NTNU
Norwegian University of Science and Technology

The Research Council of Norway

7th Annual International Workshop on
Soft & Complex Matter

Norwegian Academy of Science and Letters

Drammensvegen 78, Oslo, Norway, November 12-13, 2021

Invited speakers:

Patrick Tabeling (ESPCI, Paris, France)
Maria Helena Godinho (Univ. NOVA de Lisboa, Portugal)
Françoise Brochard-Wyart (Sorbonne, Paris, France)
Corinna Maass (Max Planck, Germany)
Alberta Ferrarini (University of Padova, Italy)
Irep Gozen (University of Oslo, Norway)
Adrian Rennie (Uppsala Univ. Sweden)
Reidar Lund (University of Oslo, Norway)
Matti Knaapila (DTU, Denmark)
Andreas Carlson (University of Oslo, Norway)
Maria Fernandino (NTNU, Norway)
Ingve Simonsen (NTNU, Norway)
Barbara Ruzicka (Sapienza University of Roma, CNR, Italy)
Ørjan G. Martinsen (University of Oslo, Norway)

Invited researchers/postdocs/PhD-student:

Barbara Pacakova (NTNU, Norway)
Paulo Brito (NTNU, Norway)
Osvaldo Trigueiro (NTNU, Norway)
Mathijs Janssen (University of Oslo, Norway)
Pedro L. O. Filho (NBI, Denmark and USP, Brazil)
Victoria A. Bjørnestad (University of Oslo, Norway)
Kristoffer Hunvik (NTNU, Norway)
Elena Burattia (Sapienza University of Roma, CNR, Italy)

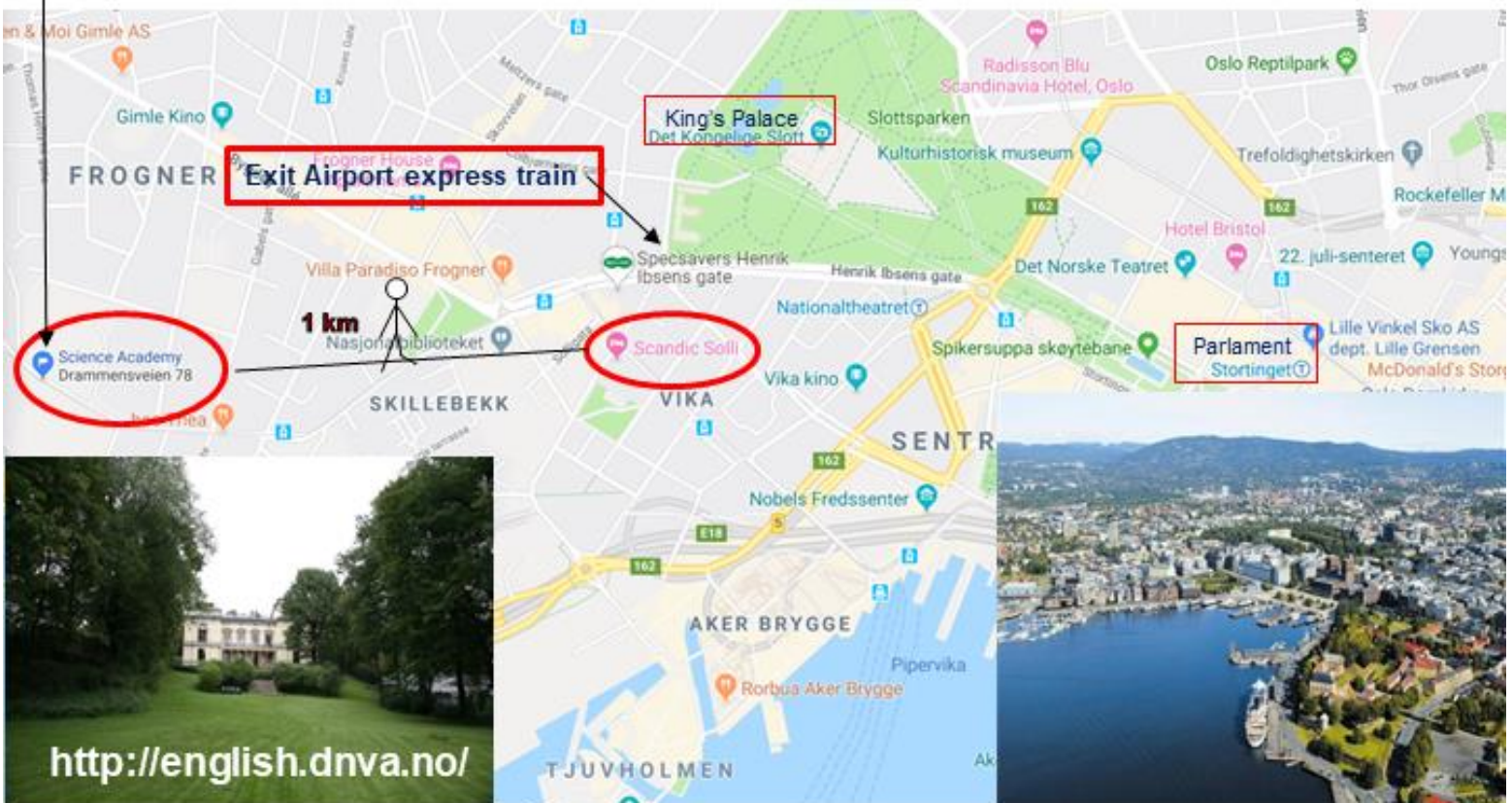
Practical information:

The workshop starts at 9:00 Nov. 12, and ends by early evening Nov. 13, 2021

Organizers and contact:

