Accelerated boundary integral simulations for interactions of drops and solids in micro-fluidics.

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In micro-fluidic applications where the scales are small and viscous effects dominant, the Stokes equations are often applicable. Simulation methods can be developed based on boundary integral equations, which leads to discretizations of the boundaries of the domain only, and hence fewer unknowns compared to a discretization of the PDE. Such a representation also yields a natural framework for including insolube surfactants when these boundaries are interfaces separating different fluids.

Two main difficulties associated with boundary integral discretizations are to construct accurate quadrature methods for singular and nearly singular integrands, as well as to accelerate the solution of the linear systems, that will have dense system matrices. If these issues are properly addressed, boundary integral based simulations can be both highly accurate and very efficient. For drops and solids in 2D, we will discuss how to apply a general special quadrature approach to achieve highly accurate simulations also for very complicated settings. Depending on the boundary conditions, the simulations are accelerated with either the Fast Multipole method or a spectrally accurate FFT based Ewald method (for periodic problems). Simulation results for very challenging problems are presented.