Fluid Flow in Nanoconfined Geometries

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Liquid and gas flows in nanochannels and confinements experience increased surface and scale effects that result in deviations form well-known continuum models. The first part of the talk will focus on force-driven nanochannel gas flows that show two distinct regions. While the bulk flow region can be determined using kinetic theory, transport in the near-wall region is dominated by gas–wall interactions. This duality enables definition of an inner-layer scaling based on the molecular dimensions. Velocity distribution in the inner-layer exhibits a universal behavior as a function of the local Knudsen number and gas–wall interaction parameters, which can be interpreted as the "law of the nano-wall." Presence of this inner-layer breaks the similarity between rarefied and nanoscale gas flows. In the second part of the talk, force-driven liquid flows in nanochannels will be presented with an emphasis on various fluid-solid pairs that result in different amounts of liquid-slip. Finally, the electroosmotic flow (EOF) of ionized water in silicon nanochannels will be presented in the Debye–Hückel regime. The onset of slip velocity within the thin electrical double layer region and its effects on EOF will be presented. Influences of increased surface charge density in the intermediate and flow-reversal regimes will also be discussed and the results will be compared with relevant high-order continuum models that include the overscreening and crowding effects.