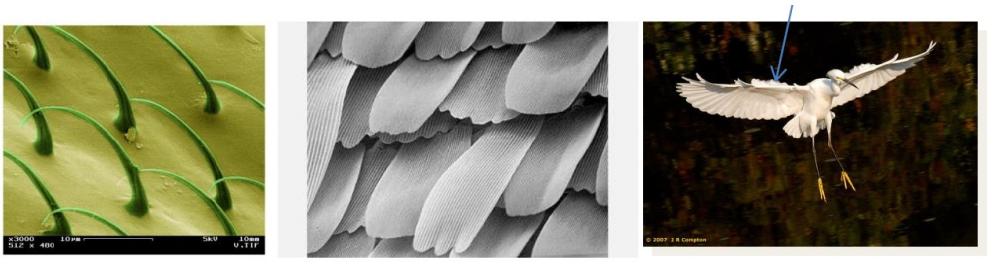
PhD Thesis at *the Institut de Mécanique des Fluides de Toulouse*, France

FLUID DYNAMICS CHARACTERIZATION OF NATURAL SURFACES: Surfaces in Nature are compliant, sometime porous, and most often not smooth. It is common the case of surfaces covered by arrays of slender, filamentous structures, anchored to a substrate and completely permeated by an incompressible fluid. Examples range from the furs of animals to the active lining of many biological organs, such as the lungs and the ears. In technological applications analogous fibrous interfaces are being used as sensors and actuators or as nanorod arrays for DNA analysis and separation. It is thus important to understand the interactions between a fluid and a poroelastic coating, and to develop methods to handle such surfaces numerically, overcoming the conventional treatment of walls as being rigid, impermeable and smooth entities.



Examples of surfaces with hair (fly wing), scales (butterfly wing) and feathers (pop-up feathers of an egret).

The project of the thesis is (*i*) to use homogenization methods (volume averaging techniques and/or multiple scale analysis) to model an anisotropic poroelastic layers, such as that composed by a dense array of filaments, and (*ii*) to develop a numerical code to couple the motion of an incompressible fluid within and outside the poroelastic medium. One of the challenges in the project is that of addressing a multiphysics/multiscale problem using efficient closures in the interface layer between a Navier-Stokes region and a Darcy-like region. Applications of the project range from the search of new, passive flow control systems in aeronautics to the development of a unique tool for the study of canopy flows.

The environment

The IMFT is one of the most important research institutes dedicated to fluid dynamics in France, with activities ranging from aerodynamics to environmental flows, multiphase flows and biological flows. The Institute hosts over 100 researchers; it is located in Toulouse (www.toulouse.fr), south-west France, a thriving, lively city of half a million people and over 100 000 students, with strong research/industrial activities in areas from aerospace to biotechnology. The grant is part of a *package* denoted as IDEX (Excellence Initiative) to foster specific research activities within the University of Toulouse.

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