UNIVERSITY OF AMSTERDAM

Prof.Noushine Shahidzadeh
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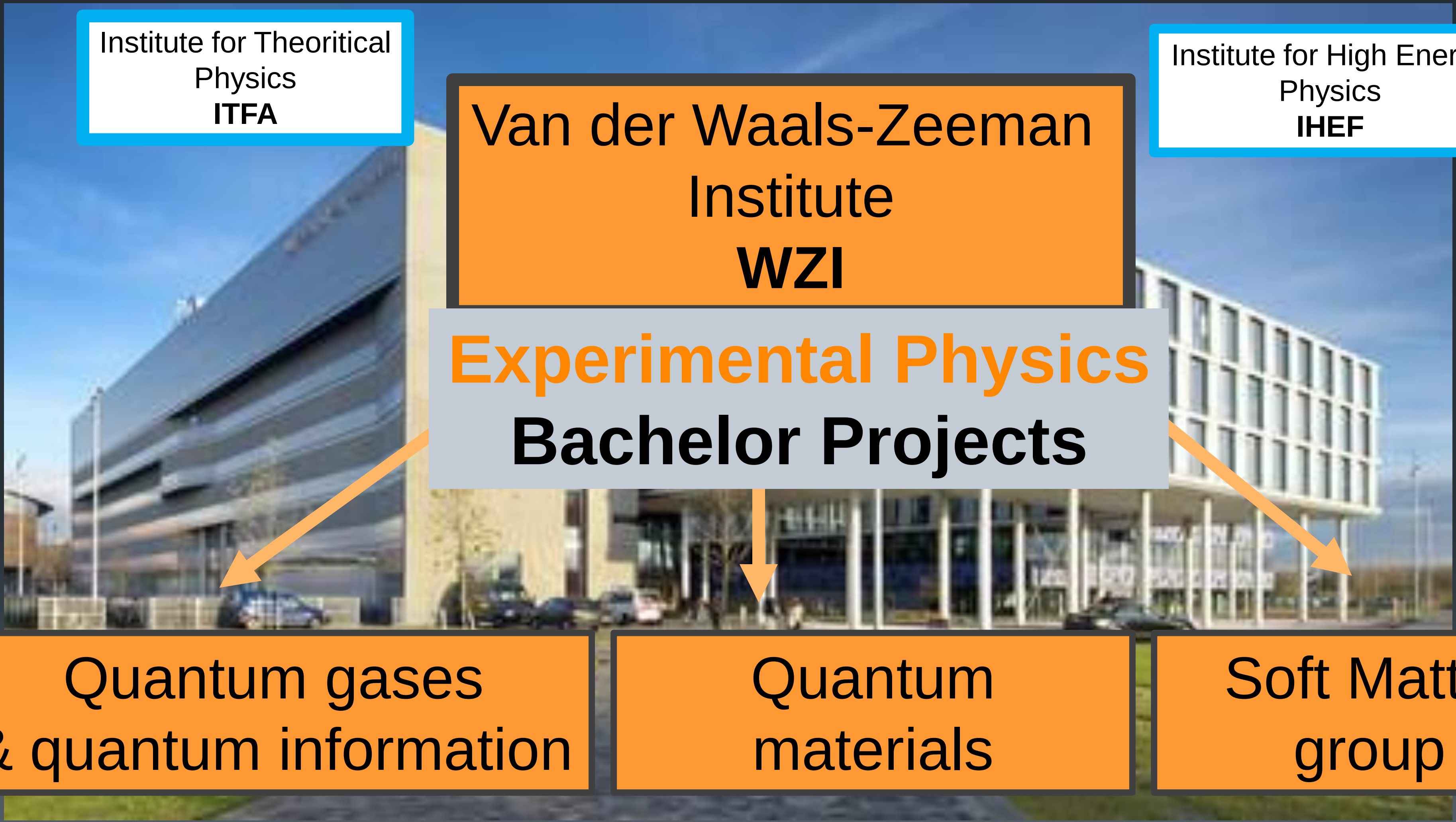
Institute of Physics



Institute for Theoritical Physics
ITFA

Van der Waals-Zeeman Institute
WZI

Institute for High Energy Physics
IHEF

Experimental Physics
Bachelor Projects

Quantum gases & quantum information

Quantum materials

Soft Matter group

UNIVERSITY OF AMSTERDAM

At the Van der Waals-Zeeman Institute (WZI) for experimental physics, scientists perform research in the areas of quantum gases & quantum information, quantum materials, and soft matter.

The WZI is a division of the Institute of Physics. IoP's contributions to the Advanced Research Center for Nanolithography (ARCNL) are coordinated through WZI.

The list of the 39 projects of WZI on Canvas is organised by the specialty of the 4 groups

Quantum gases & Quantum Information

Quantum Materials

Soft Matter group

ARCNL

UNIVERSITY OF AMSTERDAM

2022
Projects

Quantum Gases
& Quantum Information

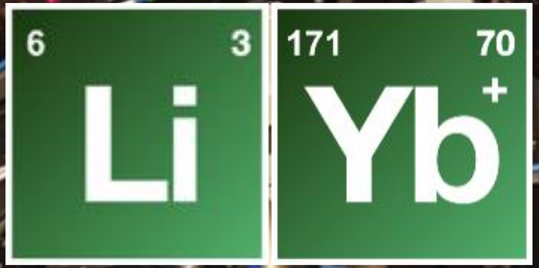
http://iop.uva.nl/content/research-groups/qgqi/quantum-gases-quantum-information.html

Bachelor Project @ Hybrid Quantum Systems

Team: Rene Gerritsma (r.gerritsma@uva.nl), Rianne Lous, Henrik Hirzler, Eleanor Trimby (http://hyqs.nl/)

Goal: Build a modulation-transfer spectroscopy set-up and measure & analyse the Li-cooling sequence

Topics: Experiment, Lasers, optics, atoms, ions, quantum



Why? We do experiments studying atom-ion interactions by trapping an Ytterbium ion and a cloud of lithium atoms in ultra-high vacuum. Preparing these samples relies on laser cooling, for which maintaining the right frequency is crucial. In this project you set-up and characterize a new locking system for our Li-lasers, giving us better control, and you will use it to take your own data to measure and analyse the cooling steps of our Li quantum gas.

Magic wavelength trap for continuous-wave atom laser

We want to build a **trap for strontium atoms that is "magic"**: the trap shifts the energy of 2 internal states of strontium in exactly the same way. Such property is referred to as a "magic wavelength", and it is for example crucial to any state-of-the-art atomic clock [1]. For our lab, it will allow us to **improve laser cooling** of trapped atoms down to 1 µK, to form a continuous Bose-Einstein condensate [2] and later a CW atom laser.

To make such trap, **we need several Watts of light at 813nm**. A tapered amplifier can amplify the light from an external cavity diode laser set at the correct wavelength. This converts about 20 mW into 2 W. The light can thus be sent onto the atoms via an optical fiber and set the trap.

In this project, you will **build such a high-power laser amplifier** at strontium's magic wavelength, and use it to trap ultracold atoms. You will assemble a home-made design for a tapered-amplifier module, send the amplified light to the vacuum chamber and trap atoms. You will **characterize the influence of the magicness** of the light on the laser cooling of strontium atoms.

