Liquids @ Interfaces

Conference in honour of Elisabeth Charlaix

University of Bordeaux, Talence, France, 22nd-25th October 2018

Organized by the French CNRS Research Network (GDR) on Liquids at Interfaces and the LOMA laboratory

Organizing committee: S. Bessus, L. Bureau. B. Cross, S. Grandet, I. Guillaume, A. Maali, F. Restagno, T. Salez

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Program

Liquids @ Interfaces

	Monday, October 22, 2018	Tuesday, October 23, 2018	Wednesday, October 24, 2018	Thursday, October 25, 2018
08:30-08:45		Chair: ***L.Bureau*** **F.Mugele**	Chair: ***J.Bico*** **D.Lohse**	Chair: ***I.Cantat*** **J-F.Joanny**
08:45-09:00				
09:00-09:15	*Welcome coffee & registration (Agora du Haut-Carré)*	**A.Smith** **Ph.Loche** **M.Eshraghi** **A.Giacomello** **P.Lidon**	**K.Okumura** **Ch.Ligoure** **E.Reyssat** **L.Keiser** **U.Delabre**	**Y.Kaufman** **P.Chantelot** **J.Kolinski** **A.Bussonnière** **E.Rio**
09:15-09:30				
09:30-09:45				
09:45-10:00	*Official opening* **A.Maali GDR LAI** **F.Pistolesi - LOMA Dir**			
10:00-10:15	Chair: ***L.Léger*** **R.Boya**			
10:15-10:30				
10:30-10:45		*Coffee break (Salle Badiane)*		
10:45-11:00	**T.Mouterde** **A.Poggioli** **S.Dal Cengio** **M.Rodriguez Matus**			
11:00-11:15		Chair: ***T.Ondarçuhu*** **R. Netz**	Chair: ***P.Damman*** **D.Quéré**	Chair: ***JP.Delville*** **J.Crassous**
11:15-11:30				
11:30-11:45				
11:45-12:00	Chair: ***L.Léger*** **L.Bocquet**	**R.Lhermerout** **A.Schlaich** **Th.Bickel**	**A.Lechantre** **M.Zhou** **S.Gravelle**	**A.Huerre** **Y.Wang** **H.Elettro**
12:00-12:15				
12:15-12:30				
12:30-12:45	*Lunch (Salle Badiane)*	*Lunch (Salle Badiane) & Poster session (Cloître)*	*Lunch (Salle Badiane) & Poster session (Cloître)*	**Poster prize**
12:45-14:00				*Lunch (Salle Badiane)*
14:00-14:15	Chair: ***A.Würger*** **C.Bechinger**			Chair: ***O.Sandre*** **D.Pine**
14:15-14:30				
14:30-14:45				
14:45-15:00	**A.Stocco** **C.Maass** **M.Goral** **H.de Maleprade** **C.Quilliet**			**M.Reyssat** **M. Arshad** **O.Manor** **V.Poulichet** **D.Zanchi**
15:00-15:15		Chair: ***J.Chevrier*** **S.Perkin**	Chair: ***C.Zakri*** **H.Kellay**	
15:15-15:30				
15:30-15:45				
15:45-16:00		**S.van Lin**	**W.Smit**	
16:00-16:30	*Coffee break (Salle Badiane)*			*Closing*
16:30-16:45	Chair: ***JB.Salmon*** **D.Bartolo**	Chair: ***E.Lorenceau*** **P.Tong**	Chair: ***G.Miquelard-Garnier*** **P.McGuiggan**	
16:45-17:00				
17:00-17:15				
17:15-17:30	**P.Illien** **TS.Chan** **G.Luengo**	**A.Keiser** **M.Grzelka** **C.Cohen** **C.Barentin**	**C.Drummond** **T.Yamaguchi** **JC.Baret** **G.Rondepierre** **F.Peaudecerf**	
17:30-17:45				
17:45-18:00				
18:00-18:15	**Tribute to Elisabeth**			
18:15-18:30		*Time lapse*		
18:30-18:45		**Public conference (in French)** **F.Restagno**	*Time lapse*	
18:45-19:00	*Time lapse*			
19:00-19:30	*Welcome cocktail (Salle Badiane)*		*Dinner (Salle Badiane)*	
19:30-20:15		*Time lapse*		
20:15-23:00		*Gala dinner (River Cruise Bordeaux)*		

Monday, October 22, 2018

09:00 - 9:45	**Welcome Coffee & Registration (Agora du Haut Carré)**	
09:45 - 10:00	**Introduction Abdelhamid Maali (GDR LAI) & Fabio Pistolesi (LOMA Dir.)**	
	Chair : Liliane Léger	
10:00 - 10:45	**Invited talk** *"Angstrom-Scale capillaries : Water Flow"*	**Radha Boya**
10:45 - 11:00	Molecular streaming and voltage gated response in Angström scale slits	Timothée Mouterde
11:00 - 11:15	Mechano-sensitive ionic conductance in conical nanopores	Anthony Poggioli
11:15 - 11:30	Geometric Ionic Diodes: the role of confinement	Sara Dal Cengio
11:30 - 11:45	Dynamic boundary layers in charged nanopores	Marcela Rodriguez Matus
11:45 - 12:30	**Invited talk** *"Sliding on ice"*	**Lydéric Bocquet**
12:30 - 14:00	**Lunch (Salle Badiane)**	
	Chair : Alois Würger	
14:00 - 14:45	**Invited talk** "*Quorum sensing and cluster formation of active particles*"	**Clemens Bechinger**
14:45 - 15:00	Active Colloids confined at the gas-liquid interface	Antonio Stocco
15:00 - 15:15	Active emulsions in confined geometries: from self-propulsion to division cascades	Corinna C. Maass
15:15 - 15:30	Bacteria swimming in droplets of liquid crystal	Martyna Goral
15:30 - 15:45	Phototactic swimming of multicellular microalgae	Hélène de Maleprade
15:45 - 16:00	Swimming under pressure	Catherine Quilliet
16:00 - 16:30	**Coffee break (Salle Badiane)**	
	Chair : Jean-Baptiste Salmon	
16:30 - 17:15	**Invited talk** "*Sounds and stubbornness of colloidal flocks*"	**Denis Bartolo**
17:15 - 17:30	Self-organisation of swimming droplets through inelastic collisions	Pierre Illien
17:30 -- 17:45	Self-propelled droplets on fibers of different geometry	Tak Shing Chan
17:45 - 18:00	Self-assembly materials for hair surface applications	Gustavo S. Luengo
18:00 - 18:45	**Tribute to Elisabeth**	**Marie-Charlotte Audry-Deschamps, Cécile Cottin-Bizonne, Cyril Picard et Audrey Steinberger**

Tuesday, October 23, 2018

	Chair : Lionel Bureau	
08:30 - 09:15	**Invited talk** "*Charge generation at mineral-electrolyte interfaces: from microscopic ion adsorption to local viscosity enhancement and macroscopic wettability alteration*"	**Frieder Mugele**
09:15 - 09:30	Charge Regulation and Stern Layer Properties at the Solid-Liquid Interface: Ion Specific Effects	Alexander Smith
09:30 - 09:45	Testing dielectric continuum theory at interfaces by atomistic simulations	Philip Loche
09:45 - 10:00	Yukawa fluids and solids near hard walls: Evidence for a pre- freezing transition	Mojtaba Eshraghi
10:00 - 10:15	Cavitation in nanoporous materials	Alberto Giacomello
10:15 - 10:30	Enhanced oxygen solubility in metastable capillary condensed water under tension	Pierre Lidon
10:30 - 11:00	**Coffee break (Salle Badiane)**	
	Chair : Thierry Ondarçuhu	
11:00 - 11:45	**Invited talk** "*Hydration friction in nano-confinement: from bulk via interfacial to dry friction*"	**Roland Netz**
11:45 - 12:00	Friction across molecular films of ionic liquid	Romain Lhermerout
12:00 - 12:15	Modeling Adsorption and Transport in Multiscale Porous Media	Alexander Schlaich
12:15 - 12:30	Unraveling the role of insoluble impurities on radial interfacial flows	Thomas Bickel
12:30 - 15:00	**Lunch (Salle Badiane)** **Poster session (Cloître)**	
	Chair : Joël Chevrier	
15:00 - 15:45	**Invited talk** *"Ionic Liquids: A Challenge to our Understanding of the Liquid State"*	**Susan Perkin**
15:45 - 16:00	Specific ion effects on oscillatory hydration forces, probed by atomic force microscopy	Simone van Lin
16:00 - 16:30	**Coffee break (Salle Badiane)**	
	Chair : Elise Lorenceau	
16:30 - 17:15	**Invited talk** *"Interfacial pinning, hysteresis and dynamics of a moving contact line"*	**Penger Tong**
17:15 - 17:30	Dynamics on liquid-infused surfaces	Armelle Gas-Keiser
17:30 - 17:45	Friction of solutions of polystyrene in diethyl phthalate on interfaces	Marion Grzelka
17:45 - 18:00	Wetting of complex textured surfaces.	Céline Cohen
18:00 - 18:15	Wetting of Yield-Stress Fluids	Catherine Barentin
18:30 - 19:30	**Conférence grand public : "*Pourquoi peut-on soulever une voiture avec deux annuaires ?*"**	**Frédéric Restagno**

Wednesday, October 24, 2018

Chair : José Bico

08:30 - 09:15	**Invited talk** *"Giant and explosive plasmonic bubbles by delayed nucleation"*	**Detlef Lohse**
09:15 - 09:30	Bubble bursting and air-film pinch-off in confined space: scaling and self-similarity	Ko Okumura
09:30 - 09:45	Impact of beads and drops on a repellent solid surface: a unified description	Christian Ligoure
09:45 - 10:00	Marangoni bursting	Etienne Reyssat
10:00 - 10:15	Bubbles rising in a closed capillary tube : a critical mobility	Ludovic Keiser
10:15 - 10:30	Laser-induced Marangoni flows for particle deposition	Ulysse Delabre
10:30 - 11:00	**Coffee break (Salle Badiane)**	

Chair : Pascal Damman

11:00 - 11:45	**Invited talk** *"The endless surprises of Doktor Leidenfrost"*	**David Quéré**
11:45 - 12:00	Capture of Viscous Fluids in Living Organisms	Amandine Lechantre
12:00 - 12:15	Capillary imbibition governed by water adsorption in hygroscopic plant-like structure	Meng Zhou
12:15 - 12:30	Design of a Unidirectional Water Valve in Tillandsia	Simon Gravelle
12:30 - 15:00	**Lunch (Salle Badiane)** **Poster session (Cloître)**	

Chair : Cécile Zakri

15:00 - 15:45	**Invited talk** "*Some examples of fluid and complex fluid flows near surfaces*"	**Hamid Kellay**
15:45 - 16:00	Confinement Effect on Dip-Coating of Yield-Stress Fluids	Wilbert Smit
16:00 - 16:30	**Coffee break (Salle Badiane)**	

Chair : Guillaume Miquelard-Garnier

16:30 - 17:15	**Invited talk** "*Interactions of Nanoparticles at the air/water interface*"	**Patricia McGuiggan**
17:15 - 17:30	Soft and Slippery: Thermoresponsive Polymer Coatings under Shear	Carlos Drummond
17:30 - 17:45	Intersonic sliding contact in gels	Tetsuo Yamaguchi
17:45 - 18:00	Surfactant dynamics in Droplet-based microfluidics	Jean-Christophe Baret
18:00 - 18:15	Influence of surfactants on the statics and dynamics of the wetting of oil on a solid in water	Gaëlle Rondepierre
18:15 - 18:30	Impact of surfactant on the drag reduction potential of superhydrophobic surfaces	François Peaudecerf

Thursday, October 25, 2018

Chair : Isabelle Cantat

08:30 - 09:15	**Invited talk** *" Actin filaments and Myosin II motors"*	**Jean-François Joanny**
09:15 - 09:30	Thermodynamic stability of supported lipid bilayers on atomically smooth surfaces and the effect of cholesterol	Yair Kaufman
09:30 - 09:45	Surface Waves on soft hydrogels	Pierre Chantelot
09:45 - 10:00	Surfing the capillary wave: contact propagation beneath an impacting drop	John Kolinski
10:00 - 10:15	Soap films communication: the role of the Plateau border	Adrien Bussonnière
10:15 - 10:30	Influence of evaporation on soap film rupture	Emmanuelle Rio
10:30 - 11:00	**Coffee break (Salle Badiane)**	

Chair : Jean-Pierre Delville

11:00 - 11:45	**Invited talk** *"Fluctuations of plasticity and failure of amorphous materials"*	**Jérôme Crassous**
11:45 - 12:00	Transient string formation in colloid monolayers at bubble interfaces under ultrafast deformation	Axel Huerre
12:00 - 12:15	Fabrication of Polystyrene Micro-lenses through Transient Ouzo Effect at Solid-liquid interfaces	Yuliang Wang
12:15 - 12:30	Influence of liquid substrates on the mechanics of single-layer graphene	Hervé Elettro
12:30 - 12:45	**Poster Prize**	
12:45 - 14:00	**Lunch (Salle Badiane)**	

Chair : Olivier Sandre

14:00 - 14:45	**Invited talk** *"Programmable colloidal self-assembly with DNA-coated colloids"*	**David Pine**
14:45 - 15:00	Microfluidic probing of the complex interfacial rheology of multilayer capsules	Mathilde Reyssat
15:00 - 15:15	Elastohydrodynamic measurement of soft PDMS surface using dynamic AFM	Muhammad Arshad
15:15 - 15:30	The pattern deposition of colloidal particles from a volatile liquid subject to particle adsorption and coagulation	Ofer Manor
15:30 - 15:45	Dynamic photocontrol of particle deposition in a moving meniscus	Vincent Poulichet
15:45 - 16:00	Rolling and ageing in soft adhesion of microparticles	Dražen Zanchi

Abstracts

Talks

Monday, October 22, 2018

09:45 - 10:30 **Invited talk** *"Angstrom-Scale capillaries: Water Flow"* **Radha Boya**

Radha Boya Manchester University (UK)

In nature, Å-scale biological protein channels play a crucial role controlling some of the essential life's functions by transporting ions across cellular membranes. Thus, understanding the effect of Å-scale confinement on properties of matter even as simple as water is vital for mimicking the natural systems to design efficient and smart artificial systems, by uncovering novel emergent phenomena which are unknown within our macroscopic world. Here we make use of Å-scale capillaries made by assembling 2D-materials in a layer by layer fashion, as perfect platform for studying Å-scale geometric confinement. The capillaries have atomically smooth walls and are made by scrupulous assembly tools which offer Å-scale precision in a controllable and reproducible fashion. These can be envisaged as if individual atomic planes are removed from a bulk layered crystal leaving behind flat voids of a chosen height. Water transport through the channels, ranging in height from one to several dozen atomic planes, is characterized by unexpectedly fast flow (up to 1 metre per second) that we attribute to high capillary pressures (about 1,000 bar) and large slip lengths. For channels that accommodate only a few layers of water, the flow exhibits a marked enhancement that we associate with an increased structural order in nanoconfined water. Our work opens up an avenue to making capillaries and cavities with sizes tunable to ångström precision, and with permeation properties further controlled through a wide choice of atomically flat materials available for channel walls. I will also explain how the water condensation in such tiny capillaries is affected by the confinement, and the applicability of well-known Kelvin equation at angstrom scale. Our results lay the basis for exploration of such Å-size slits in nanofluidics, molecular separation and other nanotechnologies.

10:45 - 11:00 Molecular streaming and voltage gated response in Angström scale slits
Timothée Mouterde

T. Mouterde[1], A. Keerthi[2,3], A.R. Poggioli[1], S.A. Dar[2,3], A. Siria[1], A.K. Geim[2,3], R. Boya[2,3], L. Bocquet[1]
1 - Laboratoire de Physique Statistique, Paris (FR)
2 - School of Physics and Astronomy, Manchester (GB)
3 – National Graphene Institute, Manchester (GB)

The field of nanofluidics has shown a great development over the past decade thanks to key instrumental advances, leading to a number of exotic transport behaviours for fluids and ions in extreme confinement [1-2]. Recently, van der Waals assembly of 2D materials allowed the fabrication of artificial angstrom scale channels that can be used for molecular confinement. This ultimate size reduction indeed revealed original behaviours for both mass [3] and ionic [4] transport. In this work, we report ionic molecular streaming induced by coupled pressure and voltage forcing. Under pressure and voltage forcing, we observe a new electro-hydrodynamic coupling leading to a gating-like response of the molecular streaming. This effect, observed with both boron-nitride and graphite slits, is found to be material dependent and related to the salt concentration in the channel. A potential difference of a fraction of a volt results in a mobility up to 100 times larger than the potassium mobility. This corresponds to an equivalent zeta potential three orders of magnitude higher than the gating voltage (higher than 100 V). Our results suggest that molecular scale confinement may lead to new flow control mechanisms.

1. Siria, A. et al. Giant osmotic energy conversion measured in a single transmembrane boron nitride nanotube. Nature 494, 455-458 (2013).
2. Secchi, E. et al. Massive radius-dependent flow slippage in single carbon nanotubes. Nature, 537, 210-213, (2016).
3. Radha, B. et al. Molecular transport through capillaries made with atomic-scale precision. Nature, 538, 222-225, (2016).
4. Esfandiar, A. et al. Size effect In Ion transport through angstrom-scale silts. Science, 358, 511-513 (2017).

11:00 - 11:15 Mechano-sensitive ionic conductance in conical nanopores Anthony Poggioli

Laetitia Jubin, Anthony Poggioli, Alessandro Siria, and Lydéric Bocquet
Laboratoire de Physique Statistique de l'ENS - Paris (FR)

Ion transporters in nature exhibit a wealth of complex transport properties such as voltage gating, activation, and mechano-sensitive behavior. When combined, such processes result in advanced ionic machines achieving active ion transport, high selectivity, or signal processing. On the artificial side, there has been much recent progress in the design and study of transport in ionic channels, but mimicking the advanced functionalities of ion transporters remains as yet out of reach. A prerequisite is the development of ionic responses sensitive to external stimuli. In the present work, we report a counter-intuitive and highly non-linear coupling between electric and pressure driven transport in a conical nanopore, manifesting as a strong pressure-dependence of the ionic conductance. This result is at odds with standard linear response theory and is akin to a mechanical transistor functionality. We fully rationalize this behavior on the basis of the coupled electro-hydrodynamics in the conical pore by extending the Poisson-Nernst-Planck-Stokes framework. The model is shown to capture the subtle mechanical balance occurring within an extended spatially charged zone in the nanopore. The pronounced sensitivity to mechanical forcing offers new leads in tuning ion transport by mechanical stimuli. The results presented here provide a promising avenue for the design of tailored membrane functionalities.

11:15 - 11:30 Geometric Ionic Diodes: the role of confinement Sara Dal Cengio

Sara Dal Cengio[1] and Ignacio Pagonabarraga[1,2]
1 - University of Barcelona (ES)
2 - Centre Européen de Calcul Atomique et Moléculaire (CH)

Recent experiments with electrolytes driven through conical nanopores give evidence of strong and unpredicted non-linear effects [1]. At this scale, competition between electrostatic characteristic lengths and confinement leads to selective, rectified and permeable [2-3] response resembling the rich functionalities of biological systems. In particular conical nanofluidic diodes have attracted much attention because of their ability to conduct ionic current in a preferential direction. In such devices, the asymmetry in the confinement is responsible for the non-Ohmic response, suggesting that the interplay of entropic and enthalpic forces plays a major role.

Here we present a theoretical model for ionic rectification based on the Fick-Jacobs (FJ) approach, a well-established theoretical framework to treat entropically driven transport [4]. FJ accounts for the elimination of the transversal degree of freedom by assuming a fast equilibration in this direction and treats the effect of the geometrical confinement as an external entropic potential. This flexible scheme allows to investigate the regime where the channel size is comparable to the Debye length. Local effects of nonequilibrium ion accumulation and depletion are also included. We derive formal expressions for the ionic fluxes and the concentration profiles as functions of an effective free energy including both enthalpic and entropic contributions. Moreover we investigate the dependence of the rectification efficiency on the screening Debye length and the phenomenological Dukhin length [5]. Our results show agreement with the enrichment/depletion mechanism first

proposed by Woermann [6]. In extension to the current understanding, we identify a regime where the rectification ratio, and therefore the selectivity of the channel, is driven by the surface-to-bulk ratio Dukhin number rather than the electrical double layer overlap. In the future we will exploit the present model to further investigate the role of Dukhin parameter in entropic electrokinetics as well as to address the coupling between electric and pressure driven transport which has recently proved to be highly non linear [7].

1. L.J Cheng, L.J Guo, Chem. Soc. Rev. 39, 923 (2010).
2. Z. Siwy, Adv. Funct. Mater. 16, 735 (2006).
3. E. Secchi, S. Marbach, A. Niguès, D. Stein, A. Siria, L. Bocquet, Nature Lett. 537, 210 (2016).
4. S. Martens, G. Schmid, L. Schimansky-Geier, P. Hänggi, Phys. Rev. E 83, 051135 (2011)
5. L. Bocquet, E. Charlaix, Chem. Soc. Rev. 39, 1073 (2010)
6. D. Woermann, Phys. Chem. Chem. Phys. 5, 1853 (2003)
7. L. Jubin, A. Poggioli, A. Siria, L. Bocquet, Proc. Natl. Acad. Sci. 115, 16 (2018)

11:30 - 11:45 Dynamic boundary layers in charged nanopores Marcela Rodriguez Matus

Marcela Rodriguez Matus, Zaicheng Zhang, Abdelhamid Maali, Aloïs Würger
Laboratoire Ondes et Matière d'Aquitaine – Bordeaux (FR)

The transport properties of charged capillaries or nanopores depend to a large extent on the electric double layer. They are relevant for nanofluidic circuits and biotechnology applications such as DNA sequencing.

In many instances, the underlying electrokinetic effects are coupled to a non-uniform pressure, such that the fluxes of both volume and charge are driven by the electric field and the pressure gradient . The volume flow consists of Poiseuille and electro-osmotic contributions, and the charge current is determined by the electrical conductivity and advection of the diffuse layer by the Poiseuille flow.

Here we report on a recent experimental and theoretical study of the coupling of electric current and Poiseuille flow [1]. Using a dynamic AFM oscillating close to a solid wall, we have measured the force F on a sphere mounted on the cantilever. We find a linear dependence of the inverse damping coefficient on the sphere-wall distance h, as expected from lubrication theory. When comparing data for a 50 mM electrolyte solution with those for pure water, we observe a shift by about 100 nm, which indicates an effective channel width reduced by the screening length l of the electric double layer.

