JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

SPRING 2021 CEAFM VIRTUAL SEMINAR

"Migration and Assembly of Microparticles in Poiseuille and Electroosmotic Flow"

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The near-wall dynamics of suspended particles of radii $a = O(0.1\ \mu m–1\ \mu m)$ flowing through a microchannel is relevant to detecting and manipulating particles with surface-mounted sensors and actuators in microfluidics. Dilute (volume fractions $\varphi_\infty < 0.5\%$) suspensions of fluorescent polystyrene particles, originally used as tracers for particle velocimetry, were visualized with total internal reflection microscopy, *i.e.*, evanescent-wave illumination, within ~1 μm of the wall in combined Poiseuille and electroosmotic flows at Reynolds numbers $Re = O(1)$ through ~35 μm deep fused-silica and PDMS-silica channels.

This close to the wall, the particles are subject to shear flow with a constant shear rate $\dot{\gamma}$. However, the particles do not follow the flow. 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. Although recent models, which neglect inertial effects, predict a qualitatively similar cross-stream lift force on a dielectric particle, the force predictions appear to be orders of magnitude greater than that observed in the experiments.

Moreover, the particles, after migrating towards the walls, assemble above a minimum electric field magnitude into concentrated streamwise "bands", or structures with a diameter of a few μm and a length comparable to that of the channel of a few cm. These bands, which exist only within a few μm of the wall, are roughly periodic in the cross-stream direction, although there are no external forces along this direction. To our knowledge, there is no theoretical explanation for this novel type of directed assembly which occurs in a flowing (*vs.* quiescent) and very dilute ($\varphi_\infty > 3\times10^{-5}$) suspension. This talk will therefore focus on "observational science" and experimental results.

Friday, April 23, 2021 at 3:00 PM
https://wse.zoom.us/j/93762992307