Jon Otto Fossum (jon.fossum@ntnu.no)
NTNU, Trondheim, Norway

Leide P. Cavalcanti
NTNU and ISIS Neutron Source, UK



Program and Book of Abstracts

7th Annual International Workshop

Soft & Complex Matter

Norwegian Academy of Science and Letters, Oslo, Norway

November 12-13, 2021

Time	Friday, 12/November	Saturday, 13/November
09:00 — 09:45	Registration / Mingling / Coffee	Registration / Mingling / Coffee
09:45 — 10:00	Welcome (Jon Otto Fossum)	
10:00 — 10:20	**Patrick Tabeling:** *Microfluidic stories*	**Barbara Pacakova:** *Magnetic Janus clay nanosheets*
10:20 — 10:40	**Maria Helena Godinho:** *Oscillating colourful patterns in cellulose-based liquid crystalline systems*	**Andreas Carlson:** *Droplet spreading dynamics on conical fibers*
10:40 — 11:00	**Françoise Brochard-Wyart:** *Crossing boundaries from mesoscopic physics to biological functions: Aspiration and fusion from granules to multicellular hybrid aggregates*	**Maria Fernandino:** *Wetting properties of conical micro-structured surfaces*
11:00 — 11:30	Coffee break/discussions	Coffee break/discussions
11:30 — 11:50	**Corinna Maass:** *History caging: how self-propelling droplets shape their chemical environment.*	**Ingve Simonsen:** *Statistical characterization of disordered surfaces by light scattering*
11:50 — 12:10	**Barbara Ruzicka:** *Dynamical behaviour of soft IPN microgels*	**Ørjan G. Martinsen:** *Memristive properties of human skin*
12:10 — 12:30	Discussions	**Ingebret Fjelde:** *Blocking of fractures in reservoir rock by laponite gel*
12:30 14:00	Lunch at DNVA	Discussions (12:30 -13:00)
		Lunch (13:00 – 14:30) at DNVA
14:00 — 14:10	**Paulo H. Michels-Brito:** *Bright, non-iridescent structural coloration from 2D clay nanosheet suspensions.*	
14:10 — 14:20	**Osvaldo Trigueiro Neto:** *Controlled Swelling of Clay Particles*	
14:20 — 14:30	**Elena Buratti:** *Synthesis control on the structure of microgels of poly(N-isopropylacrylamide) and poly(acrylic acid)*	
14:30 — 14:40	**Victoria Ariel Bjørnestad:** *Structural investigation of a styrene maleic acid copolymer in interaction with lipid bilayers*	Group discussions at **DVNA**, diner at own expenses. **DNVA** localities are available for all participants until 19:00.
14:40 — 15:10	Coffee break/discussions	
15:10 — 15:20	**Barbara Pacakova:** *Magnetic properties of natural vermiculite clay*	
15:20 — 15:30	**Mathijs Janssen:** *Electrolyte dynamics in narrow pores*	
15:30 — 15:40	**Pedro L. O. Filho:** *On the role of mesoporous silica morphology in the adsorption of diphtheria and tetanus anatoxins: Towards the development of oral vaccines*	
15:40 — 15:50	**Kristoffer W. Bø Hunvik:** *Enhanced CO2 Adsorption by Tuning the Layer Charge of a Clay Mineral*	
15:50 — 16:20	Coffee break/discussions	
16:20 — 16:40	**Alberta Ferrarini:** *Helical Inclusions in Phospholipid Membranes: Lipid Adaptation and Chiral Order*	
16:40 — 17:00	**Irep Gozen:** *Did surfaces enable the origin of life?*	
17:00 — 17:20	**Adrian R. Rennie:** *Rough and Smooth – Looking at Self-Assembly on Surfaces*	Norwegian Academy of Science and Letters (**DVNA**), Drammensvegen 78 Oslo, Norway.
17:20 — 17:50	Coffee break/discussions	
17:50 — 18:10	**Reidar Lund:** *Molecular Transport and Growth of Lipid Vesicles exposed to Antimicrobial Peptides*	
18:10 — 18:30	**Matti Knaapila:** *Local structure mapping of individual polymer fibers*	
18:30 — 19:00	Discussions	
19:00 23:00	Diner at DNVA (localities are available until 1:00 am)	

Friday, 12/November/2021

09:00	—	*09:45*	**Registration / Mingling / Coffee**
09:45	—	*10:00*	**Welcome (Jon Otto Fossum)**
10:00	—	*10:20*	**Patrick Tabeling:** ***Microfluidic stories***

ESPCI Paris, France

Microfluidics often opens new avenues in domains where fluids must be manipulated at the submillimetric scales. I will mention three examples: one in diagnostics, with applications to Covid, and the others in photonic material and cell culture, for which it becomes possible to design new photonic band gap materials and investigate, in more controlled conditions, the importance of the scaffold geometry in the determination of the cellular growth morphologies.

10:20 — *10:40* **Maria Helena Godinho:** ***Oscillating colourful patterns in cellulose-based liquid crystalline systems***

Pedro E. S. Silva[a], Ricardo Chagas[a], Susete N. Fernandes[a], Pawel Pieranski[b], Robin L. B. Selinger[c], and Maria Helena Godinho*[a]
a) i3N/CENIMAT, Department of Materials Science, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal
b) Laboratoire de Physique des Solides, Université Paris-Saclay, Bât. 510, 91405 Orsay, France
c) Department of Physics, Advanced Materials and Liquid Crystal Institute, Kent State University, Kent, OH 44242, USA
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Cellulose is one of the most studied polymers. However, the issue of self-organization under non-equilibrium conditions, which is ubiquitous in living matter, has scarcely been addressed in cellulose-based materials [1]. Here, we show that quasi-2D preparations of a lyotropic cellulose-based cholesteric mesophase display travelling colourful patterns, which are generated by a chemical reaction-diffusion mechanism being simultaneous with the evaporation of solvents at the boundaries. These patterns involve spatial and temporal variation in the amplitude and sign of the helix´s pitch. A simple model is proposed, based on a reaction-diffusion mechanism, which simulates the observed spatiotemporal colour behaviour. Foreseen technological applications include the manipulation of structural colours, the preparation of templates and the design of hydrophilic/hydrophobic surfaces on demand.

[1] Silva, P.E.S., Chagas, R., Fernandes, S.N. *et al.* Travelling colourful patterns in selforganized cellulose-based liquid crystalline structures. *Commun Mater* **2,** 79 (2021). https://doi.org/10.1038/s43246-021-00182-7.

Acknowledgements
This work is co-financed by FEDER, European funds, through the COMPETE 2020 POCI and PORL, National Funds through FCT – Portuguese Foundation for Science and Technology and POR Lisboa2020, under the projects PIDDAC (POCI-01-0145-FEDER-007688, Reference UIDB/50025/2020-2023) and PTDC/CTM-REF/30529/2017 (NanoCell2SEC) and Action European Topology Interdisciplinary Action (EUTOPIA CA17139).