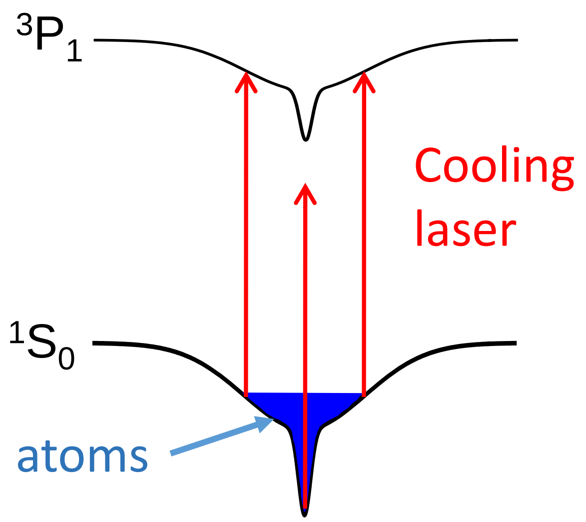
Skills at play: laser physics, optics, atomic physics, laser cooling.

Contacts

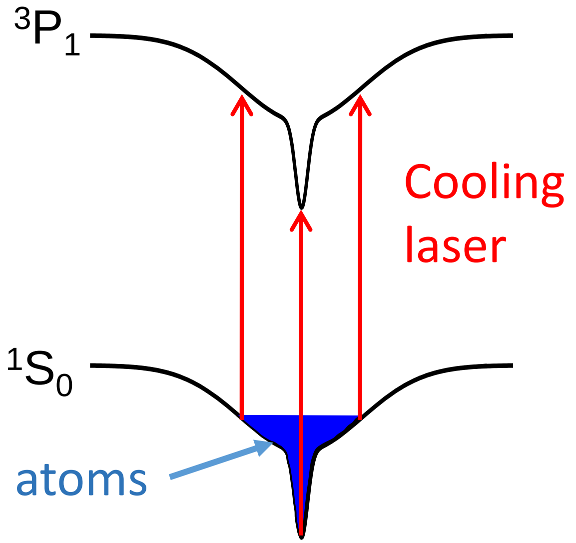
Junyu He (j.he@uva.nl)
Florian Schreck (f.schreck@uva.nl)

[1] Ye et al., Science 320, 1734 (2008).
[2] Chen et al., arXiv:2012.07605 (2020)

Potential from regular trap



Potential from ***magic*** trap



MiniMOT

The magneto-optical trap (MOT) is a key element, omnipresent in ultracold atom and molecule research. In our group [1], we are building a **compact MOT apparatus**, with the goal of using it for outreach toward a general audience and to provide the opportunity for motivated Bachelor or Masters students to have a “**quantum lab of their own**” to implement state-of-the-art science on.

The 2D MOT, lasers and electronics are now all running, leaving only the exciting parts left to do. Next is pushing the atoms in the 2nd vacuum chamber, **producing a 3D MOT**, and extending the apparatus toward making a **Bose-Einstein condensate** (vacuum permitting) or creating your own **Qbit array in optical tweezers**, the first step to turn this machine into a quantum simulator or computer.

Skills at play: laser physics, atomic physics, laser cooling, python control system development.

The MiniMOT being prepared for Science Park open day.

Contacts

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??
Florian Schreck (f.schreck@uva.nl)

[1] www.strontiumbec.com

Building an optical trap for single molecules

Chemistry of molecules are usually studied by synthesizing and characterizing them in large quantities using chemical reactions.

In RbSr ultra-cold molecule laboratory, we use an alternate route whereby we assemble the molecule from single atoms at ultra cold temperatures. We exploit techniques of laser cooling and trapping, in order to trap individual Rb-Sr atoms in optical tweezer trap. Using this approach of assembling molecules from single atoms, we intend to explore rich properties of ultracold molecules as a quantum system for studying quantum chemistry and simulations.

RbSr molecule is an alkali-alkaline earth molecule in its absolute rovibrational ground state, and it has a rich internal structure and exhibits intricate interactions, such as electric and magnetic dipole interactions. These properties of RbSr molecules along with single molecule addressing and manipulation techniques will enable us to create and study unexplored few- and many-body systems.

In this project, you will join the RbSr team and together with the team plan a tweezer setup for the preparation of individual RbSr molecules. This task includes determination of the best tweezer trap wavelengths, and characterisation of a commercial achromatic microscope objective at Rb and Sr trapping and imaging wavelengths.

Contacts:
Prem Thekkeppatt (p.thekkeppatt@uva.nl)
Florian Schreck (f.schreck@uva.nl)

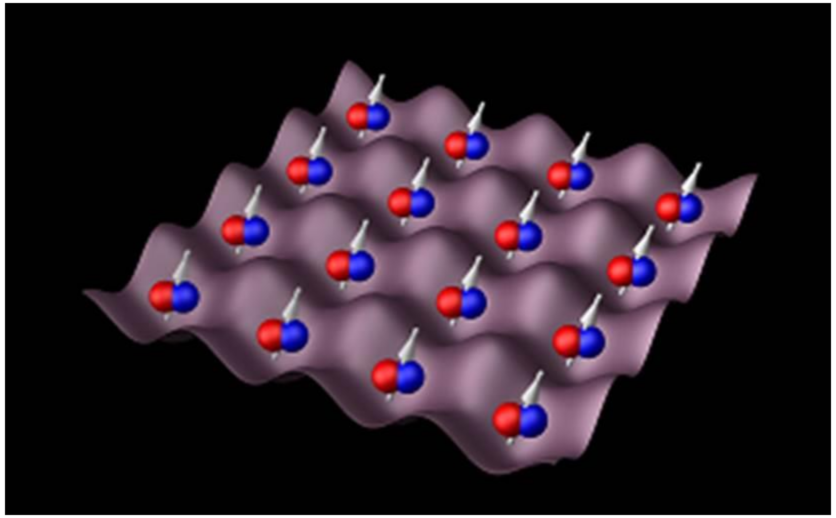


Figure: Rb-Sr single atoms pairs in a 3D optical lattice

Arts & Science: Creating physics artwork with artists Evelina Domnitch and Dmitry Gelfand

Artists Evelina Domnitch and Dmitry Gelfand are developing physics artwork in our lab, sponsored by STUDIOTOPIA. Much of their art is physics inspired. Their installations are similar to physics experiments. The photos show two examples and their website contains further examples and explanations.

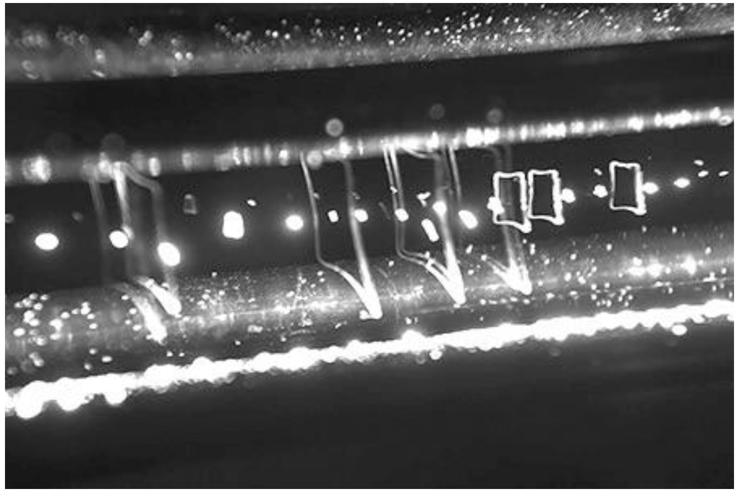
Your task will be to explore routes towards their next artwork with Evelina, Dmitry and us. The inspiration for that artwork is reference [1], an experiment that uses optical beams with orbital angular momentum to control particles in a suspension. The project will start by replicating that work and go on by modifying it into an artwork. You can play a major role in the creation of this work.

