Bio-inspired soft adhesion

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Thesis possibility after internship: YES Funding: Not secure.

Description

Biology offers remarkable examples of strong and controlled adhesion with ingenious strategies. As an example, mussels can attach firmly to rocks underwater using protein-based "glues", while geckos climb walls thanks to the microscopic hierarchy of their toes. Inspired by such dry adhesion mechanisms, scientists and engineers have designed smart materials that stick strongly yet detach easily.

Here, we turn to a different kind of adhesion—mediated by liquids. Many species exploit thin fluid layers to generate temporary yet powerful attachment. Tree frogs secrete a fluid at the tips of their toes to create capillary adhesion and climb vertical surfaces (Fig. 1(a)), while chameleons use a viscous mucus to capture prey (Fig. 1(b)). In both cases, adhesion arises from the interplay between soft deformable surfaces and a confined fluid film.

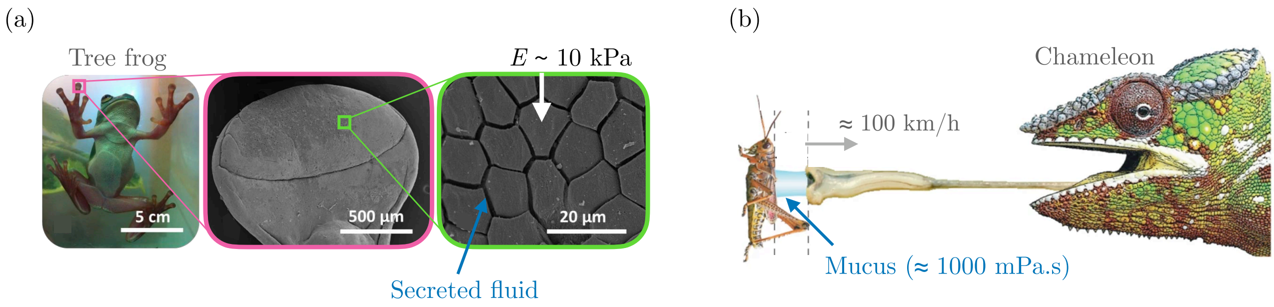

Figure 1: (a) Tree frog and successive zooms on its finger [2]. The tip exhibits a hexagonal pattern of soft pads and channels that secrete an adhesive fluid. (b) Schematic of a chameleon catching an insect with its tongue [1]. After impact, the prey remains attached via a viscous liquid film.

To uncover the physical principles behind such bio-inspired adhesion, we address a central question: **How do soft, lubricated contacts form and break?** Answering this requires coupling elastic deformation, lubrication flow, and interfacial forces—a problem at the crossroads of physics, tribology, and soft matter mechanics.

Depending on the candidate's interests, the project may take a theoretical–numerical or an experimental route. The theoretical work will involve developing home-made numerical simulations supported by asymptotic and scaling analyses to describe the formation and rupture of soft, lubricated contacts. The experimental part will consist of controlled adhesion measurements on PDMS gels, carried out either in Lyon (ILM) or Nice, depending on the candidate's preference.

Beyond bioadhesion, this project connects to a range of physical and technological contexts, including fracture in hydrated materials, mixed lubrication, microfluidics, and tactile perception. According to the student's curiosity, the internship can naturally evolve toward these related applications.

Candidate profile: Student (bachelor or master) in physics, mechanics or engineering.
Funding for the internship: YES
Date: Starting from February 2026.

[1] N. A. Crawford. PhD thesis, University of Glasgow, (2016).
[2] F. Brau et al., Nature Physics, **12**(10) 931–935, (2016)