10:40 — 11:00 **Françoise Brochard-Wyart:** ***Crossing boundaries from mesoscopic physics to biological functions: Aspiration and fusion from granules to multicellular hybrid aggregates***

Françoise Brochard-Wyart and Gregory Beaune
Sorbonne –Université Paris 05, CNRS UMR 168, Institut Curie, 26 rue d'Ulm, 75248 Paris

We apply micropipette aspiration and droplet fusion to study the mechanical properties of cellparticle aggregates and viscous granules. It has been recently discovered that in addition to membranebound organelles, cells utilize membrane-less organelles, which are formed by liquid-liquid phase separation of macromolecule mixtures. These coacervate-based supramolecular assemblies can be utilized as lipid-free cargo delivery systems for biotechnological and medical applications.
Cellular aggregates belong to the field of "Entangled active matter", which has recently emerged to provide a unified understanding of the behavior of swarms of motile adhesive particles. Unlike schools of fish and flocks of birds, cells in an aggregate are bound by transient links and behave as *active* viscoelastic pastes. We derive the mechanical properties of these cellular aggregates using the pipette aspiration technique. We observe a reinforcement of the aggregates with pressure, which may lead to pulsed contractions or "shivering". We interpret this reinforcement as an active mechanosensitive response of the acto-myosin cortex. For the fusion, we find that the contact area increases non-linearly with time, and follows the laws of fusion of jelly drops at short times. We then study the formation and mechanical properties of hybrid aggregates of microparticles and living cells. The size of the particles is varied from nanometers to few microns. 1) *Nanoparticles (size 20nm)* can be used as glue "*nanostickers*" to enable the formation of self-assembled aggregates by promoting cell–cell interactions. By increasing the cohesion of tissues and tumors, they may have important applications for cellular therapy and cancer treatment. 2) *Macro-particles (size ≈ comparable to the cell size).*
These hybrid aggregates are not only important for mimicking tissues consisting of cells and extracellular matrix, but they are an example of a mixture of active matter at two temperatures (cold particles and hot cells), belonging to the field of active granular matter. As predicted theoretically, we observe an activation of the cold macroparticles by the cells, leading to phase separations and jamming transitions. Our study may have implications on processes such as cancer metastasis and development and may guide new cancer therapies based on inert particles.

[1] Guevorkian, K., Colbert, M.-J., Durth, M., Dufour, S. & Brochard-Wyart, F. Aspiration of Biological Viscoelastic Drops. Phys. Rev. Lett. ***104****, 218101 (2010).*
[2] Gonzalez-Rodriguez, D., Guevorkian, K., Douezan, S. & Brochard-Wyart, F. Soft matter models of developing tissues and tumors. Science ***338****, 910–7 (2012).*
[3] Hu, D. L., Phonekeo, S., Altshuler, E. & Brochard-Wyart, F. Entangled active matter: From cells to ants. Eur. Phys. J. Spec. Top. ***225****, 629–649 (2016).*
[4] Nagarajan, U. et al. Inert-living matter, when cells and beads play together. Commun. Phys. ***4****, 2 (2021).*
[5] Brochard-Wyart, F. A Tour of My Soft Matter Garden: From Shining Globules and Soap Bubbles to Cell Aggregates. Annu. Rev. Condens. Matter Phys. ***10****, 1–23 (2019).*

11:00 — 11:30 **Coffee break/discussions**

11:30 — 11:50 **Corinna Maaß:** ***History caging: how self-propelling droplets shape their chemical environment.***

Babak Vajdi Hokmabad (1), Ranabir Dey (1), Chenyu Jin (1), Jaime Agudo-Canalejo (1), Ramin Golestanian (1), Corinna Maaß (1,2,*)
(1) Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany
(2) University of Twente, Enschede, Netherlands
(*) Presenter

Many ensembles in nature - think colonies of algae, motile cells or fungal spores - exhibit complex, non-linear collective behaviour based on cues from their local chemical environment or on chemical signalling between individual members of the collective. Such phenomena are e.g. vital to colony migration, space exploration or the aggregation of biofilms or tissues. However, their description would involve nonequilibrium physics and chemistry, intricate biological pathways, and all the experimental complexity associated with handling living matter.
It is therefore instructive to recreate similar phenomena in idealized, precisely controlled physicochemical model systems, in our case self-propelling microdroplets [1].
These droplets move by depleting a slowly diffusing fuel in their environment, such that they leave chemorepulsive trails in their wake. The interaction with these self-generated chemical fields aids the droplets to navigate microfluidic structures [2], explore self-avoiding walks [3] and even causes chemorepulsive arrest in dense systems [4].

[1] Maass et al., Annu. Rev. Condens. Matter Phys. 7, 171–193 (2016).
[2] Jin et al., PNAS 114, 5089–5094 (2017).
[3] Hokmabad et al., Phys. Rev. X 11, 011043 (2021).
[4] Hokmabad et al., arXiv 2012.05170 (2020).

11:50 — *12:10* **Barbara Ruzicka:** ***Dynamical behaviour of soft IPN microgels***

Roberta Angelini, Elena Buratti, Silvia Franco, Valentina Nigro, and B. Ruzicka
CNR-ISC and Department of Physics, Sapienza University of Rome, Piazzale A. Moro 2, 00185, Rome, Italy

Microgels, soft particles made of cross-linked polymer chains able to swell and retain large amounts of water in response to external stimuli, such as temperature, pH or ionic strength, have proved attractive in several technological applications and very good model systems for exploring the unconventional behaviour of soft colloids due to their softness that allows to explore high density states well beyond random close packing.
In the last years we have deeply investigated a dual responsive Interpenetrated Polymer Newtork (IPN) microgel composed of poly(N-isopropylacrylamide) (PNIPAM), a temperature sensitive polymer, and poly(acrylic acid) (PAAc), a pH sensitive polymer [1-3]. In this talk we discuss the dynamical behaviour of PNIPAM-PAAc IPN microgels approaching the glass transition investigated through Dynamic Light Scattering and X-ray Photon Correlation Spectroscopy [4,5] varying concentration, temperature and PAAC content. The slowing down of the dynamics with increasing particle concentration shows an exponential increase of the relaxation time followed by a power law in the glassy state, that, together with a stretched to compressed transition, appear to be a general common feature of many different glass-formers.

[1] V. Nigro et al., *Polymers* **13**, 1353 (2021).
[2] V. Nigro et al., *Rev. Sci. Instrum.* **92**, 023907 (2021).
[3] S. Franco et al., *Int. J. Mol. Sci.* **22**, 4032 (2021).
[4] V. Nigro et al., *Soft Matter* **13**, 5185 (2017).
[5] V. Nigro et al., *Macromolecules* **53**, 1596 (2020).

