Conference in honour of Liliane Léger

Pierre-Gilles de Gennes Institute
Paris, France, October 17th-19th 2016
Organized by the CNRS GDR Liquids at Interfaces
Organizing committee: L. Bureau, A. Maali, F. Restagno, S. Rogue, T. Salez

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Abstracts

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Monday, October 17, 2016

8:30 am - 9:30 am Welcome coffee & registration - Concordia, 41 rue Tournefort 75005 Paris

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9:30 am - 9:45 am Introduction Abdelhamid Maali

9:45 am - 10:20 am How to stick cell together to avoid cell escape from tumors? Françoise Brochard-Wyart

Francoise Brochard-Wyart : Institut Curie- Paris France

Benjamin Brunel, Gregory Beaune and Francoise Winnik : Mana Tsububa Japan

We first introduce the field of “Entangled Active Matter”. Active matter describes diverse systems of self-propelling particles. But unlike swarms of fish and flocks of birds, cells are bound by transient links and can support static loads. We show that the concept of polymer physics and wetting can be applied to this living systems (1) using multicellular aggregates as a model system for tissues. We characterize the tissue mechanical properties by a new pipette aspiration technique. We apply this technic to embryonic development.

Then we describe three scenarios where single cells can escape from the cell aggregate ,reproducing in vitro an epithelial mesenchymal transition involved in embryonic development and tumor metastasis 1) by depletion of cellular adhesion molecules (CAM’s).In the spreading of aggregates (2)we observe both partial and complete wetting regimes, where a precursor film expends around the aggregate .Depending upon cell-cell adhesion, this film can be a dense cellular monolayer or consist of individual cells escaping from the aggregate.2) by rupture of the envelope containing the tumor for non adhesive cells3) by extrusion of membrane tubes . We report here the formation of membrane tubes from Lymph Node Cancer Prostate (LNCaP) cell aggregates in partial wetting conditions(3): cells at the periphery are very motile, and try to escape from the aggregate, leading to the formation of tubes. Growth of tubes is followed by either its retraction or its rupture, leading to cell’s escape. Our study unveil a new mechanism for tumor proliferation that do not invoke a loss of adhesion (cadherin depletion), which could be observed with other types of very aggressive cells forming cohesive tumors.

Finally we show that nanostickers can glue cells together and inhibit the escape of cells We present here direct evidence that nanoparticles (NPs) can stick cells together. Using cadherin-depleted S180 murine cells lines, which exhibit very low cell-cell adhesion, we show that NPs can self-assemble aggregates from dispersed single cells. The dynamics of aggregation ruled by diffusion and collision can be described as a second order kinetic characterized by a rate of collision that depends upon the size, the concentration and the surface chemistry of the NPs. We model the cell-cell adhesion induced by the nanostickers using a three states dynamical model where the NPs are free, adsorbed on the membrane or internalized. We find that NPs of polystyrene functionalized with COOH, are more efficient that silica NPs of the same size, which have been reported to induce fast wound healing and to glue soft tissue. Nanostickers by increasing the cohesion of tissues and tumors may have important applications for cellular therapy and cancer treatment.

References:

1. David Gonzalez-Rodriguez et al. (2012) . Science 338, 910; 1226418

2. Douezan, S., et al., (2011).PNAS, 108.18

3. Gregory Beaune et al. (2014) How cells flow in the spreading of cellular aggregates. PNAS 111.22..

10:20 am - 10:55 am Liquid films at the head-disk interface of hard disk drives Remmelt Pit

Remmelt Pit

Hard disk drives (HDD) operate with a magnetic head reading and writing data encoded on a disk with magnetic layers.

Looking into the details of technologies and boundary conditions inside a hard disk drive can sometimes feel like a world that only Jules Verne might have imagined: On the media, a carbon layer of <2nm protects the magnetic layers from corrosion and wear. This layer is covered by a layer of liquid lubricant, typically a perfluoroether, to further enhance reliability. The head, also covered with <2nm of carbon, is maintained in idle mode at about 10nm from the media by an Air Bearing Surface (ABS) generating air pressures of >10atm while flying at >10m/s. During reading and writing, a small resistive heater is used to generate a protrusion of about 20nm height by 10um width to reduce the gap between the surfaces to less than 1nm. Meanwhile, charging effects on the media and head can generate a contact potential of 0.5-1V. Recently, some HDDs operate in a sealed environment with Helium inside instead of Air. Finally, a new technology still in development further adds a laser to this system that heats a ~ 30nm area on the media by approximately 500°C for less than 1ns.

In this presentation, we will introduce some of the key studies, findings and challenges related to liquid films in these extreme environments, such as lube moguls, lube waterfall or silicon smears. We will try to illustrate how understanding the fundamental behavior of liquids at the head-disk interface has been, and still is, critical to shipping reliable HDDs, and to sustaining the relentless push to higher HDD capacities and areal densities

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10:55 am - 11:25 am Coffee break (Concordia)

11:25 am - 12:00 pm Slippery roads Lydéric Bocquet

Lydéric Bocquet:Laboratoire de physique statistique, UMR CNRS 8550Ecole Normale Supérieure 75005 Paris, France.

The question of the hydrodynamic boundary condition of fluids at solid surfaces has entertained the field of fluid transport for most than 20 years. The debate has been quite intense among experimental groups reporting strongly contrasted results. This culminated notably with the measurement of ultra-fast flows in carbon nanotube (CNT) membranes by several groups ten years ago, which pointed to considerable surface slippage and nearly frictionless transport in CNT.

In this presentation I will review the main physical mechanisms underlying hydrodynamic slippage, as well as the various experimental results obtained in this domain. This involves slippage on flat surfaces, which highlights the influence of non-wettability. I will then discuss our recent experimental efforts to measure the permeability of individual nanotubes. Our experiments reveal diameter-dependent surface slippage in carbon nanotubes, with giant flow enhancements in the smallest tubes. In contrast, their boron-nitride analogues, which have the same crystalinity as CNT, but are electronically different, exhibit no slippage. This points to a hitherto not appreciated link between hydrodynamic flow and the electronic structure of the confining material.

12:00 pm - 12:35 pm Design of reinforced elastomers in tire applications: A physical tricky compromise between rheology, fracture, and tribology Maude Portigliatti

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12:35 pm - 2:00 pm Lunch (Concordia)

2:00 pm - 2:35 pm Elisabeth Charlaix

2:35 pm - 3:10 pm Robust, orthogonal and efficient macromolecular engineering for the control of surface properties

Eric Drockenmuller

E. Drockenmuller : Univ Lyon, Université Lyon 1, CNRS, Ingénierie des Matériaux Polymères, UMR 5223, F-69003, Lyon, France

The tuning of surface properties using polymer materials is crucial in several technologies such as adhesives, optics or microelectronics. Although systems such as polymer brushes or thermosetting coatings have been known for decades, it is still mandatory to improve their properties and performances through their chemical nature, morphology, functionality and responsive nature. The progresses in these fields have been accelerated since the appearance of novel robust, efficient and orthogonal chemical processes that afford advanced multifunctional macromolecular intermediates. This lecture will sum up the last advances and limitations of the different applications of such processes for the preparation of nanostructured polymer coatings.

3:10 pm - 3:45 pm Silica foams for high performance insulation by tuning the physical chemistry at the interfaces

Marie Lamblet

M. Lamblet1*, T. Saison1, M. Joanicot1, N. Denkov2, I. Lesov2, S. Tcholakova2

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*Corresponding author

Saint-Gobain Recherche, is a multidisciplinary industrial research center, at the leading edge of innovation. Our main vocation is to successfully carry out research providing short or medium-term answers to the specific needs expressed by our internal customers, as much for procedures as for products. Researchers work within multidisciplinary teams, integrating marketing and production and they are in constant contact with other Saint-Gobain research centers. In addition, we set up partnerships with the academic world and start-up businesses, in order to take advantage of the most recent scientific progress and to have access to high level skills. After a brief description of the Saint-Gobain Recherche team “Physical chemistry of Interfaces and Liquids”, a project aiming at developing new thermal insulating material will be detailed.

Building sector has a high impact on CO2 emissions and energy consumption, which can be decreased by an efficient thermal insulation. In this context, it appears important to design new materials with high performance thermal insulation, as thermal conductivity (λ) lower than 25mW/(m.K). In order to meet insulation market needs, our work aims to design materials with the following specifications: $\lambda \leq$25mW/(m.K), no ageing i.e. constant λ over years, fire resistance and reasonable cost. With these specifications, our choice for material is focused on precipitated silica. Precipitated silica is composed of aggregates of nanoparticles.

The drying of precipitated silica leads to a very dense material around 550kg/m3. This material presents a high thermal conductivity (50mW/(m.K)) due to high solid content. In order to reduce λ_{solid}, material density is decreased by foaming the silica aqueous dispersion, using a mechanical process. Foams are composed of silica wall and air bubbles, and are obtained with different densities by adjusting the process and managing the formulation of the foam.

During the conference, we will present the mechanisms of foam stabilization and the parameters we have explored to achieve a new material for building insulation.

[1] I. Lesov, S. Tcholakova, N. Denkov, J. Colloid Interface Sci., 2014, 426, 9-21.

[2] I. Lesov, S. Tcholakova, N. Denkov, RSC Adv., 2014, 4, 811.

[3] Patent FR 2977888 (A1)-Matériaux d’isolation thermique hautes performances

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3:45 pm - 4:15 pm Coffee break (Concordia)

4:15 pm -4:50 pm Non-equilibrium Properties of Crystallizable Polymers in Thin Films Günter Reiter

Sivasurender Chandran, Rishab Handa, Günter Reiter
Institute of Physics, Albert Ludwig University of Freiburg, 79104 Freiburg, Germany

Despite an extensive number of investigations, it is becoming increasingly obvious that we have not yet reached a clear understanding of properties of polymers in thin film. The origin of (some of) the puzzling behavior of thin polymer films is still not satisfactorily unveiled. Here, we will present various findings, observed in dewetting experiments, which demonstrate the influence of sample preparation and sample history on properties of crystallizable polymers.

