Iowa State University

Center for Multiphase Flow Research and Education

Near-Wall Observations of Migration and Assembly of Colloidal Particles Suspended in Poiseuille and Electroosmotic Flow

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Abstract

The near-wall dynamics of suspended particles of radii $a = O(0.1\ \mu\text{m}–1\ \mu\text{m})$ flowing through a microchannel is of interest in detecting and manipulating particles with surface-mounted sensors and actuators in microfluidics. Dilute (< 0.5 vol%) suspensions of fluorescent $a \approx 250$ nm particles, originally used as particle velocimetry tracers, were visualized with total internal reflection microscopy (TIRM) within ~1 μm of the wall in combined Poiseuille and electroosmotic flows at Reynolds numbers $Re = O(1)$ through ~30 μm fused-silica channels.

When the negatively charged particles lag the flow due to electrophoresis, the particles migrate towards the channel centerline or the low shear region; when the particles lead the flow, they migrate towards the negatively charged walls, or the high shear region—a behavior qualitatively similar to that observed in inertial migration. Furthermore, when the particles migrate towards the walls, they assemble into concentrated streamwise "bands" above a minimum electric field magnitude.

Our observations suggest that band assembly consists of three stages: 1) particle accumulation; 2) band formation; and 3) steady-state. The number and concentration of near-wall particles appears to grow exponentially during the initial accumulation phase. Moreover, estimates of the particle velocity suggest that the electrophoretic mobility of the particles is suppressed, although models predict that wall effects enhance electrophoretic mobility. Although it remains poorly understood, this novel type of colloidal assembly may be a new way to continuously produce microscale structures.

Biography

Minami Yoda received a B.S. degree in Engineering and Applied Science from the California Institute of Technology, and M.S. and Ph.D. degrees in Aeronautics and Astronautics from Stanford University. Her research areas are in experimental fluid mechanics and optical diagnostics; her group's current research topics include colloidal assembly, super-resolution microscopy for visualizing mini- and microchannel flows, and high heat flux plasma-facing components for magnetic fusion reactors. Currently a Ring Family Professor at Georgia Tech, she was a postdoctoral fellow at the Technical University of Berlin in Germany and a visiting researcher at the Delft University of Technology in the Netherlands. She is Past Chair of the American Physical Society Division (APS) of Fluid Dynamics, Editor of Fluid Dynamics Research, Associate Editor of Experiments in Fluids, Fellow of APS and American Society of Mechanical Engineers.

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

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