12:10 — *12:30* **Discussions**

12:30 *14:00* **Lunch at DNVA**

14:00 — 14:10 **Paulo H. Michels-Brito:** ***Bright, non-iridescent structural coloration from 2D clay nanosheet suspensions.***

Paulo H. Michels-Brito[1], Volodymyr. Dudko[2], Daniel Wagner[2], Paul Markus[3], Georg. Papastavrou[3], Leander Michels[1], Josef Breu[2], Jon O. Fossum[1]
[1] Department of Physics, Norwegian University of Science and Technology - NTNU, Trondheim, Norway;
[2] Department of Inorganic Chemistry I and Bavarian Polymer Institute, University of Bayreuth, Bayreuth, Germany;
[3] Department of Physical Chemistry II and Bavarian Polymer Institute, University of Bayreuth, Bayreuth, Germany
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Natural structural colors arise when photonic waves interfere constructively from nanostructures with distances comparable to wavelengths of visible light. Many reports show synthetic bioinspired iridescent structural color from 2D materials. Here we demonstrated that wide range of non-iridescent structural colors can easily be achieved by 2D clay nanosheets suspensions. In the present work, we use a clay nanolayer made by a synthetic Fluorohectorite with a very high aspect ratio, superior quality in homogeneity and charge distribution. We show that brightness is enormously improved by using double clay nanosheets, thus optimizing the clay refractive index that otherwise hampers structural coloration from such systems. We studied the non-iridescent structural colors by combine different techniques: Reflectivity spectrophotometer studies determined the characteristic wavelength of each sample, whereas birefringence demonstrated the micro domains organizations, small angle Xray scattering confirmed the periodic organization of clay nanosheets suspensions and x-ray diffraction and atomic force microscopy the confirm the production of double layers. We show also non-iridescent structural colors can efficiently be tune by clay nanosheet concentration or ionic strength. Embedding such clay designed nanosheets in recyclable solid matrices could provide tunable vivid coloration and mechanical strength and stability at the same time, thus opening a new venue for the sustainable penetration of structural coloration to everyday life.

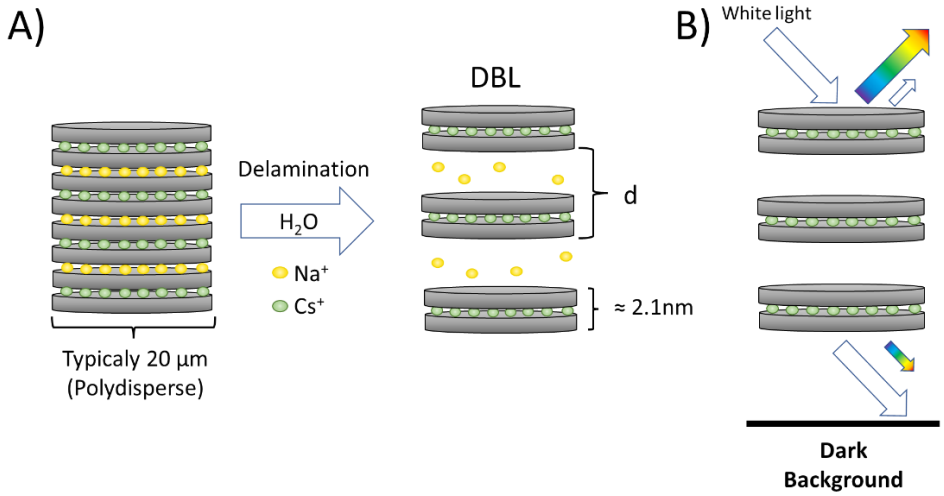

Figure 1: Principle of production of structural color from nematic clay DBLs. A) Schematics of protocol for production of nematic phases of double 2 nm thick layers (DBLs). B) Principle of reflective structural coloration obtained from a lamellar Bragg-stack suspension. Each lamella is semi-transparent, reflecting part of the incoming white light that then interfere constructively according to Bragg-Snell's law. A dark background absorbs the white light that is transmitted through the whole stack.

14:10 — 14:20 **Osvaldo Trigueiro Neto:** ***Controlled Swelling of Clay Particles***

O. Trigueiro Neto[1], K. H. Olsen[1], V. V. Liljeström[1*], P. G. Dommersnes[1], J. O. Fossum[1]
[1]Department of Physics, Norwegian University of Science and Technology – NTNU, Trondheim, Norway
**Now at Aalto University, Finland*

Clay particles swell in water [1]. We study fluorohectorite synthetic clay (NaxMg3-xLixSi4O10F2), due to their purity, crystallinity, and uniform charge distribution. The clay we studied has a magnitude of charge that allows it to completely delaminate in water, 0.5 per formula unit (p.f.u.), x on the formula. Although, when saline water is used this process of delamination can be stopped and only the swelling happens. Here, results of experiments using particles of synthetic clay (Sodium Fluorohectorite) ranging from 100 to 300 µm lateral size in saline solutions (Sodium Chloride) from 1 to 0.025 M will be shown. The experiments were done in two stages. The first one is a set of dialysis trials where multiple particles could be seen at a single time. The second stage used an open cell approach for the experiments, where with the help of micropipettes and a pressure controller the clay particles could be picked up and held in place so that the swelling would happen perpendicular to the camera. These experiments had

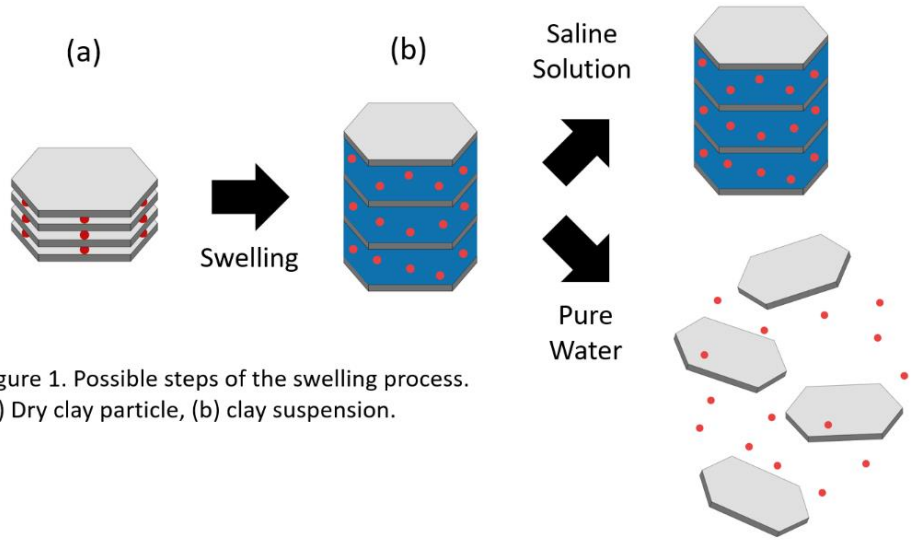

Figure 1. Possible steps of the swelling process. (a) Dry clay particle, (b) clay suspension.

the main goal of controlling and improving the delamination procedure of clay nanosheets, in order to in turn to be used for encapsulation of nanoparticles [2, 3]. We acknowledge Josef Breu (Inorganic Chemistry, University of Bayreuth, Germany) for providing the fluorohectorite samples used on the experiments. The project is granted from the Research Council of Norway, Petromaks2: “Nanofluids for IOR and Tracer Technology”, project number: 268252.

