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ECXX_LABYY_ NOMChercheur_ Numer
ECXX = ECLi, ECL, ECM, ECN, CS
LABYY = acronyme du laboratoire
NOMChercheur = nom du chercheur émetteur du sujet
Numer = numéro de la proposition (01, 02, ….) pour le chercheur

PhD Proposal 2017

School: Ecole Centrale de Lyon	
Laboratory: Laboratory of Tribology and System Dynamics	**Web site: http://ltds.ec-lyon.fr/**
Team: Tribology, Physical Chemistry and Dynamics of Interfaces	**Head of the team: Siegfried Fouvry**
Supervisor: Elise Contraires, Stéphane Benayoun and Alain Le Bot	**Email: elise.contraires@ec-lyon.fr**
Collaboration with other partner during this PhD: **In France:**	**In China:**

Title: Controlling the motion of droplets on vibrating textured surfaces
Scientific field: material science, surface science, tribology, wetting, vibrations
Key words: surface texturing, wetting, vibrations, experimental work

Details for the subject:

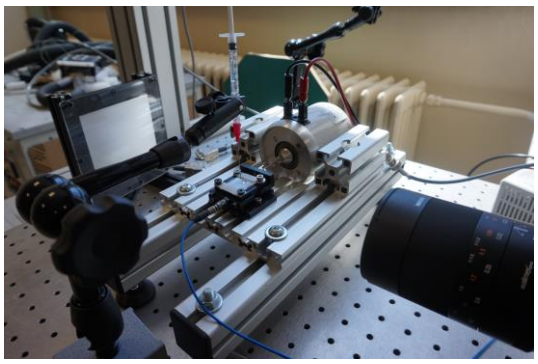
Background, Context:

The LTDS is a world renowned laboratory with international experts in tribology, materials and dynamics. The team "Tribology, Physical Chemistry and Dynamics of Interfaces" is world-wide recognized for its high number of home-made experimental set-ups and its expertise in surface phenomena. Research projects are developed in collaboration with industrial companies (like PSA, SAFRAN, MICHELIN…) as well as national and international public organisations (National Research Agency, Europe…).
One of the team's skill is the understanding of the impact of topography on surface properties, like friction, adhesion or wetting.

The control of liquid droplets on surface has applications in several fields such as microfluidics, anti-fogging, ink-jet printing[1]. Main examples are car's windshields and outside rear-view mirrors, on which rain droplets affects visibility. One objective in this field is to facilitate the motion of droplets to avoid optical perturbations.

The way a droplet sticks or rolls on a surface finds its origin in the contact angle hysteresis. This phenomenon is well understood for smooth homogeneous surfaces. Inspired by examples from nature[2]–[4], an emerging solution to control surface wetting properties is the use of textured surfaces like in the lotus leaves or mosquito eyes. For textured surfaces, the role of the topography on the hysteresis and droplet motion remains unclear and generates many questions[5], [6].
An external perturbation like mechanical vibrations appears as a powerful and promising method to emphasize and tailor the motion of liquid drops on surface[1], [7]–[9]. Thanks to mechanical vibrations it is possible to make water run up hills or move in specific and controlled directions.

The aim of this PhD is to control the motion of small droplets on textured surfaces by adjusting the vibration parameters. The coupling between surface topography and mechanical vibrations on the motion of droplets will be analysed.



In the last few years, a home-made apparatus has been developed in the laboratory. (fig. on the left). It allows following the motion of a water droplet (2-3µL) deposited on a textured surface vibrating horizontally between 10Hz and 200Hz. With this set-up we follow the droplet motion and displacement thanks to a fast camera (up to 3200 fps in full frame) and we get the droplet profile through image analysis.

For this work, the student will work with experts in material science, surface science and acoustic present in the laboratory. The student will have access to powerful techniques for surface preparation and characterization, as well as experimental set-ups for wetting measurements. He/she will also benefit of strong environment for image analysis and vibration problems.
In addition, the student will have an access to MANUTECH-USD, a common excellence equipment for surface production and characterization.

Research subject, work plan:

The work during the PhD is mainly experimental and will be organized in two main steps:

- **Analysis of the vibration parameters:** This step constitutes the main part of the work. Preliminary results in the lab have shown impact of the surface anisotropy in the onset of motion of the droplet. The student will have to identify the parameters that affects the onset and the motion of the droplet on the surface. Three types of parameters will be studied :
    - Vibrations : frequency, amplitude, signal shape
    - Topography : anisotropy, order
    - Materials : surface material, liquid viscosity, surface tension, complex fluids

Fig. 2: Droplet on a smooth (left) and textured (right) surface vibrating at 47 Hz; amplitude is ~1 mm

- **Surface adjustments:** Based on the results obtained with standard surfaces prepared in the lab, the PhD student will identify the best surface designs to control droplet motion. Surfaces with pertinent parameters of roughness, patterning, and chemistry will then be produced in the lab. Then the surfaces will be tested to confirm and improve the results obtained on previous surfaces. Several improvement loops could be done during the work.

The LTDS has a huge expertise in surface texturing by many techniques[10], [11], in particular through several studies on laser surface texturing on many type of materials. For surface characterization, powerful tools are available at LTDS like AFM, profilometer, optical and electronic microscopies.

At the end of the project, the student will have identify the key parameters for the motion of droplets on vibrating surfaces and could propose surfaces with optimized wetting properties.

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