Simulations of Ring-Like Deposits

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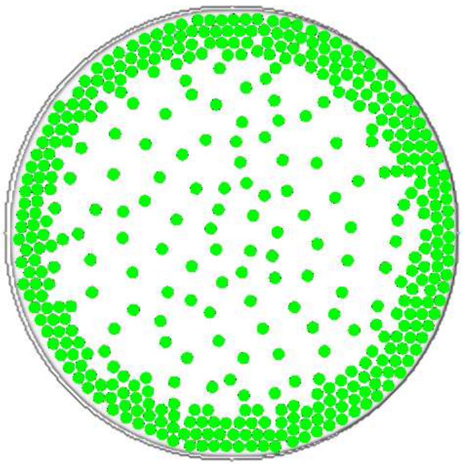
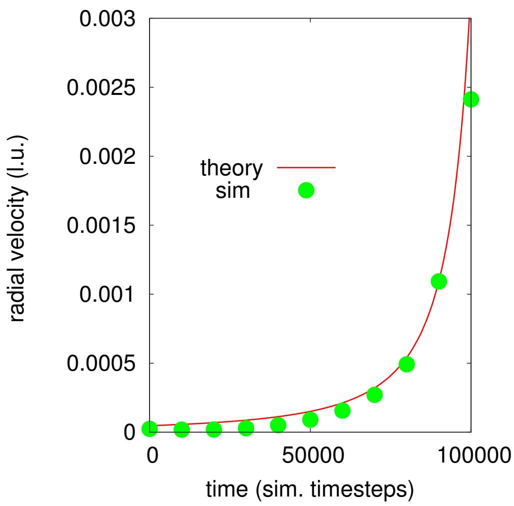
When a drop of coffee dries on a solid substrate, its suspended matter forms a ring-like stain [1]. The ring-like deposits have influence on industrial processes such as printing and coating. Controlling the distribution of a suspension during dying is vital to deposit a desirable pattern onto a substrate, which is of great importance in many industrial applications.

We study the evaporation of a colloidal dispersion droplet with computer simulations. We apply a multicomponent lattice Boltzmann method for the simulations of fluids [2]. The particles are discretized on the lattice of the fluid solver and propagated using a molecular dynamics algorithm [2]. Our code allows for interaction of the fluid with a chemically patterned substrate and the simulation of particles with arbitrary shapes, adjustable wettability and different particle-particle interactions. Moreover, we have developed an evaporation model.

We deposited a droplet containing spherical colloidal particles on a well-prepared chemically patterned substrate. During evaporation of the droplet, the contact line remains pinned. To replenish the evaporated fluid at the edge, a continuous volume flow towards the contact line is generated inside the drop, well reproduced in the simulation. This outward flow transports the colloidal particles to the edge. After evaporation, a ring-shaped stain is formed, as shown in Fig. 1a. A theoretical analysis of radial velocity as a function of time based on mass conservation is carried out [3]. Fig. 1b shows that our simulation results are in good quantitative agreement with the theoretical prediction. Finally, we investigate the active control of deposits with anisotropic particles, such as ellipsoidal particles [4] and Janus particles [5].



(a)



(b)

Figure 1: Evaporation of a colloidal dispersion droplet on a chemically patterned substrate. (a) A ring-shaped stain is left after the evaporation of droplet. (b) Radial velocity near substrate as a function of time. The simulation results are in good quantitative agreement with the theoretical prediction.

References

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