Skills at play: lasers, optics, arts.

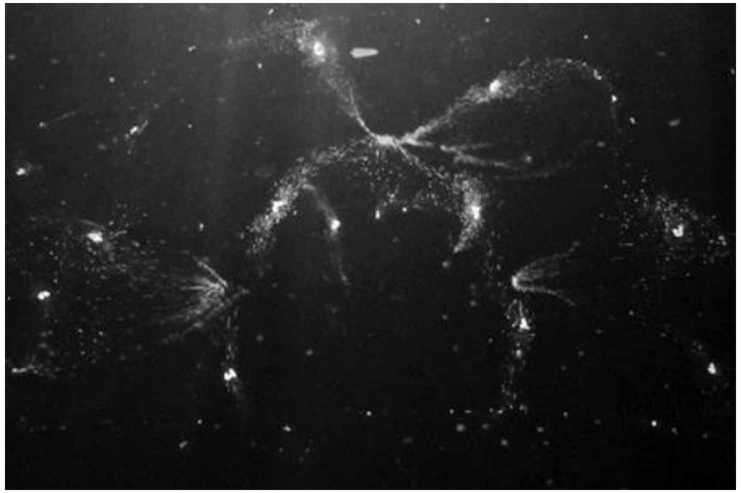
Contacts

Florian Schreck (f.schreck@uva.nl)
Evelina Domnitch and Dmitry Gelfand (edomnitch@yahoo.com)

[1] Hernando et al., Scientific Reports 11, 12284 (2021).

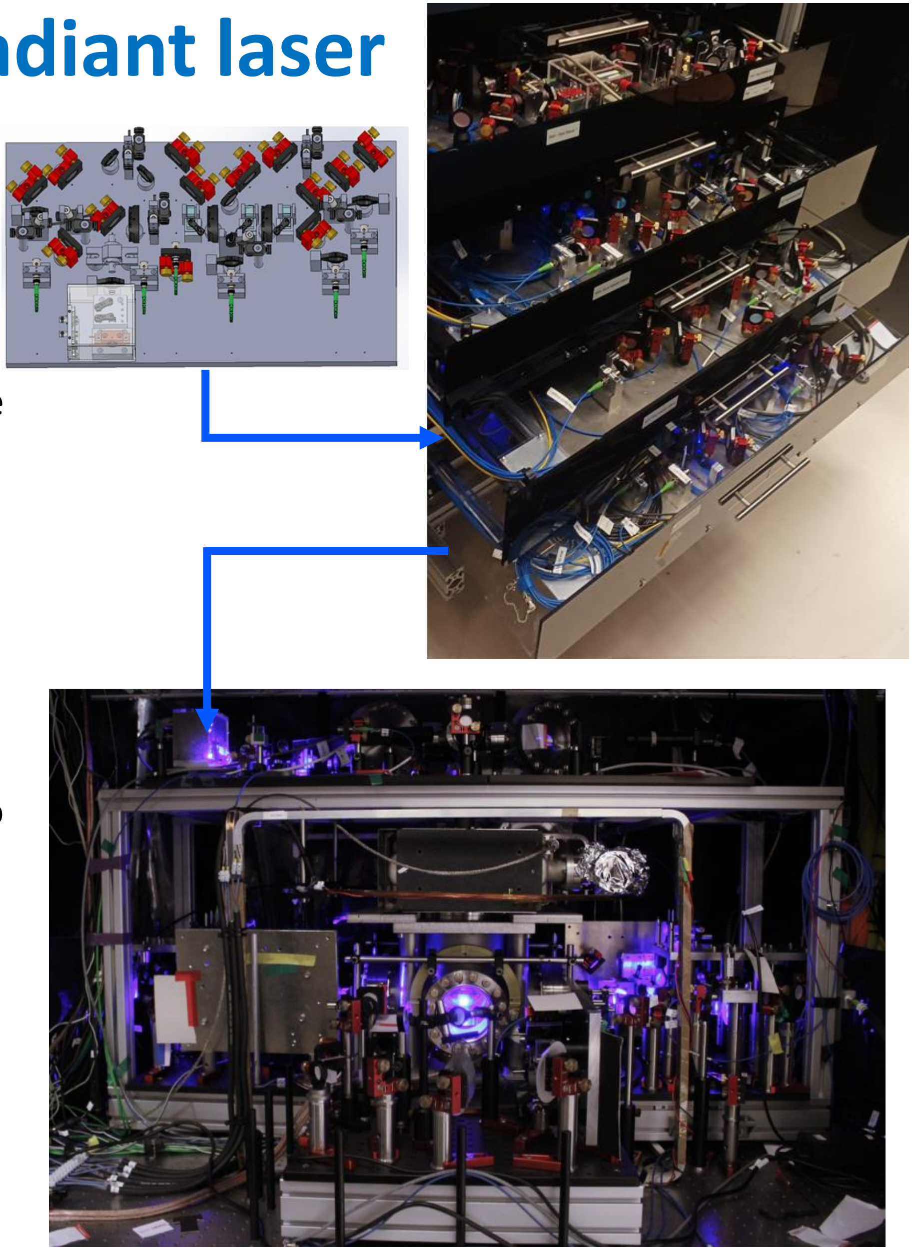


QUANTUM LATTICE | 2016



IMPLOSION CHAMBER | 2014

Atom controllers for a superradiant laser



Superradiant lasers have been proposed as next-generation optical atomic clocks for precision measurement, metrology, quantum sensing and exploration of new physics [1]. Although a clock based on a superradiance laser can offer unparalleled performance, realizing it is a complex and expensive undertaking. A theoretical proposal [2] suggested to obtain superradiance on the kHz transition (1S0-3P1) of 88Sr using a simple thermal atomic beam. Such a device promises a compact, robust and simple clock ideal for a wide range of industrial and scientific applications.

This project aims at the construction of the laser system for such a clock. The system consists of blue high power lasers for transverse cooling (461 nm) and red lasers for state preparation (679, 688, 689 and 707 nm).

The student will build several of the lasers (mainly in the form of injected diode lasers) together with the correspondent electronics for current control and temperature stabilization. The project includes also taking care of the power distribution and frequency shift of the different beams in order to produce light 'ready to be plugged' into the experiment. The experimental research involves laser optics, electronics and atomic physics.

Please join us if you want to get to know the different, small steps and challenges you need to face on a daily base to work in a lab!;)

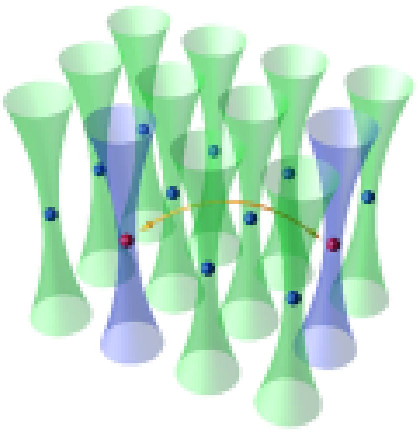
Skills at play: laser physics, optics, atomic physics, laser cooling.