We first report systematic dewetting experiments performed on polystyrene films of different thicknesses obtained (i) by spin-coating solutions of different polymer concentrations (c) at a given rotation speed (ω) and (ii) spin-coating solutions of various fixed concentrations at different rotation speeds. The films obtained by both the methods displayed an increase and decrease in stress relaxation times (τ_{res}) and the residual stresses (σ_{res}), respectively, with increasing film thickness (h). However, in contrast to the influence of c, films obtained by varying ω, especially at high ω, have shown a stronger dependence of τ_{res} and σ_{res} on h. Our results clearly indicate that the amount of preparation induced residual stresses stored in the film is an important parameter in defining the properties of spin-coated polymer films.

In the second part, we compare the high velocity dewetting behavior, at elevated temperatures, of equilibrated atactic polystyrene (aPS) and isotactic polystyrene (iPS) films, with the zero shear bulk viscosity (η_{bulk}) of aPS being approximately ten times larger than that of iPS [1]. As expected, for aPS the apparent viscosity of the films (η_{f}) derived from high shear dewetting was less than η_{bulk}, displaying a shear thinning behavior. Surprisingly, for iPS films, η_f was always larger than η_{bulk}, even at about 50 °C above the melting point, with η_f / η_{bulk} following an Arrhenius behavior. The corresponding activation energy of ~160 ± 10 kJ/mol for iPS films suggests a cooperative motion of segments, which were aligned and agglomerated during fast dewetting.

[1] Chandran, S., Reiter, G., Transient cooperative processes in dewetting polymer melts, *Phys. Rev. Lett.* **2016** 116, 088301.

4:50 pm - 5:25 pm Active cellular nematics Pascal Silberzan

Pascal Silberzan: Institut Curie – Centre de Recherche, 11 rue Pierre et Marie Curie, 75005 Paris – France

Elongated spindle-shaped cells such as fibroblasts, self-organize in bidimensional nematic phases. In large monolayers, they form domains of common orientation that don't coalescence because of the presence of the intrinsic topological defects characteristic of these phases. To control the density and position of these defects, we confine these active nematics in well-defined micropatterned geometries such as linear stripes or circular domains. We show that, in well-chosen geometries, the cells can reach a perfect macroscopic alignment and that their activity is eventually overcome by their friction with the underlying substrate.

REFERENCES

Duclos G., Erlenkämper C., Joanny J.-F., Silberzan P.: *Topological defects in confined populations of spindle-shaped cells.* Nat. Phys. doi:10.1038/nphys3876 (2016)

Duclos G., Garcia S., Yevick H. G., Silberzan P.: *Perfect nematic order in confined monolayers of spindle-shaped cells.* Soft Matter **10**, (2014), 2346.

5:25 pm - 6:00 pm Leveling of thin polymer films Elie Raphaël

Elie Raphael : UMR CNRS Gulliver 7083 ,ESPCI, 10 rue Vauquelin,Escalier F, bureau F 3.13

Thin polymer films have striking dynamical properties that differ from their bulk counterparts.

With the simple geometry of a stepped polymer film on a substrate, we probe mobility above and below the glass transition temperature Tg.

Above Tg, the entire film flows, whereas below Tg only the near-surface region responds to the excess interfacial energy.

An analytical thin-film model for flow limited to the free surface region shows excellent agreement with sub-Tg data.

The system transitions from whole-film flow to surface localized flow over a narrow temperature region near the bulk Tg.

The experiments and model provide a measure of surface mobility in a simple geometry (where confinement and substrate effects are negligible).

This fine control of the glassy rheology is of key interest to nano lithography among numerous other applications.

7:00 pm - 10:30 pm Cocktail (Concordia)

Tuesday, October 18, 2016

9:00 am - 9:35 am Influence of the Slip on the flow of (Polymer) Films Karin Jacobs

Karin Jacobs, Universität des Saarlandes, Campus D-66123 Saarbrücken - Germany

Usually, liquids exhibit a 'no-slip' boundary condition to a solid substrate, i.e. the atoms or molecules of a liquid that are the closest to the solid substrate are at rest. However, a polystyrene film that moves over hydrophobized (by a self-assembled monolayer of silanes) Si wafers can be provoked to slide, i.e. there is a non-zero interfacial velocity of the fluid in contact with the solid, and friction occurs [1,2]. This implies variations in the energy dissipation mechanisms in these systems and leads to a strikingly different behaviour of fluids in different geometric situations [3-5]: With slip, the dewetting of flat films is faster on solid surfaces (A), Rayleigh-Plateau-type instabilities exhibit an increased dynamics (B) and droplets that were prepared in a non-equilibrium situation can reach equilibrium via a stadium where their topology is concave (C). Yet, why does a liquid slide? Possible explanations including recent findings by scattering methods will be reviewed. Moreover, if more liquids were sliding, would that change things in our everyday life?

[1] O. Bäumchen et al., PRL 113 (2014) 014501; [2] J. D. McGraw et al., Colloid and Interface Science 210 (2014) 13; [3] S. Haefner et al., Nature Comm. 6 (2015) 7409; [4] S. Haefner, O. Bäumchen, K. Jacobs, Soft Matter 11 (2015) 6921; [5] J. McGraw et al., PNAS 113 (2016) 1168

9:35 am - 9:55 am Dynamics of a drop in a rough medium Ludovic Keiser

Ludovic Keiser[1], Armelle Gas[1], Khalil Jaafar[1], José Bico[1], Etienne Reyssat[1],

1 : Physique et mécanique des milieux hétérogenes (PMMH)

CNRS : UMR7636, Université Pierre et Marie Curie (UPMC) - Paris VI, Université Paris VII - Paris Diderot, ESPCI ParisTech, 10 Rue Vauquelin 75231 PARIS CEDEX 05 - France

In this study, we focus on the dynamics of a non-wetting droplet confined in a vertical Hele-Shaw cell (two parallel walls separated by a distance ranging from 0.1 to 1 mm) filled by a completely wetting liquid. The droplet is more dense than the surrounding liquid and is sedimenting at a constant speed.

For a Hele-Shaw cell made of smooth walls, two regims are characterized. As the gap between the walls is increased, the viscous dissipation is found to dominate either in the droplet or in the lubrication film between the drop and the wall. A sharp transition between those regims is observed. We discuss how this transition is affected by the roughness of the wall.

9:55 am - 10:15 am Liquid wheelbarrows Daniel Beilharz

Daniel Beilharz[1], 2, Evan Spruijt[3], Christophe Clanet[1], David Quere[2], *,

1 : Laboratoire d'hydrodynamique (LadHyX), Ecole Polytechnique, bat. 67 91128 PALAISEAU CEDEX - France

2 : Laboratoire de Physique et Mécanique des Milieux Hétérogènes (PMMH), Ecole Supérieure de Physique et de Chimie Industrielles, 10 rue Vauquelin, 75005, Paris - France

3 : Chemistry Research Laboratory (CRL)

* : Corresponding author

Clean removal of liquid stains on rough or porous solids is a recurring challenge in both industry and daily life. Whether it is oil on a filter or red wine on a carpet, classical cleaning approaches often involve aggressive chemicals which can deteriorate the solid. We propose a purely physical solution to detergency, using only interaction through surface tension in the case of immiscible liquids. We obtain a simple condition for one liquid to displace another and eventually lift it out of the roughness.

10:15 am - 10:35 am Water friction on graphene and boron nitride surfaces: insight from ab initio molecular dynamics

Laurent Joly

Laurent Joly[1]*, Gabriele Tocci[2], Samy Merabia[1], Angelos Michaelides[3],

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2 : Ecole Polytechnique Fédérale de Lausanne, School of Engineering, Lausanne

3 : University College London (Department of Physics and Astronomy), London - United Kingdom

* : Corresponding author

Nanofluidic systems (i.e. natural and artificial systems where fluids are confined at the nanoscale) play a key role in water treatment and sustainable energies, where materials based on carbon and boron nitride (BN) offer promise of radical performance improvement. New behaviors arise in nanoconfined liquids due to the predominant role of surfaces. In particular, friction is the most important interface property that limits nanofluidic transport, and its understanding is therefore crucial for the design of efficient nanofluidic devices. Here, I will illustrate with recent work how ab initio molecular dynamics (AIMD) can help unravel the molecular mechanisms underlying liquid-solid friction.

We started by comparing the structure and friction of water on graphene and BN using AIMD. While friction is usually correlated with wetting, we found that although the water/graphene and water/BN interfaces present a very similar structure, the friction of water is ca. 3 times larger on BN than on graphene. We traced back the

difference in friction to the greater corrugation of the energy landscape on BN arising from specific electronic structure effects. We then turned to studying the role of defects, which are inevitably present in real nanofluidic systems and play a crucial role in nanofluidic energy harvesting. The simulations show that water dissociates at certain defects, and that these “reactive” defects have a strong influence on friction. Furthermore, friction is extremely sensitive to the chemical structure of reactive defects and to the number of hydrogen bonds they can partake in with the liquid. Overall this work shows the crucial role of surface chemistry on the efficiency of real nanofluidic systems.

10:35 am - 11:05 am Coffee break (Concordia)

11:05 am - 11:25 am Splashing on soft surfaces Robert Style

Robert Style[1], ETH Zurich

There are not many techniques available for eliminating splashing on surfaces. Current options include reducing air pressure, tilting the substrate, or moving the substrate away from the incoming droplet. A much more simple option is to coat the substrate with a soft solid. We show how this significantly suppresses splashing -- typical droplets can require as much as twice as much kinetic energy to splash on soft surfaces as they do on rigid surfaces. We use a mixture of experiments, numerics and theory to show how this splash suppression works.