In order to provide a clear physical picture, we have developped a theory for the viscous force in the presence of surface charges. The above equations for volume and charge flows are closed by Gauss' law and an advection diffusion equation for the ions. Thus we obtain the modification of the force due to charge effects, which accounts very well for the measured enhancement of the viscous response.

Our theory also provides the visco-elastic response, as a function of product of the AFM driving frequency and the relaxation time of the non-equilibrium charge distribution due to advection. Finally, we give the oscillating charge induced in the confined film.

1. M. Rodriguez Matus, Z. Zhang, A. Maali, and A. Würger, in preparation

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11:45 - 12:30 **Invited talk** *"Sliding on ice"* **Lydéric Bocquet**

Lydéric Bocquet LPS ENS Paris (FR)

The slipperiness of ice is an everyday-life phenomenon which, surprisingly, remains controversial despite a long scientific history. The very small friction measured on ice is classically attributed to the presence of a thin self-lubricating film of meltwater between the slider and the ice. But while the macroscale friction behavior of ice and snow has been widely investigated, very little is known about the interfacial water film and its mechanical properties. In this talk, I will present experimental results using a new “stroke-probe” force measurement based on a macroscopic tuning fork and allowing to unveil the microscopic

mechanisms underlying ice lubrication. This allows to simultaneously measure the shear-friction of a bead on ice and quantify the in-situ mechanical properties of the interface as well as its thickness, under different regimes of speed and temperature. Experiments unveil a surprisingly rich mechanical behavior of the interfacial film, which exhibits the visco-elastic response of a complex fluid far from pristine water, casting a new light on ice slipperiness. Hydrophobic coatings are furthermore shown to strongly reduce friction and suggest a counterintuitive hydrodynamic slippage origin, providing an unexpected explanation for waxing effects in winter sports.
Work done with L. Canale, J. Comtet, A. Niguès, C. Cohen, C. Clanet and A. Siria

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14:00 - 14:45 **Invited talk** *"Quorum sensing and cluster formation of active particles"*
Clemens Bechinger

Tobias Bäuerle, Andreas Fischer, Thomas Speck, Clemens Bechinger
University of Konstanz (DE)

An intrinsic property of motile organisms is their ability to form dynamical clusters even in the absence of long-ranged interactions. Previous experiments and simulations have demonstrated the occurrence of phase separation into large, densely packed clusters and a dilute gas phase when the density and motility of the particles is sufficiently high. In contrast to these studies, where the particle motility was kept constant in space and time, in our experiments we are able to control the motility of each single microswimmer depending on its surrounding, e.g. the local density and configuration of microswimmers. Using a light-activated system, such individual motility control is achieved by a feedback system consisting of a rapidly scanned laser beam and a real-time particle detection algorithm. We demonstrate that formation of clusters can occur already at very small particle densities, and that their shape and density can be controlled by small variations of the interactions. Our results reveal a generic route to pattern formation of motile organisms at low global densities.

14:45 - 15:00 Active Colloids confined at the gas-liquid interface Antonio Stocco

Antonio Stocco Laboratoire Charles Coulomb – Montpellier (FR)

Active motion of microswimmers or active colloids may occur in strong confinement and in complex environments. As a consequence of the particle-environment interaction, confined active colloids show specific dynamics, which are not observable in the bulk of simple liquids. Recently, we showed that the interface between two fluids act as a confinement, which dramatically affects translational and rotational dynamics of colloidal particles [1]. Here, the impact of partial wetting dynamics on the motion of active Janus colloids will be presented. Immersion depth of the Janus colloids as well as their orientation with respect to the water surface reveal complex and rich wetting properties of Janus particles at the air-water interface [2]. Active directional and circular trajectories have been observed at the interface with a motion persistence significantly enhanced by the partial wetted state of the Janus particles. This confined state impacts the in-plane and out-of-plane particle rotational diffusions, and leads to a truly two dimensional active motion [3][4].

1. Nature Materials 14, 908 (2015).
2. Faraday Discussions 191, 305 (2016).
3. Soft Matter 11, 7376 (2015).
4. Langmuir 33 (48), 13766 (2017).

15:00 - 15:15 Active emulsions in confined geometries: from self propulsion to division cascades Corinna C. Maass

Corinna C. Maass, Kyle A Baldwin, Babak Vajdi Hokmabad
Max Plank Institute of Dynamics and Self-Organization (DE)

Active emulsions of nematic liquid crystals in micellar surfactant solutions are a flexible and well controlled model system for microswimmers, exhibiting a wealth of features like helical swimming, convection driven clustering, chemotaxis and autochemotaxis. Their propulsion is driven by Marangoni stresses caused by self-supporting instabilities in the interfacial surfactant coverage. Generally, such surface tension variations should deform the droplet interface, but we have not seen measurable deviations from a spherical shape for 50µm droplets in Hele-Shaw cells due to strong capillary forces. However, in experiments using squeezed droplets, i.e. larger, more disk-shaped objects in strong two-dimensional confinement, capillary forces are weakened due to an effective switch from areal to line tension and a decrease of the deformable interface to volume ratio. In this state, the system exhibits a wealth of shape and dynamical instabilities, characterised by multipolar Marangoni instabilities, visible deformation during self propulsion and a spontaneous self division cascade for arrested droplets.

15:15 - 15:30 Bacteria swimming in droplets of liquid crystal Martyna Goral

Martyna Goral[1,2], Teresa Lopez-Leon[2], Anke Lindner[1]
1 – Physique et Mécanique des Milieux Hétérogènes – Paris (FR)
2 – Laboratoire Gulliver – Paris (FR)

Bacteria are considered as a model system of active particles for the understanding of collective motion. Interactions with each other or with the surrounding medium can lead to non-trivial macroscopic behavior. Bacterial active motion can for example change the viscosity of bacteria suspensions [1], but the suspending medium itself can also trigger the emergence of new collective bacterial dynamics. Interesting spatio-temporal patterns have recently been observed in nematic liquid crystals, where the motion of bacteria is directed by the orientational molecular order of the liquid crystal [2].

In this work, we study bacterial motion in spherical droplets of nematic liquid crystals, where topological constraints enforce the formation of orientational vortices (topological defects) in the liquid crystal. To produce the droplets, we use microfluidic techniques, which allow us to have high control on the size of the droplet, and therefore, on the curvature of the confining space. The droplets are made of a lyotropic chromonic liquid crystal (LCLCs) in which rod-like bacteria are dispersed. We expect to observe the emergence of complex swimming dynamics resulting from the coupling between the bacterial motion and the orientational field: the field guides the bacteria that in turn modify the field.

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15:30 - 15:45 Phototactic swimming of multicellular microalgae Hélène de Maleprade

Hélène de Maleprade[1], Frédéric Moisy[2], and Raymond E. Goldstein[1]
1 – Department of Applied Mathematics and Theoretical Physics – (UK)
2 – Fluides, Automatique et Systèmes Thermiques – Paris (FR)

The unicellular algae Chlamydomonas shows two flagella, whose beating enables it to swim in a stroke and move towards light, a nowadays widely studied behaviour favouring photosynthesis. If the phototactic response of a single cell is rather well understood, the case of multicellular colonies has not yet been described. Indeed, in the absence of central nervous system, how can each cell adapt its phototactic answer with its neighbours, in order to swim in the most efficient way towards light? Experiments realised on colonies of Gonium Pectorale, made of 16 cells close to Chlamydomonas, show a strong phototactic behaviour, as colonies are able to turn within a couple of seconds and swim towards light. Observation of the flagella of cells exposed to the incident light or in the shadow enables to better understand the underlying mechanisms, based on a dramatic change in both beating frequency and shape. We also develop a theoretical model inspired by the adaptive response of Chlamydomonas to explain the phototactic swimming of these colonies.

15:45 - 16:00 Swimming under pressure Catherine Quilliet

Catherine Quilliet, Gwennou Coupier, Adel Djellouli, Philippe Marmottant
Laboratoire Interdisciplinaire de Physique – Grenoble (FR)

Swimming at small scale generally happens at low Reynolds number (viscous regime) and thus requires non-reciprocal strokes, /i.e./ the deforming body follows a sequence of shapes which are not the same back and forth. A deflation-reinflation cycle, now known to induce buckling and an hysteresis in the shape of the shell it is submitted to, seemed then to be a simple and elegant way to remotely power a displacement on a microscopic object in a fluid. The first experiments in this purpose were upscaled in order to allow a careful study of swimming through buckling. They showed the importance of postbuckling shape oscillations, that can boost the swimming for some values of the dimensionless numbers to be considered. The whole study led to a model that draws the big lines for the conception of a steerable nanosubmarine, the first results on which will be presented.

16:30 - 17:15 **Invited talk** "*Sounds and stubbornness of colloidal flocks*" **Denis Bartolo**

Denis Bartolo ENS Lyon (FR)

I will first show how to engineer spontaneously flowing colloidal liquids. Simply put, our strategy consists in letting self-propelled colloids with velocity-alinement interactions to collide. After a short transient they self-assemble into liquids with emergent long-range orientational order which translates into spontaneous unidirectional flows. I will then devote most of my talk to discussing the fluctuations and the dynamical response of these intrinsically non equilibrium materials. (i) I will show that both density and velocity fluctuations almost freely propagate along all directions and exploit these sound modes to infer the analogous of the Navies Stokes equation for active fluids. (ii) I will finally discuss the robustness of their spontaneous flows to external pressure gradients. I will evidence that (french) colloidal flocks can be collectively stubborn when one tries to waive their privilege to freely choose their direction of motion.

17:15 - 17:30 Self-organisation of swimming droplets through inelastic collisionsPierre Illien

Pierre Illien, Charlotte De Blois, Olivier Dauchot ESPCI – Paris (FR)

Self-organisation in biological systems has inspired the design of microscopic autonomous systems. Assemblies of such 'active' particles usually display intriguing properties, like dynamic clustering or collective migration. However, the theoretical description of these properties usually relies on effective descriptions of the interactions between the active agents, and ignore the microscopic details of the system. Recent experimental results on a model system of swimming droplets confined in a one-dimension channel show that inelastic collisions and relaxation to a nominal velocity are sufficient to trigger clustering and collective motion. Starting from the microscopic dynamics of this system, and inspired by paradigmatic lattice models of interacting particles, we develop a theoretical framework to describe the onset to collective motion, and reveal how the competition between inelasticity and activity triggers self-organisation.

17:30 -- 17:45 Self-propelled droplets on fibers of different geometry Tak Shing Chan

Tak Shing Chan, Andreas Carlson Department of Mathematics – Olso (NO)

Plants and insects use substrate geometry as a mode to transport droplets. In this numerical study, we show how the fiber geometry influences the speed of a self-propelled droplet by using the boundary element method. The droplet shape and the flow fields in the droplet are computed, which allow us to develop a theoretical model where we couple the fiber shape, the droplet volume, capillarity and viscous forces. We then identify the forces that maintain the motion of the droplet.

17:45 -- 18:00 Self assembly materials for hair surface applications Gustavo S. Luengo

Gustavo S. Luengo L'Oréal Recherche and Innovation, Aulnay sous Bois (FR)

In cosmetic science a great diversity of materials are used to protect or improve the structural and sensorial properties of hair. From shampoos to lacquers or gels, materials are used commonly used to perform a particular function (mechanical , optical, etc.) upon adsorption and/or penetration in the fiber or either after a particular change in a external conditions that may trigger its activation (temperature, weathering, etc.).

Knowledge of the structure and nature of hair is essential if we want to clearly determine the degree of improvement of its physical properties. This description will be further illustrated with a few examples of our current research efforts deciphering the physical chemical and tribological properties of hair at the bulk and surface level and at the macro, micro and sub-microscopic scale.

For hair's surface repair we will describe the nature and properties of polymers commonly used in shampoos and conditioners. Alternatively, in the case of fiber reinforcing materials, we will focus on our recent sol-gel based strategies to allow the penetration of big macromolecular materials. In particular our studies on reactive sol–gel systems, leading to the identification of the 3-aminopropyltriethoxysilane. Smaller than polymers, this silane has been studied on the key question of the penetration and mechanical reinforcement. Our examples will show how these materials can be effectively tuned to the consumer's advantage.

18:00 - 18:45 **Tribute to Elisabeth**

Marie-Charlotte Audry-Deschamps, Cécile Cottin-Bizonne,
Cyril Picard et Audrey Steinberger

Marie-Charlotte Audry-Deschamps	Institut des Nanotechnologies de Lyon (FR)
Cécile Cottin-Bizonne	Institut Lumière Matière - Lyon (FR)
Cyril Picard	Laboratoire Interdisciplinaire de Physique – Grenoble (FR)
Audrey Steinberger	Laboratoire de Physique – Lyon (FR)

From boundary slippage to porous media we will illustrate, through a few examples, Elisabeth's capacity to develop innovative approaches to reach deep understanding on fundamental questions and inspire scientists around her.

Tuesday, October 23, 2018

08:30 - 09:15 **Invited talk** *"Charge generation at mineral-electrolyte interfaces: from microscopic ion adsorption to local viscosity enhancement and macroscopic wettability alteration"* **Frieder Mugele**

Frieder Mugele University of Twente (NL)

The generation of charge at the interface between oxides surfaces and aqueous electrolytes is a complex process that involves protonation/deprotonation reactions, adsorption and desorption of ions as well as hydration and dehydration processes. In this lecture, I will discuss insights from Atomic Force Microscopy experiments on the surface charge of various mineral surface (silica, gibbsite, mica) upon immersion into aqueous electrolytes of variable composition. I will show in particular how the majority of the intrinsic charge density of such surfaces is typically screened within the Stern layer, leaving only a fraction of the available surface sites effectively charged if probed at colloidal scale distances of a few nanometers. This charge compensation process involves both strongly adsorbed counterions as well as hydroxyl and hydronium ions. For the specific case of silica-electrolyte interfaces, the resulting double layer structure gives rise to an enhanced effective viscosity within a few nanometers from the surface at elevated pH. For mica-electrolyte interfaces, the adsorption of divalent cations leads to charge reversal and the adsorption of heavy alkali cations (Rb^+, Ca^+) disrupts the intrinsic layers hydration structure of the solid. Both processes have important consequences for the macroscopic wettability of the interfaces: in contrast to pure water, which completely wets mica in ambient oil, solutions of strongly adsorbing cations display a transition from complete to partial wetting with macroscopic contact angles exceeding 10°beyond a certain threshold concentration. The altered chemical composition of the surface also promotes the secondary adsorption of polar components if dissolved in the oil. This leads to autophobing with contact angles up to 70° and self-propelled motion of electrolyte droplets. The latter process is driven by the deposition of a self-assembled monolayer of surfactant at the solid surface and is believed to play an important role in technological processes such as the recovery of oil from fossil reservoirs.

09:15 - 09:30 Charge Regulation and Stern Layer Properties at the Solid-Liquid Interface: Ion Specific Effects Alexander Smith

Alexander Smith, Plinio Maroni, Michal Borkovec, Gregor Trefalt University of Geneva (CH)

Direct force measurements were carried out using an Atomic Force Microscope (AFM) to study the charge regulation and Stern layer properties at the solid-liquid interface [1]. The forces between silica and sulfate latex particles were measured in LiCl, NaCl, KCl, and CsCl solutions. The measured force profiles were interpreted with Poisson-Boltzmann theory, which enables extraction of the diffuse layer potential and regulation parameter for the surface. These two parameters enable calculation of the properties of the inner layer, such as Stern layer capacitance and Stern layer thickness. We find that the Stern layer capacitance increases with salt concentration and strongly depends on the type of ion. The largest capacitances are observed in CsCl and are decreasing in the KCl, NaCl, LiCl order, which is consistent with the direct Hofmeister series. These trends can be understood when the Stern layer thickness is calculated from the Stern layer capacitances. The Stern layer thickness correlates with the hydrated cation radius, hence determining the inner layer capacitance and charge regulation properties of the solid-liquid interface. The Stern layer properties extracted from force measurements are in agreement with recent experiments based on X- ray photoelectron spectroscopy in a liquid microjet [2,3].

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09:30 - 09:45 Testing dielectric continuum theory at interfaces by atomistic simulations

Philip Loche

Philip Loche[1], Schlaich Alexander[1,2], Roland Netz[1]
1 – Department of Physics – Berlin (DE)
2 – Université de Grenoble (FR)

Based on fully atomistic simulations of ions in water, we discuss the validity of continuum models for the dielectric response at aqueous interfaces. For the electrostatic energy of an ion in the vicinity of a hydrophobic graphene surface we find the electrostatic contribution to be dominated by the non-electrostatic contribution. Linear dielectric theory breaks down, and to quantitatively describe the linear dielectric contribution an anisotropic tensorial dielectric model is needed. This demonstrates the limitation of current continuum models for the dielectric response at interfaces.

09:45 - 10:00 Yukawa fluids and solids near hard walls: Evidence for a pre- freezing transition

Mojtaba Eshraghi

Mojtaba Eshraghi, Jürgen Horbach
Heinrich-Heine-Universität – Dusseldorf (DE)

For hard spheres, confined between hard walls, a pre-freezing has been observed in computer simulations [1,2], i.e., there is the formation of one or more crystalline wetting layers at the walls slightly below the saturation pressure. Here, we show that for charged colloids confined between hard walls similar phenomena are seen, albeit much more pronounced than in the hard sphere system. Charged colloids are modeled regarding a hard-core Yukawa potential, and we focus on states around the coexistence between a fluid and a body-centered cubic (BCC) crystal [3]. In all cases, a pronounced layering in the vicinity of the hard walls is observed.

Using a thermodynamic integration scheme [4], we determined the wall-fluid interfacial free energy which is negative and monotonously decreasing with increasing bulk density of the fluid. In the case of the fluid, the layers next to the walls undergo a transition from a fluid to a hexagonal structure. This pre-freezing transition occurs well below the coexistence bulk density of the fluid. The confined BCC crystal in (111) orientation shows melted regions between face-centered cubic (FCC) layers close to the wall and the BCC bulk region.

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10:00 - 10:15 Cavitation in nanoporous materials

Alberto Giacomello

Antonio Tinti, Alberto Giacomello, Carlo Massimo Casciola
Dipartimento di Ingegneria Meccanica e Aerospaziale, Rome (IT)

Hydrophobic nanoporous immersed in water are emerging as promising means to store or dissipate energy [1,2]. In such applications, the surface energy is accumulated during liquid intrusion achieved by increasing the water pressure and can be subsequently released by decreasing pressure and triggering cavitation inside the pores. Given the extreme confinement, which for zeolites and some kinds of silicates can be below the nanometer, the phenomena of liquid intrusion and cavitation are expected to significantly deviate from the classical macroscopic laws: cavitation can happen at pressures as high as 10 MPa [2].

In this contribution [3], we study via molecular dynamics the nucleation of a vapor cavity inside nanometer-sized hydrophobic pores and the opposite process of liquid intrusion. By employing advanced rare-event techniques in order to tackle the long timescales typical of vapor nucleation, we obtain molecular-level insights into nanoconfined cavitation (and liquid intrusion) avoiding simulation artifacts [4]. In addition, in silico intrusion and extrusion experiments, in which the water pressure is increased and subsequently released, are presented. The simulation campaign reveals deviations from the macroscopic Kelvin-Laplace law for liquid intrusion in a capillary and a significant increase of the cavitation rate as compared to the predictions of the classical nucleation theory, which can be related to line contributions. Furthermore, the behavior of nanoporous materials as "molecular springs" or as vibration dampers is critically discussed and related to their physical characteristics.

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10:15 - 10:30 Enhanced oxygen solubility in metastable capillary condensed water under tension Pierre Lidon

Pierre Lidon[1], Abraham Stroock[1], Waren Zipfel[2], Rebecca Williams[2], and Justin Wilson[3]
1- School of Chemical and Biomolecular Engineering, Cornell (US)
2 – Department of Biomedical Engineering, Cornell (US)
3 – Department of Chemistry and Chemical Biology, Cornell (US)

In terrestrial conditions, bulk liquid water generally evaporates into the atmosphere. Consequently, most of liquid water is found trapped within pores of plants, soils or tissues: confinement and curvature of liquid/air menisci then allows liquid water to reach an equilibrium with the unsaturated atmosphere. In these conditions, the relative humidity of the atmosphere determines the curvature of the menisci which in turn impose the pressure in the liquid phase, which can be reduced down to strongly negative values of hundreds of megapascals under nanoconfinement.

Despite its high relevance for various physico-chemical processes in natural and technological contexts, the properties of this state are still no fully understood. In this talk, I will present an experiment which allowed us to characterize the solubility of dioxygen in liquid water trapped in nanoporous media, in equilibrium with an atmosphere of controlled humidity. We report a significant two-fold increase of concentration when humidity is decreased to 55% (corresponding to about -70MPa).

We interpret this increase as a consequence of a decrease of the solvent pressure, based on simple arguments from thermodynamics based on bulk properties of liquid water. Such a model has previously been validated experimentally for solvent under positive pressure and we thus show that it surprisingly remains valid under negative pressure and strong confinement. [1]

11:00 - 11:45 **Invited talk** "Hydration friction in nano-confinement: from bulk via interfacial to dry friction" **Roland Netz**

Roland Netz Free University of Berlin (DE)

We study the shear friction between hydrophilic surfaces by non-equilibrium molecular dynamics simulations. With decreasing water film thickness we find three consecutive friction regimes: For thick films friction is governed by bulk water viscosity. At intermediate separations of about a nanometer the highly viscous interfacial water layers dominate and increase the surface friction, while at the transition to the dry friction limit interfacial slip sets in. We propose a confinement-dependent model that accounts for the additive friction contributions from bulk-like water, interfacial water layers and interfacial slip.

