

Center for Fluid Mechanics Seminar

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Nano-Particle Image Velocimetry Measurements of Electroosmotic Flow in Rectangular Microchannels

Characterizing flow fields at sub-micron, or “nano,” length scales is important in nanotechnology applications. Yet current “state of the art” diagnostic techniques such as micro-particle image velocimetry (μ PIV) are limited to in- and out-of-plane spatial resolutions of at least a few microns. Moreover, nanoscale flows are dominated by surface, or near-wall, phenomena. Yet current techniques are best suited for bulk flow measurements, with the best “near-wall” μ PIV data (to our knowledge) at least 450 nm from the wall.

Over the last two years, we have developed a new near-wall velocimetry technique, nano-particle image velocimetry (nPIV), that uses evanescent-wave illumination generated by total internal reflection at the interface between the wall and the fluid. Nano-PIV can measure the components of the velocity field parallel to the wall over the first 100 nm adjacent to the wall (based on the penetration depth of the evanescent wave) with an out-of-plane spatial resolution of 100 nm (based upon tracer particle diameter). Because nPIV is inherently limited to near-wall velocity measurements, the technique complements the bulk flow velocimetry capabilities of μ PIV.

The technique has been used to study steady and fully-developed electroosmotic flow (EOF) of dilute (0.2–36 mM) sodium tetraborate (borax) buffer through rectangular fused silica microchannels with a minimum dimension $h = 5\text{--}25\text{ }\mu\text{m}$. The values of mobility derived from the nPIV data are in excellent agreement with the results from asymptotic model predictions of EOF and independent experimental mobility data obtained with molecular tracers. The results are used to obtain a power-law expression relating mobility to concentration. This work is the first, to our knowledge, to directly measure near-wall transport at these spatial scales and among the first studies of transport in microchannels with dimensions below 10 μm .

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