1. Rosenfeldt, Sabine, et al. "In-depth insights into the key steps of delamination of charged 2D nanomaterials." Langmuir 32.41 (2016): 10582-10588.
2. Rozynek, Z., Mikkelsen, A., Dommersnes, P., & Fossum, J. O. (2014). Electroformation of Janus and patchy capsules. Nature communications, 5, 3945.
3. Paulsen, J. D., Démery, V., Santangelo, C. D., Russell, T. P., Davidovitch, B., & Menon, N. (2015). Optimal wrapping of liquid droplets with ultrathin sheets. Nature materials, 14(12), 1206.

14:20 — *14:30* **Elena Buratti:** ***Synthesis control on the structure of microgels of poly(N-isopropylacrylamide) and poly(acrylic acid)***

E. Buratti, S. Franco, V. Nigro, R. Angelini and B. Ruzicka
CNR-ISC and Department of Physics, Sapienza University of Rome, I-00185 Roma, Italy

Stimuli responsive microgels, colloidal particles consisting of a polymeric cross-linked network, have attracted considerable interest for technological applications and theoretical implications in the last decades. Great attention has been placed on poly(N-isopropylacrylamide) (PNIPAM)-based microgels, since they are able to tune both softness and volume fraction with temperature.1 However materials with multi-stimuli responsiveness and rationally designed properties are increasingly in demand. In this work, we study a dual responsive microgel with an Interpenetrated Polymer Network (IPN), composed by PNIPAM and poly(acrylic acid) (PAAc), that allows to combine the thermo-responsivity of the latter polymer with the pH-responsivity of the former,2 creating a system with a very interesting properties. Acting on different parameters in the synthesis procedure (surfactant concentration, reaction time, and so on), we have reached a fine control over the structure of IPN particles, in particular regarding the interpenetration of the PAAc inside the PNIPAM network, with the possibility to vary ad hoc their characteristics such as radius, swelling capability and softness. Different experimental techniques have been used to investigate the behaviour of microgels particles with different sizes and PNIPAM/PAAc contents across the volume phase transition at different temperatures, concentrations and pH.3

1 Advances in Colloid and Interface Science, 85, 2000, 1-33
2 Langmuir, 20, 2004, 2094-2098
3 Journal of Colloid and Interface Science 545, 2019, 210–219

14:30 — *14:40* **Victoria Ariel Bjørnestad:** ***Structural investigation of a styrene maleic acid copolymer in interaction with lipid bilayers***

Victoria Ariel Bjørnestad [1], Marcella Orwick Rydmark [2] and Reidar Lund [1]
[1]Department of Chemistry, University of Oslo
[2]Department of Biosciences/Natural History Museum, University of Oslo
Presenting author e-mail: v.a.bjornestad@kjemi.uio.no

The amphiphilic styrene maleic acid (SMA) copolymer has received notable attention in recent times for their ability to directly extract membrane proteins into smaller lipid nanodiscs, eliminating the need for detergents in their isolation. The molecular interactions that govern the formation of nanodiscs have however not been studied at a structural level. In this study we elucidated the structural changes that occur when SMA interacts with lipid vesicles using small angle X-ray scattering (SAXS), which in combination with data modelling allows detailed in situ structural information on the nanoscale. [1] The SMA copolymer itself forms aggregates of globular structures in in solutions at pH 7.4. Upon mixing with lipid vesicle, the polymer disaggregates and inserts its styrene units into the lipid bilayer hydrocarbon region leading to fractures in the membrane. The initial polymer-lipid interactions observed with vesicle structures remain in the formed discs, with excess polymer distributing along the normal of the bilayer in a belt-like structure. The size and SMA distribution in the resulting discs strongly depend on temperature, lipid:polymer ratio, and lipid type. We find that the SMA polymer if more effective in transforming membranes at temperatures below the melting point into nanodiscs, suggesting that defects formed by the polymer in gel-like lipids membranes play a significant role in facilitating fracture and nanodisc formation. The findings provide unique insights into the structure and interactions of SMA polymer with lipid bilayers that are relevant for many applications in biotechnology, medicine and industry.

References:

[1] Bjørnestad, V.A.; Orwick Rydmark M.; Lund, R. Understanding the Structural Pathways for Lipid Nanodisc Formation: How Styrene Maleic Acid Copolymers Induce Membrane Fracture and Disc Formation. *Langmuir*. **2021**, 37 (20), 6178-6188.

14:40 — *15:10* **Coffee break/discussions**

15:10 — 15:20 **Barbara Pacakova:** ***Magnetic properties of natural vermiculite clay***

Barbara Pacakova[1], Jon Otto Fossum[1]*
[1]Department of Physics, Norwegian University of Science and Technology – NTNU, Trondheim, Norway
*e-mail corresponding author: *barbara.pacakova@ntnu.no*

Vermiculite, layered ionic material, belongs to the family of layered philosilicates. It is very difficult to exfoliate vermiculite into the single sheets, compared to the other layered clays with low surface charge, as the surface charge of vermiculite is too high, reaching values between 0.7 – 1.
We present here efficient method of exfoliation of vermiculite crystals into the 1 nm thin single sheets, and their magnetic properties. Single vermiculite sheets are composed of three layers, with the distorted octahedra layers sandwiched between two tetrahedral. Layered silicates in general exhibit diamagnetic susceptibility. In our case, we propose anisotropic diamagnetic susceptibility arising in distorted tilted octahedra.
The in-plane diamagnetic susceptibility of vermiculite is in general larger than the out-of-plane magnetic susceptibility, as is typical for many phyllosilicates, hence sheets always orient with their plane normal perpendicular to the external magnetic field. The reason for anisotropic magnetic susceptibility originates in the crystal structure of vermiculite– i.e. distorted octahedra. Maximum susceptibility lies in the direction of the longest axis of the octahedra. Lattice planes with the metallic atom bonded to four oxygen atoms, perpendicular to the longest axis of octahedra, has much higher electron density than the plane parallel with the longest octahedral axis. The largest susceptibility component is always perpendicular to the plane with the highest density of electrons, as can be demonstrated on naphthalene and graphite, where very mobile delocalized electrons induce currents around the edges of the ring. As the diameter of the rings is much higher than atomic diameter, maximum susceptibility lies in direction perpendicular to the ring plane. To confirm this hypothesis about anisotropic susceptibility of vermiculite, we will present results of experimental measurement of field dependence of magnetization.