11:45 - 12:00 Friction across molecular films of ionic liquid Romain Lhermerout

Romain Lhermerout, Susan Perkin
Physical and Theoretical Chemistry Laboratory – Oxford (UK)

Friction is of crucial importance in a number of practical situations (walking, car brakes, matches, violin), and in applications related to the energy issue (engines, wind turbines etc.). Despite having been studied for over five centuries, a quantitative understanding is still lacking. A first difficulty is that most real solid surfaces are rough, leading to non-trivial collective behaviors between multiple asperities. Secondly, when the lubricant separating two sliding surfaces forms a nano-confined film, continuum theories are challenged and friction is governed by subtle mechanisms at molecular scale [1]. Ionic liquids, which are pure salts that are liquid in ambient conditions, have recently been considered as promising lubricants, not only because of their exceptional physico-chemical stability (low vapor pressure, wide electrochemical window) but also due to their ability to sustain high loads without being squeezed-out as well as their relatively low friction coefficients. In particular, ionic liquids tend to order in alternating cation/anion layers in the vicinity of charged surfaces, with a friction coefficient indexed by the number of layers (phenomenon reported as "quantized friction") [2].
An ideal tool to tackle this problem is the Surface Force Balance. First, cleaving mica makes possible to produce macroscopic surfaces that are smooth down to the molecular scale, and hence to study friction on a single contact. Then, white light interferometry coupled to piezoelectric elements allows controlling the confinement of the liquid with a precision better than the molecular scale. There, normal and lateral forces are measured using springs. In this talk, I will report on a new measurement protocol that allows for an instructive exploration of friction across ionic liquids.

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12:00 - 12:15 Modeling Adsorption and Transport in Multiscale Porous Media Alexander Schlaich

Alexander Schlaich, Benoit Coasne
Laboratoire Interdisciplinaire de Physique – Grenoble (FR)

Porous materials combining several porosity scales, such as hierarchical zeolites, are widely used in industry for adsorption, separation or catalysis to overcome slow diffusion in strongest confinement (< 2 nm) and enhance access to the materials large surface area. Available modeling approaches for adsorption and transport in such multiscale porous media are limited to empirical parameters which cannot be derived from molecular coefficients.
In particular, existing approaches do not offer the ground for a bottom up model of adsorption/transport in multiscale materials as (1) they describe empirically the adsorption/transport interplay and (2) they do not account for the molecular details for hydrodynamics at the nm scale. We use atom-scale molecular simulations to obtain explicit relations between adsorption and the transport coefficients, which capture different regimes upon varying the temperature, pore size, pressure, etc and compare to typical models. We present a multiscale lattice model of adsorption and transport in hierarchical materials taking explicitly into account the adsorption and for which the transport coefficients can be rigorously obtained from simple models in the framework of Statistical Mechanics. As first application, we show how such a model can be employed to optimize the recovery of liquids confined in a nanoporous material.

12:15 - 12:30 Unraveling the role of insoluble impurities on radial interfacial flows
Thomas Bickel

Thomas Bickel Laboratoire Ondes et Matière d'Aquitaine – Bordeaux (FR)

We investigate theoretically the flow of a viscous incompressible liquid due to a jet-like source located near a free interface. The liquid is injected at low Reynolds number at some distance H below the interface. The presence of surface-active molecules irreversibly adsorbed onto the interface then strongly modifies the flow. The nonlinear coupling with the surface concentration is characterized analytically. It is shown that, as soon as impurities are present, the flow acquires a toroidal structure. The coupling is quantified by the (dimensionless) surface compressibility B. In the regime 0< B< 1, the concentration decays continuously in the vicinity of the origin, whereas for B> 1, surfactant molecules are entirely depleted from a circular region. Issues regarding the stability of the flow will also be discussed.

12:30 - 15:00 Poster session (Cloître)

15:00 - 15:45 **Invited talk** *"Ionic Liquids: A Challenge to our Understanding of the Liquid State"*
Susan Perkin

Susan Perkin University of Oxford (UK)

Particle and surface interactions in electrolytes underpin the behavior of many systems in soft and biological matter, electrochemical devices, and materials science. Of particular recent interest are electrolytes at very high concentration, and the extreme case of *ionic liquids*: solvent-free salts in the liquid state under ambient conditions. Recent work has illuminated several important gaps in our understanding of interactions in concentrated electrolytes, together presenting fascinating puzzles for those interested in the nature of the (ionic) liquid state.

In my laboratory we perform high-resolution measurements of the force between uniform charged surfaces across liquids using a Surface Force Balance (SFB), and in this talk I will present some examples of recent experiments with highly concentrated electrolytes and ionic liquids. Measurements of structure in the confined liquid show a switch in wavelength at a characteristic ion density indicating a transition from solvent- to ion-determined correlation length[1]. Beyond the structural region an anomalously long electrostatic screening length is observed which *increases* with increasing volume fraction of ions in direct contrast to predictions of standard theories of dilute electrolyte[2,3].

To finish, I will outline new procedures under development in my laboratory to measure properties and interactions in liquids and soft matter confined to nanoscopic films between two atomically smooth graphene electrodes[4,5]. By polarizing the two graphene electrodes with opposite sign, an electric field can be applied across nano-films of liquid. This provides a new method for directly measuring the influence of electric fields on the optical and mechanical properties of nanoconfined liquids.

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15:45 - 16:00 Specific ion effects on oscillatory hydration forces, probed by atomic force microscopy
Simone Van Lin

Simone Van Lin, Igor Siretanu, Frieder Mugele University of Twente (NL)

High resolution AFM spectroscopy was used to investigate the oscillatory hydration forces at mica-electrolyte interfaces for the chloride salts of alkali cations for concentrations up to 4M. Pronounced force oscillations reflecting the layering in purified water are modified in an ion specific manner beyond an ion-dependent threshold concentration. While only a slight enhancement of the oscillatory forces is seen for the so-called kosmotropic (`structure forming') ions Na+ and K+, the force oscillations completely disappear for the chaotropic (`i.e. `structure-breaking') ions Cs+ and Rb+ suggesting a disruption of the hydration layers.

16:30 - 17:15 **Invited talk** *"Interfacial pinning, hysteresis and dynamics of a moving contact line"* **Penger Tong**

Penger Tong*
Department of Physics, Hong Kong University of Science and Technology (HK)

Contact angle hysteresis (CAH), where the motion of a contact line between a liquid interface and a solid substrate is pinned by the physical roughness and/or chemical inhomogeneity on the solid surface, is an outstanding problem in interfacial dynamics and has been with us for many years. Despite of numerous efforts, one still has a poor understanding of CAH on many ambient solid surfaces of interest. The study of CAH is of fundamental interest for our general understanding of a common class of problems involving elastic dynamics in random force fields and has immense practical applications in tertiary oil recovery, drag reduction, advanced materials and microfluidics. In this talk I will present our recent experimental efforts in developing an atomic force microscope (AFM) based hanging fiber probe for the study of contact line dissipation and pinning-depinning dynamics [1-3]. With this new technique, AFM is used as a force sensor to measure the speed-dependent capillary force hysteresis and relaxation of a moving contact line formed on a long vertical glass fiber of a few microns in diameter with one end glued onto a AFM cantilever and the other end in contact with a liquid-air interface. Applications of this technique to the study of contact line dissipation and wetting dynamics will be discussed.
*Work done in collaboration with Dongshi Guan, Yongjian Wang, Elisabeth Charlaix and was supported by the Research Grants Council of Hong Kong SAR.

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17:15 - 17:30 Dynamics on liquid-infused surfaces Armelle Gas- Keiser

Armelle Keiser[1], Christophe Clanet[1,2], David Quéré[1,2]
1 – Physique et mécanique des milieux hétérogènes – Paris (FR)
2 – Laboratoire d'Hydrodynamique – Palaiseau (FR)

Trapping a thin liquid film in the roughness of a micro-textured material creates a surface partially solid and partially liquid, referred to as a lubricant-impregnated surface (LIS). Such surfaces have recently raised a great interest, flowing to their promising industrial applications. Indeed, they proved to drastically reduce adhesion of a broad range of liquids, leading to enhanced mobility, and strong anti-biofouling, anti-fogging, and in some cases anti-icing properties. In addition, they can self-heal and resist drop impact. During this talk I will highlight the originality of those surfaces, found to be very different from either pure solid or pure liquid substrates. A special attention will be given to the meniscus that surrounds drops deposited on LIS. Through canonical experiments (drops sliding on an incline, dewetting of a thin film), I will illustrate how the combination of texture and lubricant leads to very unique dynamics.

17:30 - 17:45 Friction of solutions of polystyrene in diethyl phthalate on interfaces

Marion Grzelka

Marion Grzelka, Marceau Hénot, Liliane Leger, Frédéric Restagno
Laboratoire de Physique des Solides – Paris (FR)

Friction of polymers has been actively studied for its importance in many fields such as assisted oil recovery, biology or lubrication. Depending on the chemical properties of the flowing polymers and of the surfaces, polymers may exhibit an adhesive behavior thanks to the entanglement of the polymer chains, or an anti-adhesive behavior, as for antifouling treatment.

The slippage of polymer melts is now well understood. In particular, Hénot et al. have investigated the dependence of the slip length on the viscosity of the sheared polymer melt [1]. The linearity between the slip length and the viscosity of polymer melts predicted by de Gennes has been observed. Moreover, they proved that the friction coefficient of melts does not depend on the length of the polymer chains. Thus the friction of polymer melt is due to the friction of monomers on the surface.

Moreover, shearing polymer melts on polymer brushes is known to change the conformation of polymer brushes. An indirect evidence of this change of conformation is the existence of different regimes of slippage depending on the shear rate [2]. More precisely, a transition from a small to a large slip regime has been reported. For low shear rates, the polymer chains of the melt stretch the grafted chains, but the grafted chains relax rapidly enough so that the number of entanglement between grafted chains and melt remains constant. Therefore, the force friction between melt and brush is high and there is a small slippage close to the brush. For higher shear rates, the polymer chains of the melt can disentangle from the grafted chains, the force friction decreases and the slippage increases.

Even though the impact of shearing of melts on polymer brushes has been observed, shearing of polymer solutions on polymer brushes has not been studied in much detail. With solutions, the concentration of the solutions is an important parameter since it can change, even at rest, the interdigitation between the chains anchored to the surface and the solution. Furthermore, as the local concentration is not necessarily fixed, depletion layer may appear. [1]

The disentanglement and depletion are competing.

We will present the results of experiments of friction of polystyrene in diethyl phthalate on a polystyrene brush and on a silicon wafer. We investigate the dependence of the slip length on concentration of the solutions in the Newtonian and the shear-thinning regimes.

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17:45 - 18:00 Wetting of complex textured surfaces.

Céline Cohen

Céline Cohen, Yann Bouret, Xavier Noblin
Institut de Physique de Nice – Nice (FR)

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-at surfaces [1, 2].

We present here a novel fabrication method to obtain new complex superhydrophobic surfaces: transparent, curved and textured. This method consist in taking 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. The aim of our study is then to study wetting properties (advancing and receding contact angles) of those complex surfaces with unconventional method: the capillary bridge technics [3]. Indeed, to our knowledge, apparent contact angles on superhydrophobic surfaces were measured so far using a goniometer in combination with a video camera and a drop shape analysis. Recent experiments of Schellenberger et al. [4] show that this method can significantly underestimate apparent advancing contact angle. We have used capillary bridge setup to explore textured superhydrophobic surfaces and show that both receding and ad- vancing contact angle increase with decreasing of pillar density. In addition, comparing, those measures with ones realized with a classical sessile drop setup, we show that advancing apparent contact angles measured with capillary bridge technic are systematically higher than ones measure with sessile drop method which is in good agreement with Schellenberger et al. experiments. Moreover, wetting behavior of our surfaces observed with capillary bridge measurement could been explained with the Kink model proposed recently by Rivetti et al. [5]. Finally, capillary bridge experiments allow to explore wetting contact area much bigger than contact area generally explored with a simple millimetric droplet. This allows us to observe new impalement transition behaviors as function of experimental conditions.

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4. Schellenberger F., Encinas N., Vollmer D., Butt H. J., Physical review letters, 116(9), 096101,2016.
5. Rivetti M.., Teisseire J., Barthel E.,, Physical review letters, 115 (1), 016101., 2015.

18:00 - 18:15 Wetting of Yield-Stress Fluids Catherine Barentin

Catherine Barentin and Loren Jorgensen Institut Lumière Matière – Lyon (FR)

Yield-stress fluids such as emulsions, polymer microgels or foams exhibit interesting mechanical properties depending on the applied stress: they behave like an elastic solid below a critical stress called "yield stress" and flow like a liquid above it. This intermediate solid/liquid behavior makes them particularly interesting for applications but fundamentally difficult to describe.

In this talk, I will study the wetting properties of yield stress fluids and especially the spreading of a yield-stress-fluids droplet on a solid surface. In the case of simple fluids, this experiment is classical and the corresponding Young-Dupré wetting law is well known. Here I will study the influence of the yield stress on the final contact angle and show the strong impact of the dynamical history and of the boundary conditions. More importantly, I will show that exploring the competition between surface tension, which is an equilibrium property, and yield stress effects that often keep the system out of thermodynamical equilibrium due to a dynamical arrest is possible as soon as force balances are performed [1,2] . Finally I will extend Young Dupré law to the case of yield-stress fluids.

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18:30 - 19:30 **Conférence grand public** : *"Pourquoi peut-on soulever une voiture avec deux annuaires ?"* **Frédéric Restagno**

Frédéric Restagno Laboratoire de physique des solides – Paris (FR)

Les frottements sont cette chose à la fois insupportable quand ils provoquent le grincement d'une porte, et indispensable quand l'hiver on se retrouve à glisser sur une plaque de verglas. Malgré l'intérêt pratique de maitriser la glisse, les mécanismes microscopiques du frottement restent largement mal compris. Pourtant, des scientifiques prestigieux comme Léonard de Vinci ou Charles Coulomb ont essayé d'en percer les mystères... Dans cette conference faisant une part belle aux expériences, nous reproduirons l'expérience historique de Vinci décrite dans ses carnets avant de tenter de comprendre pourquoi il est possible de soulever une voiture avec deux annuaires entremêlés.

Wednesday, October 24, 2018

8:30 - 09:15 **Invited talk** *"Giant and explosive plasmonic bubbles by delayed nucleation"*

Detlef Lohse

Yuliang Wang[1,2], Mikhail E. Zaytse[1,3], Guillaume Lajoinie[1,4], Hai Le Thed[5], Jan C. T. Eijkeld[5], Albert van den Bergd[5], Michel Versluisa[4], Bert M. Weckhuysen[6], Xuehua Zhangg[7,1], Harold J. W. Zandvliet[3], and Detlef Lohse[1,7]
1 - Physics of Fluids & J.M. Burgers Centre for Fluid Mechanics – Twente (NL)
2 - School of Mechanical Engineering and Automation – Beijing (CN)
3 - Physics of Interfaces and Nanomaterials – Twente (NL)
4 - MIRA Institute for Biomedical Technology and Technical Medicine - Twente (NL)
5 - BIOS Lab-on-a-chip – Twente (NL)
6 - Inorganic Chemistry and Catalysis - Utrecht (NL)
7 - Department of Chemical and Materials Engineering – Alberta (CA)
Max Planck Institute for Dynamics and Self-Organization – Göttingen (DE)

When illuminated by a laser, plasmonic nanoparticles immersed in water can very quickly and strongly heat up, leading to the nucleation of so-called plasmonic vapor bubbles, which have huge application potential in e.g. solar light-harvesting, catalysis, and for medical applications. How do these bubbles form and what is their gas composition? Whereas the long-time behavior of such bubbles has been well-studied, here, by employing ultra-high-speed imaging, we reveal the nucleation and early life phase of these bubbles. After some delay time τ_d after beginning of the illumination, a giant bubble explosively grows, up to a maximal radius of 80 *μm*, and collapses again within ≈ 200*μs* (bubble life phase 1, see figure 1). The maximal bubble volume $Vmax$ remarkably increases with decreasing laser power P_ℓ. To explain this behavior, we measure the delay time τ_d from the beginning of the illumination up to nucleation, which drastically increases with decreasing laser power, leading to less total dumped energy $E = P_\ell \tau_d$. This dumped energy E shows a universal linear scaling relation with V_{max}, irrespectively of the gas concentration of the surrounding water. This finding supports that the initial giant bubble is a pure vapor bubble. In contrast, the delay time does depend on the gas concentration of the water, as gas pockets in the water facilitate an earlier vapor bubble nucleation, which leads to smaller delay times and lower bubble nucleation temperatures. After the collapse of the initial giant bubbles, first much smaller oscillating bubbles form out of the remaining gas nuclei (bubble life phase 2, up to typically 10*ms*). Then the known vaporization dominated growth phase takes over and the bubble stabilizes (life phase 3). In the final life phase 4 the bubble slowly grows by gas expelling due to heating of the surrounding. In this final growth phase the bubble behavior is distinctly different for air-equilibrated water and degassed water, which we attribute to the uptake of dissolved gas expelled from the water around the hot nanoparticle. Our scaling analysis reveals that the bubble radius scales with time as $R(t) \infty t^{1/3}$ for air-equilibrated water and is constant for perfectly degassed water. These scaling relations are consistent with the experiments.* – Our findings on the initial explosive growth and collapse during the early life phase of a plasmonic vapor bubble have strong bearings on possible applications of such bubbles, affecting their risk assessment.

1. Y. Wang et al., ACS Nano 11, 2045 (2017)

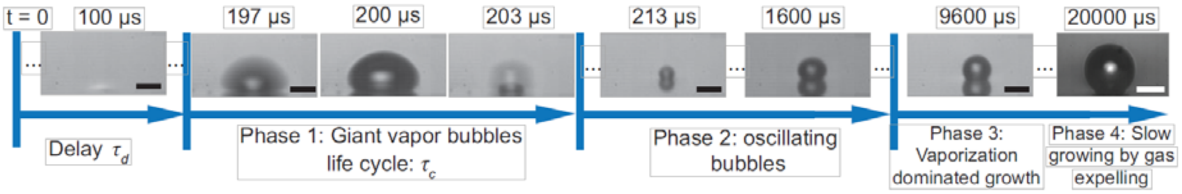

Fig. 1. Time sequence of the bubble dynamics under continuous laser irradiation on the patterned gold nanoparticle sample surface in gas-rich water and P_l = 83 mW. According to their nucleation and growth dynamics, the evolution of the plasmonic bubbles is divided into four phases. The scale bar is 25 m.

09:15 - 09:30 Bubble bursting and air-film pinch-off in confined space: scaling and self-similarity

Ko Okumura

Ko Okumura Ochanomizu University (JP)

We first discuss an unusual type of bubble bursting occurring in between two confining plates. This bursting, governed by viscosity, proceeds at a constant speed and the bursting tip does not grow [1]. We also discuss the crossover of this viscous regime to an inertial regime. Second, we discuss two-dimensional pinch-off of air sheet surrounded by viscous liquid that leads to an exactly solvable case of self-similar dynamics of a topological transition: scaling functions for velocity and shape are both analytic and precisely describe experimental observations [2]. If the time allows, we also discuss various dynamics associated with drops and bubbles in Hele-Shaw cells [3], such as thinning of liquid film surrounding a bubble [4], coalescence of liquid drops [5,6] and viscous friction acting on fluid drops [7,8].

1. M. Murano and K. Okumura, Phys. Rev. Fluids (Rapid Comun.) 3, 031601R (2018);
2. H. Nakazato, Y. Yamagishi, and Ko Okumura Phys. Rev. Fluids (2018, in press);
3. K. Okumura, Adv. Colloid Interface Sci. (2017, in press); https://doi.org/10.1016/j.cis.2017.07.021;
4. A. Eri and K. Okumura, Phys. Rev. E (Rapid Commun.) 76 (2007) 060601R;
5. M. Yokota and K. Okumura, Proc. Nat. Acad. Sci. (U.S.A.), 108:6395 (2011);
6. A. Eri and K. Okumura, Phys. Rev. E (Rapid Commun.) 82, 030601R (2010);
7. A. Eri and K. Okumura, Soft Matter, 7, 5648 (2011); [8] M. Yahashi, N. Kimoto, and K. Okumura, Sci. Rep. 6, 31395 (2016).

09:30 - 09:45 Impact of beads and drops on a repellent solid surface: a unified description

Christian Ligoure

Srishti Arora[1], Laurence Ramos[1], Serge Mora[2], Ty Phou[1], Jean-Marc Fromental[1], Christian Ligoure[1]
1 – Laboratoire Charles Coulomb – Montpellier (FR)
2 – Laboratoire de Mécanique et Génie Civil – Montpellier (FR)

We investigate freely expanding sheets formed by ultrasoft gel beads, and liquid and viscoelastic drops, produced by the impact of the bead or drop on a silicon wafer covered with a thin layer of liquid nitrogen that suppresses viscous dissipation thanks to an inverse Leidenfrost effect. Our experiments show a unified behaviour for the impact dynamics that holds for solids, liquids, and viscoelastic fluids and that we rationalize by properly taking into account elastocapillary effects. In this framework, the classical impact dynamics of solids and liquids as far as viscous dissipation is negligible, appears as the asymptotic limits of a universal theoretical description. A novel material-dependent characteristic velocity that includes both capillary and bulk elasticity emerges from this unified description of the physics of impact.

09:45 - 10:00 Marangoni bursting

Etienne Reyssat

Etienne Reyssat[1], Ludovic Keiser[1], Hadrien Bense[1], Cyril Sturtz[1], Pierre Colinet[2], José Bico[1]
1 – Physique et Mécanique des milieux hétérogènes – Paris (FR)
2 – Université Libre de Bruxelles (BE)

At the surface of a sunflower oil bath, a drop of water adopts a lenticular shape. Conversely, alcohol totally wets the oil and spreads. Depositing a mixture of water and alcohol reveals a spectacular fragmentation phenomenon [1,2]. If it contains enough alcohol, the drop spontaneously spreads and fragments into a myriad of tiny droplets whose size may be tuned through the initial mixture composition. Marangoni flows resulting from the differential evaporation of alcohol and water play a key role in this self-emulsification process. The intricate coupling of hydrodynamics, wetting and evaporation is well captured by analytical scaling laws that predict the characteristic radius and timescale of spreading. Other combinations of liquids also lead to this fascinating phenomenon and further confirm our scenario.

1. L. Keiser et al., Marangoni bursting: Evaporation-induced emulsification of binary mixtures on a liquid layer, Physical Review Letters, 118, 074504 (2017)
2. The Lutetium project Youtube channel: https://www.youtube.com/watch?v=DgA5ZKRR0vM

10:00 - 10:15 Bubbles rising in a closed capillary tube : a critical mobility. Ludovic Keiser

Ludovic Keiser, Giacomo Gallino, Wassim Dhaouadi, John Kolinski, François Gallaire
EPFL (CH)

A non-wetting bubble contained in a vertical capillary tube filled with oil tends to rise, due to gravity. In the case of a closed cylindrical tube, the rise of the bubble requires the complementary volume of oil to fall across the lubricating film, along the walls [1]. If the tube radius is decreased below the capillary length, F. Bretherton theoretically demonstrated that the drop should be blocked, as the lubricating film thickness vanishes [2-3]. This threshold of mobility has hitherto not been observed experimentally.

