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Accelerated boundary integral simulations of particulate and two-phase flows

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In micro-fluidic applications where the scales are small and viscous effects dominant, the Stokes equations are often applicable. The suspension dynamics that is observed already with rigid particles and fibers are very complex also in this Stokesian regime, and surface tension effects are strongly pronounced at interfaces of immiscible fluids. 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. 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. We will discuss simulations of periodic suspensions of rigid particles and rigid fibers in 3D, where the simulations are accelerated by a newly developed spectrally accurate FFT based Ewald method, as well as highly accurate simulations of many interacting drops in 2D.