Density oscillations and confinement-induced forces in particulate fluids

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Understanding how particulate fluids organize near surfaces is essential for interpreting the behavior of colloidal and other confined soft matter systems. Under confinement, particles form condensed phases that support layering and crystal-like ordering of particulate systems that generate osmotic stresses on the confining surfaces. When in contact with a reservoir, the particulate fluid in the confinment can further support attractive depletion forces between the confining boundaries. A substantial body of literature describes the behavior of particulate fluids comprising uniformly sized particles. However, for multicomponent particulate fluids with size asymmetry—such as blood, blood plasma, and commercial particulate fillers in polymer melts—predicting the particulate structure under confinment and the stresses therein remains a challenge.
In this work, we employ Fundamental Measure Theory and free-energy minimization to investigate how particle size distribution, density, and confinement influence the structure and stress in confined particulate fluids (see illustration in the figure). We compute equilibrium density profiles under confinement and characterize density oscillations and particle segregation. Altogether, this study provides microscopic insight into how structural correlations and confinement jointly determine interfacial forces accross complex fluids.

Keywords:
Complex fluid, Density functional theory, Fundamental measure theory, Osmotic stresses, Interfacial layering

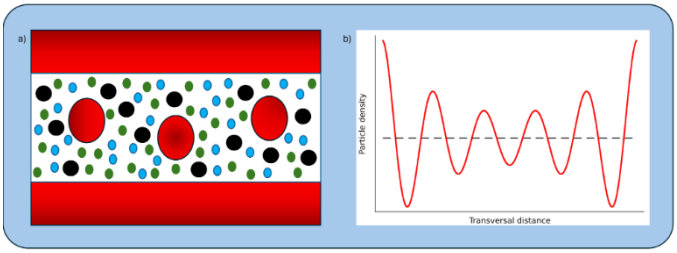

Figure: (a) Schematic of a confined particulate fluid between planar walls. (b) Density profile across the confinement, showing layering near the walls and a damped oscillatory structure around the bulk density (dashed line) in the interior.