Mounting the tube on a centrifuge, we propose to characterize this threshold by a precise control of the rotation speed (and the centrifugal acceleration). A continuous variation of the effective capillary length is thus achieved for a given tube radius, enabling the measurement of the bubble velocity in the neighborhood of the threshold.

Numerical simulations are performed to support the experiments. They provide a detailed description of this sharp mobility transition, where the bubble speed may drop by several orders of magnitude for a slight change of the effective capillary length.

1. J. Bico & D. Quéré, Rise of Liquids and Bubbles in Angular Capillary Tubes, J. Coll. Int.Sci., 2002
2. F. Bretherton, The Motion of Long Bubbles in Tubes, J. Fluid Mech., 1961
3. C. Lamstaes & J. Eggers, Arrested Bubble Rise in a Narrow Tube, J. Stat. Phys., 2017

10:15 - 10:30 Laser-induced Marangoni flows for particle deposition Ulysse Delabre

Ulysse Delabre, Nicolas-Alexandre Goy, Jean-Pierre Delville
Laboratoire Ondes et Matière d'Aquitaine – Bordeaux (FR)

Controlling the deposition of microparticles at microscale is essential to design new materials such as new photonic structures. An interesting approach combines the advantages of bottom-up approach based on evaporation-induced-deposition approaches, well-known for the coffee ring effect for example and the optical lithography techniques to control optically the flows inside the liquid. Here, we use an infrared laser beam to induce thermal Marangoni flows inside a droplet and reverse the classic coffee ring effect. We have identified two specific regions in the drop : a first region due to Marangoni flows at the center of the drop (see figure 1a). As shown in the figure, Marangoni flows trap and concentrate particles in a specific region of the drop. This opens the route towards a better control of the deposition pattern. We have analyzed the dynamics of the flows and the Marangoni ring and investigate the effects of surfactants. A second region, close to the contact line, is mainly dominated by evaporative flows. We develop a simple model to quantify the extent of these two regions based on lubrication analysis depending on the spacial extent of the temperature field imposed by the infrared laser beam. In addition, using specific masks to shape the laser beam, we succeed in patterning the temperature field distribution to induce a specific deposition of particles (Figure 1b).

11:00 - 11:45 **Invited talk** *"The endless surprises of Doktor Leidenfrost"* **David Quéré**

David Quéré

A quarter of millennium after his discoveries on the behavior of volatile liquids on hot solids, Leidenfrost has still some surprises in store. We discuss a few of them.

11:45 - 12:00 Capture of Viscous Fluids in Living Organisms Amandine Lechantre

Amandine Lechantre[1], Alejandro Rico Guevara[2], Denis Michez[3], Pascal Damman[1]
1 – Laboratoire Interfaces et Fluides Complexes, Mons (BE)
2 – Animal Flight Laboratory, Cal (US)
3 – Laboratoire de Zoologie, Mons (BE)

Some insects, birds and mammals use flower nectar as their energy resources. For this purpose, they developed specific skills to ingest high viscous fluids. Depending on the sugar content in the nectar, different strategies are observed: some animals like bees and some bats exhibit a specific papillary structure well-suited to viscous dipping; in contrast, hummingbirds have a tongue made from two thin flexible sheets that bend to form a tube when immersed in the nectar.

In the first case, bees and some bats possess a tongue decorated with complex structures that, according to biologists, are optimized for fluid capture. In this talk, we first make an extensive investigation of the viscous drag with smooth rods and we will confront the actual physical model of viscous dipping with a visco-gravitational model for experiments with high capillary number. From combined experiments and theoretical analysis, the nature of the relevant forces has been determined. Then experiments on structured rods that mimic biological morphologies were performed. For this study we artificial tongues decorated with lateral protrusions and we determined the influence of the structure on the viscous dipping and the drainage. Finally, we compared results to the capture of nectar for living bees.

In the second case, hummingbirds use their tongue as a semi-open tube. The physical model for this capture of viscous fluid is unknown. To understand it, biological experiments have been done on living hummingbirds.

12:00 - 12:15 Capillary imbibition governed by water adsorption in hygroscopic plant-like structure Meng Zhou

Meng Zhou, Sabine Caré, Denis Courtier-Murias, Stéphane Rodts, Philippe Coussot
Laboratoire Navier – Paris (FR)

Plant matter is being used increasingly in construction and in various other applications thanks to its remarkable porous and mechanical properties, but water transfers play a critical role on these properties and their possible alteration. Water in plants may be either in a "free" liquid state in capillaries, or in a "bound" state after adsorption in cell-walls. Here we show that the coexistence of these two effects strongly affect the transport properties.

We demonstrate this from Synchrotron and MRI observation in hardwoods, which exhibit a relatively simple hydraulic structure. Capillary imbibition dynamics appears to be dramatically damped (velocity decreased by several orders of magnitude), but the liquid can still climb over significant heights (in contradiction with its dynamics) as soon as sufficient bound water has been adsorbed. This contradiction is confirmed by 3D Synchrotron images of the internal structure obtained during imbibition, which show that the liquid-air interfaces in the capillary vessels remain planar, which implies negligible Laplace pressure, but significantly advance along the vessels, again unexpectedly.

From MRI measurements allowing to distinguish bound and free water, we then show that this contradiction is explained by the adsorption of a slight amount of bound water in the capillary walls. This adsorption governs the process: it momentarily damps wetting and then allows further advance later when the walls are saturated with bound water. The generality of the process for hygroscopic systems is demonstrated with a model material, i.e. hydrogel, from which both the position and shape evolution of liquid-air interface and the adsorption and propagation of bound water may be directly observed. This suggests the development of bio-inspired porous materials able to absorb liquid with a tunable timing, for pharmaceutical or chemical engineering applications

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12:15 - 12:30 Design of a Unidirectional Water Valve in Tillandsia Simon Gravelle

Simon Gravelle[1], Pascal Raux[1], Jacques Dumais[2]
1 – Surface du Verre et Interfaces, Paris (FR)
2 – UAI (CL)

Plants have evolved unique structures to control their water and gas exchanges. Here, we analyze the structure and function of the Tillandsia trichome to explain the trichome's uncanny ability to absorb water from fog while also minimizing evaporative losses within the hyperarid Atacama Desert. We find that a clever juxtaposition of a thick hygroscopic wall, an air space, and a semipermeable membrane is key to maintain the asymmetric transport property of the trichome. This conclusion was confirmed with artificial composite membranes mimicking the trichome design. The trichome's reliance on intrinsic properties of materials instead of moving parts makes this design a promising basis for the development of novel valves for microfluidics applications.

12:30 - 15:00 Poster Session

15:00 - 15:45 **Invited talk** "Some examples of fluid and complex fluid flows near surfaces"
Hamid Kellay

Hamid Kellay Laboratoire Ondes et Matière d'Aquitaine - Bordeaux (FR)

I will first focus on fluid flows in the vicinity of a solid surface and examine the validity of the so called non slip boundary condition. I will briefly explain the optical technique used, show results for water flow on glass and glass rendered hydrophobic. A comparison with a technique based on AFM measurements of the hydrodynamic resistance of a small sphere approaching the surface and immersed in the liquid will be carried out. In a second part I will describe coating flows of complex fluids (emulsions and polymer solutions). In the two cases considered, the interplay between the rheology of the fluid and the interaction between the fluid flow and the surface give rise to a variety of surface patterns which may be useful for a variety of processes.

15:45 - 16:00 Confinement Effect on Dip-Coating of Yield-Stress Fluids Wilbert Smit

Wilbert Smit, Christophe Kusina, Jean-François Joanny, Annie Colin ESPCI – Paris (FR)

Dip-coating is a widely-used industrial process in which surfaces of solid objects are covered by a thin layer of liquid. The thickness of the coating generally depends on both fluid and geometrical properties and its mastery is of major interest. Albeit the problem is well- studied for Newtonian fluids, it remains largely elusive for yield-stress liquids-in spite of the industrial relevance. We study the effect of geometry by withdrawing rods from cylindrically- shaped baths filled with a Carbopol gel (yield stress 4-130 Pa). The coating thickness is observed to strongly depend on the geometrical confinement. The thickness decreases with decreasing separation between the rod and the sides of the bath. This confinement effect is stronger for high yield stress. A high curvature of the rod is observed to result in thinner coatings. Furthermore, we vary the surface tension by adding a surfactant to the Carbopol gel. A high surface tension is observed to lead to thicker coatings, but the influence of surface tension decreases with increasing yield stress. We will discuss and interpret these results.

16:30 - 17:15 **Invited talk** *"Interactions of Nanoparticles at the air/water interface"*
Patricia McGuiggan

Patricia McGuiggan John Hopkins University – Baltimore (US)

TiO_2 is known as a self-cleaning surface, with a decreasing water contact angle on exposure to UV light. Stable water-in-oil (W/O) Pickering emulsions were created with hydrophobically modified TiO_2 residing at the water/oil interface. The emulsions were made unstable by exposure to UV light. The results of the destabilization are compared to macroscale studies of the TiO_2 surfaces. The behavior of nanoparticles at the air/liquid boundary will also be discussed

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17:15 - 17:30 Soft and Slippery: Thermoresponsive Polymer Coatings under Shear
Carlos Drummond

Carlos Drummond, Pierre Vialar, Suzanne Giasson
Centre de Recherche Paul Pascal, Bordeaux (FR)

Anchoring of polymer chains at solid surfaces is an effcient way to modify their interfacial properties. Polymer layers immobilized at the interface affect the stability and rheology of colloidal dispersions, the lubrication properties and the biocompatibility of artificial surfaces. Analogously, static and dynamic forces arising upon crowding of polymeric layers immobilized onto facing surfaces modify the effective interaction between them. In this work we have investigated the behavior of surfaces coated with dense layers of thermoresponsive pNIPAM-based microgels under compression and shear. We observed the presence of shear-induced lift forces, which are evidenced by a variable gap between the surfaces under shear. The effect of different variables (driving speed, temperature, applied normal force, grafting method and physicochemical environment) on this shear-induced lift force was investigated in detail. The origin and consequences of this force will be discussed in detail.

17:30 - 17:45 Intersonic sliding contact in gels Tetsuo Yamaguchi

Tetsuo Yamaguchi Kyushu University (JP)

In normal sliding contact between metals, sliding speed is negligibly smaller than the propagation speeds of elastic waves. However, if at least one side of the frictional pair is made of soft materials like rubbers or gels, the sliding speed can be comparable or even larger than the wave speed; i.e., the sliding contact becomes intersonic. Here we conduct friction experiments between cylinders made of silicone gel and metal, observing an abrupt increase in friction coefficient when the Mach number (V/V S) exceeds one. We perform in-situ contact visualizations and photoelasticity observations, and find that such increase is associated with deformation mode transition from conventional Hertzian contact to Flat punch-like edge contact even for the line contact between cylinders.

17:45 - 18:00 Surfactant dynamics in Droplet-based microfluidics Jean-Christophe Baret

Jean-Christophe Baret Centre de Recherche Paul Pascal – Bordeaux (FR)

Surfactants play a major role in droplet-based microfluidics technology. They control the stabilisation of emulsions against coalescence, the long term aging of these emulsions through molecular transport and the biocompatibility of the system for practical applications, especially for single cell biological assays [1].

We develop microfluidic methods to unravel the dynamics of surfactant at interfaces at the time-scale and lengthscale of relevance for emulsification combining both a millisecond time resolution and micron space resolution. The fine control of emulsification and of droplet manipulation in microchannels provides means to quantitatively measure molecular transport between droplets. We determine the time scale of transport and link it to diffusive processes accross the continuous phase [2]. The understanding of the process now opens the door to a full control of the molecular transport between droplets usable to construct new types of communicating microcompartments. Beyond the diffusive transport, we measure the kinetics of adsorption and desorption of surfactant. The exchange of molecules at the interface provides new means to actively control the composition of droplets [3].

In the long run, these dynamic processes at interfaces will be of interest to control the chemical composition of droplets while maintaining the physical identity of the microco partment, a principle of interest to the build-up of more complex microcompartments, for example acting as living cells mimicks [4].

1. Surfactants in droplet-based microfluidics, J.-C. Baret, Lab Chip 12 422-433 (2012)
2. Controlling molecular transport in minimal emulsions, P. Gruner, B. Riechers, B. Semin, J. Lim, A. Johnston, K. Short & J.-C. Baret, Nature Communications, 10392 (2016)
3. Surfactant adsorption kinetics in microfluidics, B. Riechers, F. Maes, E. Akoury, B. Semin, P. Gruner & J.-C. Baret, Proceedings of the National Academy of Sciences U.S.A, 113, 41, 11465-11470 (2016)
4. Sequential bottom-up assembly of mechanically stabilized synthetic cells by microfluidics, M. Weiss, J. P. Frohnmayer, L. T. Benk, B. Haller, J.-W. Janiesch, T. Heitkamp, M. Boersch, R. B. Lira, R. Dimova, R. Lipowsky, E. Bodenschatz, J.-C. Baret, T. Vidakovic-Koch, K. Sundmacher, I. Platzman & J. P. Spatz, Nature Materials, 17, 89-96 (2018)

18:00 - 18:15 Influence of surfactants on the statics and dynamics of the wetting of oil on a solid in water

Gaëlle Rondepierre

Gaëlle Rondepierre[1,2], Laurence Talini[1], François Lequeux[1], Emilie Verneuil[1], Bertrand Levache[2], Nicolas Passade-Boupat[2]

1 – Sciences et Ingénierie de la Matière Molle – Paris (FR)
2 – Pôle Etudes et Recherche de Lacq, Total (FR)

The behaviour of oil droplets driven towards a solid substrate in water, and particularly the possible wetting of oil, is of interest to the petroleum industry. Without surfactants, the formation of a stable water film was demonstrated and its stability and drainage have been characterized [1]. In practice, adding surfactants to the water phase has been shown to promote wetting of the solids by either the oil or the water phase, but no clear picture has emerged yet.

In the literature, the role of surfactants on the static wetting behaviour of liquids onto a solid substrate has been intensively studied in the past, in the frame of flotation of solid particles at air/water interfaces. At equilibrium, the adsorption of the surfactants to the solids strongly depends on concentration. As it increases, the arrangement of the surfactants on the surface goes through successive steps (monolayer, bilayer) which modifie the wetting properties of the substrate [2]. Regarding the dynamics of wetting, the role of these different possible phases is less understood. It has been shown that some surfactants can improve the spreading of oil on solids, but this phenomenon depends on many parameters and no theory has been developed yet [3]. More precisely, the transfers of the surfactants to and within the solid/liquid and liquid/liquid interfaces and their competition for adsorption require further investigations.

In this framework our objective is to characterize the mechanisms of the dynamic processes occurring when a water film, squeezed between oil and a solid, is destabilized and yields to the wetting of the oil phase onto the solid, in the presence of surfactants.

To achieve this goal, the experimental framework is the following: a dodecane droplet is immersed into a water/surfactants solution at concentrations varying from pure water to several times the critical micellar concentration. The droplet is then driven towards a silica surface, initially trapping and then draining an aqueous film, possibly followed by the wetting of oil on silica. The whole process is imaged using a high-speed camera with an interferometry technique [1].

It appears that, depending on their spontaneous curvature and their concentration, cationic surfactants form structures that lead to different equilibrium situations. They can stabilize a water film, induce wetting of oil on silica or even create instabilities during the drainage.

When surfactants prevent the wetting of oil, the interferometry set-up enables to evidence a stable water film of a few tens of nanometers, which thickness depends on the concentration. In the case of wetting, we show that spreading velocity depends on both the concentration of surfactant and its spontaneous curvature. Moreover, the speed can vary over five orders of magnitude between the different surfactants (see figure). This illustrates that the wetting of oil through a water film may be energetically favoured but could be avoided due to a significantly reduced kinetics.

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2. 2: Haidara et al, J. Adhesion Sci. Technol., Vol,13, No 12., 1999
3. 3: T. Stoebe et al, Langmuir, Vol. 13, N o . 26, 1997 72 79

18:15 - 18:30 Impact of surfactant on the drag reduction potential of superhydrophobic surfaces François Peaudecerf

François Peaudecerf[1], Julien R. Landel[2], Fernando Temprano-Coleto[3], Frédéric Gibou[3], Raymond E. Goldstein[4], and Paolo Luzzatto-Fegiz[3]

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2 - School of Mathematics – Manchester (UK)
3 - Department of Mechanical Engineering –Santa Barbara CA (US)
4 - Department of Applied Mathematics and Theoretical Physics –Cambridge (UK)

Superhydrophobic surfaces (SHSs) have the potential to achieve large drag reduction for internal and external flow applications. However, experiments have shown inconsistent results, with many studies reporting significantly reduced performance. Recently, it has been proposed that surfactants could be responsible for this reduced performance, by creating adverse Marangoni stresses under flow conditions [1, 2]. Yet, testing this hypothesis is challenging. Careful experiments with purified water already show large interfacial stresses and, paradoxically, adding surfactants yields barely measurable drag increases [3].

To test the surfactant hypothesis, we perform numerical simulations of flows over a SHS inclusive of surfactant kinetics [4]. These simulations reveal that surfactant-induced stresses are significant at extremely low concentrations, potentially preventing any slip at the air-water interface (the "plastron") even in nominally clean conditions.

To provide an experimental metric of surfactant effects, we perform microchannel experiments with thermally-controlled SHSs consisting of streamwise parallel gratings [4]. Under a steady pressure gradient generating a flow in the channel, we observe an immobilized interface at the plastron. After a loading phase with steady flow, we drop the driving pressure gradient to zero. We observe a backflow developing at the plastron, which can only be explained by surfactant gradients formed during the loading phase. These effects, which arise from the interplay of trace surfactant and flow, are highly sensitive to geometry. We exploit this fact in [5] to show that similar surfactant effects can display maze-solving abilities.

This work demonstrates the significance of surfactants in deteriorating drag reduction, and thus the importance of including surfactant stresses in SHS models. Our load-and-relax experimental protocol can assess the impact of surfactants in SHS testing and guide future mitigating designs.

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Thursday, October 25, 2018

8:30 - 09:15 **Invited talk** *"Actin filaments and Myosin II motors"*

Jean-François Joanny

Jean-François Joanny ESPCI Paris (FR)

Actin filaments are the essential components of the cytoskeleton that provide the elasticity of a cell. In a cell they interact with many proteins and in particular molecular motors. This talk will present 2 biological situations where actin filaments interact with molecular motors in relation with important cellular functions : intracellular transport and cell migration. Molecular motors navigate the cytoskeleton to position vesicles and organelles at specific locations in the cell. In order to understand this transport process, the group of Pascal Martin at Institut Curie has used an antiparallel network of overlapping filaments. Beads coated with myosin motors accumulate at the midline of the pattern. The accumulation is well described by a three-state model of bead transport, in which active beads locally sense the net polarity of the filament network by frequently detaching from and reattaching to the filaments. The migration of immune cells is guided by several chemical signals, but also by physical cues such as the hydraulic resistance of the vessels in which they travel. This barotaxis effect has been studied in vitro by the groups of M. Piel and A.M. Lenon using microfluidic channels. We show that barotaxis results from a force imbalance at the scale of the cell, amplified at the scale of a network of vessels.

09:15 - 09:30 Thermodynamic stability of supported lipid bilayers on atomically smooth surfaces and the effect of cholesterol Yair Kaufman

Yair Kaufman, Shiju Avraham, Dyuti Benejee Ben Gurion University (IL)

Supported lipid bilayers (with or without membrane proteins) on solid surfaces have promising potential for bio-sensing applications, unique separation processes, and can be used as simplified models to study biological membranes. The simplest technique to prepare supported lipid bilayer is often called `vesicle fusion', were lipids are hydrated in aqueous solution to allow the self-assembly of vesicles. These vesicles can then adhere to the surface, rupture, and fuse into supported lipid bilayer. It is often assumed that vesicles fuse into a continuous lipid bilayer on the surface; however, AFM studies show that upon vesicle fusion, lipids can adapt different structures, such as isolated islands of lipid bilayer, lipid bilayer with holes (defects), or in other cases, layer of intact vesicles on the surface. Importantly, some applications require specific lipid structure. For instance, for separation process, the lipid bilayer must be continuous (defect-less); yet, there is no clear understanding of what is the thermodynamically favorable lipid configuration on the surface for a given system (lipid composition, solution composition and surface). During the talk, I will present a simple, yet quantitative mechanism for vesicle fusion on atomically smooth hydrophilic solid surfaces, such as silica or mica. The model includes the effect of adhesion energy between the lipids and the surface, the lipid bilayer line tension, the effect of cholesterol, and the bending modulus of the lipid bilayer. Then, AFM, fluorescence imaging, and impedance spectroscopy measurements will be presented in order to demonstrate the `vesicle fusion' mechanism. The proposed mechanism is expected to be useful for engineering thermodynamic stable (long lasting) supported lipid bilayers for diverse applications

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09:30 - 09:45 Surface Waves on soft hydrogels Pierre Chantelot

Pierre Chantelot[1,2], Lucie Domino[1], Sander Wildeman[1], Emmanuel Fort[3], David Quéré[2,1], and Antonin Eddi[1]
1 – Physique et mécanique des milieu hétérogènes – Paris (FR)
2 – LadHyX – Paris (FR)
3 – Institut Langevin – Ondes et Images – Paris (FR)

We study the waves propagating at the surface of a soft (0.1 to 1 kPa) Agar hydrogel.

We send waves in a gel placed in a rectangular tank of depth h using either a point source or a vertical vibration (Faraday instability). The observation of the wave field using a synthetic schlieren technique allows us to measure the dispersion relation and to probe the interaction between elastic and capillary effects.