11:25 am - 11:45 am Confined sliding drops Etienne Reyssat

Etienne Reyssat[1], *, Peter Donnel, Misato Yahashi, Richard Kennedy,

1 : Physique et mécanique des milieux hétérogenes (PMMH)

CNRS : UMR7636, Université Pierre et Marie Curie (UPMC) - Paris VI, Université Paris VII - Paris Diderot, ESPCI ParisTech, 10 Rue Vauquelin 75231 PARIS CEDEX 05 - France

* : Corresponding author

We will discuss the shapes and velocities of droplets sliding under gravity between closely spaced quasi-parallel walls. Viscous dissipation opposing the motion takes place both in the bulk of the liquid and in the vicinity of contact lines. In this model geometry, bulk and line effects may be measured independently. We investigate contact line dissipation by studying the motion of drops on prewetted surfaces, a way to regularize the contact line singularity in a controlled way. Results on this model system may shed light on more complex dynamic wetting experiments.

11:45 am - 12:05 pm Dewetting on lubricant impregnated surfaces Armelle Gas

Armelle Gas[1],

1 : Physique et mécanique des milieux hétérogenes (PMMH)

CNRS : UMR7636, Université Pierre et Marie Curie (UPMC) - Paris VI, Université Paris VII - Paris Diderot, ESPCI ParisTech,10 Rue Vauquelin 75231 PARIS CEDEX 05 - France

Dewetting speed on lubricant impregnated surfaces (LIS) can be tenfold more rapid than dewetting on solid surfaces, revealing the critical role of the impregnating liquid. By changing the viscosity of the lubricant and of the dewetting liquid, we characterized this dynamics, taking into account the various sources of dissipation.

12:05 pm - 12:25 pm Dynamic wetting of textured vibrating surfaces Elise Contraires

Elise Contraires[1], Matthieu Guibert[1], Stephane Valette[1], Alain Le Bot[1], Stephane Benayoun[1],

1 : Laboratoire de Tribologie et Dynamique des Systèmes (LTDS), CNRS : UMR5513, Ecole Centrale de Lyon, Ecole Nationale d'Ingénieurs de Saint Etienne, 36 Avenue Guy de Collongue, 69134 Ecully Cedex - France

Polymer surfaces with low surface energies and textured by femtosecond laser technique were analyzed in term of wetting properties. Small droplets were deposited and surfaces were submitted to horizontal vibration. This mechanical stimulation affects the droplet displacement.

The impact of surface tension on the droplet displacement and on the value of the first Eigen frequencies is analyzed. The impact of the surface patterning is also analyzed, taking into account anisotropy effects.

(1) Belaud, V.; Bigerelle, M.; Valette, S.; Stremsdoerfer, G.; Benayoun, S. Tribology International 2014

(2) Daniel, S.; Chaudhury, M. K.; De Gennes, P.-G. Langmuir 2005, 21, 4240–4248

(3) Noblin, X.; Kofman, R.; Celestini, F. Phys. Rev. Lett. 2009, 102, 194504

12:25 pm - 1:25 pm Lunch (Concordia)

1:25 pm - 2:25 pm (Concordia) - Posters

2:25 pm - 3:00 pm Viscoelastic response of nano-miniscus Joël Chevrier

Joël Chevrier : Laboratoire interdisciplinaire de Physique (LIPHY), Université Grenoble Alpes-CNRS France

We report the observation of a transition in the dynamical properties of water nano-meniscus, which dramatically changes when probed at different time scales. Using an AFM mode that we name Force Feedback Microscopy, we observe this change in the simultaneous measurements, at different frequencies, of the stiffness G′ (N/m), the dissipative coefficient G″ (kg/s) together with the static force. At low frequency we observe a negative stiffness as expected for capillary forces. As the measuring time approaches the microsecond, the dynamic response exhibits a transition toward a very large positive stiffness. When evaporation and condensation gradually lose efficiency, the contact line progressively becomes immobile. This transition is essentially controlled by variations of Laplace pressure.

3:00 pm - 3:20 pm Atomic Force Microscopy investigation of nanomenisci: hydrodynamics and interface elasticity Caroline Mortagne

Caroline Mortagne[1], *, Julien Dupré De Baubigny[1], Michael Benzaquen[2], Marc Legros[1], Jean-Pierre Aimé[3], Thierry Ondarçuhu[1]*

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The description of hydrodynamic interactions between a particle and a surrounding liquid, down to the nanometer scale, is of primary importance in many fields including biology, micro and nanofluidics and materials science. This work shows that Atomic Force Microscopy used in the Frequency Modulation (FM) mode is a relevant tool to probe the mechanical properties of nanomenisci.

The method consists in oscillating a non-conventional AFM tip ended by a cylindrical fiber (radius R from 5 up to 100 nm) at its resonance frequency and with constant amplitude while approached, plunged and withdrawn from a liquid interface. The resonance frequency shift and excitation signal of the cantilever are monitored all along the different steps performed (Fig.1) which enables to investigate:

The effective spring constant of the liquid interface which is deduced from the jump of resonance frequency at the meniscus formation (z = 0 on Fig.1). The stiffness is quasi proportional to the surface tension of the liquid for contact angle greater than 30°, regardless of the excitation frequency (from quasistatic up to 450 kHz). A model based on the equilibrium shape of the meniscus reproduces well the experimental data [1].

The hydrodynamics of the viscous layer which is the layer of liquid that the immersed nanofiber makes oscillate. The mass of the viscous layer is added to the effective mass of the {tip-cantilever} system and an extra shear stress appears at the rod's surface. These mass and friction coefficients can both accurately be described by a hydrodynamic model based on the resolution of the Stokes equation. All the data collected for a large range of viscosity values (from 1 up to 500 mPa.s) and excitation frequencies (up to 500 kHz) are gathered on master curves which provide a comprehensive description of the velocity field around a nanoprobe.

FM-AFM is consequently an efficient method to probe quantitatively the dynamic interactions between nanoparticles and liquids down to the nanometer scale. This work paves the way for direct measurements of dissipation processes in intrinsically small liquid volumes such as nanomenisci in the vicinity of the contact line [3], issues which are not fully understood despite their great importance in wetting.

This work has been partially funded by the ANR project Nanofluidyn (grant ANR-13-BS10-0009) and the LABEX NEXT (grant ANR-10-LABX-0037). Fruitful discussions with Clémence Devailly, Sébastien Kosgodagan, and Audrey Steinberger from the ENS Lyon are acknowledged.

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3:20 pm - 3:40 pm Osmosis without rejecting membranes Christophe Ybert

Choongyeop Lee, Cecile Cottin-Bizonne[1], Laurent Joly[1], Christophe Ybert[1], *,

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Osmosis -a liquid flow or a pressure difference induced by concentration differences- is a key phenomenon in cell exchanges, plant mechanics food processing or water desalination. Until recently however, the ability of concentration gradients to drive transport was only recognized for stringent conditions: the presence of a separating semi-permeable membrane. Here we present our recent works demonstrating generation of osmotic flows without membranes. Using nanofluidic systems and state-of-the-art ultra-low flow rate measurements, we evidence a surface-driven flow generated along solid walls in a mechanism resembling elecrtro-osmosis for electric potential gradients. Characterizing solutes from salts to polymers to alcool, we unravel the subtle entanglement between surface interactions and dynamics that sets flow intensity and direction. Overall this work shed some light on an overlooked osmotic transport which now appears of large potential: from colloidal dynamics to DNA translocation to water filtration and energy harvesting.

3:40 pm - 4:00 pm Proteins at liquid interfaces: insights from molecular simulation David Cheung

David Cheung[1], National University of Ireland Galway (NUI Galway), National University of Ireland, University Road, Galway - Ireland

The adsorption of proteins onto fluid interfaces, for example the air-water and oil-water interfaces, is central to a number of biological processes and applications in biotechnology. Absorption of proteins onto such interfaces is typically associated with changes in protein conformation, often with a consequent loss of function. Obtaining a detailed molecular description of this structural change is a key step to understanding protein structure and function in complex, interfacial environments.

In this presentation I will describe some recent work aimed at investigating adsorption and conformational change of proteins at liquid interfaces. Specifically the adsorption of hydrophobins, amphiphilic, fungal proteins onto oil-water interfaces will be discussed [1]. Using coarse-grained simulations the adsorption strength of two examples of these proteins has been determined and related to their surface structure. The conformations adopted by two peptides derived from myoglobin, for which the emulsification behaviour has been studied experimentally [2], will also be discussed. Both peptides adopt similar, compact conformations in bulk solution and readily adsorb onto the air-water interface. They adopt significantly different conformations at with one of these adopting a flat, extended conformation, with the other peptide remaining close its solution conformation [3] and these different interfacial conformations can be related to their emulsification behaviour.

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4:00 pm - 4:20 pm Surfactant action at solid surfaces Bijoy Bera

Bijoy Bera [1], Noushine Shahidzadeh [1], Odille Carrier [1], , Ellen Backus [2], Mischa Bonn [3], Daniel Bonn [1]

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We investigate the wetting of charged surfaces by aqueous surfactant solutions using contact angle measurements, surface-sensitive spectroscopy and ellipsometry. Surfactants are widely used to improve the wetting of liquid on surfaces. The Zisman plot is a much-used technique to investigate the 'critical' surface tension for complete wetting of a solid surface by a (simple) liquid of a given liquid-vapor tension. The action of surfactants, however, may also influence the solid-liquid and solid-vapor interfaces during such wetting process.

We modify the method of Zisman plots to also assess the effects of surfactant on solid-liquid and solid-vapor interfaces. Contrary to the expectation that surfactant adsorption leads to improved wetting, we observe an insignificant change or even an increase in the contact angle with various surfactants compared to pure liquids of the same surfasse tension. The latter is called `anti-surfactant' behavior. To investigate surfactant action on the solid-vapor tension, we investigate the precursor films using ellipsometry. Sum-frequency generation spectroscopy reveals how the surfactants adsorb at the solid-liquid surface.

