finite difference schemes with central difference approximations. The developed algorithms allows for highly parallel implementation. Description of the simulation domain is based on voxel representation wich allows to use μ-CT data with minimal preprocessing.

A number of simulations demonstrating consistency of the model and algorithms as well as "realistic" flow simulations within realistic μ-CT models are presented.