LadHyX Seminar – March 6, 10:45

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Drop-reinforced fibres and fibre-reinforced drops

Abstract

Solids and liquids are on the opposite sides of the mechanical spectrum: the former is stiff while the latter is (almost) infinitely stretchable. Can we get the best of both worlds ? In this talk, I will show how the combination of liquid interfaces and slender structures can lead to unexpected properties for hybrid mechanical systems in two specific examples.

The first part of my talk will be dedicated to a specific type of spider silk fibres, naturally covered with glue droplets. While the primary function of the glue is to maintain insects in the web after impact, we found that the droplets are also capable of reeling and coiling excess fibre. The mechanical response of the natural system is two-fold: solid-like (linear response) upon stretching but liquid-like (constant response) upon compression. The evolutionary advantage of this mechanism is to secure minimal tension in the web structure and maximize resilience under harsh natural conditions. We explained this behaviour in terms of transfer of surface energy into bending energy, and further showed that a fully synthetic system made of a soft thin structure and a wetting fluid can have the same exotic mechanical response than the natural spider silk.

In the second part of my talk, I will focus on the dual configuration and explain how we fabricated fibre-in-drop systems. We embedded in situ production by photoreticulation of a microjet, micromanipulation methods and mechanical testings into a single microfluidic chip. Our results show a reinforcement of the drops due to the contribution of the bending rigidity of the fibre. Through the analysis of the drop enveloppe and the local profile of the fibre, we measure the surface and bending energies of the system. We show that the reinforcement mechanism stems from a competition between drag, drop surface and fibre curvature minimizations, leading to a new hydroelastocapillary response.

Short bio

Hervé Elettro defended his PhD in 2015 at Institut D'Alembert (Paris VI) on elasto-capillary interactions in spider silks, under the supervision of Profs Arnaud Antkowiak and Sébastien Neukirch. He then moved to Santiago de Chile to apply surface energy-based actuation methods to the topic of 2D materials in collaboration with Prof. Francisco Melo. He is now a Marie Curie fellow in the group of Prof. François Gallaire at EPFL (Switzerland) and develops microfluidics methods for the characterization of fibre-reinforced drops.