09:45 - 10:00 Surfing the capillary wave: contact propagation beneath an impacting drop John Kolinski

John Kolinski[1], Shmuel Rubinstein[2]
1 – EPFL (CH)
2 – Paulson School of Engineering and Applied Sciences – Harvard (US)

The propagation of a contact line at the interface between liquid and a dry solid is of great fundamental and practical importance. We experimentally probe the dynamics of wetting that occur when an impacting drop first contacts a dry surface. We show that the liquid-solid contact line propagates outward from nanoscale liquid bridges. As the liquid bridge expands, the liquid-air interface deforms and lifts away from the surface immediately ahead of the liquid-solid contact line. The wetting front advances at a velocity well below the liquid capillary velocity; we explain this anomalously low velocity using a simple model for the interaction between the liquid and the air motivated by the observed liquid-air interface kinematics. As we increase the liquid viscosity, the contact line velocity decreases. A simple boundary layer argument can explain the scaling of contact line velocity as viscosity to the -1/3 power. These results suggest interesting avenues for further study of dynamic wetting on a variety of substrates.

10:00 - 10:15 Soap films communication: the role of the Plateau border Adrien Bussonnière

Adrien Bussonnière, Isabelle Cantat Institut de Physique de Rennes (FR)

The origin of the high effective viscosity of a liquid foam remains unclear due to the missing description of the local flow in the liquid matrix. In particular, the transmission of a stress from a thin film to another through a Plateau border (PB) is still not well understood. In this study, we experimentally investigate this crucial elementary brick of foam mechanics using a horizontal soap film connected to 2 peripheral films at 120◦ to mimic the foam structure (see figure). Simultaneous stretching of the peripheral films is imposed using 2 motors mounted at the film extremity. Interestingly, the central film is set in motion, indicating that the PB does not act as an infinite reservoir, able to screen the imposed deformation, as commonly assumed in local models. The central film moves toward the stretched side during the deformation: some film is extracted from the Plateau border on the left and some film flows into the PB on the right. The extracted film, govern by Frankel's equations (Mysels et al.) is much thicker than the initial film and appears brighter on the image. To get deeper insight into this local deformation we measure (1) the thickness field using a spectral camera and (2) the velocity field in the central film using a recently developed technique based on fluorescent soap film and photobleaching (see figure). Our results indicate that a non-negligible fraction of the motor velocity is transmitted to the horizontal film. Some solution from this film is absorbed in the right PB resulting in a local extension which in turn drives the extraction of the Frankel film from the left Plateau border. The analysis of the velocity and thickness field allows us to quantify, for the first time, the velocity gradient and therefore the viscous dissipation at the bubble scale. This study provides important insights into the motions and their dissipations at the root of the foam effective viscosity.

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10:15 - 10:30 Influence of evaporation on soap film rupture Emmanuelle Rio

Lorène Champougny, Jonas Miguet, Robin Henaff, Frédéric Restagno[1], François Boulogne[2], Emmanuelle Rio[1]
1 - Laboratoire de Physique des Solides – Paris (FR)
2 – Department of Mechanical and Aerospace Engineering – Princeton (US)

Although soap films are prone to evaporate due to their large surface to volume ratio, the effect of evaporation on macroscopic film features has often been disregarded in the literature. In this work, we investigate experimentally the influence of environmental humidity on soap film stability. An original experiment allows us to measure both the maximum length of a film pulled at constant velocity and its thinning dynamics in a controlled atmosphere for various values of the relative humidity.

11:00 - 11:45 **Invited talk** *"Fluctuations of plasticity and failure of amorphous materials"* **Jérôme Crassous**

Jérôme Crassous Institut de Physique de Rennes (FR)

We present an experimental study of the plastic flow of sheared athermal amorphous materials. Using a dynamic light scattering probe, we are able to follow the fluctuations of the plasticity which organizes progressively in order to form permanent shear band. Spatio-temporal correlation functions of fluctuations reveals the coupling between plastic zones before and after failure.

11:45 - 12:00 Transient string formation in colloid monolayers at bubble interfaces under ultrafast deformation Axel Huerre

Axel Huerre, Marco De Corato, Valeria Garbin Imperial College London (UK)

Droplets and bubbles stabilized by a monolayer of microparticles are exploited in encapsulation and catalysis. Particle-stabilized bubbles are the building blocks of lightweight materials based on foams, and are central in enhanced oil recovery. Despite their importance in applications, our fundamental understanding of the behaviour of particle-laden interfaces under dynamic deformation remains limited. While shear rheology has been the focus of recent research [1-2], the effect of compression remains largely unexplored. To impart controlled, dynamic compression of a particle-laden interface, we subject particle- coated bubbles to ultrasonic driving. This method enables us to achieve compression- expansion of the monolayer in the frequency range 10-100 kHz [3, 4]. The bubbles (60-400 µm), stabilized by a monolayer of microparticles (1-5 µm), are monitored with high-speed video microscopy to resolve the evolution of the monolayer, and extract single-particle trajectories. We then characterize the dynamics of the 2D microstructure through order parameters, interparticle distance and pair correlation function. We find that the periodic oscillation of the interface drives a qualitatively different evolution of the monolayer compared to what is commonly observed under shear deformation. Specifically, we observe self-assembly of the particles into a network of strings.

We ascribe the emergence of strings to transient interparticle interactions occurring during dynamic deformation. A simple force balance on a sphere attached to the interface by capillary forces, and undergoing oscillations normal to the interface, reveals the importance of the particle's inertia for a micron-sized colloid on the ultrafast timescale of our experiments. The motion of the particle normal to the interface causes a deformation of the interface leading to transient capillary interactions between the particles. Particle-based simulations show that the emergence of strings can be explained by the coupling of this transient deformation with the equilibrium deformation initially present due to nanoscale undulations of the contact line.

This work [5] provides the first demonstration of unique dynamical phenomena upon extreme deformation of complex fluid interfaces, and lays the foundations for studies of high- frequency rheology of particle-laden interfaces.

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12:00 - 12:15

Fabrication of Polystyrene Micro-lenses through Transient Ouzo Effect at Solid-liquid interfaces

Yuliang Wang

Yuliang Wang Beihang University (CN)

Micro/Nano lens-shaped objects fabricated on solid surfaces have extensive applications, such as enhanced optical imaging, micro/nanofabrication, and data storage. In such applications, it is of significance and challenging to achieve controlled formation of size, density, and contact angle of the micro-lenses on sample surfaces. In this study, we systematically developed a new method to fabricate polystyrene (PS) micro-lenses on glass substrates by applying a "transient Ouzo effect". Right after the addition of water droplets into toluene/ethanol binary solutions will cause local and temporary over-saturation of toluene in the formed toluene/ethanol/water ternary solutions. This results in the nucleation of toluene droplets on the spin coated PS films on glass substrates. The PS films were then dissolved by the nucleated toluene droplets and formed toluene/PS mixture droplets. After the toluene was dissolved back into the ternary solutions, the PS micro-lenses were obtained on the glass surfaces. The influence of PS film thickness and toluene concentration in the toluene/ethanol binary solutions on the fabricated PS lenses was investigated, followed by the tuning of micro-lens contact angle through a thermal reshaping method. Moreover, experiments were conducted to verify that the fabricated lenses can achieve enhanced optical imaging with an improved resolution..

12:15 - 12:30

Influence of liquid substrates on the mechanics of single-layer graphen

Hervé Elettro

Hervé Elettro[1], Francisco Melo[2]
1 – Ecole Polytechnique Fédérale de Lausanne (CH)
2 – Universidad de Santiago de Chile (CL)

Emerging 2D materials are excellent candidates for next generation technologies such as supercapacitors, highly efficient filtration membranes and flexible solar cells. In particular, the production of high quality graphene, a 2D carbon honeycomb lattice, has become exponentially cheaper over the past decade, driving studies at macroscopic scales. Only an atom thin, graphene does not obey the laws of continuum mechanics such as the plate phenomenology for bending.

By studying the wrinkling of a graphene sheet floating on a liquid, we show that adsorption of liquid molecules dramatically disrupts graphene mechanics, yielding new records of flexibility, on the scale of 0.01 kT. Furthermore, the addition of alcohols to the bulk liquid substrate promotes spontaneous wrinkling, no compression needed. We characterize this new adsorption-induced wrinkling transition by coupled optical microscopy and Raman confocal spectroscopy. The mismatch in C-C bond length in graphene and alcohol produces a curvature-dependent adsorption that drives the appearance of a spontaneous curvature. The predictions from our "atomic pinchers" mechanism show good quantitative agreement with the experimental results.

Our results open possibilities of simple routes to the tuning of the equilibrium elastic constants and geometry of large scale graphene-based devices, as well as cost-efficient studies of the interaction energy of graphene with a range of liquid molecules.

14:00 - 14:45 **Invited talk** *"Programmable colloidal self-assembly with DNA-coated colloids"* **David Pine**

David Pine New York University (US)

Colloidal particles functionalized with DNA open new strategies for colloidal self-assembly. Particles can be coated with one or more DNA “sticky ends” that can be programmed to hybridize at different temperatures. Particles can be either uniformly coated with DNA or coated on well-defined patches with different "valence". Of these, valence 2, which form chains, and valence 4, which coordinate tetrahedrally, are particular interesting. In addition, we also make Janus particles with varying patch size. Using these different particles, we demonstrate how to make new crystal structures, including diamond and pyrochlore, new surfactant-like micelle structures like chains, rings, and lamellae, and new crystal transformations, including thermally-reversible face-centered cubic to cesium chloride crystals and other transformations.

14:45 - 15:00 Microfluidic probing of the complex interfacial rheology of multilayer capsules Mathilde Reyssat

Mathilde Reyssat[1], Corentin Tregouet[1,2], Thomas Salez[3], Cécile Monteux[2]
1 – Gulliver – Paris (FR)
2 - Sciences et Ingénierie de la Matière Molle – Paris (FR)
3 – Laboratoire Ondes et Matière d'Aquitaine – Bordeaux (FR)

In order to improve control over the delivery of chemicals, industries are interested in encapsulation. A promising method to produce artificial micro-capsules consists in assembling several layers of polymer at the interface of an oil droplet. Our work consists in using microfluidics to form different multilayer assemblies of polymers and to probe in situ the mechanical properties of the membranes formed. We show that after a deformation, the capsules relax in a manner that depends on their composition. We developed a model and performed numerical simulations to extract the main interfacial properties of our capsules from the measurement of their deformations in the micro-channels.

15:00 - 15:15 Elastohydrodynamic measurement of soft PDMS surface using dynamic AFM Muhammad Arshad

Muhammad Arshad, Zaicheng Zhang, Abdelhamid Maali
Laboratoire Ondes et Matière d'Aquitaine – Bordeaux (FR)

Here, we present a non-contact measurement of the mechanical properties of soft polymer thin films. Our measurement is based on the elastohydrodynamic coupling between the vibration of a glass sphere glued to the AFM cantilever tip and the deformation of the soft substrate. From the amplitude and the phase of the cantilever vibrations, we extract the loss and the storage modulus of the interaction versus the distance. We have developed a simple model to get the value of young modulus and our experimental values fit well with our model.

15:15 - 15:30 The pattern deposition of colloidal particles from a volatile liquid subject to particle adsorption and coagulation Ofer Manor

Ofer Manor, Anna Zigelman Chemical Engineering, Technion (IL)

We investigate the deposition of colloidal particles from a volatile liquid drop atop a solid substrate. Surface forces, experienced by the colloidal particles, support the coagulation of particles in the liquid and the adsorption of particles to the solid substrate. Moreover, the evaporation of liquid generates flow, displacing the particles and aggregates along the drop. By further accounting for the diffusion of particles and aggregates in the liquid, we elucidate the interplay of the different mechanisms that govern the deposition process. In particularly, we show that the morphology of the deposit is dependent on the ratio between the rates of particle coagulation and particle advection, the ratio between the rates of particle adsorption and liquid evaporation, and the ratio between the rates of the advection and diffusion of particles in the liquid. We introduce the interaction-force boundary layer theorem for particle adsorption and an augmented Smoluchowski theorem for particle coagulation in a dynamic advection-diffusion equation. The theorems connect the rates of the adsorption and coagulation processes to the surface forces in the system of colloidal particles. The advection- diffusion equation governs the transport of the particles and aggregates in the liquid. We thus present a continuum formulation for the direct influence of surface forces on the morphology of the particulate deposit. It appears that the fast adhesion of particles to the solid substrate will smear the deposit. The fast coagulation of the particles will further support the appearance of slowly diffusing aggregates of particles. Simulations of the spatiotemporal distribution of colloidal particles in a volatile drop show the dynamic change in the populations of particle aggregates of different sizes in the liquid and on the substrate. The simulation further highlights the resulting spatial distribution of the deposited particle mass.

15:30 - 15:45 Dynamic photocontrol of particle deposition in a moving meniscus

Vincent Poulichet

Vincent Poulichet, Sergii Rudiuk, Mathieu Morel, Damien Baigl
Department de chimie de l'ENS – Paris (FR)

Controlling the organisation of particles on surfaces is essential for exploiting their emerging collective properties and for their integration into devices. A popular technique for organising particles on surfaces consists in using a moving meniscus that traps particles between a liquid layer and a solid surface at the three-phase contact line[1, 2]. Particle deposition from a moving meniscus is defined by the surface properties and hence does not offer the possibility for reconfiguring and dynamically controlling the deposition.

For its spatio-temporal resolution, tunability, and contactless nature, light appears as an ideal stimulus to remotely control the particle deposition in a dynamic way. Our group has shown in the past various ways to optically control the particle deposition process using photosensitive surfactants to exploit either optical Marangoni flows [3, 4] or light-dependent particle-interface interactions[5]. However, this was done in sessile drops with a modest pattern resolution and on a limited deposition area.

In this talk, I will present how we implemented these light-induced effects in the case of particle depositions assembled by a moving meniscus. A microparticle suspension was spread at a controlled speed onto substrates of different wettabilities and topologies. Different concentrations of photosensitive surfactants were added to the suspension and ligth was shined following different spatio-temporal patterns on the moving meniscus. I will show how light affects the deposition in both capillary and evaporative regimes, and emphasize how light- dependent particle interactions or optical interfacial flows in the meniscus can change the deposition process. Notably, we identified conditions where the particle deposition was dynamically switched on and off using light. These first resuts illustrate interesting coupling effects between particle interactions, interfacial flows and capillary forces, as well as open perspectives for arbitrary, reconfigurable particle deposition protocols in a user-defined manner.

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3. Diguet et al., Angew. Chem. Int. Ed. 2009, 48, 9281.
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15:45 - 16:00 Rolling and ageing in soft adhesion of microparticles Dražen Zanchi

Giuseppe Boniello[1], Christophe Tribet[2], Emmanuelle Marie[2], Vincent Croquette[3], Dražen Zanchi[2,4]

1 - School of Engineering Applied Sciences - Philadelphia, PA (US)
2 - Pôle de Chimie Biophysique de l'ENS – Paris (FR)
3 - Laboratoire de Physique Statistique de l'ENS – Paris (FR)
4 - UFR de Physique - Paris 7 (FR)

Immediately before adsorption to a horizontal substrate, sinking soft colloids can undergo a complex sequence of landing, jumping, crawling and rolling events. Using video tracking we studied the soft adhesion to a horizontal at plate of micron-size colloids coated by a controlled molar fraction f of the polymer PLL-g-PNIPAM which is temperature sensitive. It allows for sticking of colloids to the surface when the temperature is above Tc = 32°C. In order to capture the very final events before the immobilization of colloids the T-ramp protocol was designed: the particles suspension is injected in the cell at room temperature, the temperature is increased at 10°C/min. up to 38°C> Tc , and kept constant until the end of the acquisition. Attraction between beads and the at plate is thereby triggered by crossing the critical temperature Tc = 32°C. 3D beads motion is real-time tracked using slightly defocus microscopy in parallel illumination decorating bead image with interference rings observed with video camera. Analysis of the tracking records indicates the Brownian rolling is the most relevant phenomenon in last moments before the immobilization. The experimental results are discussed in the framework of a simple theoretical model that includes ageing effects of the soft contact area between the microparticle and the flat substrate.
Acknowledgements: This work was supported by ANR DAPPlePur 13-BS08-0001-01 and program "investissement d'avenir" ANR-11-LABX-0011-01.

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Posters

Active control of individual photo-bio-convective plumes

Jorge Arrieta[1], Marco Polin[2], Ramon Saleta-Piersanti[1], and Idan Tuval[1]
1 - Instituto Mediterraneo de Estudios Avanzados (ES)
2 – Department of Physics – University of Warwick (GB)

The potential use of light to precisely control the dynamics of micro-swimmers has just recently started to be realized and includes substantial development in the fabrication of artificial active particles reactive to light, the design and control of micro-motors powered by genetically engineered light-sensitive bacteria or the trapping of passive colloids by light-induced "hydrodynamic tweezers". These suspensions of self-propelled particles are paradigmatic examples of active matter and readily display non-equilibrium collective 45ocalize and pattern formation. Moreover, individual swimmers often showcase biased swimming known as –taxes towards light, chemical, temperature or other optimal conditions which frequently lead to the emergence of macroscopic phenomena.

In particular, many bacteria and green algae modify their swimming path under light stim- uli in a tightly controlled process called phototaxis. The model micro-algae Chlamydomonas reinhardtii (CR) is the best studied phototactic organism with individual cells showing helical swimming trajectories powered by the synchronous breaststroke beating of its flagellar pair. In this study we show, for the first time, a new form of active control in living fluids exploiting the phototactic ability of CR to locally induce fluid flows in a time-dependent manner. By photo-accumulating cells around an optical fibre here we demonstrate the onset of a global instability, characterize the emerging patterns in cell concentration and convective flows, and extend previous continuous models to include phototaxis and to resolve the main features of the dynamics. This buoyancy driven instability is reminiscent of bioconvection, one of the best known examples of collective 45ocalize in suspensions of swimming microorganisms and, hence, the resulting pattern may be viewed as a phototactically induced instance of bioconvective plume. Nevertheless, it is worth stressing that the observed instability is quite different from classical bioconvection in a number of fundamental features.Previous studies have been limited to horizontally uniform light fields, yielding a modulated cells vertical swimming speed (so-called photokinesis) and resulting in negligible control over either timing or spatial position of the induced photo-bioconvective patterns. In contrast, the described set up (projecting orthogonal light into a vertical sample) allows for fully controllable patterns that are not restricted to deep suspensions (i.e. large enough Rayleigh's number) as they are globally unstable, nor bind to become unstable at a specific location in the sample (i.e the upper free boundary) as we have complete freedom for the spatio-temporal dynamics of the projected light field. As a consequence, the pattern can be turned on and off at will, can contain multiple local maxima and can be moved dynamically.

We further illustrate numerically how active spatio-temporal control can be employed for efficient bio-mixing, an attractive solution to improve current photo-bio-reactor technology for biofuel production. A horizontal displacement of the fibre from its central position in the chamber produces two asymmetrical strained vortices. By alternating periodically two light sources positioned symmetrically with respect to the chamber's centre in a cycle of period T, as in the blinking vortex, a paradigmatic example of mixing by chaotic advection we are able to produce chaotic mixing of a passive scalar within the chamber.

Topological Stabilization in Marangoni-Driven Swimming Shells

Kyle Baldwin, Babak Vajdi Hokmabad , Christian Bahr , and Corinna C. Maass
Max Planck Institute for Dynamics and Self-Organization (DE)

Active emulsions – solutions that contain microscopic swimming droplets that self-propel due to sustained Marangoni stresses – display a rich variety of solo and collective swimming behaviours, from self-avoiding helices to collective raft formation, which are strongly influenced by factors such as wall proximity, auto-chemotaxis, and liquid crystal (LC) structure. Here, we report on the dynamics and stability of active water-oil-water double-emulsions; swimming LC shells. We observe new periodically oscillating swimming modes, and find that shell stability is strongly influenced by nematicity, which imparts a topological barrier that inhibits coalescence of the aqueous phases. The utility of these double-emulsion swimmers as cargo carriers, and the ability to release this cargo on-demand, makes this system an ideal mechanism for chemical delivery to localized, switchable reaction sites, with prospects for drug delivery.

Single-beam acoustical tweezers as a new tool for soft matter research

Diego Baresch, Regis Marchiano , Jean-Louis Thomas , and Valeria Garbin
Imperial College London (GB)

Recently, the conditions required to trap and manipulate micrometric objects with the radiation pressure of sound have been identified. A single helicoidal ultrasonic beam – or acoustical vortex – can generate a force attracting elastic particles in all three dimensions towards the beam focus. Vortex beams also carry orbital angular momentum that can be transferred to trapped objects. This important rotational degree of freedom is appealing for applications and is entirely decoupled from the acoustic trapping force, enabling *in situ* controllable rates of rotation of spherical probes. In this presentation, we will present the theoretical and experimental background that enabled the demonstration of acoustical tweezers. We will also show preliminary results on the contactless manipulation of microbubbles and particle-coated bubbles that are a key soft matter system. Compared to their optical counterpart, acoustical tweezers can exert forces and torques orders of magnitude higher in complex, bulky, absorbing and opaque media opening exciting perspectives to probe soft solids, liquids and interfaces for biological and soft matter research.

Shape of a drop inside a texture

Daniel Beilharz[1,2], Elodie Couttenier , Claire Schune , Evan Spruijt[3], Christophe Clanet[1,2], and David Quéré[1,2]
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2 - Physique et mécanique des milieux hétérogènes –Paris (FR)
3 - Radboud University – Nijmengen (NL)

A film of a wetting liquid can be trapped on a textured substrate. The material becomes slippery and is now called a liquid-infused surface (LIS). To understand the reduced friction and the stability of the liquid film, the shape of the liquid-vapor interface is of interest. We simply deposit a drop inside a texture. About ten years ago, Courbin et al. [1] found that the two-dimensional shape of the resulting stain depends on both the contact angle theta and the solid pattern. Recent papers concentrate on the dynamics of spreading [2,3,4] and evaporation [5], but generally ignore the shape of the liquid-vapor interface. We explore it by analyzing the three-dimensional shape of stains (Figure 1) for different liquids and textures (varying pillar size, spacing and arrangement).

Analytical implicit solvent theory of electrolytes

Hélène Berthoumieux
Laboratoire de Physique Théorique de la Matière Condensée – Paris (FR)

Electrolytes are solutions containing ions immersed in a solvent like alcohol, acetone or water to name a few. Understanding how an electrolyte reacts in the presence of a voltage is of primary importance in many scientific areas. Extensive computer simulations of electrolytes detailed down to the atomic scale are possible but very costly. Likewise, theoretical models at the scale of the material gain in simplicity and reliability but at the cost of predictability. It is precisely to avoid the shortcomings of the ”too small” and the ”too big” that we have developed an nanometric length scale theoretical modelling which treats the ions and the solvent on the same footing, like atomic simulations do, but without retaining all the atomic details, like material simulations do; thus, combining the advantages of both. More precisely, an expansion ”a la Landau” of the effective free energy of the solvent is proposed to go further the Primitive Model of Electrolytes in two ways: first by accounting for non-linearities in the response of the polarisation to an external field and second by accounting for the non-local character of the electric susceptibility of the solvent due to short range molecular interactions. It is combined with a linearized Poisson-Boltzmann theory describing the statistic of the ions. This model results in a tractable and analytical implicit solvent theory of the dielectric properties of electrolytes.

