ME Seminar

Soft and Slippery Hydrodynamics

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ABSTRACT

Hydrodynamics at soft and mobile interfaces differs fundamentally from rigid boundary systems, resulting in rich, complex fluid phenomena. This attracts physicists, biologists, and engineers alike, suggesting their fundamental and applied significance. In this talk, I will present two perspectives on soft and slippery flows.

In the first part, I will share about the magnetic confinement of the flow channel resulting in a stable, deformable, and mobile liquid-liquid interface. The coupling between fluid magnetic pressure, viscous forces, and the Laplace pressure results in a coupled non-linear hydrodynamic problem, which has experimentally shown a route to nearly shear-less flow, smart deformable interface, tuning instability, and remarkably, an order of magnitude improvement in biomaterial transport. In the second part, I will discuss ultra-monodisperse emulsions. Here, the hydrodynamics is subjected to internal rearrangements of droplets, collective behavior, and long-range order of the system. The droplets are essentially frictionless and deformable, and the monodisperse nature provides a model soft matter system to understand the fundamental behavior of crystalline soft and frictionless particles. Key questions include modes of stress relaxation in jammed crystalline emulsions and the relevant length and time scales.

These systems not only reveal novel flow conditions that need further fundamental investigations but also open doors for a wide range of applications, including biomimetic and smart materials, drug delivery and microfluidics, surface engineering and wetting phenomena, hyperuniform surfaces and sensor applications, cosmetics, porous media transport and flow chemistry. This broad scope motivates us to study this emerging class of complex fluids, which covers the interplay between hydrodynamic forces, interfacial mechanics, and collective phenomena for fundamental and applied research.

ABOUT THE SPEAKER

Dr. Arvind obtained his BE in Mechanical Engineering from India and MSc in Applied Physics from the University of Twente, the Netherlands, where he studied electrowetting of soft structured surfaces. He completed his PhD in Physics as a Marie Curie early stage researcher at the University of Strasbourg, focusing on magnetic confinement of flow channels and liquid–liquid interfaces. He has since held postdoctoral positions at Cornell University (USA) and ESPCI Paris, where he currently serves as Maître de Conférences (ATER). His current work includes understanding the rheological behavior of emulsions. Broadly, his research explores the physics of complex fluids, with particular interest in emulsion rheology, interfacial mechanics, soft interfaces, and liquid–liquid systems.

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