Contacts

Camila Beli (c.belisilva@uva.nl)
Florian Schreck (f.schreck@uva.nl)

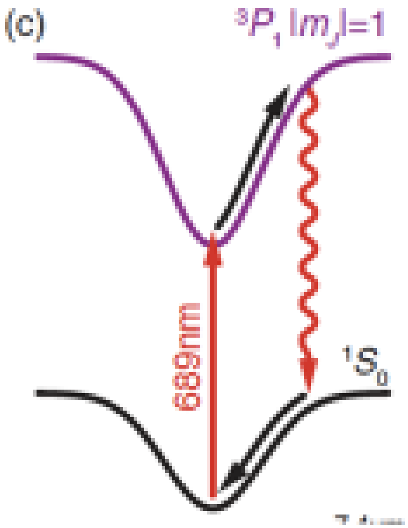
[1] Meiser et al., Phys. Rev. Lett. 102, 163601 (2009)
[2] H. Liu et al., Phys. Rev. Lett. 125, 253602 (2020).

Cooling a single Sr atom in an optical tweezer



Array of single atoms in optical tweezers

- Single atoms held in tight laser focus (‘optical tweezer’)
- Sisyphus cooling by irradiation with near-resonant laser light
- Simulate in Mathematica/Python
- Compare with experiment:
  find optimum parameter regime for experiment



Sisyphus cooling cycle

Supervisors: Ivo Knottnerus, Robert Spreeuw, r.j.c.spreeuw@uva.nl

UNIVERSITY OF AMSTERDAM

2022 Projects

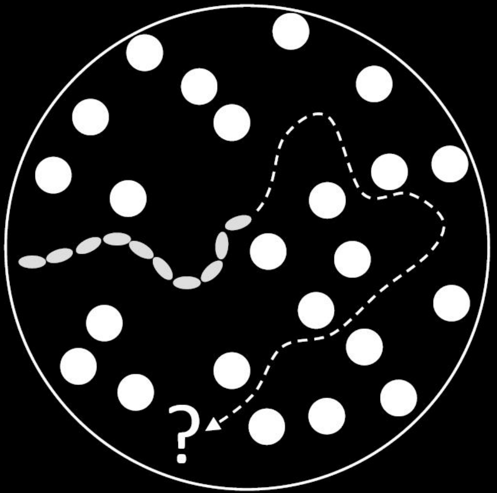
Soft Matter Group
SMG

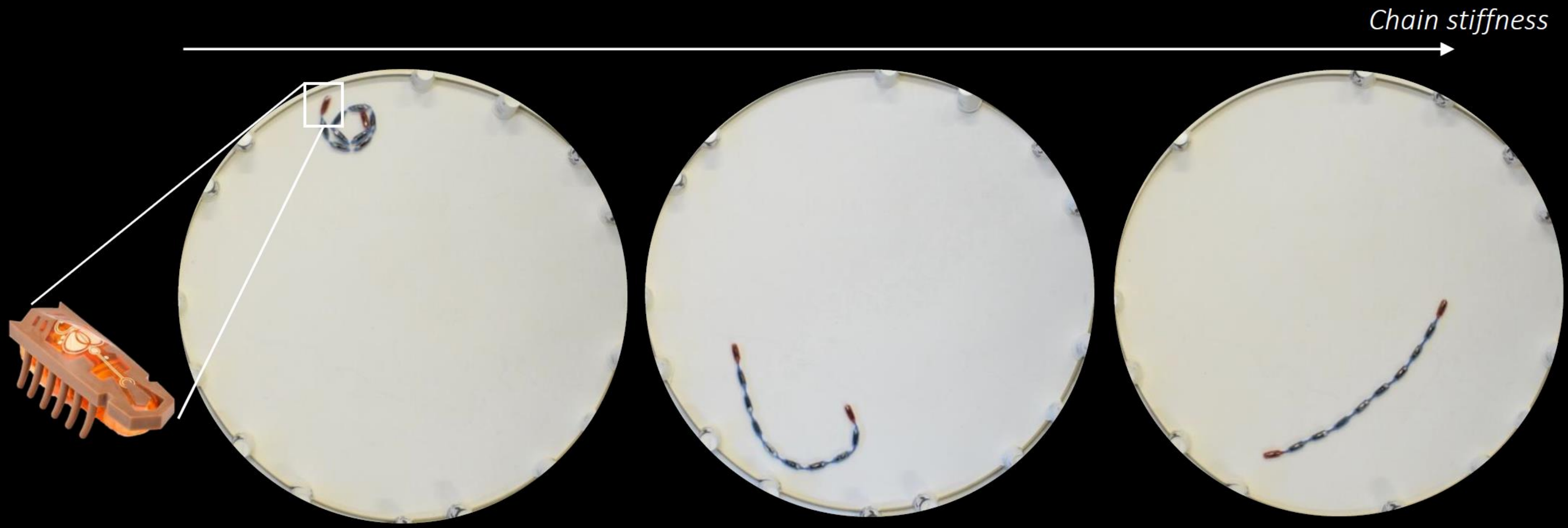
https://iop.fnwi.uva.nl/scm

Active Flexible Chain in a Crowded Environment

Institute of Physics, Soft Matter group

Active polymerlike systems are found everywhere in nature: From the cytoskeleton in cells to a snake moving in the desert, understanding how these active filaments move through crowded and porous environments is key for our understanding of many biological systems. Because these systems are active, they are out of equilibrium and therefore break with much of our understanding of regular polymer physics.





In order to understand these systems better, we will look at a **model system** made up of **small connected bots**. In this research project, you will work on designing improvements of the setup and perform experiments to investigate the underlying physics that govern **the dynamics of these active polymers in crowded environments**.

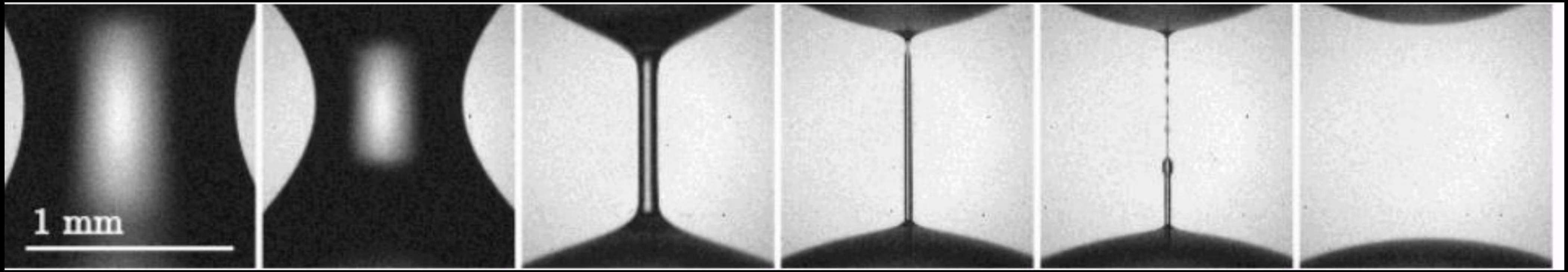
Team: Elham Mirzahossein, Rosa Sinaasappel, Antoine Deblais

Contact: A.Deblais@uva.nl

Polymer Pinching

Institute of Physics, Soft Matter group

When pushed out of a syringe, polymer solutions form droplets attached by long, slender cylindrical filaments whose diameter decreases with time before eventually breaking. Such long-lasting filament can be observed with saliva for example, which is also a polymer solution. In the last stages of this process, a striking feature is the self-similarity of the interface shape near the end of the filament. This means that shapes at different times if adequately rescaled, collapse onto a single universal shape.