Capillary Levelling of a Liquid Stepped Film Supported on an Immiscible Liquid Film

Vincent Bertin[1], Carmen Lee[2], John Niven[2], Thomas Salez[3], Elie Raphaël[1], and Kari Dalnoki-Veress[2]
1 - Laboratoire de Physico-Chimie Théorique – Paris (FR)
2 - McMaster University - Hamilton, Ontario (CA)
3 – Laboratoire Ondes et Matière d'Aquitaine – Bordeaux (FR)

Thin polymeric films have numerous technological applications and their stability has garnered intense interest. The stability and flow of a thin, viscous film is sensitive to the boundary conditions as the film thickness approaches the nanoscale. Here we probe a liquid-liquid boundary condition: a stepped polymer film is placed above a different, immiscible polymer film. The ensemble is supported by a solid substrate. The temporal evolution of the air-polymer interface, as well as the polymer-polymer interface were studied using atomic force microscopy. The polymer-polymer interface was exposed by using a selective solvent to remove the top film. Experimental results show that the step at the air-polymer interface levels off to minimize the excess surface area, and that there is substantial deformation at the interface between the two polymers during the levelling process. These findings are discussed in light of a developed lubrication model.

Electroosmosis in liquid foams

Oriane Bonhomme, Li Peng, Anne-Laure Biance Institut Lumière Matière – Lyon (FR)

Liquid foams consist in gas bubbles dispersed in a surfactant solution. These aerated materials, whether they remain liquid or they are solidified, have many interesting properties like their lightness, their insulating power or their large specific areas. However, they are out of equilibrium and unstable. In particular, gravity driven drainage result in foam inhomogeneity, in foam drying and destabilization. We propose here to use electroosmosis (EO) to limit and counteract this drainage. By combining experiments and simple models, we have been able to show that EO is indeed a tool of choice to control liquid foam stability. In a more general framework, this model system allows us to investigate the tricky phenomena at stake in electrokinetic transport near free liquid interfaces and in poroelastic materials.

Elastocapillary adhesion of a soft contact lense

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Liquid foams consist in gas bubbles dispersed in a surfactant solution. These aerated materials, whether they remain liquid or they are solidified, have many interesting properties like their lightness, their insulating power or their large specific areas. However, they are out of equilibrium and unstable. In particular, gravity driven drainage result in foam inhomogeneity, in foam drying and destabilization. We propose here to use electroosmosis (EO) to limit and counteract this drainage. By combining experiments and simple models, we have been able to show that EO is indeed a tool of choice to control liquid foam stability. In a more general framework, this model system allows us to investigate the tricky phenomena at stake in electrokinetic transport near free liquid interfaces and in poroelastic materials.

Thermophobic Leidenfrost drops

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The high mobility of Leidenfrost drops is commonly attributed to the lack of contact with the hot substrate, and it makes them sensitive to tiny forces, such as gravity or air- flows. However, we found that drops deposited without initial velocity on horizontal substrates self-propel in random directions. This phenomenon is triggered by evaporation-driven confinement. PIV measurements reveal that, as the drop aspect ratio of the drop becomes of order unity, the symmetry of the internal motions systematically breaks. Large drops flattened by gravity host symmetric convective cell structures whereas droplets, kept quasi spherical by capillarity only host one rotating cell. Internal flows thus switch from symmetric to asymmetric rolling. Such a flow reshapes the vapor thickness and tilts it, as evidenced by interferometric measurement, hence yielding to propulsion in the rolling direction. Droplets are thus found to generate their own dynamics and self-propel isotropically despite the absence of external field. This finding can be exploited to control these systems. Drops placed at rest on a substrate submitted to a horizontal thermal gradient self-propel in a preferential direction. Large drops spontaneously are observed to systematically move toward the colder region, a tragic behavior as decreasing the substrate temperature shortens their lifetime up to the Leidenfrost threshold temperature where boiling cause a sudden death. In contrast with this thermophobic behavior, droplet self-propelling directions are not random anymore but biased. This thermal trick could be of particular interest to subdue the legendary mobility of these elusive objects.

Two-dimensional analog of Rayleigh-Taylor instability in a soap film

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Foam films dynamics is governed by Marangoni effects and exhibits several peculiar features that have not yet revealed all their mysteries. Here, we present a new gravity driven instability in a vertical foam film, analogous to the well-known Rayleigh-Taylor instability. When a solid frame is pulled out of a foaming solution, a soap film is extracted from the bulk. The same phenomenon appears when a soap film is stretched: the meniscus (also called "Plateau border") bound to the film acts as a reservoir, and a new film is extracted from it. Depending of the configuration and the pulling speed, the thickness of the new film can be very different from the thickness of the preexisting one. In particular, if a liquid film is placed vertically, it naturally drains under its own weight and can become very thin. Therefore, if the meniscus is at the top of a film that is stretched, the new film extracted is much thicker than the film initially present. Because of this thickness difference a fingering instability appears: the thick film at the top rapidly destabilizes and forms "strikes" falling downwards, while "plumes" of the thinner film flow upwards. We have experimentally studied this instability with liquids films made from a solution of Tetradecyltrimethylammonium Bromide (TTAB) and dodecanol. We show that the instability can be mapped to the Rayleigh-Taylor instability, by replacing the fluids densities by the films thicknesses, the hydrodynamic pressure gradient by the surface tension gradient, and the bulk viscosities by the surface viscosities of the films. This hydrodynamic model allows us to compute the characteristic wavelength of the fingering pattern, and the characteristic growth rate of the instability. Moreover, this instability provides a new situation where the interfacial viscosity of a foam film plays an important role, and could be used to calibrate this otherwise hard to measure quantity.

Why is ice slippery? An experimental investigation

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The slipperiness of ice is an everyday-life old phenomenon which surprisingly does not have yet a proper explanation. The very small friction coefficients (of the order of 0.02) measured

on ice are classically attributed to the presence of a thin interfacial lubricating wa- ter film between the slider and the ice [1, 2]. Although this macroscopic friction behavior has been widely explored, very little is known about the interface properties and structure. Therefore, reducing friction on ice is still mainly empirical nowadays (for example in winter sports).

In this study, we have developed a new macroscopic tuning fork based tribometer [3] (Fig.1) to uncover the microscopic mechanisms behind ice lubrication. As in an atomic force microscope, the shift in the resonance frequency and the broadening of the quality factor give quantitative informations about conservative and dissipative forces at stake. In our case, the tangential oscillation induces frictional melting and enables to measure the friction force, while the normal oscillation is used as a probe to measure the thickness and reological properties of the interfacial film. For the very first time, we are able to measure simultaneously the friction profile of a bead shearing the ice, and the liquid properties of the interface under different regimes of speed and temperature (Fig. 2). We observe a viscoelastic fluid with an exotic hydrodynamic behavior.

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Ultrasound transmission through monodisperse microfoams

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While the acoustic properties of solid foams have been abundantly characterized [1], sound propagation in liquid foams remains poorly understood. J. Pierre and collaborators recently evidenced the key contribution of free liquid films to the ultrasonic response of 3D polydisperse liquid foam samples [2, 3]. However, further progress requires to investigate the acoustic response of better-controlled foam structures.

In this work, we introduce a new experimental setup designed to study the transmission of ultrasound (frequencies in the range 100 – 1000 kHz) through model monodisperse liquid foams generated by microfluidics. We first study the case of monodisperse bubble monolayers (i.e. 2D foams) of various liquid fractions and bubble sizes. In such structures, our analysis shows that the acoustic wave undergoes a ‘sieving’ effect due to the liquid network, which is well described in analogy with sound propagation in solid porous media [4]. The sound velocity within the bubble monolayer itself is found to be equal to that in the gas phase, but the attenuation in the monolayer cannot be explained by thermal dissipation alone, as already observed for 3D polydisperse foams [5]. We finally present preliminary results on monodisperse bubble bilayers, for which we combine ultrasonic transmission measurements and Surface Evolver simulations of the bilayer equilibrium structure.

This discrete approach, allowing to isolate the signature of a single layer of free films in the acoustic response, will hopefully contribute to a better understanding of sound propaga- tion in liquid foams. On the long term, this work could be useful for the design of optimized acoustic metamaterials created by solidification of liquid foams.

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Guiding original micrometric morphologies induced by acoustical and optical focused waves on liquid interfaces

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We present here a study about liquid waveguides which can self-adapt continuously to optical or acoustical wave propagation. Exploiting the radiation pressure exerted by a wave, it is possible to deform a flat two-phase liquid interface and create a liquid/liquid waveguide. The incident wave can induce two kinds of morphologies depending whether the wave celerity decreases or increases when crossing the interface ; the latter will either adopt a step-like or a funnel-like profile. The aim of this investigation is to study numerically the coupling between propagation of the wave and deformation of the interface by solving simultaneously Helmholtz and Stokes equations. The simulation of the whole deformation's dynamic allow us to explain the formation and the sustainment of these original fluid objects. On the one hand, step-like interfaces behave as superposition of cylindrical waveguides, and in the other hand, funnel-like interfaces are induced by a total internal reflection of the incident wave into the deformation. These results could serve as a basis to develop versatile and adaptable microfluidic waveguides and flow channels.

Role of interfacial fluid transport in hydrogel-tissue adhesion

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The fixation of hydrogels to soft biological tissues is of outmost interest for numbers of biomedical applications but it is a highly challenging task due to the fragile and wet nature of both hydrogels and tissues. Here, we explore the role of interfacial fluid transport in hydrogel-tissue adhesion. For that, an ex vivo peeling experiment was devised to measure the adhesion between model polyethylene glycol hydrogel films and the surface of explanted porcine livers. We find that bioadhesion strongly depends on the hydration of the tissues. In particular, we show that a transition from a lubricated contact to a strongly adhesive contact is governed by the transport of liquid across the tissue-hydrogel interface. A simple model describing the fluid exchanges between biological tissues and hydrogel membranes captures this transition for both the liver capsule and parenchyma. In vivo experiments demonstrate that this effect still holds on actively hydrated tissues like the liver capsule. These results have important implications for the design of predictive bioadhesion tests as well as for the development of improved bioadhesive strategies exploiting interfacial fluid transport.

Liquid Friction on soft textured substrates

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Droplets deposited on soft elastomers or gels (with elastic modulus ~ 1-100kPa) induce an elastic deformation at the contact line, that can reach a micrometric scale [1]. This deeply modifies the wetting properties of the solid. It has been shown that the speed of sliding of droplets can be reduced by orders of magnitude on soft substrates compared to hard substrates with same surface energy, due to the elasto-capillary deformation [2]. This effect is called visco-elastic braking. For the droplet to slide, the solid has to be deformed, thus dissipation occurs in the solid instead of taking place in the liquid (see for example [3]). We study the sliding of droplets on soft textured substrates with elastic modulus of order 100 kPa. With substrates of low energy and high textures, liquid-solid contact can be restricted to the top of the roughness that covers the solid [4]. We can thus control the size of the contact line, hence the area on which dissipation occurs by changing the density of textures on which the liquid sits.

Preliminary results show that visco-elastic braking is suppressed with water on highly diluted textures, millimetric droplets slide at speeds on the order of 0.1-1 m/s. We now plan to vary continuously the density of pillars, and the viscosity of the liquid.

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How to increase the stiff of granular matter ?

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Granular chain packings exhibit a striking emergent strain-stiffening behavior despite the individual looseness of the constitutive chains. Using indentation experiments on such assemblies, we measure an exponential increase in the collective resistance force with the indentation depth, and with the square root of the number of beads per chain. These two observations are respectively reminiscent of the self-amplification of friction in a capstan or in interleaved books, as well as the physics of polymers. The experimental data are well captured by a novel model based on these two ingredients. Specifically, the resistance force is found to vary according to a universal relation. This study suggests that theories normally confined to the realm of polymer physics at a molecular level can be used to explain phenomena at a macroscopic level.

Pearling Instabilities of a Viscoelastic Thread

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Pearling instabilities of slender viscoelastic threads have received much attention, but remain incompletely understood. We study the instabilities in polymer solutions subject to uniaxial elongational flow. Two distinctly different instabilities are observed: beads on a string and blistering. The beads-on-a-string structure arises from a capillary instability whereas the blistering instability has a different origin: it is due to a coupling between stress and polymer concentration. By varying the temperature to change the solution properties we elucidate the interplay between flow and phase separation.

Capturing liquids with elastic strips

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If hummingbirds' wings beat at 80 strokes per seconds, it is not only to show off with their acrobatic flight ability, but also to hover above flowers while they harvest nectar, a highly energetic food to fuel their consuming metabolism.

To capture the precious liquid, hummingbirds use their tongue to drink, a major difference with their insects counterparts who use a trunk to suck up nectar. This feature is interesting to understand, since pumping a small quantity of liquid with a strip is uneasy. Observing a feeding cycle, it has been noticed that hummingbirds rely on capillarity to drink more efficiently [1].

We mimicked this feeding technique with a small plastic strip that deforms under capillary action in order to capture a wetting liquid (figure 1). We played with the shape of these capillary pumps to enhance their efficiency, and discuss the dynamics of the liquid uptake.

Contactless Optorheology at the nanoscale of Complex Fluids

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Measurements of the surface tension, the viscosity and the viscoelasticity at small scale, typically for sub-millimeter drops, shells or films, may be extremely difficult because most methods utilize contact and cannot be implemented in situ; the situation is even more complex for soft matter as the rheological properties becomes strongly dependent on the confinement, preventing against any estimation from a bulk characterization. Highly concerned by the fluid rheology at small scale for biophysics and microfluidics, many groups developed over the past new strategies to down-scaled classical rheometers, offering on the one hand a local investigation of the rheology but keeping in the other hand the side effect of contact interaction. This prompted the emergence of contactless electrical, magnetic, acoustical and optical techniques which are now considered as ultimate approaches for milli- and micro- rheology. Within this frame, we propose a radically new time-resolved optical strategy with nanometer resolution, which is local, active and contactless, and allows for the first time in situ investigations of the rheology from Newtonian to non-Newtonian fluids and from bulk to confined or enclosed micrometric volumes such as drops and thin soft films. The method is based on optical radiation pressure to dynamically deform an interface and on interferometric measurement of the induced nanometric deformation. In order to demonstrate the capabilities of this new optorheology, we present results on evaporating films in order to show how it can be deduced in a single run and in a contactless fashion (i) the thickness dependence of the rheology of a thin film, (ii) the viscosity dependence in concentration of binary mixtures and (iii) thermophysical properties when the fluid partially absorbs light.

Breath figures under electrowetting: Electrically controlled evolution of drop condensation patterns

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We show that an electric field in an electrowetting (EW) configuration can be used to actively control the distribution of drops condensing onto flat hydrophobic surfaces. Under-standing condensation of vapor on functionalized surfaces is scientifically challenging and simultaneously technologically relevant (heat transfer; fog harvesting). Our work represents the first application of EW in this context. A quantitative description of the positional and size distribution of the drops, in conjunction with electrostatic energy calculations, reveals how EW strikingly modifies condensation patterns by aligning drops and enhancing coalescence. Such alignment results in a definite periodicity of the droplet pattern, which is determined by the electrode geometry. The EW-controlled evolution of drop condensation pattern significantly alters the statistical characteristics of the entire ensemble of droplets from those established for classical breath figures. A scaling analysis shows that under EW, the evolution of the drop size distribution displays self-similar characteristics that significantly deviate from classical breath figures on homogeneous surfaces once the electrically induced coalescence cascades set in beyond a certain critical drop size. We also show using preliminary heat transfer measurements that the droplet pattern characteristics under EW eventually lead to enhanced net heat transfer. The present work provides a new active approach towards controlling dropwise condensation, which goes beyond the current passive strategies based on superhydrophobicity, liquid-infused and wettability-patterned surfaces. We hope that this study will not only trigger a general theoretical analysis of drop condensation patterns in arbitrary energy landscapes but will be also useful for optimizing various applications involving dropwise condensation, like heat exchangers.

Drying of a water-filled channel within an artificial leaf

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The transport of sap in the vascular network of leaves is driven by evaporation at the surface of leaves, and it has been shown [Noblin et al., PNAS (2008)] that a relevant analogous physical system is a network of liquid-filled channels in a permeable polymer. As such, microfluidic systems made of PDMS are particularly suited. To understand how a leaf is susceptible to dry out if its supply of sap is stopped, we investigate the drying of water-filled channels, looking at air invasion in such channels. We create a series of isolated channels of different widths and heights in thin layers of PDMS of different thicknesses, using standard microfluidic techniques. All channels are open at one end and closed at the other hand. They are initially filled with water, then placed under a dry atmosphere. They progressively dry as a meniscus separating the still liquid-filled part and the newly dried part advances in the channel. We record the motion of the meniscus, thereby measuring the rate of evaporation as a function of time. This rate decreases as the channel progressively dries, but does not vanish at the moment where liquid water disappears in the channel. We rationalize our measurements by a model combining two contributions: (i) direct diffusion of water to the atmosphere through the PDMS layer; (ii) diffusion between newly dried parts containing humid air and the dry atmosphere. The model is solved exactly using analytical techniques, and its predictions are found to be in good agreement with experiments, thereby providing a physical description for the drying-up of leaves. Preliminary results in more complex networks will also be presented.

Surfing wave driven turbulence at a fluid surface

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When a laminar flow becomes turbulent, its energy is spread over a range of scales in a process named energy cascade. It has recently been discovered that turbulent flows can be forced by steep waves at a fluid surface, those flows possess features of two-dimensional turbulence. In particular, an inverse energy cascade has been identified and a substantial amount of energy is stored into the turbulent fluctuations. An interesting question is whether it is possible to efficiently use the energy of this strongly out-of-equilibrium state. In the wave driven turbulence, we show how to create floating devices able to extract energy from the turbulent motion fluctuations by coupling with underlying features of the energy cascade. The operational principle of these devices relies on the rectification of the chaotic motion of correlated bundles of fluid trajectories. By changing the shape of the device, we can turn it into a vehicle or a rotor powered by turbulence.

Understanding the effect of interfacial hydrodynamics on thermoosmosis using molecular dynamics

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The fundamental influence of thermal gradients on the flux has received scanty attention until only the past decades. Thermophoretic phenomena were firstly studied for numerous applications such as optothermal DNA trap [1] or disease-related protein aggregates [2]. On the other hand, thermo-osmosis at solid-liquid interfaces is the least studied among the osmotic phenomena. It is usually interpreted as a thermal gradient-induced Marangoni flow, but the molecular level understanding is still lacking. Using molecular dynamics simulations, we measured the thermo-osmosis coefficient by both mechanocaloric and thermo-osmosis routes, against different solid-liquid interfacial energies. We show the critical role of inter- facial hydrodynamics, which can reverse the direction of the flow, and strongly amplify it. Notably, we predicted giant thermos-osmotic flows at the water-graphene interface [3]. Following this prediction, we explored the practical implementation of waste heat harvesting with carbon-based membranes, focusing on model membranes of carbon nanotubes (CNT) [4]. We show that, despite viscous entrance effects and a thermal short-circuit mechanism, CNT membranes can generate very fast thermo-osmotic flows, which can be used to desalinate seawater.

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Clogging of nanopores

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In filtration processes, the clogging of pores by Brownian particles represents a severe decrease of the lifetime of a membrane. Using a model microfluidic membrane, we study the formation of an array of clogs at pores entrance when a pressure drop is applied to the system. We focus on the growth rate of the clog and the interaction in between clog. Moreover, the desintegration of clogs when the pressure drop is removed provides some information about their structure.

Marbles sliding a soap film

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When gently deposited, solid particles can be maintained in horizontal soap films without breaking them: elastic deformation compensates the weight of the particles, so that 5 μm-thick films can effectively support objects more than a hundred times larger than them. We discuss here the gliding dynamics of millimeter-sized marbles deposited on large rectangular soap films (with typical lenght 40 cm), that are slightly inclined. The soap film acts as a elastic slide, and the marbles released close to the top of the frame glide down until they eventually reach the other end of the frame. The interaction between the particle and the deformation it generates (and undergoes) creates unusual dynamics: after an quick acceleration, the marbles decelerate, first with a constant rate and then much faster in the last centimeters. We investigate experimentally this phenomenon by varying the particle size and the frame characteristics (aspect ratio, inclination), and we propose a simple model to account for the film deformation and how it impacts the marble dynamics.

Dynamical intrusion and drying of water in hydrophobic ZIF-8 nanoporous matrix

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The experimental studies of lyophobic nanoporous materials coupled with liquids under hydrostatic pressure has provided the scientific community with several facts regarding this kind of systems. Thus, it is now established that the pressure at which water enters the porous volume is given by the Laplace-Washburn law of capillarity for mesoporous materials with pore diameters of size down to a few nanometers with a negligible impact of the intrusion velocity [1]. For smaller pores, Michelin-Jamois experimentally shown that this behavior breaks, in particular when considering electrolyte aqueous solutions. For most saline solutions combined with ZIF-8 microporous matrix, the intrusion pressure of liquid is observed to follow the same trend as with pure water but with an offset pressure found to obey the Van’t Hoff osmotic pressure law [2]. Moreover we have recently shown with this system that the intrusion time scale has a significant impact on the intrusion and extrusion pressure; in this case, pressures should not be understood solely under the assumption of equilibrium thermodynamics. In particular when decreasing temperature close to 0°C an unusual pressure-volume characteristic is observed in dynamical regime, with a non monotonic decrease of pressure during the extrusion process.

