Simulation of the sedimentation process of hydrodynamically interacting colloids in a polydisperse particulate system

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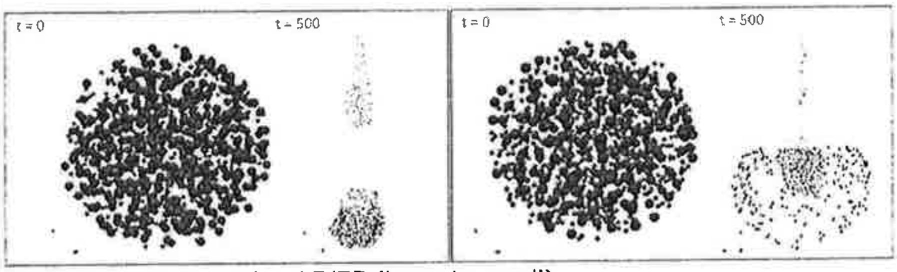
Suspensions of colloidal particles, i.e. particles of diameter between 1nm and 1μm, are part of many industrial processes in the fields of chemical, biological or environmental engineering. A considerable amount of work has been done to investigate and to describe the settling process of such particle systems. Nevertheless, the sedimentation behavior especially of polydisperse systems is not yet fully understood.

The influencing factors of this process can be analyzed by numerical simulations. In this work we especially investigate the influence of pure hydrodynamic interaction and that of hydrodynamic forces plus other interparticle forces occurring between colloids.

Due to the small size of colloids, the particle Reynolds number is typically small, such that one can assume the fluid flow to be a Stokes flow. Along with the description of the motion of single particles by Newton's equations of motion, this gives rise to an efficient numerical method called Stokesian Dynamics. With this method it is possible to simulate systems with large numbers of particles while taking hydrodynamic interactions into account. The DLVO theory gives a good approximation of the interparticle forces, such as the London-van der Waals force and the electrostatic repulsion between colloids. The combination of these two approaches allows the simulation of large systems of colloidal particles at affordable numerical cost.

We utilize the method of Stokesian Dynamics combined with the DLVO theory to simulate the settling behavior of clouds of differently sized particles under the influence of a centrifugal field. Distinct behavior can be observed when taking only hydrodynamic interactions into account or when attractive and repulsive forces described by the DLVO theory are involved as well. Even in the case of only hydrodynamic interactions, a variation of the ratio of large to small particles in a bidisperse system has a large influence on the settling behavior (cf. fig. 1).

As already pointed out, different factors influence the described process. Among them, besides agglomeration due to attractive forces, the ratio between the number of large and small particles, which has a significant effect on the separation time.



Ratio left: 50/50. Right: 25/75 (large to small).