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Dynamics of suspended colloidal particles near a wall: Electrokinetic effects and implications for particle-based velocimetry

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Interfacial phenomena due to surface forces are important in microfluidic devices with their relatively large surface areas and small volumes, and may lead to new ways to control microscale flows. Most experimental studies of interfacial transport estimate flow velocities from the motion of "nanoparticles," *e.g.* polystyrene (PS) beads and quantum dots, and assume that the particle displacements over a known interval are the fluid velocities. This talk discusses some of the challenges in extracting fluid velocities within about 500 nm of the wall from the motion of fluorescent PS spheres as small as 100 nm illuminated by evanescent waves. Because the evanescent-wave intensity decays exponentially with wall-normal distance, the particle-wall separation can be determined from the brightness of each particle image. Unlike a similar technique, total internal reflection microscopy, which usually studies the dynamics of a single colloidal particle in a quiescent fluid, this work considers instead an ensemble of $O(10^4)$ particles convected by a flow. For steady Poiseuille and electrokinetically driven flows through channels less than 50 μm deep, the distribution of this ensemble of colloidal particles near the wall is strongly nonuniform, due mainly to repulsive particle-wall electric double layer interactions and van der Waals forces. An electric field parallel to the wall changes the particle distribution by creating an additional "electrokinetic lift" force that depends upon particle and fluid properties as well as the electric field magnitude. After accounting for this nonuniform distribution, the diffusion coefficients and the fluid velocities extracted from the particle displacements are in agreement with theoretical predictions. Due to electrokinetic lift, particle displacements in a shear flow could vary for different tracers, and give different velocity results unless corrected for variations in particle distribution.