4:20 pm - 4:50 pm Coffee break (Concordia)

4:50 pm - 5:10 pm Wetting properties of partially suspended graphene monolayers Thierry Ondarçuhu

Thierry Ondarçuhu[1]*, Vincent Thomas[1], Marc Nuñez[1], Erik Dujardin[1], Atikur Rahman[2], Charles Black[2], Antonio Checco[2]

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Among several potential outlooks, graphene holds promises to revolutionize coating applications. The dependence of the wettability of graphene on the nature of the underlying substrate remains yet only partially understood. Here, we systematically investigate the role of liquid-substrate interactions on the wettability of graphene by varying the area fraction of suspended graphene from 0% to 95% by means of nanotextured substrates. Our results show that 80% of the water-substrate interactions are screened by the graphene monolayer, the wettability of which is primarily determined by short-range graphene-liquid interactions. By its well-defined chemical and geometrical properties, supported graphene therefore provides a model system to disentangle the relative contributions of short and long range interactions to the macroscopic contact angle.

5:10 pm - 5:30 pm Some considerations on water-hydrophobic interfaces Carlos Drummond

Carlos Drummond[1], George Bepete, Alain Penicaud, Leonor Perez-Fuentes, Delfi Bastos-Gonzalez, Jordi Faraudo,

1 : Centre de Recherche Paul Pascal (CRPP-UPR CNRS 8641), Université Bordeaux 1, CNRS

The interface between water and hydrophobic surfaces plays a central role in a number of important subjects like proteins folding, surfactant self-assembly, detergency or oil recovery. These interfaces often show a complex behavior not always well-understood, determined by (apparently) secondary actors like ions or gases dissolved in the aqueous phase. In this seminar I will describe few examples illustrating the complexity of these interfaces. More precisely, I will discuss the interaction between water and hydrophobic polymers, the behavior of single layer graphene in water, and ion-specific effects on the behavior of temperature-responsive Poly(N-isopropylacrylamide). Finally, I will discuss some examples of how the complexity of water-hydrophobic interfaces can be exploited to manipulate the properties of materials

5:30 pm - 5:50 pm Capillary freezing of ionic liquids confined at metallic interfaces - Jean Comtet

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Using a quartz tuning fork based AFM, we investigate the behavior of ionic liquids under confinement. Using nanorheological measurements, we show that nanometric confinements can lead to capillary freezing of the ionic liquid. The critical length at which the liquid-solid transition occurs depends strongly on the bulk electronic properties of the substrate, with larger length observed for metallic surfaces. We interpret this trend by showing that the surface energy of ionic crystals with respect to metallic substrates is decreased for better metals. Finally, we show that this capillary freezing transition can also be tuned by electrifying the confining interfaces.

5:50 pm - 6:10 pm Dynamics of electric double layer: the rheological contribution Léo Garcia

Léo Garcia : LiPHY, Université Grenoble Alpes

Nearby a charged liquid-solid interface, a non-zero net charge zone, the so called electrical double layer (EDL), is formed to counterbalance the surface charge. In presence of a gradient of electric potential or of ions concentration, this EDL is responsible for advective transport phenomena. Yet many experiments lead to inconsistent properties when comparing equilibrium and out of equilibrium behaviour. What is the link between these two kinds of properties and why are the results so different?

After a brief overview of the EDLs, I will show a new approach to characterize the EDLs that might clarify these previous results. Simultaneous equilibrium and dynamic measurements enable us to study EDLs and to probe both surface charge and transport properties as the zeta potential. These measurements are done with a dynamic surface force apparatus of our own design. Our results show an overdissipative behaviour due to the presence of ions and a frequency dependence of the mechanical response of the EDLs.

6:10 pm - 6:30 pm Nanotribological Properties of Biocompatible Polyzwitterionic Brushes Zhang Zhenyu

Zhang Zhenyu, University of Birmingham

BACKGOUND:Polymer brushes are an important smart coating in many applications due to their ability to modify surface properties and enhance biocompatibility. The frictional properties of polymer brushes is of great interest because they can act as lubricants in good solvent conditions.

OBJECTIVES:We intend to measure the nanotribological properties of polymer brushes to examine their potential as smart surface coating upon exposure to external stimuli.

METHODS:Friction force microscopy (FFM), a variant of Scanning Probe Microscopy (SPM), has been introduced to quantitatively examine the mechanical properties of surface grown zwitterionic polymer brushes: poly(2-(methacryloyloxy)ethyl phosphorylcholine) (PMPC).

RESULTS & CONCLUSION

1. Effect of molecular weight and solvent on the frictional properties

In a good solvent, it was found that the coefficient of friction (µ) decreased with increasing film thickness. We conclude that the amount of bound solvent increases as the brush length increases, causing the osmotic pressure to increase and yielding a reduced tendency for the brush layer to deform under applied load.1,2 When measured in a series of alcohol/water mixtures, a significant increase in µ was observed for ethanol/water mixtures at a volume fraction of 90%. This is attributed to brush collapse due to co-nonsolvency, leading to loss of hydration of the brush chains and hence substantially reduced lubrication (Figure 1). Such a result is in agreement with recent ellipsometric studies of PMPC brushes.3 FFM has also been used to demonstrate that PMPC brushes exhibit different frictional properties depending on the medium (methanol, ethanol, 2-propanol, and water) in which the measurement was made.

2. Frictional properties as a function of structure and density of polymer brushes

To develop design principles for the construction of molecular objects at the nanometre scale, photolithography was utilized to facilitate the growth of polymer brushes that are patterned on different length scales. Structures were formed on surfaces that exhibited varying densities of initiator sites. Using AFM, it was possible to measure the effect of the initiator density on both the heights and the frictional properties of the resulting nanostructured brushes. The coefficient of friction was found to decline as the brush height increased, with a smooth variation in both parameters being observed as a function of the density of initiator sites.4

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7:00 pm - 9:30 pm Dinner (CROUS Restaurant)

Wednesday, October 19, 2016

8:30 am - 9:05 am Dynamics of prey prehension by chameleons through viscous adhesionPascal Damman

P. Damman(1), M. Houze(1), F. Brau(2), V. Bels(3)

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(2) Nonlinear Physical Chemistry Unit, Université Libre de Bruxelles, CP231, 1050 Brussels, Belgium

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Among predators using an adhesive tongue to feed, chameleons are able to capture large prey by projecting the tongue at high acceleration. Once in contact with a prey, the tongue retracts with a comparable acceleration to bring it to the mouth. A strong adhesion between the tongue tip and the prey is therefore required during the retraction phase to ensure a successful capture. To investigate the mechanism responsible for this strong bond, the viscosity of the mucus produced at the chameleon's tongue pad is measured, using the viscous drag exerted on rolling beads by a thin layer of mucus. We show that the viscosity of this secretion is about 400 times larger than that of human saliva. We incorporate this viscosity into a dynamical model for viscous adhesion, which describes the motion of the compliant tongue and the prey during the retraction phase. The evolution of the maximum prey size with respect to the chameleon body length is then derived, and compared with in vivo observations for various chameleon species. Our study shows that the size of the captured prey is not limited by viscous adhesion, owing to the high mucus viscosity and large contact area between the prey and the tongue.

9:05 am - 9:25 am Unexpected droplet sliding dynamics on elastomer plates Aurélie Hourlier-Fargette

Aurelie Hourlier-Fargette[1,2], Arnaud Antkowiak[1], Sebastien Neukirch[1]

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Droplet dynamics on an angled surface results from a competition between the weight of the droplet, capillary forces, and viscous dissipation inside the drop. The motion of droplets on stiff surfaces has been investigated for a long time, both experimentally and theoretically, while recent studies have shown the interesting physics underlying the sliding of droplets on soft surfaces. Here, we focus on the dynamics of water-glycerol mixture droplets sliding down vertical plates of silicone elastomers.

We show that a water (or water-glycerol mixture) droplet sliding down a vertical elastomer surface (e.g. on polydimethylsiloxane cross-linked elastomer) exhibits unexpected behavior. The droplet dynamics on such a surface includes two different regimes, with two different constant speeds. However, there is no modification of the substrate on which the droplet is sliding at the transition point.

This dynamics is completely different from the observations made in the litterature on materials like treated glass. Thus, we investigate the universality of this behavior on various elastomers. We study in detail the two different regimes, by looking at the different shapes of the droplets and at the sliding speeds in each regime as a function of droplet volume and liquid properties. The position of the transition point as a function of the different parameters has also been thoroughly analyzed.

Different candidates can be responsible for this sudden speed change: bistability, softness of the material, chemical interaction with the substrate, etc. Our experiments to clarify the role of each of them revealed an unexpected link between microscopic phenomena at the scale of the polymer matrix and the macroscopic dynamics of a droplet.

9:25 am - 9:45 am Polymer multilayers at liquid interfaces: assembly, interfacial rheology and microfluidic probing

Corentin Trégouët , Corentin Tregouet[1,2],

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2 : Gulliver, ESPCI ParisTech, CNRS : UMR7083, 10 rue Vauquelin, 75231 Paris cedex 05 - France

Microencapsulation offers a solution to protect, transport and deliver active substances. The efficiency of microcapsules depends on their thickness and mechanical properties. The goal of our study is to produce model capsules with controlled mechanical properties. We developed a microfluidic method to produce capsules based on layer-by-layer assembly of polymers directly on oil droplets and to study their deformation in constrictions. First, the droplets are rinsed with different solutions to build the membrane. Then we use an extensional flow to apply a viscous stress on the capsules to probe the mechanical properties of the membrane.

In parallel we perform surface rheological measurements to characterize the shear and compression properties of the membranes assembled in model geometry. We show that the mechanical properties of the capsules depend on the type and strength of the interactions involved between the polymer layers [1]. Using an interplay of hydrogen bond and hydrophobic interactions we obtain a wide range of behaviours, from purely viscous to viscoelastic [2], where the elastic modulus and relaxation time can be varied over orders of magnitude.