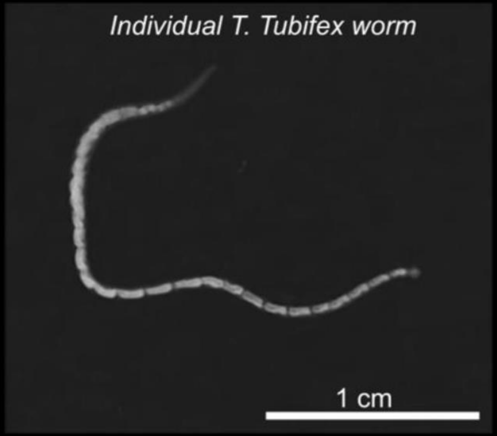
In this research project, we ask if this universality stands depending on the geometry and the initial conditions of the problem. Using a very high-speed camera (up to 1 million frames per second) we will follow the breakup event and look at the shape of the filament connecting the two drops in time.

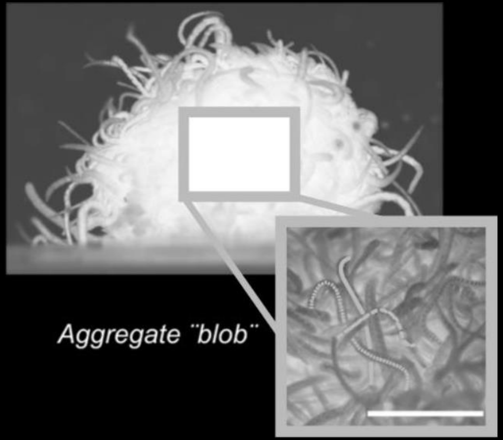
Team: Antoine Gaillard & Antoine Deblais
Contact: A.Deblais@uva.nl

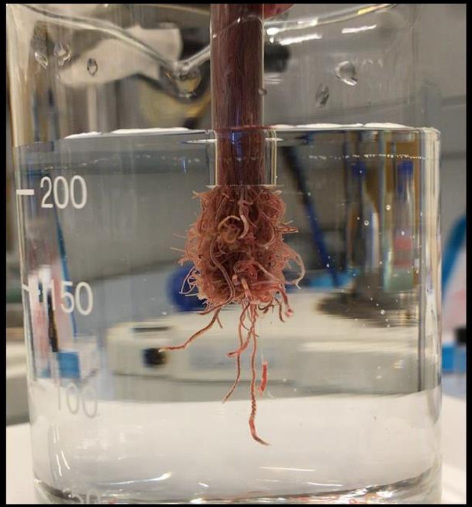
Blob of Worms: Liquid or Solid?

Institute of Physics, Soft Matter group

Aquatic *T. Tutifex* polymerlike worms have the ability to aggregate and form large clusters **“blob” of worms** by entanglement. Because this living systems is active by nature, they are out of equilibrium and therefore break with much of our understanding of regular polymer physics.







A drop of worm pinching from a funnel

This system exhibits a plethora of interesting behaviors that found some analogy with liquids: blobs looks similar to a drop of liquid wetting a surface, but they can also flow through a funnel to finally pinch and form a droplet. In this research project, you will explore the **physics of these blob of worms** in **analogy with the physics of liquids**. This experimental project will combine **imaging technics and image processing** to extract quantities such as the **surface tension** of these blobs.

Team: Rosa Sinaasappel & Antoine Deblais
Contact: A.Deblais@uva.nl

Chasing the liquid-liquid transition of D-mannitol

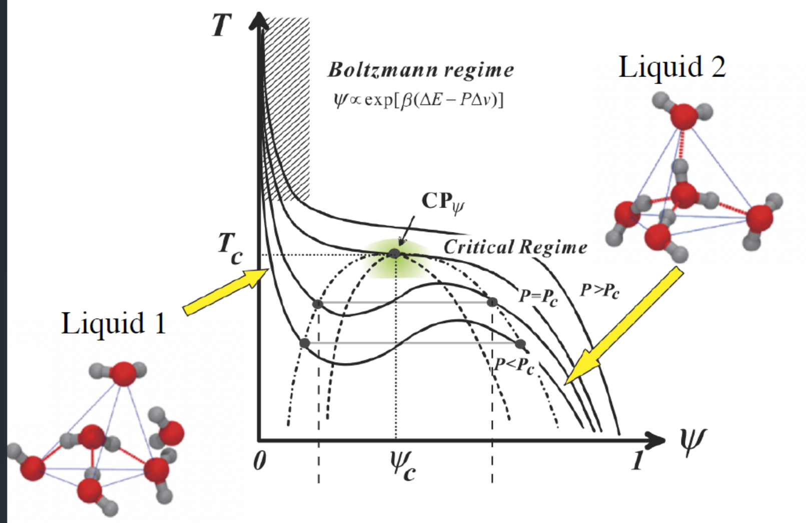


Figure 1: Sketch of the phase diagram of LLT transition. The two liquid phases have different local structure [1].

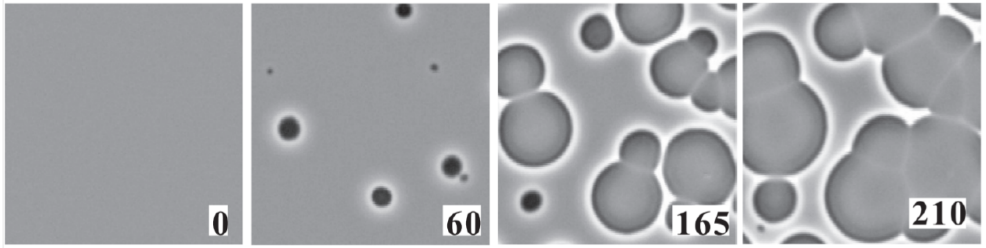


Figure 2: LLT transition in **triphenyl phosphite as seen by phase contrast microscopy (image size 100 um x100 um). The new liquid phase has smaller density and appears darker in the image.** *[1]*

- **Liquid-liquid transition (LLT):**
  a liquid transforms into another liquid via a first-order phase transition [1]
- The two liquid phases are characterized by **different structure and density** (see the example of amorphous water! https://www.nims.go.jp/water/hda_lda_tr.html)
- **LLTs challenge the common idea of a liquid as a pure disordered system**

In this project you will measure the microscopic and macroscopic properties of the **LLT of the polyalcohol D-mannitol [2]** using:

- **Linear and non-linear IR spectroscopy**
- **Phase contrast microscopy**

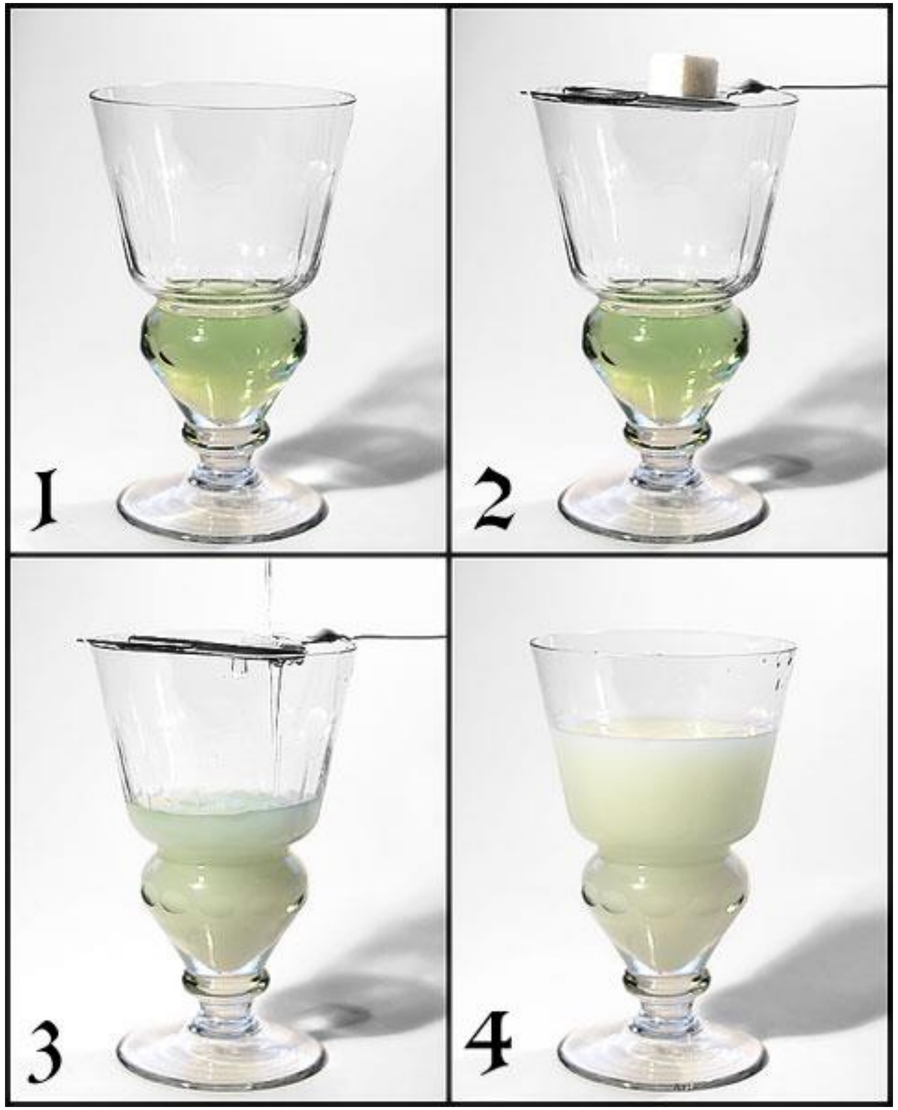
And you will try to answer the following questions:

- What is the difference between the structures of the two liquid phases?
- What is the kinetics of the process? Does it involve nucleation?

Contact: f.caporaletti@uva.nl

References
[1] H. Tanaka,, J. Chem. Phys. 153, 130901 (2020)
[2] W. Tang et al . J. Chem. Phys. 149, 074505 (2018)

BSc project: The Ouzo effect



When water is added to Ouzo (or Pastis)
two clear liquids together become milky-white
Because the aniseed oil forms an emulsion:
small drops of oil suspended in the liquid.

Questions:

- How does this happen? (Study under the microscope)
- How stable is the emulsion, and what determines its stability? (Drop size and surface tension measurements)

Contact: Daniel Bonn (d.bonn@uva.nl)

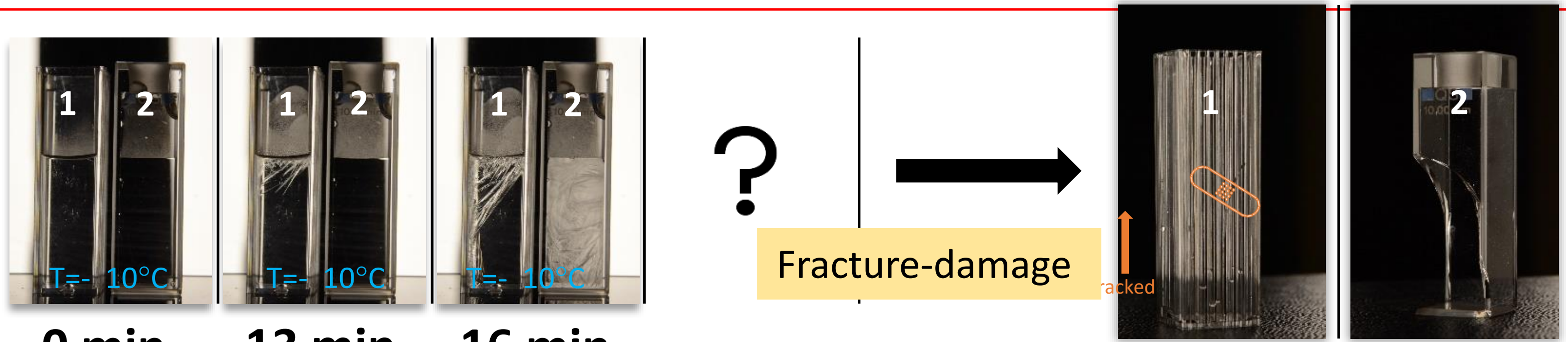
UNIVERSITY OF AMSTERDAM
INSTITUTE OF PHYSICS
Soft Matter Group

BACHELOR PROJECT 2022

How does the freezing of water lead to damage?

Problematic

- When water freezes, it can expand; this is known to damage water pipes, buildings, artworks and roads (frost heaving) or even rocks (ice wedging) in a natural environment.
- How can we control the ice propagation, and how is the water freezing mechanism defined?



0 min **13 min** **16 min** **…**

Objective

- To study the freezing of water and the formation of bulk ice as a function of different parameters:
  - ➢ speed of cooling
  - ➢ wettability and geometry of the recipient
  - ➢ volume of the confinement
- We will investigate the ice growth morphology and the resulting mechanical stresses that can lead to damage.

Contact: IoP-WZI- soft matter group Prof.Noushine Shahidzadeh, n.shahidzadeh@uva.nl; Paul Kolpakov, **p.kolpakov@uva.nl**

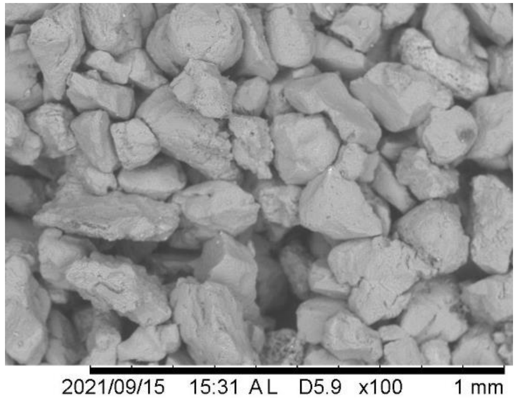
University Of Amsterdam
Institute Of Physics
Soft Matter Group

Bachelor Project 2022

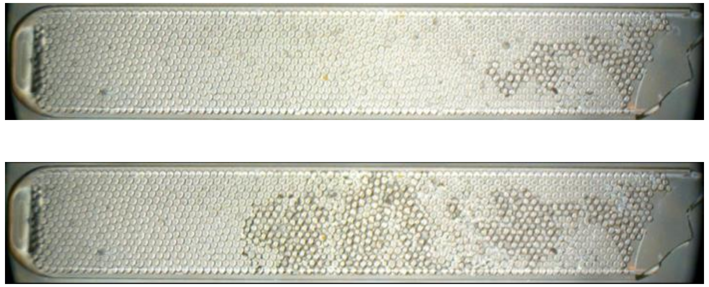
How physics can help in preserving artworks?

Historical monuments and sculptures are damaged with time (frost, salt crystallization...).
Gel and consolidant are injected into the damaged porous medium to improve its mechanical properties.
The aim is to understand the **kinetics of drying and gel formation** in various porous media.