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Freezing into dense packing of particles

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Understanding the freezing into dense packing of particles is essential in various areas, from the prevention of frost heaving in building engineering, to the creation of novel material through ice templating. Using a confocal microscope, we investigate *in situ* the freezing into a dense packing of monodisperse colloids under a controlled temperature gradient. As expected, we observed that porosity leads to freezing point depletion, meaning that smaller pores freeze later than larger ones. We also obtained a quantitative agreement with Gibbs-Thomson equation, namely that freezing temperature is inversely dependent on pore radius. This behavior resulted in a heterogeneous freezing front that extended over several colloids. While this effect was experimentally limited by the strong applied temperature gradient, it can be expected to reach macrometric scales in more realistic scenarios. Overall we highlight that even in a model system, small variation of pore size due to random close packing are essential to fully comprehend freezing in dense packing of particles. Therefore the freezing front cannot be reduced as a homogeneous interface between ice and liquid water.

Optical manipulation and deformation of soft interfaces

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Understanding the mechanical properties of soft matter at the micron scale is a major issue from the fundamental and applied points of view. A global macroscopic approach is usually not sufficient to comprehend the full complexity of processes. The aim of this study is to fill this gap by setting up contactless and active optical tools, in order to manipulate complex fluids at micron scale in two essential geometries: flat interfaces and spherical ones. It is already known that the optical radiation pressure of a continuous laser wave can deform, and even destabilize, a soft liquid interface and gives birth to a jet for high laser power. In the case of a flat interface we show for different fluid systems that a specific liquid cone, similar to Taylor cones under intense electric fields, can also emerge from the interface instability. We characterized this conical deformation, especially the 55haracte of its angle according to the experimental parameters and showed the differences with electro-hydrodynamics. A numerical investigation as well as an analytical model have been developed and they are able to account for the observed variations.

In order to study the rheological properties of soft interfaces in spherical geometry, such as droplets or vesicles, we have developed a dual-beam optical trap called *optical stretcher*. It permits to trap and deform at the same time a single soft spherical object into a microfluidic device, which allows a fast and sequential 55haracterization. Our approach consists in studying the deformation of model objects to obtain a complete rheological 55haracterization.

Mechanisms and Control of particles' deposition by optical texturing

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In this work, we want to understand how we can control the deposition of micron-sized particles using the optical absorption of a continuous IR laser wave by a sessile water droplet deposited on a substrate. The experiment is performed with an inverted microscope (fluorescent microscopy technique) in order to first visualize the flow driven by the temperature gradient induced by laser absorption. We observe that an inverted coffee ring effect can be obtained due to the emergence of recirculating Marangoni flows. In order to understand the profile of the induced flow, we performed a measurement of the temperature profile due to the laser absorption using a temperature-sensitive-fluorescent dye and we found that the temperature can be well-adjusted by a lorentzian profile. Finally, we tried to predict the link between the typical size of the recirculating flows (ring shape) and the width of the temperature field using linear Stokes equations. As our predictions well fit with experimental data, we conclude that in our case, the evaporation rate at the contact line plays a minor role in the process compared to the light-induced Marangoni contribution

Chirality-controlled self-assembly via screw dislocations

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Chirality plays an important role in science from enantiomeric separation in chemistry to chiral plasmonics in nanotechnology. However, the understanding of chirality amplification from chiral building blocks to ordered helical superstructures remains a challenge. Here, we demonstrate that topological defects, such as screw dislocations, can drive the chirality transfer from particle to supramolecular structure level during the self-assembly process. By using a model system of chiral particles, which enables direct imaging of single particlein- corporation into growing crystals, we show that the crystallization kinetic pathway is the key parameter for monitoring, via the defects, the chirality amplification of the crystalline structures from racemic to predominantly homohelical. We provide an explanation based on the interplay between geometrical frustration, racemization induced by thermal fluctuations, and particle chirality. Our results demonstrate that screw dislocations not only promote the growth, but also control the chiral morphology and therefore the functionality of crystalline states.

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Experimental study of interfacial dynamics at a three-phase contact line using a long-needle AFM

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While liquid interfaces between two (immiscible) fluids are common in nature and industry, their motion over an ambient solid surface is complicated and not well understood, as the motion of the contact line (CL) between the liquid interface and solid surface is strongly influenced by the physical roughness and/or chemical heterogeneity on the solid surface. In this talk, I will present our direct atomic-force-microscope (AFM) measurements of capillary force hysteresis and relaxation of a circular moving CL formed on a long micron-sized hydrophobic needle intersecting a liquid-air interface. The measured capillary force hysteresis and CL relaxation show a strong asymmetric speed dependence in the advancing and receding directions. A unified model based on force-assisted barrier crossing is utilized to find the underlying energy barrier E_b and size λ associated with the defects on the needle surface. The experiment demonstrates that the pinning (relaxation) and depinning dynamics of the CL can be described by a common microscopic framework, and the advancing and receding CLs are influenced by two different sets of relatively wetting and nonwetting defects on the needle surface. This work opens the door to a wide variety of new experiments using a fiber surface with controlled patterns or micro-textures to study the CL dynamics.

First passage times for random walks with memory

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How long does it take a random walker to reach a target site? First passage (FP) quantities have recently raised interest among physicists, notably for their relevance for example diffusion-controlled reactions or search processes. Up to now, methods for FP problems in confinement have been limited to Markovian (memoryless) processes. This limits their applications to objects appearing in soft-matter physics (e.g. macromolecules, interfaces, tracer particles in viscoelastic fluids...), where memory effects generally arise due to the interactions of the random walker with other variables in its environment. Here we present an analytical approach to calculate the mean first-passage time to a target for a non- Markovian Gaussian random walker in confinement. The theory is generalized to describe memory effects in rare first passage times, which appear in theories of adhesion, reptation of entangled melts or wormlike chain closure. We show that memory effects can be quantified by calculating the average trajectories followed by the random walker in the future of the first passage event.

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Functionalized interfaces direct colloidal layer deposition by enhancing particle-particle interactions

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DNA-mediated interactions are used to program colloidal self-assembly, for example, to engineer crystals lacking molecular analogs1 or multicomponent gels consisting of inter-penetrating networks or core-shell structures2. In the present work, we design and simulate a system in which colloidal particles assemble at functionalized interface forming a crystalline structure with a controllable thickness. We consider DNA coated colloids where DNA linkers are mobile and terminated with sticky ends C and C' which are complementary to each other. Complementarity between C and C' results in the formation of intra-particle loops and inter-particle bridges. The later are responsible for inter-colloid attractions. A flat surface functionalized with Cs sticky ends specifically interacts with C' binding ends of the colloids and forms colloid-surface bridges. The selectivity of the functionalized interface, enhances the pair interaction between the colloids where one of the particles is in direct contact with the surface. This underlying principle is the key component to control over the thickness of the deposited colloidal layers. The designed system is tested by performing Brownian dynamics simulations. We observe a colloidal assembly that leads to face-centered cubic (111) crystals with a controlled number of layers d, where d=1, 2, and 3. We use different simulation techniques where we account for DNA reaction times, therefore, probing the kinetics of the process3. We have also developed a quantitative mean field theory that is validated by the simulations and can guide the experiments to check our design principle.

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Dewetting in polymer multilayer films analyzed by numerical and experimental means

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Nanolayer coextrusion is an innovative polymer processing tool allowing the formation of nanostructured materials made of alternating layers of different polymers each having nanometric thicknesses. It has been shown that for a model polymer pair of polystyrene/poly (methyl methacrylate) (PS/PMMA), the layers break spontaneously below a critical thick-ness around 10nm, whatever the processing conditions. This layer break-up was attributed to small interfacial fluctuations amplified by van der Waals forces [1]. To further investigate this interfacial instability, a model experiment was designed, consisting in studying the dewetting of a thin PS film embedded in between two thicker PMMA layers [2]. First, it has been shown that the thin film dewetting kinetics can be modeled by balancing interfacial tension with viscous dissipation in the surrounding matrix [3]. In a second step, the effect of a shear flow on the rupture kinetics of the thin film is studied with both experimental and numerical approaches. Preliminary results on the latter aspect will be presented.

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The polymorphic plethora of Wigner bilayer systems

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We consider an ensemble of mobile point charges (nominal charges e), immersed in a dielectric medium and confined between two parallel plates, which are separated by a distance d and which bear uniform charge densities, with the asymmetry parameter A defined as the ratio of these charge densities. Combining complementary theoretical approaches (i.e., analytical calculations, numerical optimization techniques based on evolutionary algorithms) we provide at vanishing temperature a comprehensive diagram of ordered ground state configurations of the charges as we systematically vary the asymmetry parameter A and the plate separation d [1]. The complex interplay between commensurability requirements between the ordered structures on each of the layers, on one side, and the quest for local charge neutralization, on the other side, leads to a plethora of exotic Wigner bilayer configurations: among those are Archimedean tilings or pentagonal structures (see Figure, where the particles pertaining to the different layers are coloured in red and blue, respectively), both of which can be considered as precursors of quasi-crystalline structures. Complementary Monte Carlo simulations, carried out at small, but finite temperatures provide evidence of the thermal stability of the predicted structures. In addition, the system comes up with other unexpected features, such as long-range attractions between the plates, the appearance of macroscopic charges, or the emergence of non-conventional phase transitions, pertaining to different universality classes. Our investigations demonstrate that even in a simple system the emergence of complex structures can easily be triggered via a systematic variation of two external parameters (in our case A and d).

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Ionic Coulomb blockade and fractional Wien effect in ion transport across nanopores

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The transport of fluids in nanochannels is exquisitely sensitive to the properties of the confining surfaces. The ability to actively control these properties would open new avenues for tuning fluid flow at the molecular scale, with potential applications in ultrafiltration and desalination processes. I will present the theoretical study of a model system where active tuning of the surface properties unveils contributions of single ions to the electrical conductance.

Our system consists of a long nanochannel filled with a salt solution, which is coupled to a gating electrode. The gating electrode creates an effective tuneable surface charge in the middle of the channel. We probe the properties of the system using brownian dynamics simulations. At equilibrium, the simulations reveal a striking non-linear behaviour of the ion density, which evades mean field description, and is only accounted for by the exact solution of a 1D Coulomb gas type model.

When driven out of equilibrium by an electric field, our system exhibits oscillations of ionic conductance as a function of surface charge, which are a signature of the discrete nature of

ions. This effect is qualitatively similar to Coulomb blockade in electron transport. We show that here, however, the underlying mechanism is completely different, and is reminiscent of Onsager's Wien effect. We develop an analytical theory accounting for this mechanism, which is in good agreement with simulation results.
Our findings reveal a new way of controlling fluid transport at the nanoscale, with the ultimate perspective of manipulating single ions in fluids at room temperature.

Ballistic molecular transport through two-dimensional channels

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Gas permeation through nanoscale pores is ubiquitous in nature and has an important role in many technologies. Because the pore size is typically smaller than the mean free path of gas molecules, the flow of the gas molecules is conventionally described by Knudsen theory, which assumes diffuse reflection (random-angle scattering) at confining walls. This assumption holds surprisingly well in experiments, with only a few cases of partially specular (mirror like) reflection known. Here we report gas transport through angström-scale channels with atomically flat walls and show that surface scattering can be either diffuse or specular, depending on the fine details of the atomic landscape of the surface, and that quantum effects contribute to the specularity at room temperature. The channels, made from graphene or boron nitride, allow helium gas flow that is orders of magnitude faster than expected from theory. This is explained by specular surface scattering, which leads to ballistic transport and frictionless gas flow. Similar channels, but with molybdenum disulfide walls, exhibit much slower permeation that remains well described by Knudsen diffusion. We attribute the difference to the larger atomic corrugations at molybdenum disulfide surfaces, which are similar in height to the size of the atoms being transported and their de Broglie wavelength. The importance of this matter-wave contribution is corroborated by the observation of a reversed isotope effect, whereby the mass flow of hydrogen is notably higher than that of deuterium, in contrast to the relation expected for classical flows. Our results provide insights into the atomistic details of molecular permeation, which previously could be accessed only in simulations, and demonstrate the possibility of studying gas transport under controlled confinement comparable in size to the quantum-mechanical size of atoms.

Tribological properties of ionic liquids

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Room temperature Ionic liquids (RTIL) are molten salts at ambient temperature. Electrostatic interactions are ubiquitous in such solvent-free liquids composed of charged ions only. Peculiar properties emerge under confinement as the ions significantly interact with electrified interfaces . These exotic interfacial properties call for a better fundamental understanding of these liquids properties and make RTIL appealing for supercapacitor applications and electroactive lubrication . Here we use a tuning fork based dynamic SFA (figure 1A), under vacuum condition, to probe the rheological and frictional properties of the ionic liq- uids under controlled sphere-plane confinement. The millimetric probe oscillates normally and tangentially to the surface with controlled subnanometric amplitudes, showing nanoscale capillary freezing for ionic liquid confined between metallic surface as demonstrated by the observation of a significant distance difference Delta D =100nm between the frictional and hydrodynamic zeroes (figure 1B). Rheological, frictional and electronic properties of this confined RTIL film are studied as a function to an external shear focusing on the possibility to control the frictional properties of RTIL via the application of an external electric field.

Particle removal efficiency correlation with the droplet impact pressure of high velocity spray

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In order to keep a high yield during integrated circuits production, a continuous improvement has been carried out in the particles cleaning area. Moreover, as typical dimension of microelectronic circuit is getting smaller and smaller, tinier and tinier particles have to be removed. Integrated circuit industry is thus seeking for robust solutions to clean nanoparticles, keeping finest transistors features integrity, and extremely low material consumption [1]. Indeed, to remove a particle from a surface, an external stress large enough to break the link between the particle and the surface must be applied. This has been successfully performed for several years using the pressure developed during the impact of micronic high speed droplets of the cleaning sprays.

Even though the adhesion of particles and droplet impact on solid surfaces have been studied and documented for years, there is no clear physical understanding on the spray process cleaning mechanism. Indeed, measurements from literature using micronic transducer [2], report dynamical impact pressures in the order of.

Brownian motion in confinement

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Brownian motion in confinement is a paradigm for numerous biological situations. Here, we study the diffusion of micrometer-sized beads in water confined between two walls that are separated by a micrometric distance. Using holographic microscopy, we track the particles in three dimensions with a precision approaching the nanometric range. From statistical analysis performed on the individual trajectories, we extract for the first time the local (i.e. not averaged) diffusion coefficient as a function of the position of the bead in the microcavity. The experimental results are in good agreement with the numerical and analytical predictions — which paves the way towards the study of other situations of confinement.

Dynamical antifogging

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Recent studies have shown that sufficiently small hydrophobic textures can induce antifogging abilities and repel hot liquids. In this talk, we focus on the practical case of hot drops impacting superhydrophobic substrates of controlled features size. In such dynamical conditions, the condensation time becomes comparable to the contact time of the drop so that both the drop and the condensation dynamics play a role in antifogging performances of superhydrophobic materials. Contrary to the static case, increasing the structures size from ~100 nm to 1 µm is observed to decrease the antifogging properties. Surprisingly, this property is recovered by increasing again the structures height to the tens of microns. We explain this non-monotonic variation of the antifogging performance by considering both the condensation and the impact dynamic. For highest textures, the condensation time is larger than the contact time, so that condensation cannot pin the drop to the surface. Conversely, for smaller textures, condensation is sufficiently fast to be in a quasi-static regime. In this case, condensation pins the drop to the surface but the high textures density strongly reduces the adhesion force, hence preventing the sticking of drops.

Rheoacoustics of granular media near yielding

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We describe study the rheology of a dense granular suspension under periodic shear strain combined with a simultaneous acoustic probing. By analyzing the correlation function of multiply scattered waves through the shear band we observe that in the rheological linear regime, the grains exhibit reversible caged motions. Beyond this linear regime, the oscillatory shear drives a small fraction of the grains to be irreversibly displaced while another one is still caged. For a given shear amplitude, both fractions remain constant for a high number of cycles, but their population is renewed at each cycle, reflecting the non-affine motion of grains. Moreover, we find that the cyclic response contain a strain stiffening part in which the correlation function between successive acoustic signals suggests a specific dynamics. Then, we investigate with an incline how yielding of a granular system is modified by non-linear sound vibrations. Close to the angle of avalanche, we find that ultrasound of amplitude in the nanometer range can fluidize the granular medium from the jammed state to quasistatic and continuous flowing states, via a lubrication effect at the contacts between grains.

Dynamics of viscous adhesion

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The adhesion between solid surfaces coated with a viscous liquid is limited by the propagation of a capillary bridge through the narrow gap separating both surfaces. Although the viscous adhering liquid pushes air of low viscosity, the adhesion front undergoes, in some situations, a fingering instability. What are the ingredients involved in the adhesion dynamics and in this unexpected instability? To address these questions, we consider a simplified model experiment where a solid beam is placed horizontally above a bath of liquid at a small distance in comparison with the capillary length. As a liquid bridge is created at one end of the beam, the bridge spontaneously expands towards the opposite extremity. We first show the strong dependence of the meniscus velocity with the liquid properties, the separation gap and the thickness of the reservoir. We then investigate the interactions between bridges propagating along parallel beams.

Foams flowing along rough interfaces

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Liquid foams can behave like solids or fluids, depending on the stress applied to them. The mechanical response of foams is shown to be strongly affected by the size of the roughnesses on solid walls. However, this phenomenon has not been studied systematically [1,2]. Thus, we performed experiments on the effect of the roughness on the entrainment of a foam by a solid (see Fig1).

The influence of the bubble radius, the liquid fraction and the substrate roughness on the flow of a 3D foam is quantified by coupling direct visualization of the bubbles with force measurements. Our visualizations reveal different slip regimes of the soap films along the rough surface and we show that the transition between these different regimes is controlled by the ratio between the radius of the Plateau borders and the typical roughness. In addition, from the force measurements, we deduce the range of parameters for which the energy dissipation is the most important during the flow, and we identify the region of the foam in which rearrangements events (T1) occur

These results will allow a better understanding of the different regions inside a flowing foam along a rough surface, and can be useful to know exactly which roughness to use to avoid the slip of foam during its characterization.

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Stability of bubbles at the surface of a soapy bath

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The stability of soap films has raised a lot of interest for both fundamental and industrial purposes in the last decades. This work focuses on the stability of bubbles at the surface of a weakly concentrated soapy bath. Before bursting eventually, such a bubble is of crucial interest since it favours the transport of material from the bulk to the overlying atmosphere through the production of aerosols. This can be applied for example in climate models (production of sea-spray aerosols), air pollution studies in the vicinity of pathogen-bearing pools or in the carbonated beverage industry since the produced aerosols are enriched with surface-active materials that contain most of the flavour.

The quantity of aerosols produced depends on the shape of the bubble (its size for a given physico-chemical system) and on the thickness of the film upon bursting. The evolution of a bubble after reaching the interface can be decomposed in two phases: the thinning of the film through drainage and the development of an instability leading to the nucleation of a hole. A characteristic time can be associated to each phase and their ratio determines whether the overall stability is rather deterministic (governed by drainage time) or stochastic (development of an instability).

An experiment will be presented that allows for the measurement of the lifetime of a great number of bubbles (necessary to assess the determinist or stochastic nature of the system) in a humidity-controlled environment. We show that the bubble lifetime increases with the bubble size and the relative humidity in the measuring chamber. The results are compared to measurements of the drainage of the film at the top of the bubble performed in the same conditions. The impact of the purity of the solutions on the results will be discussed.

Dewetting dynamics of a thin polymer film embedded in an immiscible matrix

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In this work, we describe a model trilayer dewetting experiment elucidating the effect of solid, no-slip confining boundaries on the bursting of a liquid thin film in a viscous environment.

This experiment was inspired by an industrial polymer processing technique, multilayer coextrusion, in which thousands of alternating layers of two polymers are stacked atop one another. As showed in a systematic study of multilayer coextrusion of polystyrene (PS)/poly(methyl methacrylate) (PMMA), when pushed to the nanoscale limit, the individual layers are found to break up on time scales shorter than the processing time whatever the processing conditions.

To gain insight on this dynamic problem, we directly observe the growth rate of holes in the middle layer of a PMMA/PS/PMMA trilayer system, wherein the distance between the inner PS film and solid boundary can be orders of magnitude (~10 µm) larger than its thickness (~100 nm). In otherwise identical experimental conditions, thinner films break up faster than thicker ones. This observation is found to agree with a scaling model that balances capillary driving power and viscous dissipation with, crucially, a no-slip boundary condition at the solid substrate/viscous environment boundary. In particular, even for the thinnest middle-layers, no finite-size effect is needed to explain the data.

Confocal Raman Imaging for studying the distribution of molecules at liquid-solid interfaces for Enhanced Oil Recovery (EOR)

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Low salinity water flooding, wherein injection of sea water of low divalent cations concentration (relative to concentrations already present) to displace more oil from rock reservoirs, is a novel technology for enhanced oil recovery. However, the possible mechanisms of this process are debatable. Wettability alteration, facilitated by reduction of divalent cation concentrations could play a key role, since these species can bind oil molecules to the rock surface. We address the chemical specificity of the process, using Confocal Raman Imaging and the aspect of rock porosity, using a microfluidic channel. Mimicking the rock surface with a quartz window deposited with clay particles, we study the efficiency of the mechanism by dynamically Raman mapping the different species adsorbed/desorbed at the liquid – solid interface. We qualitatively show the differences in the displacement of thin oil layers on the walls by brine of varying concentrations. The results show that a low salinity brine injection can facilitate the desorption of divalent cation bridged surface active oil molecules bound to the quartz wall, rendering it hydrophilic and subsequently enhancing the amount of the adsorbed oil. We believe that the work will be of significant contribution to the understanding of adsorption/desorption induced wettability alteration in similar systems with high chemical specificity and also in the field of Enhanced Oil Recovery using low salinity water flooding.

Relaxation of an elastic sheet on viscous films

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The dynamics of an elastic membrane supported by a viscous fluid on a solid substrate is a phenomena commonly observed in nature, from the creation of laccoliths due to magma injection in the earths crust to small scale phenomena such as cell adhesion and microchip coating. Allthough many aspects of the sheet evolution have been studied, not much have been done to highlight the sheet dynamics dependence on the thickness of the supporting fluid film. We study this phenomena by deploying the elastohydrodynamic lubrication equation. Through a self-similar scaling analysis we derive two regimes for the dynamics which depends on the thickness of the supporting film. Numerical simulations verify our analytical model and highlights how the sheet dynamics is infuenced by the viscous film thickness.

Impact of polymer microstructure on flow of Carbopol near surfaces

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Carbopol is a suspension of microgels behaving as a yield-stress fluid: solid-like at rest, it becomes liquid under a sufficient stress. Despite its wide use in applications like cosmetics or oil extraction, the microscopic origin of this complex rheological response remains to be understood, which necessitates to characterize the microstructure of the crosslinked polyelectrolyte blobs.