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9:45 am - 10:05 am Contact line and contact angle around a spherical particle at anisotropic fluid interfaces
Nesrin Senbil

Nesrin Senbil[1]*, Anthony Dinsmore

1 : University of Fribourg, * : Corresponding author

A spherical particle trapped at a fluid interface forms a contact line where the solid and the two immiscible fluids meet. The shape of the contact line is the key to determining the overall interface shape and capillary interactions with other particles. At a planar interface, the contact line is a circle. When the interface has anisotropic curvature, however, the leading order deformation of the contact line has quadrupolar (cos(2*phi)) symmetry[1]. In our experiments,we measured the shape of the contact line and the contact angle around 3.2 mm PDMS-coated glass spheres. Anisotropy of the interface is quantified by deviatoric curvature, half of the difference between the principal curvatures where center of the sphere is placed. Our experience shows that the steady state conditions for advancing and receding are different. For the advancing case, the measured quadrupolar deformation around the sphere agrees with the theoretical prediction[2]. However, for receding cases at high deviatoric curvature, our results are greater than the prediction. This might mean that advancing angle is closer to the Young-Dupre contact angle used in the theory. We also find that that receding contact angle of the same sphere decreases as the deviatoric curvature of the interface is increased[3]. This contradicts the Young-Dupre contact angle prediction of a constant contact angle. However, no difference in advancing angle is measured at anisotropic interfaces. Our contact line measurements are, to our knowledge, are the first direct observation of contact line deformation induced by anisotropic shape of the fluid interface. Our results both on contact line and contact angle are important for the use of assembly/interaction of colloids at fluid interfaces in technological aspects. This research was made possible in part by a grant from BP/The Gulf of Mexico Research Initiative through the C-MEDS consortium, and in part by the U.S. National Science Foundation (CBET-0967620).

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10:05 am - 10:35 am Coffee break (Concordia)

10:35 am - 10:55 am The taming of umbilics, hedgehogs and disclinations Pawel Pieranski

Pawel Pieranski[1], Maria Godinho[2], Simon Copar[3]

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The beauty of liquid crystal textures is paradoxically due not to their perfection but, on the contrary, to defects occurring in them such as umbilics, hedgehogs or disclinations.

Let us remind that Liliane Léger, at the beginning of her carrier, in collaboration with Albert Rapini and Alexis Martinet worked on defects generated during Frederiks transition. In particular, in homeotropic nematic cells submitted to an electric field they observed point-like defects which they proposed, successfully, to call “umbilics”.

Usually, umbilics, hedgehogs and disclination are “wild” that is to say they appear erratically. The aim of my talk is to show how these defects can be tamed. Umbilics can be generated and manipulated in a controlled manner by magnets or flows. Disclination loops can be threaded on polymeric fibers. Once being captive, disclinations can be rotated by torsion of fibers or put into motion along fibers by fields. As to hedgehogs, they are the wildest because they require special conditions for coming out. It is known that a cylindrical glass capillary with homeotropic anchoring on its walls favors the scarce occurrence of hedgehogs. The dowser (pseudo-planar) metastable texture of a homeotropic flat cell is also suitable for generation of hedgehogs. We will point out that in certain conditions its life-time can be infinite so that hedgehogs can be generated and manipulated in a controlled manner. The dowser texture on its own is sensitive to a gradient of the cell thickness and has therefore a cuneitropic behavior.

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10:55 am - 11:15 am Reduction of real contact area under shear and the value of static frictionJulien Scheibert

Riad Sahli, Gael Pallares, Christophe Ducottet, Julien Scheibert[1]*

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The frictional properties of rough contact interfaces are controlled by the area of real contact. Dynamical variations of this area are at the roots of our modern understanding of the ubiquitous state-and-rate friction law. In particular, the area of real contact is proportional to the normal load, slowly increases at rest through aging and abruptly drops at slip inception. Here, through direct measurements on various elastomer contacts, we show that it is also a decreasing function of the tangential load, with reductions as large as 30%, starting well before macroscopic sliding. All data are well captured by an empirical quadratic reduction law which enables excellent predictions of the observed static friction force. The overall reduction in rough contacts is the result of a shrinking of each micro-junction, with the same behaviour as that of model mono-contacts. These findings are shown to also apply to contacts involving human fingers.

11:15 am -11:35 am Light-switchable Adhesion of Microalgae Oliver Bäumchen

Max Planck Institute for Dynamics & Self-Organization (MPI-DS)
Am Fassberg 17, 37077 Göttingen, Germany

The natural habitats of living microorganisms are typically complex geometric environments and include a plethora of interfaces. For motile organisms like bacteria and microalgae that move through a liquid medium within their microhabitat, the prevailing picture is that the precise nature of contact and hydrodynamic forces governs their interactions with boundaries. For such microorganisms, flagella play a crucial role since they are the source of locomotion and may come into direct contact with an interface. The interactions of individual microalgae and their flagella with solid surfaces are characterised by means of time-resolved *in vivo* adhesion measurements on the single cell level. In micropipette force spectroscopy experiments, we observe that only the flagella adhere to different model surfaces. We discovered that the flagella reversibly adapt their adhesiveness in different light conditions, resulting from protein redistributions at the flagella membrane in response to a blue-light photoreceptor signal. The way microorganisms interact with interfaces does not only entail fundamental implications for the colonization of porous media and the formation of biofilms, but is also of great relevance for applications involving water filtration, bioremediation of contaminated soil, biofuel production, targeted delivery of pharmacological cargo and cell sorting in lab-on-a-chip devices.

11:35 am - 11:55 am Principles of a biomimetic kidney-on-a-chip for advanced nanofiltration Sophie Marbach

Sophie Marbach, Lyderic Bocquet[1]

1 : Institut Lumière Matière (ILM), Université Claude Bernard - Lyon I, Villeurbanne - France

The clear need in fresh water is one of the main challenges now faced by humanity. While water desalination and water recycling involve costly separation processes in terms of energy, the domain has been boosted over the last decades by the progresses made in membrane technology for water purification, such as reverse osmosis or nanofiltration [1], and more recently by the possibilities offered by nanoscale materials [2,3]. In this paper we investigate the physical mechanisms underlying one of the most efficient filtration devices: the kidney. Building on a minimal model of the Henle Loop - the central part of the kidney filtration -, we investigate theoretically the detailed out-of-equilibrium fluxes in this separation process in order to obtain theoretical bounds for its efficiency in terms of separation ability and energy consumption. A key discovery is that this separation device operates at a remarkably small energy cost as compared to traditional sieving processes, while working at much smaller pressures This unique energetic efficiency originates in the serpentine geometry of the nephron, which operates as an active osmotic exchanger. The principles for such a "kidney on a chip" could be readily mimicked based on existing technologies to build compact and low-energy artificial dialytic devices. They also point to new avenues for advanced water recycling, in particular during sea-water pretreatment for decontamination and hardness reduction.

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11:55 am - 12:15 pm Wetting of Yield Stress Fluids Catherine Barentin

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Wetting phenomena and yield-stress fluids rheology are subfields of soft matter physics where big understanding steps have been made during the last centuries. In addition, these two fields have very important potential implications for industry, which contributes to their dynamism. Indeed, yield stress fluids like foams, emulsions, gels, granular materials, paints are encountered in many industries such as food industry, cosmetics, building industry, oil and gas industry ... What makes such systems particularly interesting for applications is their intermediate fluid/solid behaviour: at rest they behave like an elastic solid, but they are able to flow like a liquid under sufficient applied stress. Moreover wetting properties are crucial when processing or using the fluids, as many processes involve interfaces with air or a solid surface. But their combination, the wetting of yield-stress fluids, has received little interest until the very last years, although it is a situation that happens all the time.

In this talk, I will present two experiments of wetting: the capillary imbibition and the adhesion force of a capillary bridge with a yield-stress fluid called carbopol, and I will address the following questions: Why the wetting of yield stress fluids is so special compared to the case of simple fluids? What is the influence of the yield stress on the Jurin's law? How the Washburn law is modified by the rheology of the yield stress fluid? What is the influence of the yield stress on the adhesion force of the capillary bridge?

The first experiment of capillary imbibition shows that the final height decreases with the yield stress, few depends on the capillary gap and strongly depends on the roughness of the wall contrary to simple fluids [1]. Moreover the study of the capillary dynamics allows to investigate the visco-plastic properties of the yield stress fluids and we propose a modified Washburn law. The second experiment that consists in measuring the adhesion force of a capillary bridge shows the importance of the fluid elasticity and of the deformation history, contrary to the case of simple fluids. We propose an elasto-plastic model to capture the main results [2].

[1] B. Géraud et al., Eur. Phys. Letters, vol. 107 (2014)
[2] L. Jorgensen et al., Soft Matter, vol 11,(2015)

Keywords: Wetting, Yield-stress fluids, Carbopol, Surface tension, Rheology

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12:15 pm - 1:15 pm Lunch (Concordia)

1:15 pm - 2:15 pm (Concordia) - Posters

2:15 pm - 2:50 pm Hot active particles: thermoelectric interface properties Alois Würger

Alois Würger : Laboratoire Ondes et Matière d'Aquitaine-LOMA, UMR5798 CNRS-Université Bordeaux1, 351 Cours de la Libération, 33405 TALENCE Cedex - FRANCE

Chemically or thermally active Janus particles (JP) have become a toy model for artificial microswimmers. Their self-propulsion mechanisms are often poorly understood, and even the direction of the motion, cap ahead or cap at the rear, lacks a rationale so far.

Here we report on recent theory work on the self-propulsion of laser-heated JP in an electrolyte solution [1], which provides an explanation for the specific-ion effects observed for the motion of gold-capped particles in an optical trap [2]: Particle motility differs in solutions of LiCl, NaCl, NaOH, indicating the role of the electrolyte Seebeck effect, similar to previous findings for thermophoresis of polystyrene particles in an applied temperature gradient [3]. We discuss the electric-double layer at a hot JP, and in particular how the electric conductivity of its gold cap influences thermo-electro-osmosis along the particle surface.

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[2] S. Simoncelli, J. Summer, S. Nedev, P. Kühler, J. Feldmann., Small (2016)

[3] K.A. Eslahian, A. Majee, M. Maskos, A. Würger, Soft Matter 10, 1931 (2014).

