Title:
Observations of Near-Wall Dynamics of Colloidal Particles Suspended in Poiseuille and Electroosmotic Flow

Abstract:
The near-wall dynamics of suspended particles of radii $a = O(0.1 \text{ mm} - 1 \text{ mm})$ flowing through a microchannel is of interest in detecting and manipulating particles with surface-mounted sensors and actuators in microfluidics. Dilute ($< 0.4 \text{ vol\%}$) suspensions of fluorescent $a > 250 \text{ nm}$ particles, originally used as particle velocimetry tracers, were visualized with total internal reflection microscopy (TIRM) within $\sim 0.6 \text{ mm}$ of the wall in combined Poiseuille and electroosmotic (EO) “counterflow” at Reynolds numbers $Re = O(1)$ through $\sim 30 \text{ mm}$ fused-silica channels.

The negatively charged particles, which lead the flow due to electrophoresis, migrate towards the negatively charged walls, and the number of near-wall particles appears to grow exponentially over time more than $150$-fold, suggesting that near-wall particle concentrations can exceed $25 \text{ vol\%}$. Recent models predict a qualitatively similar cross-stream migration due to differential fluid-particle inertia.

After the particles concentrate near the walls, they assemble into very elongated streamwise “bands” that only exist near the wall. The particle velocities throughout this process are significantly less than the expected value, namely the superposition of the flow and particle electrophoretic (EP) velocities. If the flow velocity remains the sum of the Poiseuille and EO flow velocities, this suggests that particle electrophoresis is suppressed by a factor of $2–3$ near the wall, although all previous models predict that wall effects enhance EP velocities. This novel type of flow-based colloidal assembly may provide a new approach to continuously produce and extract microscale structures.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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