We have thus performed optical measurements of the polymer structure through confocal microscopy [Géraud et al EPJE 2017]. In particular, we investigate the role of the fluorescent dye ---which can be attracted to polymer or solvent rich regions--- on these measurements.

Changing both the Carbopol type and preparation, we investigate the role of the size of the polymer blobs on the flow properties in different configurations: wall slip close to a solid surface, or confined flow in a soap film withdrawn from a liquid bath, where the thickness of entrained liquid is comparable to the microstructure size.

Super-hydrophobic sliders

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In our daily experience, an object tends to sink into water if its density is larger than the water density. However, when the surface of the object is hydrophobic it can be made to float on the water surface due to the effect of surface tension. We prepared floating disks of different geometries and coated them with a commercially-available super-hydrophobic spray coating. We then made them slide across the water surface, guided by an externally-actuated magnetic field. Our custom setup allowed us to characterize the friction of these super-hydrophobic sliders as a function of their shape and mass. We find that the observed friction it is predominantly due to the viscous stress in the boundary layer beneath the sliders.

Dynamics of a growing and spreading viscous drop under gravity

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Inspired by various natural and technological settings, we consider the sprea-ing of a growing viscous drop that is subjected to a constant injection debit. For this problem, we propose a lubrication model involving gravity and viscosity, and a matching of two solutions — an inner quasi-static shape and an outter travelling wave — at the contact line. This leads

$$R \propto \eta^{-1/7} Q^{3/7} t^{4/7}.$$
$$H \propto \eta^{2/7} Q^{1/7} t^{-1/7}.$$

to the following two scaling relations between the drop’s radius (R) or height (H) and the viscosity (η), injection debit (Q) and time (t) :
We also carried out experiments with silicon oils of viscosities ranging from 0.05 to 1.1 Pa.s, on a clean glass surface, for flow rates ranging from 50 to 150 mL/h. We monitored the characteristic dimensions of the drop over time and found good agreement with our proposed model.

Investigating liquid slip over surface nanobubbles

Srinivasa Ramisetti, Dongsheng Wen University of Leeds (GB)

Understanding liquid slip at solid surfaces is important in micro/nano fluidic applications such as lab-on-chip devices. Several experimental and numerical studies have suggested surface nanobubbles, which are gaseous domains formed at the liquid-solid interfaces, act as lubricant to enhance liquid slippage1. Both simulations and theoretical models were used to justify the slip predictions from experiments. The effects of average bubble height, surface coverage area of nanobubble, and surface morphology on the effective slip length were investigated previously2. However, none have considered the effect of gas rarefaction within surface nanobubbles. Recently, one of the authors had used non-equilibrium molecular dynamics (NEMD) simulations to investigate the importance of gas rarefaction effect on slip over nanofilms3. In this talk, I will present results from our NEMD simulations extended to the case of liquid flow over surface nanobubble covering a solid surface and discuss the effect of gas rarefaction within surface nanobubble on liquid slip.

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Life and death of a particle-ladden liquid sheet

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Thin films of suspensions are involved in many industrial processes, such as surface coating or liquid transport in tubes. For dilute suspensions, it is well known that the particles increase the effective viscosity. However, this only holds in the continuum approximation, and should fail in a confined situation such as a liquid sheet.

Here, we investigate the dynamics of a thin film of suspension, formed upon the impact of a suspension drop. Beyond the expansion phase which follows the behavior of an equivalent liquid with the same effective viscosity, capillary interactions between particles arise when the thickness of the liquid film is smaller than the particle' size. Particle agglomerate into clusters, and ultimately it leads to a loss of stability of the sheet. We study how this mechanism impacts the atomization process. Our results highlight the influence of capillary effects in this confined flow.

Particle motion near rough, porous and elastic surfaces

Aidan Rinehart Royal Institute of Technology – Stockholm (SE)

Controllability of particles and flow over surfaces provides a rich problem with numerous practical applications. This study seeks to contribute to the understanding of the interaction between surfaces (rough, porous and elastic) and particles traveling near the surface. Previous work (Salez 2015) has revealed a complex zoology of particle motion above elastic surfaces invoked through the broken symmetry of the pressure field between the surface and particle.

Our work seeks to extend particle surface interaction understanding through focusing on how surface slip length and transpiration velocity can be used to control particle motion. It turns out that inhomogeneous slip at the surface is another way to produce asymmetric pressure distribution (Fig.??{Pressure}). Stokes flow will be used to describe the physical problem allowing for characterizing particle-surface interaction beyond lubrication theory. We use multi-scale expansion to arrive with computationally feasible effective models for the surface in question and necessary boundary conditions (Lacis 2017). Using this approach enables us to model effective behavior of the surface to specific micro structures of the underlying material. A range of physical parameters and their magnitudes will be identified through the use of analytic and finite element methods. Classification of particle motion will be explored within the identified parameter domain. These results could contribute to applications ranging from bio-medical fields, passive sorting of cells or enhanced mixing, to industrial applications with precise control of pressure distribution. Future work will extend into elastic and poroelastic surfaces which should provide more variety of particle behavior.

Acoustically enhanced bubble removal in yield-stress fluids

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Yield stress fluids only flow when a sufficient, finite shear stress is applied to them. Toothpaste, mascara, inkjet ink, cement and whipped cream are common examples of yield stress fluids present in our daily lives. Industrial processing – mixing, blending, agitation ... – introduce gas bubbles in yield-stress fluids, the smallest of which remain trapped after processing since buoyancy effects may not suffice to yield the fluid [1]. This results in microbial contamination, poor aspect or bad mechanical performance of commercial products. Controlling introduction or removal of bubbles from yield stress fluids is then desirable. We explore the use of ultrasound waves to release small (100 µm) bubbles from yield stress fluids. Preliminary experiments performed in our laboratory suggest that such bubbles escape after less than a minute of exposure to ultrasound in thixotropic yield stress fluids. We hypothesize that, due to the high-frequency oscillations of the bubbles in the ultrasound field, extensional rates in the range 104–106 s-1 are applied to the surrounding fluid, causing local yielding of thixotropic, but also simple yield stress fluids.

We use a model based on the Rayleigh-Plesset equation to investigate the bubble dynamics taking into account the complex behaviour of the surrounding fluid. The resulting bubble vibration amplitude dictates both the extensional stress and strain fields experienced by the fluid. For sufficient vibration amplitude, we can use extensional yielding criteria [2] to deduce the amount of yielded fluid and predict optimal conditions for bubble removal. We confront our model with finite-element numerical simulations and experimental data obtained using high-speed imaging techniques.

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Single Droplet Evaporation Dynamics in Critical Mixtures

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Nucleation and growth phenomena, i.e. the formation and the evolution of distinct domains of a new stable phase within a metastable parent phase, have been investigated for almost all types of first-order phase transitions. When the order parameter is conserved, as for phase separation in simple and binary fluids, the kinetics can be schematically divided into three main stages: i) the very early growth following nucleation, ii) the intermediate diffusion-driven free-growth regime, and iii) the Ostwald ripening, i.e. the late stage regime of droplet growth by evaporation and condensation. In the early growth regime, it has recently been demonstrated numerically that fluctuations may play a crucial role as the surface tension of small droplets may depend on their size in a universal way for Ising universality class systems. Indeed, if the surface tension almost corresponds to its value for a flat interface for droplet radii much larger than the correlation length ξ of density fluctuations, for radii of the order of the correlation length the surface tension should decrease as the ratio R/ξ becomes smaller. This dependence, has not been observed experimentally so far, despite its wide-ranging implications in nucleation and early growth (critical radii are always estimated using the conventional definition of the surface tension), and late stage evaporation in Ostwald ripening.

To tackle this important issue, we used the radiation pressure of a laser wave at a near-critical interface to induce liquid columns of one coexisting phase in the other. Drops of different sizes are then produced at different altitudes through the Rayleigh Plateau instability when turning off the laser. We first tested classical mean field theories that predict a surface-tension driven regime where the radius of the droplet R(t) varies as K(tf-t)^(1/3), with tf the final evaporation time and K a prefactor proportional to the surface tension. Since deviations from this law at small scales could indicate the effects of curvature dependent surface tension, or be the consequence of side effects such as the influence of buoyancy or of the critical stratification, we investigated single droplet evaporation at different distances in temperature from the critical one. We indeed observe several regimes of evaporation including the mean field prediction, but also regimes related to concentration effects and stratification, as well as near criticality effects due to the increasing amplitude of density fluctuations.

The Visco-Elastic Water Nanofilm?

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Diffusive fluorescent rhodamine molecules were tracked on silica surfaces as a function of ambient humidity, which controlled the thickness of interfacial water nanofilms. At low humidity, the molecules exhibited confined diffusion in the vicinity of isolated adsorption sites characterized by a heavy-tailed distribution of binding strengths. When the humidity was increased, thin water films condensed on silica, with thicknesses of the order of a few molecules, permitting more extensive interfacial transport of rhodamine molecules. The diffusion process was found to be subdiffusive, temporally anticorrelated, and ergodic, but also intermittent. This was consistent with diffusion within viscoelastic nanofilms, suggesting molecular structuring within the first nanometers above the silica surface. Interestingly, the subdiffusive exponent was directly correlated to the thickness of the water nanofilm.

Polymer melts precursor films in pseudo-partial wetting

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When a liquid wets a surface different situations can arise, depending on the nature of the liquid and the substrate. Total wetting is characterized by a zero contact angle at equilibrium whereas in partial wetting the liquid droplet does not spread completely, leading to a non-zero equilibrium angle. We here focus on pseudo-partial wetting, which combines a non-zero equilibrium angle and the presence of a precursor film spreading ahead of the droplet.

We experimentally study the wetting of polymer melts on silica wafers. Wetting on high energy surfaces leads to a nanometer-thick precursor film spreading out of the macroscopic liquid droplet. Depending on the polymer, Van der Waals interactions occurring in the film can either induce disjoining or conjoining Derjaguin pressure, which respectively tends to separate or join the film interfaces.

Polymers with a lower polarizability than silica will be in total wetting, with a disjoining Derjaguin pressure in the precursor film. We here report for the first time measurements of high polarizability polymer droplets and their precursor films on silica, leading to a pseudo-partial wetting situation.

We clearly evidence via ellipsometry the structural and dynamical differences of the precursor film compared to total wetting, with less than 0.2 nm z-resolution. In total wetting, the precursor film presents a sharp step at its front and molecules are in a dense state. In the case of pseudo-partial wetting, the film profile is diffusive and the molecules exhibit a crawling motion at the substrate surface. These isolated molecules form a quasi-two-dimensional gas with a diffusion coefficient specific to each polymer. These results were extended to a series of common organic polymers.

We also observed that in the case of functionalized polymers (PBd-OH for instance), changing the silica layer thickness and the molar mass leads to important modifications in the typical thickness of precursor films and to a wide variety of behaviors.

Key words: pseudo-partial wetting, precursor films, surface interactions, polymer melts.

Hydrodynamic self-assembly of active colloids near a surface: chiral spinners and dynamic crystals

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Using large-scale simulations, we show that hydrodynamic interactions, together with an aligning field, lead to the stabilisation of tunable self-assembled structures of active colloids near a surface. The observed structures are motile and depend on the hydrodynamic characteristics: particles driven at the front, pullers, form small chiral spinners consisting of two or three particles, whereas those driven at the rear, pushers, assemble to large dynamic crystals. The collective motion arises from the alignment of the swimmer directors and can be tuned with the external field. The rotational motion of the puller spinners occurs due to a spontaneous chiral symmetry breaking. Our results demonstrate that hydrodynamic interactions mediate a chiral transfer between the spinners, resulting in their synchronised rotation.

High resolution AFM imaging of ion adsorption and charge distribution at heterogeneous mineral nanoparticle-liquid interfaces

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The solid-liquid interface and electrostatic interactions in solution is a quite complex topic. It is known for playing an extremely important role in determining molecular structure and binding activity, since almost all surfaces become charged by a variety of mechanisms when they come in contact with an aqueous medium. A typical picture with such a charged surface is that small ions of opposite sign accumulate in its immediate neighborhood, resulting in the formation of an electric double layer (EDL). Depending on the local solid-liquid and liquid-liquid molecular interactions, the interfacial liquid does not behave like a bulk liquid, often exhibiting higher densification and ordering that strongly depend on the local properties of the solid surface. However, experimental research remains challenging due to the lack of techniques offering sufficient resolution over inhomogeneous surfaces. Herein, unprecedented high resolution measurements of the ion adsorption and charge distribution on composite silicon oxide/gibbsite nanoplatelet surfaces using atomic force spectroscopy with sharp tips will be presented. AM-AFM spectroscopy results allow us to determine the local surface charge with a lateral resolution in the 5 nm range and to identify specific ion effects. Ultrahigh resolution AM-AFM images reflect the solvation structure of the interfacial liquid and the structure of the ions adsorbed in the Stern layer. Unlike Na+ and K+ ions, divalent ions like Ca2+ and Mg2+ modify and fully define the interface probed by AFM tip, consequently confirming their strong absorption to the surface. Complemented by density functional theory, our experiments produce a detailed picture of the formation of surface phases by templated adsorption of cations, anions and water, stabilized by hydrogen bonding.

Liquid droplets on a stretched soft substrate

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Surface stress plays a crucial role in interfacial mechanics, particularly on soft solids at small length scales. In order to further investigate the effect of strain on surface stress, we examine glycerol droplets across a range of sizes on a stretched silicone gel substrate. The equilibrium shape of the droplets after applied strain reveals a size-dependent response of both the droplet and the surface of the gel adjacent to the droplet. We aim to understand the origin of the size-dependent behavior and how it may relate to strain-dependent surface stress.

Rearrangement of a cluster under compression : from crystal to glass

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A crystal and a glass are different at a molecular level which leads to strong consequences at the macroscopic scale, [1] [2]. We have developed an ideal experimental system to model such structures. The 2D clusters are made of an emulsion of lightly attractive, stabilized oil droplets (of radius $R \sim 10\mu m$) in water which are assembled droplet by droplet (tens of droplets). We study the response of the cluster when it is compressed between two thin glass rods. One glass rod is used as a force transducer in order to measure the forces as the droplets spatially rearrange under compression. Coupling the optical microscopy images of structural rearrangements within the 2D cluster with the direct force measurements provides insight into the failure mechanisms. Perfectly ordered crystals (highly monodisperse droplets) show well defined transitions. As the number of defects (substitution of a droplet by a smaller one) is increased in the crystal, we can study the transition toward a glassy system (bidisperse cluster). We study the number of force peaks which represents the number of non-simultaneous events in the system.

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Capillary force on a tilted cylinder: AFM measurements

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The capillary force in situations where the liquid meniscus is asymmetric, such as the one around a tilted object, has been hitherto barely investigated even though these situations are very common in practice. We investigate experimentally the capillary force that applies on a tilted cylinder as a function of its dipping angle i, using a home-built tilting Atomic Force Microscope (AFM) with custom made probes. A micrometric-size rod is glued at the end of an AFM cantilever of known stiffness, whose deflection is measured when the cylindrical probe is dipped in and retracted from reference liquids [1]. We show that a torque correction is necessary to understand the measured deflection. Finally, the results are compatible with a vertical capillary force varying as 1/cos(i), in agreement with recent numerical simulations 2].

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Friction in complex assemblie of paper

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A striking macroscopic phenomenon is that trucks and even military tanks tried and failed to pull apart two phonebooks with their sheets interleaved like a shuffled deck of cards. While physicists have long guessed that this observation must be due to enormous frictional forces, the exact mechanism at play has been an enigma until a recent study. A simple model based on AC laws captures the effect of the number of sheets, their thickness and the overlapping distance. Furthermore, the data collapse onto a self-similar master curve with one dimensionless amplification parameter. The fitting of experimental curves to our model gives two parameters: the friction coefficient and a T* parameter that is defined as the force exerted by the outer sheet on the previous one. We conducted a systematic study of the impact on the friction coefficient and T* of several experimental parameters: the width of the sheets, their length, the pulling speed and the overlapping distance of the books at the beginning of the experiment.

Spatio-temporal control of water waves using electric fields

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The free surface of a liquid provides the ideal playground for studying wave propagation through complex materials whose properties vary in both space and time. A spatial inhomogeneous medium can for example be simulated using bathymetry, while temporal manipulation can be achieved through vertical acceleration of the liquid container (as in the Faraday instability). Here we show that similar wave control may be achieved by exerting static or time-varying electric forces on the water surface. The ease of control of the electric fields and the possibility of applying time-varying fields locally opens up new ways to manipulate (water) waves and simulate new types of complex media. Several recent experiments will be presented.

Mechanisms of Interactions between Lipid Membranes in Solution with Biological Cosolutes

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Lipid membranes form the diffusional barrier of every eukaryotic cell. Therefore, the study of interactions between these membranes is important, as they determine every process during which cells come into close contact with one another (e.g. during cell fusion or vesicle formation). We specifically analyze three different cosolutes, which are all abundantly found in biological systems, namely urea, TMAO and sodium chloride and their respective influence on bilayers composed of either DMPC or POPC lipids. The effect of the polar solutes urea and TMAO on protein stability has been studied extensively, but their influence on lipid bilayers has only recently started to be investigated.

Using molecular dynamics simulations and theoretical modeling we analyze different mechanisms of lipid-cosolute and lipid-lipid interactions. By means of solution thermodynamics we model the effect of the cosolutes on the hydration repulsion between lipid bilayers. Results from our atomistic simulations compare well to experimental calorimetric measurements. We find that the osmotic pressure due to the added solute is the most important influence on the hydration repulsion. Taking cosolute-specific deviations from thermodynamic ideal behavior into account, our model quantitatively explains the modified hydration interaction between bilayers in cosolute solutions. Furthermore, we find that the interaction mechanism of sodium chloride with lipid bilayers is dominated by the ion-membrane potentials of mean force. Other factors such as the dielectric response seem to be of less importance.

Visco-capillary response of gas bubbles probed by thermal noise atomic force measurement

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We present thermal noise measurements of a vibrating sphere close to micro-sized air bubbles in water with an atomic force microscope. The sphere was glued at the end of a cantilever with a resonance frequency of few kHz. The sub-Angstrom thermal motion of the micro- sphere reveals an elasto-hydrodynamic coupling between the sphere and the air-bubble. The results are in perfect agreement with a model incorporating macroscopic capillarity and fluid flow on the bubble surface with full slip boundary conditions.

Novel uses of thin glass capillaries for investigating interfacial and other fluid properties

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Glass microcapillaries are very versatile tools, available at low cost in a large variety of shapes and dimensions, and their wettability can be adjusted by means of silane chemistry. They can be easily loaded with powders, liquids and gases and brought to temperatures and pressures not accessible with conventional (macroscopic) cells. Most importantly, high quality capillaries are compatible with various contrast modes of high resolution optical microscopy.

We report how round capillaries can be used as optical cells for studying a variety of interfacial phenomena and fluid properties, including contact angles, thin films on the glass substrate, and fluid refractive indices. These capillaries are thin but have thick walls compared to their bore, which induces strong refraction effects responsible for an apparent magnification of the inner diameter. These effects must be properly handled to extract the wetting angle from a meniscus micrograph. Thus we were able to measure contact angles of brine/CO2/silica systems in conditions representative of CO2 geological storage (ref. 1).

By exploiting the reflection on the inner capillary wall of the illumination (either in brightfield or between crossed polarizers), we also show how to measure the refractive index of the fluid present in the capillary, and to detect very thin (<0.1 µm) films propagating over the wall (refs. 1&2). In these processes, the inner and outer diameters of the capillary and the refractive index of the glass are critical parameters, which must be chosen in the appropriate range.

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Mansur	Alexandre	alexandre.mansur@espci.fr	Paris	FR	Participant
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Péméjà	Justin	justin.pemeja@univ-lyon1.fr	Lyon	FR	Poster

Lastname	Firstname	Mail	City	Country	Category
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Lastname	Firstname	Mail	City	Country	Category
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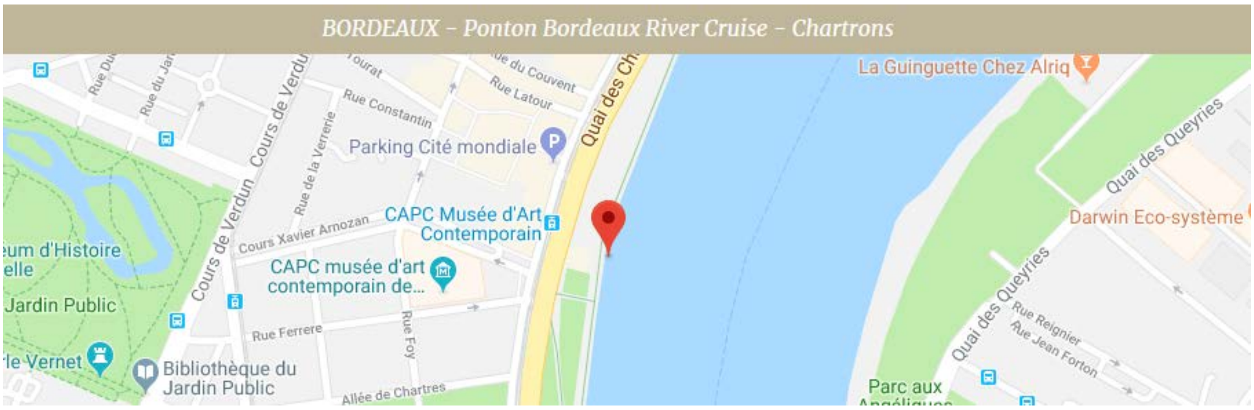
Zhou	Kedi	kedi.zhou@univ-pau.fr	Pau	FR	Poster
Zhou	Meng	meng.zhou@ifsttar.fr	Marne-La-Vallee	FR	Talk

Social Event

Tuesday evening a Gala Dinner is organized on the river boat "Sicambre”. The participants who registered for that event are expected to be at the pontoon "Bordeaux River Cruise" **no later than 20:15.** Allow 45 min to get there with the **B Tramway from the Peixotto or Forum stops to the CAPC Musée d'Art Contemporain stop**.



Access Map

The conference will take place at University of Bordeaux,

in the **Agora auditorium of the Haut-Carré Domain** located at:

43 rue Pierre Noailles 33400 Bordeaux, France.

The closest **B Tramway** stops are **Forum** and **Peixotto**,

10 min away from the auditorium.