2:50 pm - 3:10 pm Dynamics of an experimental colloidal glass of active particles Félix Ginot

Felix Ginot, Mathieu Leocmach, Christophe Ybert and Cécile Cottin Bizonne

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The behaviour of self-propelled colloids, that are intrinsically out of equilibrium, is rather fascinating. Using gold/platinum active colloids we have shown experimentally that, if at low density they behave as perfect hot gas, at intermediate densities we observe a new phenomena: the formation of clusters. We then describe the non-equilibrium equation of state of this system, that is profoundly affected by self-propulsion. We are now interested in the dense phase of the system, and have studied an experimental active glass. We show that activity has a complex non monotonic influence on the dynamics of the glass: first activity slows the dynamics, and then the behavior reverses and activity increases the mobility of the particles.

3:10 pm - 3:30 pm Light-driven actuation of particles at liquid interfaces Thomas Bickel

Thomas Bickel : Laboratoire Ondes et Matière d'Aquitaine (LOMA), Université de Bordeaux, 351, Cours de la Libération 33400 Talence - France

Conventional methods for particle manipulation with light, such as optical tweezers, rely on optical forces. Still, the range of forces and velocities that can be achieved remains limited. In contrast, light-induced surface flows have proven to produce powerful propulsion forces to move small objects. This point will be illustrated in two examples. I will first discuss the actuation of liquid marbles (millimeter-size water droplets coated with hydrophobic powder) along the water-air interface. The liquid phase contains photosensitive surfactants that generate a surface tension gradient under UV illumination. Strikingly, it is observed that the particles move against the Marangoni flow when the thickness of the liquid layer is smaller than a critical value [1]. A hydrodynamic model is developed to explain this behavior. I will then present experimental results regarding the actuation of micron-size colloids at the water-air interface upon laser heating. It is shown that the particles behave as microswimmers with velocities in the order of several hundred micrometer per second with just a few milliwatts of laser power [2]. These findings open new horizons for remote control of the locomotion of small objects.

[1] N. Kavokine, M. Anyfantakis, M. Morel, S. Rudiuk, T. Bickel and D. Baigl, Angew. Chem. Int. Ed., in press (DOI: 10.1002/anie.201603639)

[2] A. Girot, N. Danné, A. Würger, T. Bickel, F. Ren, J.-C. Loudet, and B. Pouligny, Langmuir 32, 2687 (2016)

3:30 pm - 3:50 pm Wetting and orientation of Janus colloids at the surface of water Antonio Stocco

Antonio Stocco : Laboratoire Charles Coulomb (L2C), Université Montpellier II - Sciences et techniques, CNRS : UMR5221, 1 place Eugène Bataillon Université Montpellier II 34095 Montpellier Cedex 5 - France

Janus colloidal particles show remarkable properties in terms of surface activity, self-assembly and wetting. Moreover they can perform autonomous motion if they can chemically react with the liquid in which they are immersed. In order to understand the self-propelled motion of catalytic Janus colloids at the air-water interface, wetting and the orientation of the catalytic surface are important properties to be investigated. Wetting plays a central role in active motion since it determines the contact between fuel and catalytic surface as well as the efficiency of transduction of chemical reaction into motion. Active motion is not expected to occur either when the catalytic face is completely out of the aqueous phase or when the Janus boundaries are parallel to the interfacial plane. The design of a Janus colloid possessing two hydrophilic faces is required to allow the catalytic face to react with the fuel (e.g. H2O2 for Platinum) in water and to permit some rotational freedom of the Janus colloid in order to generate propulsion parallel to the interfacial plane. Here, we discuss some theoretical aspects that should be accounted when studying Janus colloids at the surface of water. The free energy of ideal Janus colloidal particles at the interface is modeled as a function of the immersion depth and the particle orientation. Analytical expressions of the energy profiles are established. Energetic aspects are then discussed in relation to the particle ability to rotate at the interface. By introducing contact angle hysteresis we describe how the effects of contact line pinning modifies the scenario described in the ideal case. Experimental observations of the contact angle hysteresis of Janus colloids at the interface reveal the effect of pinning; and orientations of silica particles half covered with a platinum layer at the interface do not comply with the ideal scenarios. Experimental observations suggest that Janus colloids at the fluid interface behave as kinetically driven system, where the contact line motion over defects decorating the Janus faces rules the orientation and rotational diffusion of the particle.

[1] X. Wang et al, Faraday Discussions, DOI: 10.1039/C6FD00025H (2016)

3:50 pm - 4:20 pm Coffee break (Concordia)

4:20 pm - 4:30 pm Poster Price - Ralf Blossey, François Boulogne, Mathilde Reyssat

4:30 pm - 4:50 pm Extrusion instabilities of a gel-forming polymer solution Tristan Baumberger

Tristan Baumberger[1]*, Lise Picaut

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Extrusion instabilities of polymer melts has been extensively studied for the past decades, shedding light on the role played by the stress singularity resulting from the no-slip to no-shear transition at the die exit and suggestion the possible role of viscoelastic turbulence. Here we study various instabilities occuring when an alginate solution is extruded in a calcium salt solution which triggers fast crosslinking. Amazingly, the instabilities occur at vanishing Reynolds small Weissenberg and giant Peclet numbers, a priori precluding inertial, viscoelastic and ion mediated mechanisms.

We show that gelling ions can however strongly affect the singular exit zone by triggering slip to stick transition. We discuss the formation and charactristics of periodic surface cracks. Paradoxically, we observe that clogging by a gel chunk occurs at the highest velocities, for which ion diffusion is expected to play the weakest role. We propose that in this regime, viscoelasticity of the pregel plays a crucial role, allowing a stagnation zone to form upstream of a gel nucleus.

4:50 pm - 5:10 pm Dynamic elasto-capillarity Bruno Andreotti

Bruno Andreotti : Physique et mécanique des milieux hétérogenes (PMMH), CNRS : UMR7636, Université Pierre et Marie Curie (UPMC) - Paris VI, Université Paris VII - Paris Diderot, ESPCI ParisTech, 10 Rue Vauquelin 75231 PARIS CEDEX 05 - France

A liquid deposited on a soft solid surface can deform it substantially. The motion of the contact line with respect to the substrate leads to a visco-elastic dissipation that can dominate dissipation in the liquid. I will review recent progresses on this topics.

5:10 pm - 5:30 pm Chain dynamics in melts at the flat interface Jack Kirk

Jack Kirk, Patrick Ilg, : Complex Fluids and Theoretical Polymer Physics, Department of Mathematics and Statistics, University of Reading, Department of Mathematics and Statistics, Whiteknights, University of Reading, Reading, RG6 6AX - United Kingdom

We present a single-chain theoretical model for describing the influence of steric hindrance on the dynamic properties of non-entangled chains in polymer melt near a flat surface. We extend the Rouse model by an additional potential that results from the assumption that chain conformations coincide with reflected random-walk statistics, as first advocated by Silberberg[1]. The dynamics at equilibrium are compared with multi-chain molecular dynamics simulations using the Kremer-Grest bead-spring model[2]. In this presentation I will discuss results for chains end-tethered to the surface at grafting densities in the “mushroom” regime, immersed in a matrix of free chains of identical molecular weight. The end-to-end vector and Rouse modes correlation functions of the grafted chains show good agreement with the predictions of our modified-Rouse model.

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2. *K. Kremer and G. S. Grest, J. Chem. Phys, 92, pp. 5057-5086, 1990*

Posters

Elastic superhydrophobic surfaces

Martin Coux[1], David Quere[2], Christophe Clanet[3]

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On superhydrophobic surfaces, the density of pillars is the main parameter controling the water adhesion. We study surfaces with textures of controlable geometries, hence with tunable contact angle hysteresis. To modify the geometry of the pillars, we produced elastic superhydrophobic surfaces that can be reversibly deformed in a wide range.

Shaping water with macrotextures

Pierre Chantelot, Anaïs Gauthier[1,2], Christophe Clanet[3], David Quere[2]

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[3] : LADHYX, Ecole Polytechnique de Palaiseau, Ecole Polytechnique, 91128 Palaiseau Cedex - France

Point like superhydrophobic macrotextures attached to a flat substrate of same repellency can modify the dynamics of impacting water droplets and lead to shorter bouncing times than on a flat substrate. We discuss how macrotextures influence the impact figure and link it to the contact time reduction.

Micro/nanostructured surfaces wetting characterization by high-frequency acoustic reflectometry

Christophe Virgilio[1], *, Julien Carlier[1], *, Lucile Broussous[2], *, Philippe Garnier[2], Pierre Campistron[1], Vincent Thomy[3], Bertrand Nongaillard[1],

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Wetting characterization of real DTI and TSV structures with high aspect ratios has been performed by high-frequency acoustic reflectometry. The method enables the determination of static wetting states when the depth of the structures is a few microns. It has been showed that DTI wetting depends on surface state and liquid surface tension. Full wetting was never achieved maybe due to patterning issues. For TSV structures with depth of a hundred of micrometers, as wetting state was not stable with time, it was also possible to determine the wetting kinetics. Even with a hydrophilic surface, round-shaped TSV wetting was completed in a hundred of seconds. This time goes down to 10 seconds for square-shaped TSV and imbibition phenomenon seems driven by local air evacuation. If the surface is hydrophobic, the liquid penetration can be impossible if the TSV depth is too high even with very low surface tension liquids like ethanol or IPA. Now, TSV wetting kinetics has to be performed including a liquid flow on the wafer to recreate industrial cleaning conditions.

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The Origin of Strong Slip Of Polymer Melts on Structured Surfaces: A Molecular Approach.

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Flow dynamics at the solid/liquid interface gain more importance when it comes to small scales. In special systems, a liquid can reach a finite velocity at the boundary to the solid. Our experiments probe this phe- nomenon via the dewetting of thin polymer films on hydrophobic sub- strates [1]. As hydrophobic coatings we use thin amorphous polymers films or different types of ordered self-assembled silane monolayers on silicon substrates. On silane surfaces, polystyrene (PS) of low molec- ular weight exhibit slip lengths up to micrometers [2]. On AF1600, no significant slip is observed. Scattering studies indicate an interfa- cial layer at the interface depending on the structure of the substrate [3]. Simulations where able to refine the molecular idea of the used SAMs [4]. However, strong slip is reduced if PMMA or polyvinylpyri- dine (PVP) are used instead of PS. MD-Simulations of our systems allow detailed insights into the dynamics of the polymer melt.

