Complex Electrokinetic/Electrohydrodynamic Flows in Microfluidic Applications

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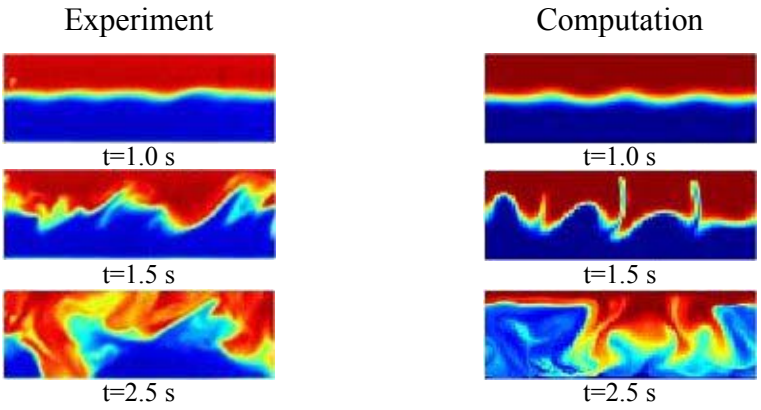
Electrokinetic flow is leveraged in a variety of microfluidic systems, and is a key enabler of on-chip electrophoretic processes with chemical and bio-analytical applications. The electromechanical coupling of electric field and electrolyte solution in these applications may sometimes lead to novel flow behavior as well as complex electromigration patterns. In this work I will explore two related subjects: electrokinetic instability, and electrophoretic sample preconcentration methods.

Electrokinetic instability (EKI) widely occurs when a heterogeneous buffer is subject to strong applied electric fields. Although undesirable for on-chip assays where controlled sample management is required, EKI is also proposed as efficient means for rapid micro-mixing which is intrinsically difficult for low-Reynolds number, micro-scale flows. I will present analysis, simulations, experimental observations, as well as reduced modeling results on this topic.

For sample preconcentration methods, I will focus on the development of high-fidelity simulation tools for electrophoregram prediction in on-chip electrophoresis, with application towards the design and optimization of detection and separation processes. I will explore the characteristics of different methods such as field-amplified sample stacking and isotachophoresis. I will also discuss the issues and challenges en route to the efficient and accurate modeling of this class of phenomena.



Electrokinetic instability in microchannels. Left: *experimental data* showing instability mixing of high (red) and low (blue) electric conductivity streams. Right: reproduction of dynamics from *numerical computations* (from Lin *et al.*, *Phys. Fluids* 16(6), 1922-1935, 2004).