LadHyX Seminar – November 30, 10:45

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Dynamical consequences of near-surface, charge-induced heterogeneity in colloidal and polymeric suspensions

It is well known that a glass surface immersed in water develops surface charges that may give rise to a charge imbalance in the adjacent liquid. Similarly, in polyelectrolyte solutions, a polymer depletion layer may be formed near the glass-water interface. In both cases, a charge or composition heterogeneity extends typically a few, to a few tens of nanometers into the bulk liquid. Both of these effects can be described quantitatively in equilibrium; additionally, their dynamical effects have many practical realizations. Due to the nanometric length scales involved, measuring dynamical implications of these well-known surface heterogeneities is challenging. In this presentation, I will present our work [1, 2, 3] using total internal reflection fluorescence coupled with particle tracking velocimetry to probe interfacial dynamics of aqueous soft matter. First, the case of flowing, semi-dilute polyelectrolyte solutions will be addressed [1]. Here we demonstrate the crucial need for assessing, in-situ, the near-surface rheology in order to understand the hydrodynamic boundary condition of such solutions. After, we turn to a well-known phenomenon called Taylor dispersion [2, 3]. Here, coupling between flow gradients and diffusion leads to a large amplification of the concentration dispersal of a particle ensemble, as compared to pure diffusion. We show experimentally that an order-of-magnitude reduction in the observed dispersion results from particle- surface interactions, including electrostatics and absorption, for sub-micron domains. This reduction is compared to the classical Taylor analysis not including any interaction with the boundaries. Collectively, these works demonstrate the need for a fine control of surface interactions in order to quantitatively predict near-surface transport phenomena.

References

[1] Guyard et al., Soft Matter 2021

[2] Vilquin et al., Physical Review Fluids, 2021

[3] Vilquin et al., Physical Review Letters, 2023