Technion – Israel Institute of Technology | Faculty of Mechanical Engineering

MECHANICAL ENGINEERING SEMINAR

Monday, January 12, 2026 at 14:30, Lady Davis Building, Auditorium 250

Exploring Complex Flows: from Radial Flow of Shear-Thinning Fluids to Fluid-Structure Instability Driven by Diffusioosmotic Flow

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Hosted by Prof. Alon Wolf

The Technion Complex Fluids Lab studies fluid mechanics of non-Newtonian fluids and complex flow and transport phenomena at the microscale through a combination of theoretical reduced-order modeling, numerical simulations, and comparison to experiments. In this talk, I will present my group's interdisciplinary research that combines non-Newtonian fluid mechanics, rheology, mass transfer, electrokinetics, and elasticity to advance our understanding of how the interplay of these phenomena influences the hydrodynamics in both rigid and soft configurations.

First, I will discuss pressure-driven radial flows of shear-thinning fluids, which are commonly encountered in industrial polymer processes such as injection molding and extrusion. The complex rheological characteristics of non-Newtonian fluids significantly influence the hydrodynamic features of these flows, which remain not fully understood, compared to Newtonian flows, even at low Reynolds numbers. Using the Ellis model, which accurately reproduces the rheological behavior of shear-thinning fluids, we provide a theoretical framework for calculating the pressure distribution and the relationship between flow rate and pressure drop. I will demonstrate how shear-thinning rheology modifies the hydrodynamic features in radial flow and show that our theory is in excellent agreement with numerical simulations and available experimental data. Furthermore, I will elucidate the entrance length required for the radial velocity of a shear-thinning fluid to reach its fully developed form, showing that this length approximates the Newtonian low-Reynolds-number value at low shear rates, but may strongly depend on the fluid's shear-thinning rheology and exceed the Newtonian value at high shear rates.

In the second part, I will discuss diffusioosmotic flow in microfluidic devices, which arises due to solute concentration gradients. In soft microchannels, internal pressures generated by diffusioosmotic flow result in elastic deformation of the channel walls, triggering low-Reynolds-number fluid-structure interactions governed by the interplay of fluid flow, mass transfer, and elasticity. To provide insight into this coupling, we develop a simplified one-dimensional model, in which a viscous film is confined between a rigid bottom surface and an elastic top substrate, modeled as a rigid plate connected to a linear spring. We derive a set of two-way coupled governing equations for the evolution of the gap height and the solute concentration. Our theoretical predictions show that above a certain concentration gradient threshold, negative pressures induced by diffusioosmotic flow give rise to fluid-structure instability, causing the elastic top substrate to collapse onto the bottom surface. I will elucidate the physical mechanisms underlying this instability, identify three distinct dynamic modes, and demonstrate that our theory agrees closely with numerical simulations. Understanding this instability is important for the design of electrokinetic systems containing soft elements.

Seminars Coordinator: Prof. Sefi Givli