# Sorbonne Université/ China Scholarship Council program 2020

## Thesis proposal

Title of the research project: **The mechanics of spider webs**

Keywords: elasticity, capillarity, dynamics.

Joint supervision: yes

Joint PhD (cotutelle): no

Thesis supervisor: **sebastien neukirch & arnaud antkowiak**

Email address of the thesis supervisor: sebastien.neukirch@upmc.fr

Institution: **Sorbonne Université**

Doctoral school (N°+name): ED **ED SMAER 391**

Research laboratory: **Institut d'Alembert for Mechanics**

Address of the laboratory: case 162, 4 place jussieu, 75005 Paris, France.

Name of the laboratory director: **Pierre-Yves Lagrée**

Email address of the laboratory director: pierre-yves.lagree@upmc.fr

## Subject description (2 pages max):

### 1) Study context

We work on the mechanics of the spider webs and want to understand the mechanisms involved in the prey capture: adhesion to the insect, oscillations of the web, dissipation of kinetic energy, and structural integrity of the web.

### 2) Details of the proposal

Orb webs comprise three different types of threads, frame, radial, and capture threads. The capture thread is laid down by the spider following a spiral path. We believe this thread has important mechanical properties which are responsible for the capture of flying insects.

The goal of the thesis is to show that liquid droplets sitting on spiral threads of a spider web are responsible for the capture, dissipation, and structural integrity of the system.

We have shown that both synthetic and natural threads are capable of coiling inside liquid drops sitting on them, see figure. Now, we want to show that this mechanism takes place in real spider webs, and we want to study its dynamical properties.

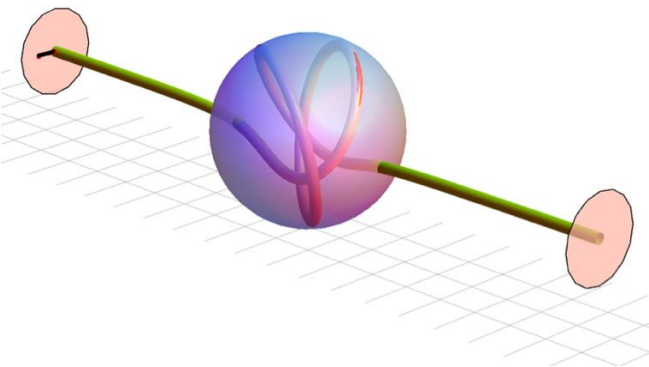
How does a spider web capture a flying insect without breaking?

How is the kinetic energy dissipated?

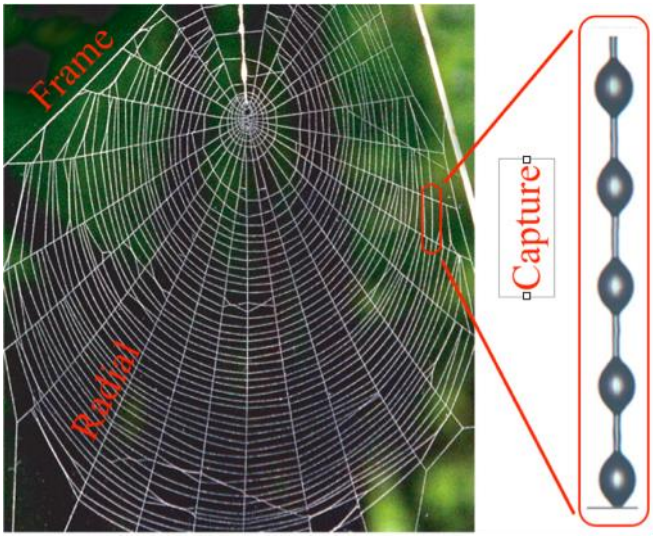
How does the web keep its integrity under high wind conditions?

Collaboration with **Oxford** department of Zoology (Prof. Fritz Vollrath) and French museum of natural history (**MNHN** Christine Rollard).

Experiments involve spiders, high-speed camera, and nano-newton force transducers.



*A thread decorated with a small droplet exhibits the* ***windlass mechanism***




A spider web with its 3 different types of thread

**3) References**

H. Elettro, S. Neukirch, F. Vollrath, and A. Antkowiak,
In-drop capillary spooling of spider capture thread inspires hybrid fibers with mixed solid-liquid mechanical properties,
PNAS, 113 (2016) 6143-6147

P. Grandgeorge, N. Krins, A. Hourlier-Fargette, C. Laberty-Robert, S. Neukirch, and A. Antkowiak
Capillarity-induced folds fuel extreme shape changes in thin wicked membranes
Science, 360 (2018) 296-299

**4°) Profile of the Applicant (skills/diploma…)**

The applicant should be interested in experimental aspects of mechanical engineering, sensors, camera, force transducers. An interest in biological systems and an affinity with spiders would be a bonus.

## Contacts:

### Thesis supervisor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| **arnaud antkowiak**<br>arnaud.antkowiak@upmc.fr | **sebastien neukirch**<br>www.ida.upmc.fr/~neukirch |