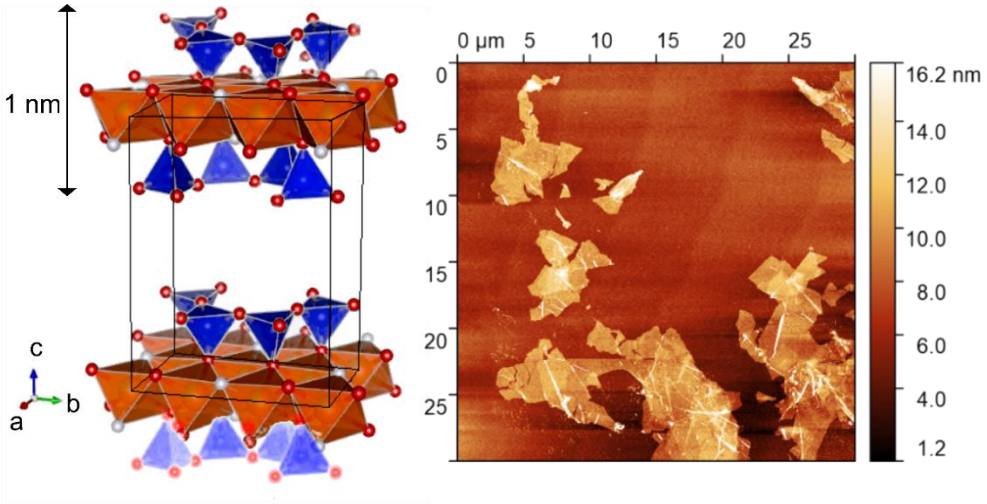

Figure 1. (a) Crystal strucure of 1 nm thin vermicullite single sheet. (b) The AFM topography images of single-layer vermiculite clay.

15:20 — *15:30* **Mathijs Janssen:** ***Electrolyte dynamics in narrow pores***

Department of Mathematics, University of Oslo

The dynamics of electrolytes in narrow pores underlies key functionalities in biology and technology. Examples include axons firing in the brain, plant cells signalling through plasmodesmata, and “supercapacitors” for storing and converting electrical energy. In all these examples, the charge on a pore's surface is screened in a liquid phase by a cloud of ions, forming electric double layers. In this talk, I will discuss how these double layers form dynamically, using the so-called transmission line model. This model goes back to Lord Kelvin’s work on trans-Atlantic telegraph cables and has since been adapted to describe the signalling of dendrites [1] and the charging of porous electrodes [2,3].

[1] Keener and Sneyd, Mathematical Physiology Vol. 1 (2009)
[2] de Levie, Electrochim. Acta 8, (1963)
[3] M. Janssen, Phys. Rev. Lett. 126, (2021).

15:30 — 15:40 **Pedro L. O. Filho:** ***On the role of mesoporous silica morphology in the adsorption of diphtheria and tetanus anatoxins: Towards the development of oral vaccines***

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Diphtheria (DT) and tetanus (TT) are potentially deadly infectious diseases caused by bacteria, usually *Corynebacterium Diphtheriae* and *Clostridium Tetani*.1, 2 Fortunately, they are prevented, in most cases, by the vaccination with the respective antigens, DTd and TTd, often combined to form a single vaccine, parenterally administrated. Despite the effectiveness of the actual tetanus-diphtheria vaccine, other immunization routes, such as oral and nasal methods, have been explored for more than 20 years. As the needle-free immunization process is a simplified concept, it is seen as more cost effective. Among various strategies to select a suitable antigen carrier (adjuvant), the use of ordered mesoporous silica (OMS), particularly SBA-15, is especially interesting.3-8. Recently, it has been demonstrated that the OMS morphology plays a significant role in the anatoxins protection.8. This morphology is dictated by the precursors and the conditions of synthesis, such as the concentration of the copolymer, the type and amount of swelling agent (in general, an alcohol), time and temperature of hydrothermal treatment in a conventional oven or microwave, among others.9. The change in one or more parameters leads to materials with different size, shape, porosity and pore structure, that affects both adsorption and release of the antigens. In this context, the present work seeks to investigate the effect of the OMS morphology in the adsorption of DTd and TTd aiming to select the best suitable one, which may improve the humoral response and, consequently, provide basis for DTd/TTd oral vaccine development. This work is supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (process number 2020/13204-7).

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15:40 — 15:50 **Kristoffer W. Bø Hunvik:** ***Enhanced CO2 Adsorption by Tuning the Layer Charge of a Clay Mineral***

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Due to the compact 2D interlayer pore space and high density of interlayer molecular adsorption sites, clay minerals are competitive adsorption materials for carbon dioxide capture. Nickel-exchanged fluorohectorite (Ni-Hec) has recently been shown to form an ordered interstratification of smectite-like $[Ni(H_2O)_6]^{2+}$ and condensed, chlorite-like $[Ni(OH)_{2-y}(H_2O)_y]_x^{y+}$ interlayers, where x refers to the degree of condensation [1]. This chlorite-like interlayer structure has been shown to promote swelling and adsorption in both dried and hydrated Ni-Hec in response to CO_2 exposure, where swelling occurs solely in the interlayers where this condensed species is present [2]. The influence of the layer charge on the hydration properties of smectites has received considerable interest. However, only simulations have shown that on montmorillonite that a higher layer charge facilitates water molecules entering the clay interlayers and decreases CO2 adsorption, while a higher CO2/(CO2 + H2O) mole fraction is acquired when the charge is low[3].
We demonstrate that with decreasing interlayer surface charge in a clay mineral, the adsorption capacity for CO2 increases, while the pressure threshold for adsorption and swelling in response to CO2 decreases. Synthetic nickel-exchanged fluorohectorite was investigated with three different layer charges varying from 0.3 to 0.7 per formula unit of Si4O10F2. We associate the mechanism for the higher CO2 adsorption to more accessible space and adsorption sites for CO2 within the interlayers. The low onset pressure for the lower charge clay is attributed to a weaker cohesion due to the attractive electrostatic forces between the layers. The excess adsorption capacity of the clay is measured to be 8.6, 6.5 and 4.5 wt.%, for the lowest, intermediate, and highest layer charges respectively. Upon release of CO2 the highest layer charge clay retains significantly more CO2. This pressure hysteresis is related to the same cohesion mechanism, where CO2 is first released from the edges of the particles thereby closing exit paths and trapping the molecules in the center of the clay particles.

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15:50 — 16:20 Coffee break/discussions

16:20 — *16:40* **Alberta Ferrarini:** ***Helical Inclusions in Phospholipid Membranes: Lipid Adaptation and Chiral Order***

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The lipid bilayer is a flexible matrix that is able to adapt in response to the perturbation induced by inclusions, such as peptides and proteins. We have used molecular dynamics simulations with a coarse-grained model to investigate whether a lipid bilayer is able to propagate the chirality of helical inclusions [1]. The behavior of this system is rationalized using elastic continuum theory and is compared with that of colloidal membranes [2].
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16:40 — *17:00* **Irep Gozen:** ***Did surfaces enable the origin of life?***

My soft matter research group investigates the autonomous transformation of phospholipid agglomerates into membrane compartments through a sequence of topological changes on solid interfaces. This process is initiated by contact and wetting of artificially created as well as natural surfaces by the lipids, and proceeds via a network of interconnected lipid nanotubes to produce nearly uniform lipid bilayer compartments. Under minimal assumptions it is conceivable that such process could have occurred on the early Earth, where the autonomous formation of simple membrane compartments is presumed to have enabled encapsulation of nucleotides and prebiotic chemistry precursors. According to the currently accepted “bulk hypothesis”, such compartments have spontaneously formed under moderate environmental conditions from lipids suspended in bulk aqueous medium. Only very recently, surfaces have emerged as potential supporting structures for the self-assembly of prebiotic compartments. In my talk, I will report on new evidence for the involvement of surfaces in protocell nucleation and development. The talk will highlight the implications of the new findings for our understanding of possible origin of life processes, and argue that materials properties-driven autonomous processes on solid interfaces might have greater role in the development of life than currently considered.