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Hydrodynamic instabilities in presence of Marangoni surfers

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In hydrodynamics, the emergence of a flow stemming from a surface tension gradient is known as the Marangoni effect. The surface tension gradient can originate from either a temperature gradient (thermocapillary flow) or a concentration gradient (solutal Marangoni flow). This phenomenon is encountered in numerous situations, ranging from the stability of foams and emulsions to coating and printing processes, or even the locomotion of insects.

Recently, an intriguing hydrodynamic instability has been observed at the water-air interface with a pattern consisting of an even number of azimuthal cells that are symmetrically growing about a pointlike heat or matter source, something like the petals of a flower blossoming all around its heart. Our aim is then to characterize Marangoni flows at the micro-scale, where inertial effects can be discarded. In particular, we wonder to what extent advection could be sufficient to give birth to such an interfacial instability. Answering this question is crucial to better understand hydrodynamic instabilities at small scales, offering the hope to control the motion of microswimmers trapped at the water-air interface.

Specific-ion effects on self-thermophoresis of charged Janus particles

Aboubakry Ly[1]

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In recent years active particles have attracted much attention. Here we report on recent theory work on the self-propulsion mechanism of laser-heated JP immersed in an electrolyte solution [1]. The temperature gradient along the particle surface exerts thermal forces on the salt ions, depending on their solvation enthalpy, move to the hot or the cold side. As the consequences, the two poles of the JP carry an opposite thermocharges, which in turn result in a dipolar electric field in the order of kV/m. This field acts on the particle's electric double-layer and thus induces thermo-electrophoretic self-propulsion. As a main result we find that JP motility is to a large extent determined by the electrolyte Seebeck effect, similar to what was observed previously for thermophoresis [2,3]. From typical parameters, S=50µV/K for NaCl and S=-220µV/K for NaOH [3], we conclude that sign and magnitude of the velocity vary with the electrolyte composition. We discuss our results in view of available experiments

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Influence of processing and molecular parameters on the stability of the multinanolayer coextrusion process

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Coextrusion through a series of multiplying die elements enables the production of polymeric films containing thousands of layers of alternating polymers with individual layer thicknesses below 100 nm. Previous studies have shown improved macroscopic properties (especially permeability) related to the nanoconfinement of the polymers within the layers. However, when a lower limit in thickness is reached, breaks and instabilities during process may occur and thus affect integrity and homogeneity of layers. In this study, films with 1025 to more than 8000 alternating layers of PMMA and PS, mass ratio of 50/50, 90/10 and 95/5 wt% and different draw ratios were fabricated in order to identify the materials and processing parameters responsible for these instabilities. Films were characterized by atomic force microscopy (AFM) and a statistical analysis was used to determine the distribution in layer thicknesses and the stability of layers. Results demonstrate the existence of a critical thickness around 20 nm for the PS/PMMA multilayer system, below which the layers break up. This critical thickness is reached whatever the processing parameters studied, suggesting it might be a physical limit due to macromolecular parameters.

Wetting statics and spreading dynamics on soft gels

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How a liquid wets the surface of a solid substrate has been long studied, and is still attracting researchers from different fields because of the fundamental nature of the topic and its wide industrial applications, such as biofouling, printing, coating. When the substrate is soft, the out-of-plane component of the capillary force may deform the substrate surface on scales comparable to or larger than other random defects on the substrate surface. These deformations affect both the statics and the dynamics of wetting. A thorough knowledge of elastowetting is still missing because of experimental limitations and mathematical intricacies. In particular, precise control of both the surface and mechanical properties of the substrate has challenged scientists for decades, and appropriate optical methods that allow the visualization of the substrate surface both in the vicinity and far from the contact line are required. A complete study of the surface deformation induced by resting droplets from both experimental side and theoretical side under different parameters remains to be performed.

In our research, we studied finite-thickness effects in the statics and dynamics of wetting on soft substrates. The interface deformation is typically larger than the elastocapillary length. First, a quantitative Schlieren optics was developed enabling us to directly observe the contact line region between a sessile water on soft substrates of various thicknesses as a function of time. We measured the out of plane deformation as a function of droplet size, gel thickness and elasticity. We also characterized the receding dynamics of contact lines as a function of substrate thickness. We found that the thickness of the substrate influences both the shape of the substrate surface in the vicinity of the static contact line and the value of the dynamic contact angle. We rationalize our findings with an analytical model developed by J. Dervaux and L. Limat that is in excellent agreement with the experimental data.

Low temperature friction of water on a crystalline surface

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Switching from macroscopic to nanoscopic scale in hydrodynamics gives rise to striking properties like fast transport or nonlinear electrokinetic effects, which open up new perspectives in the development of devices and sensors at nanoscale [1, 2, 3]. Generally speaking, sensors as usually used with various temperature conditions. However, to this day, one know very few about the evolution of interfacial water properties with temperature. In the present work, we analyse by classical molecular dynamics water friction in the vicinity of a Lennard-Jones crystal surface from 225 to 360 K, using the TIP4P/2005f forcefield [4], that we recently proved to be very efficient to reproduce bulk transport properties (shear viscosity, self-diffusion) over this range of temperatures [to be published].

Surprisingly, non-equilibrium shear calculations reveal a non-monotonic evolution of the slip length with temperature, whereas equilibrium calculations within the Green-Kubo formalism [5] show a monotonous decrease of this length with temperature. Previous studies on graphene and carbon nanotubes showed a very good agreement between both methods [6]. With crystaline surface used in the present work, the friction coefficient with water is much higher than in the case of graphene and carbon nanotubes. This means the Green-Kubo formalism might be only valid for low friction regimes. Calculations are currently under way to control this hypothesis.

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VISCOUS DIPPING, APPLICATION TO THE CAPTURE OF FLUIDS IN LIVING ORGANISMS

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Some insects, birds and mammals use flower nectar as their energy resources. For this purpose, they developed specific skills to ingest high viscosity fluids. Depending on the sugar content in the nectar, different strategies are observed: hummingbirds have a tongue made from two thin flexible sheets that bend to form a tube when immersed in the nectar; other animals exhibit in contrast a specific papillary structure well-suited to viscous dipping. Bees and some bats possess a tongue decorated with complex structures that, according biologists, are optimized for fluid capture. In this poster, we will benchmark this assumption by using physical models of viscous dipping. As a prerequisite to the study of the influence of these complex lateral morphologies on viscous dipping, we first make an extensive investigation of the viscous drag with smooth rods. From combined experiments and theoretical analysis, the nature of the relevant forces has been determined. We could separate the

global process in two main stages: i) fluid capture by the rod withdrawal, ii) draining of the fluid when the rod is at rest. We have confirmed that the quantity of fluid captured by the rod is determined by the capillary number, through a balance of viscous drag and capillary forces. In contrast, the drainage can be adequately described by a visco-gravitational model.

In a second stage, experiments on rods that mimic biological morphologies were performed. For this study we used two types of artificial tongue structures: a brush like decorated by small flexible filaments obtain by 3D printing (bee's model), and artificial tongues decorated with lateral protrusions (bat's morphology).

Contact angle hysteresis on two model surfaces with controlled nanodefects.

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Real surfaces exhibit contact angle hysteresis due to surface heterogeneity. A surface is often considered to have low hysteresis when it is less than a few degrees. In recent experiments we found that short chains of polydimethsiloxane (PDMS) adsorbed on silicon can reduce it to 0.1° or below (accepted, Nature Communication). There, we proposed that using good solvents of PDMS produces chains that are stretched and free, yielding a liquid-like surface capable of hiding defects on the underlying solid. Here, we further test this scenario by comparing with silicon coated with octadecyltrichlorosilane (OTS). We show that for nanoscale defects the estimated energy dissipation per defect is about 10 times larger for the OTS surface than for the PDMS surface, whereas the two surfaces are similiar for larger defects.

Spreading and Shrinking of a Surfactant Droplet

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Spreading and shrinking of a hydrosoluble surfactant droplet on thick water layer and also on glycerol layer is investigated experimentally. When a surfactant droplet contacts the water-air (glycerol-air) interface, Marangoni spreading begins. We observe after Marangoni spreading ends, the droplet can experience shrinking on the appropriate situation of experiment. Therefore, the whole process can be divided into three stages including spreading, shrinking and resting. Spreading on the water is accompanied by fingering instability, but on the glycerol we see a circular spreading layer of surfactant. By measuring the radius of droplet on the glycerol and root of mean square displacement for all parts of droplet on the water, it is possible to distinguish the stages and calculate the spreading and shrinking exponents for the surfactant droplet as well. An alternate method we use to distinguish the stages for spreading on water is fractal dimension measurement. We also measure the average length of fingers for spreading droplet on water by calculating the angular box-counting dimension for droplet.

The impact of Surface Geometry, Cavitation and Condensation on Wetting Transitions on Superamphiphobic Surfaces

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The maintenance of superamphiphobicity on physically textured surfaces is of paramount importance for engineering a sustainable future: from drag reduction in marine shipping, to minimising fuel waste in storage and pipelines. The relative success of such operations rely on the ability of the surface texture to maintain a suspended liquid-vapour interface, relative to the liquid penetrating into the texture. This has to be achieved even under challenging conditions such as at large pressures, and for low surface-tension liquids.

However, the fundamental impacts of surface geometry on the stability of wetting states and the transitions between them are often masked by factors such as droplet size and vapour stabilisation. We address this by using a phase field model to elucidate the geometrical influence on the wetting states and transitions for posts and reentrant structures, in both two and three dimensions. We identify three principal outcomes of particular importance for future surface design of liquid-repellent surfaces. Firstly, we demonstrate and quantify how capillary condensation and vapour cavitation affect wetting state stabilities, and the roles condensates play in wetting transitions. Crucially, this leads to a description of the surface structures which exhibit a monostable suspended state. Secondly, two morphologically distinct collapse mechanisms are observed for 3D reentrant geometries, Base Contact and Pillar Contact, which are operative at different pillar heights. Finally, three distinct collapse mechanisms are observed for 2D reentrant geometries, in which symmetry breaking becomes prevalent.

