Master 2 Internship

Title: (Micro)surfing the wave: lift forces at the microscale

Type: Theoretical

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PhD funding (if any):

The motion of micron-sized particles close to boundaries is a common feature of many biological systems. Examples include viruses seeking receptors on cell membranes, or actin fibers interacting with membrane proteins. To describe such dynamics, it is crucial to understand the interactions with the boundaries. While most studies focus on conservative forces like electrostatics or gravity, **hydrodynamic interactions** are long-ranged and often dominant in confined systems, yet remain largely overlooked [1].

The objective of this project is to **theoretically investigate lift forces acting on colloidal particles moving along an interface**. Lift forces are typically associated with macroscopic systems such as airplanes or birds. Yet recent studies --- both theoretical and experimental --- have revealed that microscopic particles moving parallel to a soft surface can also experience a perpendicular force [2,3]. This lift force is generally driven by the **elastic deformations of the interface** in response of hydrodynamic stresses.

In this project, we will explore a **new scenario**: the motion of a particle near a **surfactant-laden interface**. In this case, the particle dynamics is expected to couple with the concentration of surfactant through the **Marangoni effect** [4,5], leading to a potentially rich and complex behavior. Theoretical analysis and **analytical calculations** will be the primary tools to address this problem.

This work will be conducted in close connection with **ongoing experiments** carried out at LOMA within the Nanophysics group led by A. Maali. The project also represents a **first step toward a PhD thesis** opportunity.

Keywords: soft matter theory, nonequilibrium and nonlinear physics, low-Re hydrodynamics

References

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[3] Rallabandi R. Fluid-elastic interactions near contact at low Reynolds number. *Ann. Rev. Fluid Mech.* **56**, 491 (2024)
[4] Bickel T. Blockage of thermocapillary flows by surface-active impurities. *Phys. Rev. Fluids* **9**, 104001 (2024)
[5] Kumar D., Panigrahi P.K., Bickel T. Competition between thermocapillary and solutocapillary flows in thin liquid films. *Phys. Fluids* **37**,022134 (2025)