17:00 — *17:20* **Adrian R. Rennie:** ***Rough and Smooth – Looking at Self-Assembly on Surfaces***

Adrian R. Rennie, Uppsala University, Sweden
Many real interfaces are not atomically smooth and it is clear that the structure can influence the interactions in a number of different ways. For a number of years, we have looked at a number of different surfaces to investigate how self-assembly is influenced by roughness and curvature. Rough surfaces can introduce asymmetry to adsorbed layers of surfactant [1] and modify the orientational alignment that is induced by a planar interface [2] as well as the order. Other studies have shown that a lamellar surfactant phase may form at a surface (pre-wet) at concentrations different to those in the bulk. [3] Recently, studies have been made on interfaces structured with nanowires and lipid assembly investigated by reflectometry and scattering. Coverage on different interfaces of the same sample is found to be different. [4]. Physical ideas relating these topics will be discussed.

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17:20 — *17:50* **Coffee break/discussions**

17:50 — *18:10* **Reidar Lund:** ***Molecular Transport and Growth of Lipid Vesicles exposed to Antimicrobial Peptides***

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It is well-known that lipids constituting the cytoplasmic membrane undergo continuous reorganisation to maintain the exact composition important for the integrity of the cell. The transport of lipids is controlled by mainly membrane proteins, but also spontaneous lipid transport between leaflets, lipid "flip-flop", occurs. In previous work we have shown that the dynamics of lipids is significantly altered by the presence of antimicrobial peptides. The results showed that a large variety of peptides sourced from a variety of species all accelerate the flip-flop motion and molecular exchange processes without necessary creating any permant damge or structured pores in the bilayer.[1,2] This led us to speculate that dynam,ioc effects might have important implications for damage on bacterial membranes possibly constituting a minimal mode-of-action of AMPs. In this presentation we review recent results on the effect of AMPs on lipid vesicle using scattering techniques to unravel both the structural and dynamic aspects. We will specifically focus on the how the peptide-lipid interaction may lead to structural alteration of the bilayer, morphological transitions and growth processes such as Ostwald ripening.

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18:10 — *18:30* **Matti Knaapila:** ***Local structure mapping of individual polymer fibers***

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Anton Davydok: Institute of Materials Physics, Helmholtz-Zentrum Geesthacht, 22607 Hamburg, Germany
Erik G. Hedlund and Maarten Roeffaers: cMACS KU Leuven 3001 Leuven, Belgium
Gert de Cremer and Luigi Balzano: DSM Applied Science Center, 6167RD Geleen, The Netherlands
Matti Knaapila: Department of Physics, Norwegian University of Science and Technology, 7491 Trondheim, Norway

We discuss emerging possibilities to study structural and morphological uniformity of individual polymer filaments. As an example, we report on gel-spun ultrahigh-molecular-weight polyethylene (UHMWPE) fibers (thicknesses spanning from 60 μm to 300 μm) whose processing includes draw and quench. These materials were studied using X-rays and Raman microscopy. The degree of orientation of PE crystallites were found to increase near the surface of the fiber filaments (skin-core structure) in all samples when considering the <P 2 > orientation parameter calculated from wide angle X-ray scattering (WAXS). The degree of orientation increases with drawn down ratio (keeping the quench temperature constant) and decreases with increasing quench temperature (keeping the draw down ratio constant). Orientation parameter values calculated from polarized Raman spectroscopy measurements of the symmetric C-C stretching (1130 cm^{-1}) bond of PE showed clear skin-core structure in the samples with the highest overall orientation. We also employ small-angle X-ray scattering (SAXS) computed tomography to show that the morphology (on the length scale of tens of nm) exhibit clear skin-core structure in two of the samples. The thickness of the skin region was estimated from the real-space SAXS morphology.

18:30	*19:00*	**Discussions**
19:00	*23:00*	**Diner at DNVA (localities are available until 1:00 am)**

Saturday, 13/November/2021

09:00	—	*10:00*	***Registration / Mingling / Coffee***
10:00	—	*10:20*	**Barbara Pacakova:** ***Magnetic Janus clay nanosheets***

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Emerging field of 2D materials shifts nowdays towards preparation of metamaterials, combining efficiently functionality of 2D layers themselves with additional components such as nanocrystals, forming together multifunctional 2D material with complex properties[1,2]. It has been shown that combination of 2D sheets with the nanoparticles does not bring together just individual properties of both components[2,3], but also affect behaviour of 2D sheets themselves[4]. These 2D nanosheets are of high interest for various applications, such as for those relying on encapsulation of droplets or particles, capture of molecules or liquid crystalline organization of suspended nanosheets. Of particular importance are 2D nanosheets that respond to, and can be manipulated by applied magnetic fields, thus enabling extractions or aiding nematic self-organization. Here we report the successful fabrication of 2D magnetic Janus nanosheets composed of clay nanosheets decorated with magnetic nanoparticles on one of the surfaces. The nanosheets were studied and characterized using various methods to reveal their structure, Janus layout and physical properties.
We also show methods how to prove that nanosheets are decorated from both or one side, respectively, their interaction with magnetic field and further perspectives of use of this unique material.

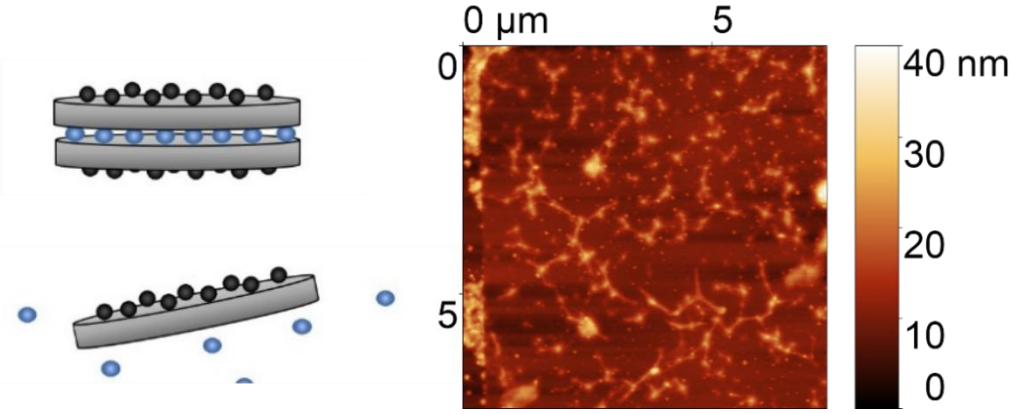

Figure 1. Left – decorated double and single layer clay, respectively. Right – the AFM topography image of wrinkled decorated single layer sheet with the nanoparticles underneath the clay sheet.

