

Model reduction for efficient simulation of fiber suspensions

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There is a strong anisotropy in the motion of slender rigid fibers. This anisotropy contributes to the very rich and complex dynamical behavior of fiber suspensions. The forming of "clusters" or "flocs" are purely three dimensional phenomena, and the direct simulation of these problems require simulations with many fibers for long times.

Earlier, we have developed a numerical algorithm to simulate the sedimentation of fiber suspensions, considering a Stokes flow, for which boundary integral formulations are applicable. The algorithm is based on a non-local slender body approximation that yields a system of coupled integral equations, relating the forces exerted on the fibers to their velocities, which takes into account the hydrodynamic interactions of the fluid and the fibers. Even though there is a great gain in reducing a three-dimensional problem to a system of one-dimensional integral equations, the simulations are still computationally expensive, and the code has been parallelized and run on large computers to allow for more fibers and longer simulation times.

In this talk, I will present a model where approximations have been made to reduce the computational cost. Modifications have mainly been made concerning computation of long range interactions of fibers. The cost is substantially reduced by e.g. adaptively truncated force expansions and the use of multipole expansions combined with analytical quadrature.

I will present results from various simulations and discuss the accuracy of the new model as I compare these results to results from large parallel simulations with the full model. A substantial reduction of the computational effort is normally attained, and the computational cost may comprise only a small fraction of the cost of the full model. This is however affected by parameters of the problem, such as the geometry and the fiber concentration, as will be discussed.