Dynamics of confined liquids close to lipid membranes: from macro to microscale

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Highly confined fluids between flexible interfaces such as lipid membranes or soap films exhibit fascinating and still poorly understood physical properties in terms of their structures, interactions and dynamic properties. They play an important role in many processes including lubrication phenomena. In particular, Nature has produced water-based lubrication systems that outclass by far the best of man-made devices [1]. Biological contacts such as the articulating cartilage surfaces in human hips or knees often operate under severe conditions (i.e., high load and low speed), corresponding to the boundary lubrication regime. In this regime, direct contact between the surfaces can be prevented by a boundary lubricant of nanometer range thickness that attaches to the solid surfaces, thereby reducing drastically the friction coefficient down to μ=0.005-0.02 for the human joint. Phospholipid layers are well controlled model systems to mimic boundary biolubrication (Fig. 1).

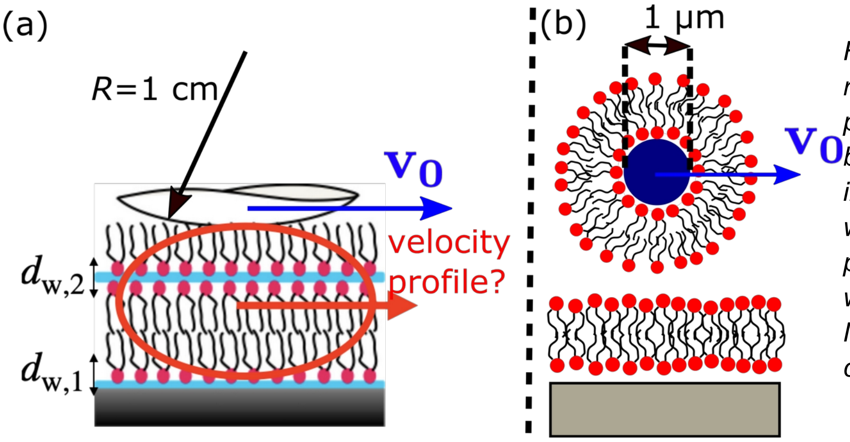

Figure 1: (a)Schematic representation of a phospholipid trilayer sheared between a rigid spherical indenter (diameter~5 cm) for which localization of the sliding plane at low and high velocities will be performed. (b) Microparticles (1 μm size) covered with a lipid bilayer.

The present PhD project aims to better understand the role of these phospholipid bilayers in biolubrication. In a first part we will investigate the tribological properties of a macroscopic contact (~1 mm^2). We have developed an original experimental set-up [2], coupling the precise tribological characterization of the system with the measurement of velocimetry by Fluorescence Recovery After Patterned Photobleaching. By associating velocimetry and tribology experiments on well controlled model systems, it will give us the unique opportunity to address the question of the localization of the sliding plane (see Fig.1(a)). In a second part, we want to investigate friction and membrane dynamics at the microscale by taking advantages of our expertise in the manipulation of microparticles by optical tweezers. These particles will be covered by lipid bilayers [3] and investigated close to supported lipid bilayers (see Fig.1(b)).

The candidate should be a physicist with a strong background in soft condensed matter and material sciences. The project is mainly experimental, but modelisation and numerical simulations aspects will also be important.

[1] M. Urbakh, J. Klafter, D. Gourdon, and J. Israelachvili, *Nature*, **430**, 525–528 (2004).
[2] L. Fu, D. Favier, T. Charitat, C. Gauthier, and A. Rubin, *Rev. of Sci. Instrum.* **87**, 033903 (2016).
[3] M. Rinaldin, R. W. Verweij, I. Chakraborty and D. J. Kraft, *Soft Matter*, **15**, 1345–1360 (2019).