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4. *Progress in Materials Science* 2017, 90: 75–127.

10:20 — *10:40* **Andreas Carlson:** ***Droplet spreading dynamics on conical fibers***

University of Oslo, Norway

Plants and insects use slender conical structures to transport and collect small droplets, which are propelled along the conical structures due to capillary action. These droplets can deposit a fluid film during their motion, but despite its importance to many biological systems and industrial applications the properties of the deposited film are unknown. I will in this talk discuss how these droplets are able to self-propell and deposit a liquid by developing an asymptotic analysis together with experimental measurements and numerical simulations based on the lubrication equation. We show that the deposited film thickness depends significantly on both the fiber radius and the droplet size, highlighting that the coating is affected by finite size effects relevant to film deposition on fibres of any slender geometry. We show that self-propelled droplets have significant potential to create passively coated structures.

10:40 — *11:00* **Maria Fernandino:** ***Wetting properties of conical micro-structured surfaces***

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The wettability of a surface is a fundamental physical property with scientific and industrial relevance. Many surfaces in nature exhibit superhydrophobic and superhydrophilic characteristics tailored to some specific functionality. It is remarkable that for conical structures with a base diameter in the range of nano- to micron- size the apparent contact angle and other wetting properties are similar. Hence, conical structures provide a template for designing super-repellent surfaces where the wetting characteristics look to be invariant in the microscale range.
This presentation will focus on the wetting properties of conical structures, the possibility of controlling the wetting transition from Cassie–Baxter to Wenzel state and its dependence on the geometrical parameters. Further it will be shown that conical structures can maintain a super-repellent state for all intrinsic contact angles larger than 90° and the transition from the Cassie-Baxter to the Wenzel state is controlled by the apex angle of the conical structures.

11:00 — *11:30* **Coffee break/discussions**

11:30 — 11:50 **Ingve Simonsen:** ***Statistical characterization of disordered surfaces by light scattering***

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All surfaces possess roughness at some scale. Many physical processes are inuenced by roughness; therefore, it is of interest to characterize the surface topography. Randomly rough surfaces in particular are challenging to characterize since it is typically their statistical properties that one is interested in. If such information should be derived from a topography map of the surface, a large surface area has to be measured with high resolution. In this talk an approach is introduced for the non-parametric reconstruction of the statistical properties of penetrable, isotropic randomly rough surfaces from in-plane, co-polarized light scattering data. Starting from expressions within the Kirchhoff approximation for the light scattered diffusely by a two-dimensional randomly rough surface, an analytic expression for the normalized surface height correlation function is obtained as an integral over the in-plane and co-polarized scattering data with the introduction of only a couple of additional approximations. The inversion approach consists of two main steps. In the first step, the surface roughness is estimated. Next, this value is used to obtain the functional form of the surface height correlation function without initially assuming any particular form for this function (non-parametric inversion). The input data used to validating this inversion approach consist of in-plane and co-polarized scattering data obtained for different forms of the correlation function by either computer simulations or by experiments for two-dimensional randomly rough dielectric or metallic surfaces. Good agreement was obtained between the correlation function and surface roughness obtained during the reconstruction and the corresponding quantities assumed when generating the input scattering data; this was the case for both dielectric and metallic surfaces, for both p- and s-polarized light, and for different polar angles of incidence. The proposed inversion approach provides an accurate, efficient, robust, and contact-less method based on in-plane and co-polarized scattering data for the non-parametric characterization of the statistical properties of isotropic two-dimensional randomly rough dielectric and metallic surface.

Reference:
V.P. Simonsen, D. Bedeaux, and I. Simonsen, Nonparametric reconstruction of the statistical properties of penetrable, isotropic randomly rough surfaces from in-plane, co-polarized light scattering data: Application to computer generated and experimental scattering data, Phys. Rev. A 104, 043502 (2021).

11:50 — *12:10* **Ørjan G. Martinsen:** ***Memristive properties of human skin***

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Department of Clinical and Biomedical Engineering, Oslo, University Hospital

The memristor was first described by Prof. Leon O. Chua at Berkeley in a 1971 paper, and it was claimed to be the fourth basic, passive component, complementing the resistor, capacitor, and inductor. The name is an acronym for memory resistor, indicating that the device incorporates some kind of memory function. However, this finding did not receive much attention until the HP Labs were able to produce a physical memristor in TiO2 and publish this achievement in Nature in 2008. One year later we were able to show that human skin also has these properties, and it should theoretically be possible to store analog information in the skin over a period of time. The lecture will give a brief introduction to the memristor and explain the memristive mechanisms in human skin.

12:10 — *12:30* **Ingebret Fjelde:** ***Blocking of fractures in reservoir rocks by laponite – polymer gel***

NORCE Norwegian Research Centre

When fluids are injected to reservoir rocks, e.g. for CO2-storage, geothermal energy production and oil production, high volumetric sweep (good contact with the reservoir volume) is required to get efficient processes. If the reservoirs have fractures (original or formed during the process) or high permeability zones, the efficiency of the processes will be poor due to low volumetric sweep. The potential for laponite – polymer gels to block fractures and thereby improve the volumetric sweep, has been investigated in the laboratory. Gelation time and rate were determined in bulk experiments for brines of different ionic compositions, and also in presence of minerals. Formation of gels inside fractured rock models was also studied in flooding experiments. Modelling of the placement of gels in fractured models was carried out using a flow simulator.

12:30 — *13:00* **Discussions**

13:00 *14:30* **Lunch at DNVA**

Group discussions at **DVNA**, diner at own expenses. **DNVA** localities are available for all participants until 19:00.

List of Participants

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Paul Dommersnes NTNU
Matti Knaapila NTNU
Ingve Simonsen NTNU
Osvaldo Trigueiro Neto NTNU
Konstanse Seljelid NTNU
Yue Yu NTNU
Carlos Alberto Dorao NTNU
Barbara Pacáková NTNU
Maria Fernandino NTNU
Paulo H. Michels-Brito NTNU
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Andreas Carlson UIO
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