Triple line kinetics and instabilities in solid-state dewetting.

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Dewetting of thin liquid and polymer films has been studied for decades. In this process, mass transport is usually dominated by hydrodynamics. However, recent experiments suggest that mass transport in thin polymer films below the glass transition is actually dominated by surface diffusion[1] . Other experiments with nano-scale crystalline solid film under annealing, such as Si/SiO2 or metals/Oxides[2] , exhibit surface-diffusion-limited dewetting[3] . We present a model based on a mesoscopic continuum description, which catches the main physical ingredients of surface-diffusion-dominated dewetting. From an asymptotic study of this model, two non-equilibrium conditions are obtained at the triple-line. They not only determine the non-equilibrium contact angle – as in the case of liquids, but also point to the relevance of additional physical phenomena pertaining to the non-equilibrium diffusion flux through the triple line. The consequences of these triple line conditions on the dewetting dynamics are discussed. Furthermore, the mesoscopic continuum model allows us to show that the mass shedding effect, by which holes are formed in the film at some finite distance from the triple-line during surface-diffusion-dominated dewetting[4] , is accelerated by orders of magnitudes for nano-scale films.

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Imbibition of Micro-Patterned Surfaces

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We experimentally and theoretically investigated imbibition of two different micro-patterned surfaces as follows: (1) Capillary rise on the surface of a leg of a small animal (wharf roach) and on the surfaces mimicking it [1]. In this work, we found that imbibition of artificial surfaces mimicking the surface of legs is described well by a composite theory. (2) Capillary rise into "open-capillary" [2]. In this study, we found simple scaling laws for the capillary rise in open capillary channels with clear physical pictures for both the statics and dynamics, similarly as in other cases of textured surface. Furthermore, we fabricated two open-capillary mixing devices and demonstrated the expression of the green fluorescent protein (GFP) and simultaneous color changes of the Bromothymol blue (BTB) solution.

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Wetting of complex textured surfaces

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Superhydrophobic surfaces feature remarkable water repellency which are widely known to be governed by a combination of roughness at the micro/nano scale and low surface energy. Because of their considerable practical importance, they have been the center of extensive research for the last decades, both in terms of manufacturing and microfabrication and in terms of fundamental studies of these "super-surfaces" which exhibit noteworthy behaviors such as rebound, drag reduction, anti-icing. Despite this intense research activity, obtaining superhydrophobic surfaces, robust, versatile and easy to implement is still a current issue in particular in case of non-flat surfaces [1, 2]. In order to realize new complex superhydrophobic surfaces (transparent, curved and textured), we have taken advantage of the deformable nature of crosslinked PDMS to reproduce regular patterns (micro-plots) obtained by photolithography, on the desired curved substrate using micro printing method. We have studied wetting properties (advancing and receding contact angles) of those complex surfaces at different wetting contact area scales: i) at scale of a single droplet (millimetric area) with a homemade sessile drop setup and ii) at larger scale (centimetric area) using capillary bridge method [3]. We'll expose first the adapted theoretical analysis of capillary bridge profile for extending the method to the measurement of high contact angles which haven't been explored yet with this method. Comparing capillary bridge with sessile drop results, we'll then show the influence of microstructures on wetting properties and more particularly the differences observed for large wetting contact area explored with capillary bridge.

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Deciphering β-Lactoglobulin Interactions at different Oil–Water Interfaces: A Molecular Dynamics Study

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Controlling and manipulating protein behavior at an interface is of immense relevance to a broad range of physicochemical and biological phenomena and technological processes. Although many experimental studies have contributed to rapid progress in the fundamental knowledge of protein behavior at interfaces, detailed molecular-level understanding of the mechanism of protein adsorption at an interface is still remarkably lacking [1]. In this study, atomistic molecular dynamics simulations were used to characterize the adsorption of β-lactoglobulin at three different oil/water (O/W) interfaces, where the oil was either hydrophobic decane, marginally hydrophilic octanol or the more hydrophilic triolein, Both the approach to the surface and the mechanism of adsorption depend upon the hydrophilicity of the oil and the interfacial tension of the O/W interface, with the nature of the adsorption, the accompanying structural changes, and the energetic driving force differing markedly *between the different oils. Intriguingly, the behavior of the protein resembles that predicted for a soft spherical particle at an O/W interface [2, 3]. The results are in agreement with key experimental findings, particularly the observation that proteins undergo more conformational change upon adsorption to hydrophobic surfaces, flattening out to expose hydrophobic interior residues to the surface, and that a thicker layer of native-like adsorbed protein forms at hydrophilic surfaces, and reveal structural and mechanistic detail behind each mechanism of adsorption [3].*

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Influence of the membrane charge on the binding affinity of cell-penetrating peptides

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Cell-penetrating peptides (CPPs), short peptides whose low toxicity and capacity to interact with a wide range of cell types, are useful tools for drug delivery applications [1]. However, their lack of specificity towards infected versus healthy cells, and the reduction of their penetration efficiency when a cargo molecule is attached to them are still two major issues [2]. In this work, we used elastin-like diblock polypeptides end-grafted with CPPs. They self-assemble into micelles above a defined temperature, thus possibly triggering the uptake on infected cells by increasing the local density of the CPPs [3]. In order to understand the cell translocation mechanism, which may not only be active, we performed on Giant Unilamellar Vesicles (GUVs), quite a model membrane systems, temperature controlled experiments under a confocal laser scanning microscope. We tuned membrane charge density and temperature to investigate their influence on the peptides binding efficiency. By measuring the number of peptides adsorbed per membrane surface, we show that the peptides membrane affinity increases along with the temperature and with the membrane charge density but not always in a trivial way.

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Static and dynamic aspects of a liquid film bearing a nonconstant surface topography by molecular dynamics simulations

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Thin liquid films have attracted considerable attention over the past twenty years due to their numerous applications. As several experimental and theoretical studies have revealed, molecular mobility and dynamics in confined environments substantially deviates from the corresponding bulk case. In recent approches in liquid films exhibiting an imposed topography on the film surface, the leveling of the nonflat surface was exploited in order to probe viscocapillary effects [1,2]. The present contribution is inspired by experimental and theoretical studies in polymer stepped films and addresses static and dynamic aspects of a supercooled binary Lennard-Jones film with a periodic square pattern at the free surface. By the aid of molecular dynamics simulations, we elucidate the factors that govern the mobility and relaxation of the step at a wide temperature range.

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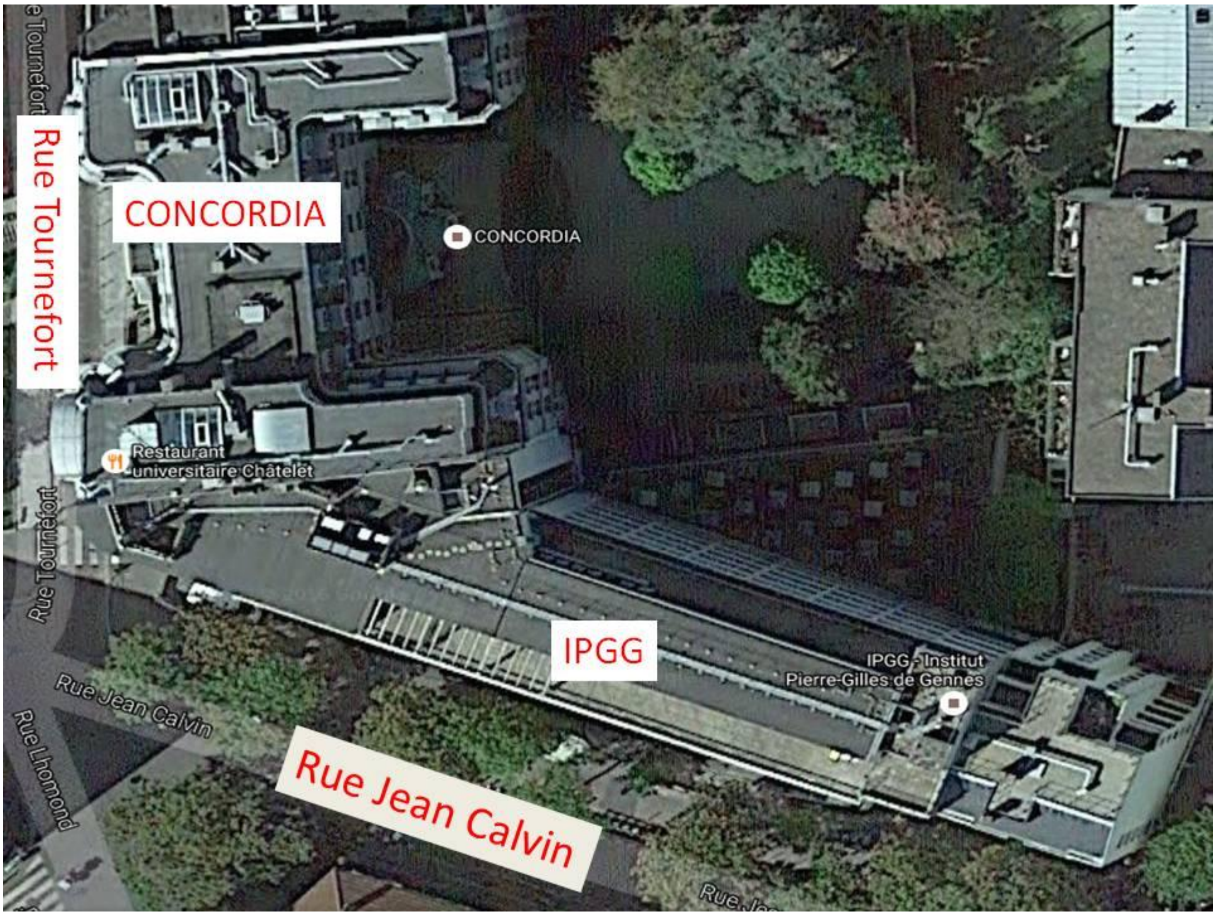
Access Map



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