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Massively parallel simulations of multiphase flows using Lattice Boltzmann methods

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In the last two decades the lattice Boltzmann method (LBM) has matured as an alternative and efficient numerical scheme for the simulation of fluid flows and transport problems. Unlike conventional numerical schemes based on discretizations of macroscopic continuum equations, the LBM is based on microscopic models and mesoscopic kinetic equations. The fundamental idea of the LBM is to construct simplified kinetic models that incorporate the essential physics of microscopic or mesoscopic processes so that the macroscopic averaged properties obey the desired macroscopic equations. Especially applications involving interfacial dynamics, complex and/or changing boundaries and complicated constitutive relationships which can be derived from a microscopic picture are suitable for the LBM. In this talk a modified and optimized version of a Gunstensen color model is presented to describe the dynamics of the fluid/fluid interface where the flow field is based on a multi-relaxation-time model. Based on that modeling approach validation studies of contact line motion are shown. Due to the fact that the LB method generally needs only nearest neighbor information, the algorithm is an ideal candidate for parallelization. Hence, it is possible to perform efficient simulations in complex geometries at a large scale by massively parallel computations. Here, the results of drainage and imbibition (Degree of Freedom > 2E11) in natural porous media gained from microtomography methods are presented. Those fully resolved pore scale simulations are essential for a better understanding of the physical processes in porous media and therefore important for the determination of constitutive relationships.