Stone under microscope



2D micro model porous media



Microcapillaries

Your objective

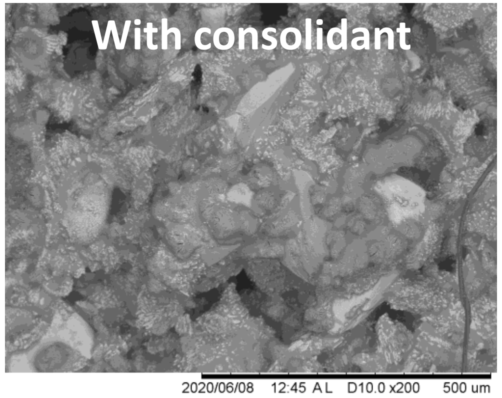
Investigate at microscale the gel formation in model porous media:
What are the different regimes that govern the drying ? How the pores sizes and the porosity affect the gelation?

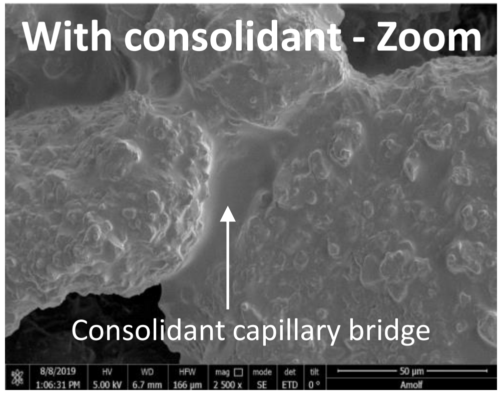
- You will determine the drying kinetics in microcapillaries and 2D model porous media using different imaging techniques.
- You will also investigate the spatial distribution of gel during and after the drying

Contact: IoP-WZI- soft matter group :Noushine Shahidzadeh, n.shahidzadeh@uva.nl; Romane Le Dizès r.ledizes2@uva.nl

The impact of ageing on the mechanical properties of stones

Artworks made of limestones (statues, historical monuments …) are exposed to degradations over time. Organosilane consolidants can be used to **reinforce the porous network** and improve the mechanical properties of the stone by surrounding and **strengthening the brigdes between the stone's grains.**





Your objective

The effect of **organosilane consolidants on limestones** exposed to **changing weather conditions** has not been studied yet. You will evaluate how treated limestone can resist to those climate changes. For that you will look at:

- The influence of the relative humidity
- The effect of wetting and drying on the stones
- Temperature changes

Finally you will determine the mechanical properties of the aged stones and conclude about the effectiveness of the consolidant.

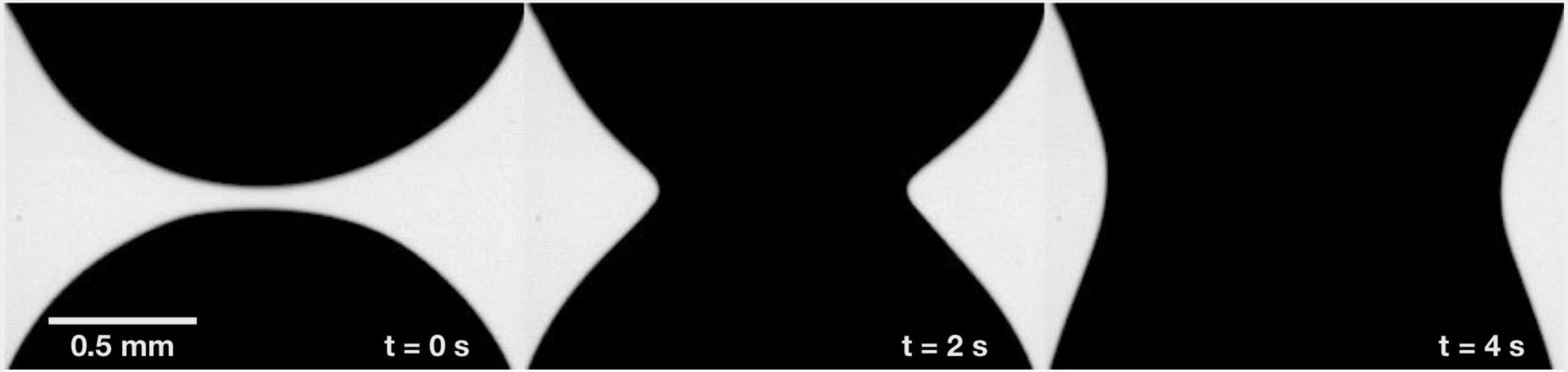
Contact: IoP-WZI- soft matter group: Noushine Shahidzadeh, n.shahidzadeh@uva.nl; Romane Le Dizès r.ledizes2@uva.nl

Macroscopic coalescence of emulsion droplet

Manon L'Estimé, Antoine Deblais, Marion Grzelka

Soft Matter group, IoP Science Park

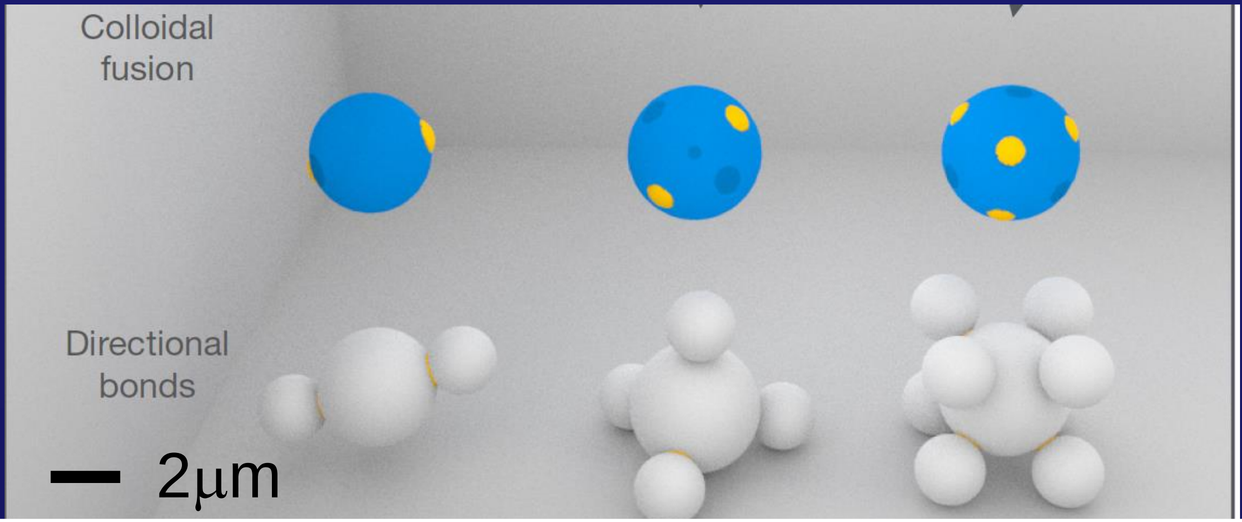
When two droplets of simple liquids are gently brought into contact, they merge into a single larger drop to minimize surface energy, a mechanism referred to as coalescence. The situation is markedly different when looking at emulsion droplets, where finite-size effects, non-local rheology and complex rheology are present. By combining ultra-fast imaging technics, rheology and image processing, we aim to reveal the mechanisms at play in the coalescence dynamics of emulsion drops.



