Equation-free lifting: A lattice Boltzmann case study

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Recently, techniques have been proposed to efficiently perform 'equation-free' macroscopic simulation and bifurcation analysis. A macroscopic time step is realized by combining time integration of the microscopic model with 'downscaling' and 'upscaling' operators that transfer information from the macroscopic to the microscopic level and vice versa. Also, in the context of hybrid multiscale methods, microscopic simulations can replace a macroscopic model locally in those parts of the domain where the latter is not known (or invalid). To ensure smooth behavior of the solution at the interface between the two models, the coupling requires similar 'downscaling' and 'upscaling' operators.
In this talk, we focus on the crucial downscaling (or 'lifting') step. An appropriate initialization of the (higher dimensional) microscopic model is required to obtain relevant macroscopic information already after a short time. We discuss different downscaling techniques for mesoscopic lattice Boltzmann models. One approach incorporates the first order perturbations of the distributions (related to slaving relations for the higher order moments). Another approach (constrained runs scheme) uses short bursts of microscopic simulations to approximate these slaving relations numerically. We will present recent results on the stability and convergence of the constrained runs scheme for reaction-difffusion lattice Boltzmann models.