Contact : manonlestime@gmail.com

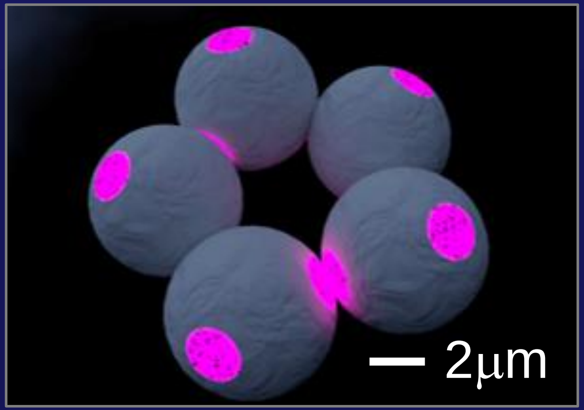
Project : Nanoarchitectures

Build analogues of molecules on μm scale



Obtain 3D insight into molecular dynamics!

Bonded "patchy" particles



e.g. Cyclo-pentane C_5 ring

Contact: Peter Schall, p.schall@uva.nl

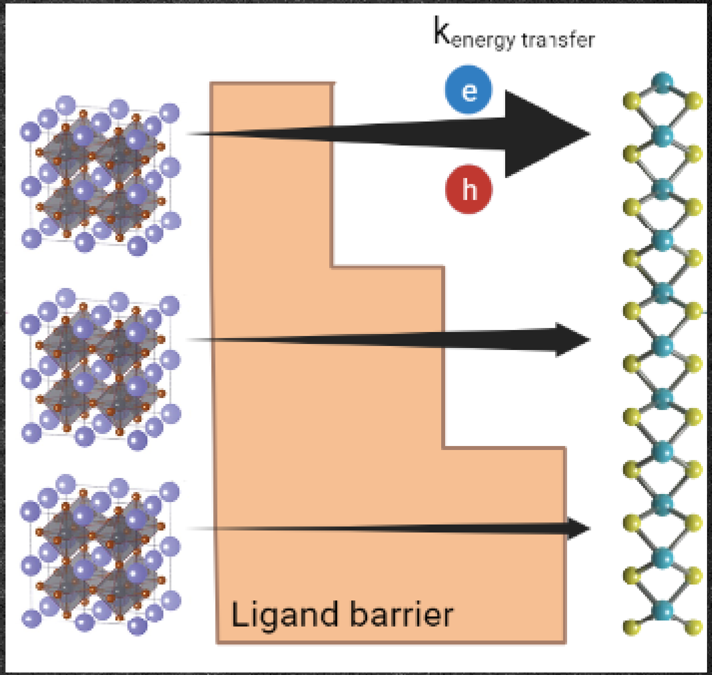
Project :
Energy Transfer in Nanomaterials

Combine strongly absorbing Nanocrystals with strongly conducting 2D-materials for **future flexible solar cells.**

Good solar cells:
1. Strong light absorption
2. Efficient charge-extraction

Combine 1&2

investigate charge transfer from the absorbing to the transporting layer.



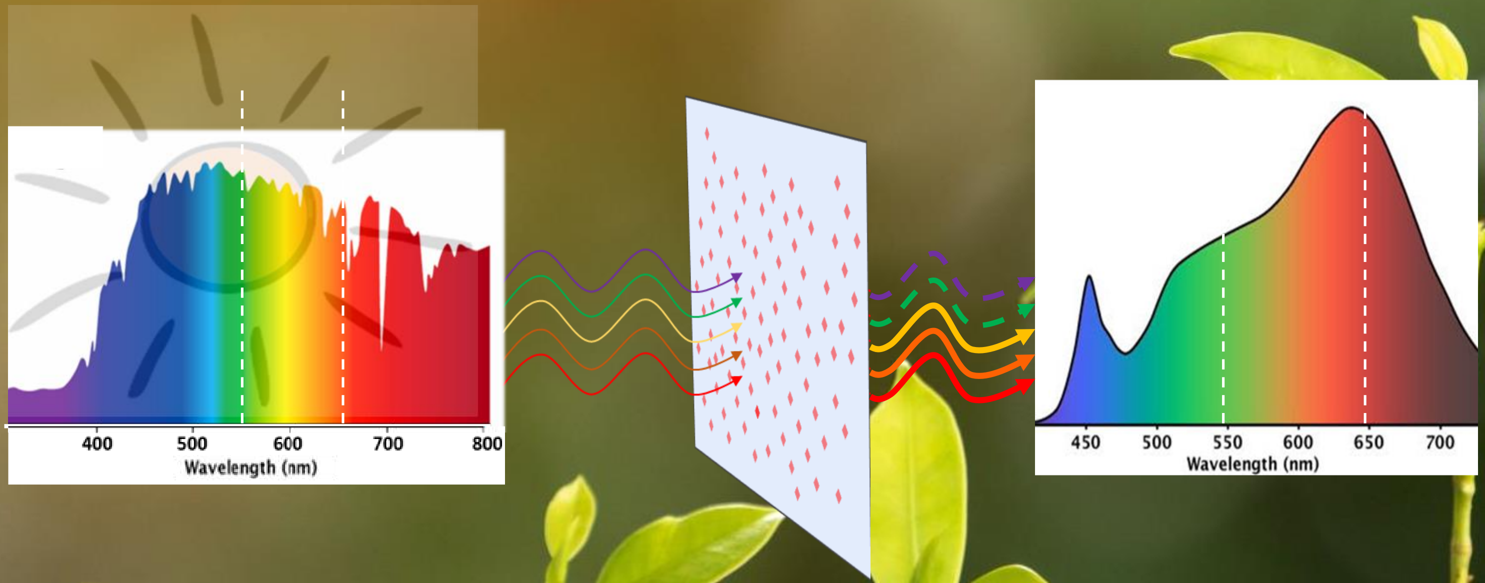
This should yield thinner and more flexible solar cells

Contact: Peter Schall, p.schall@uva.nl

Project :

SolarFoil

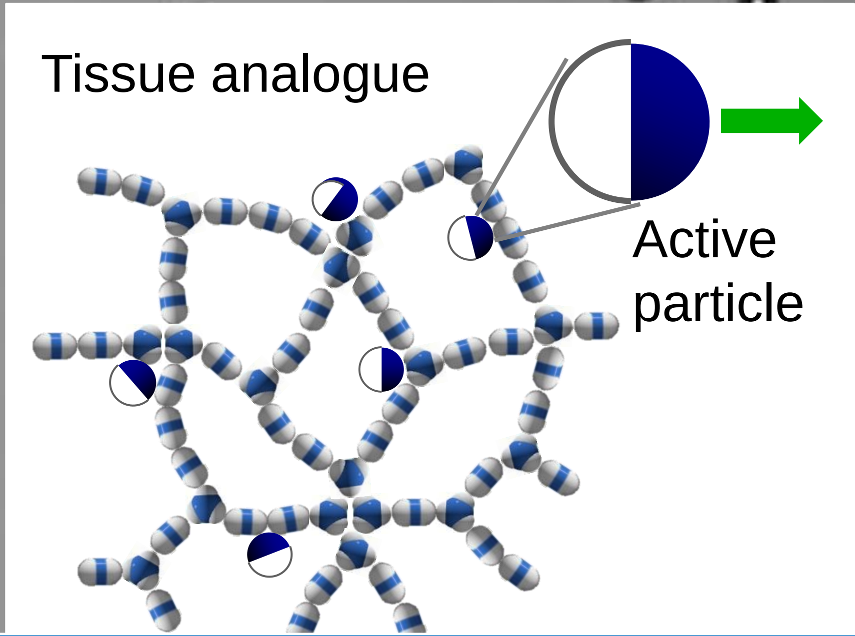
Shaping the solar spectrum for enhanced plant growth

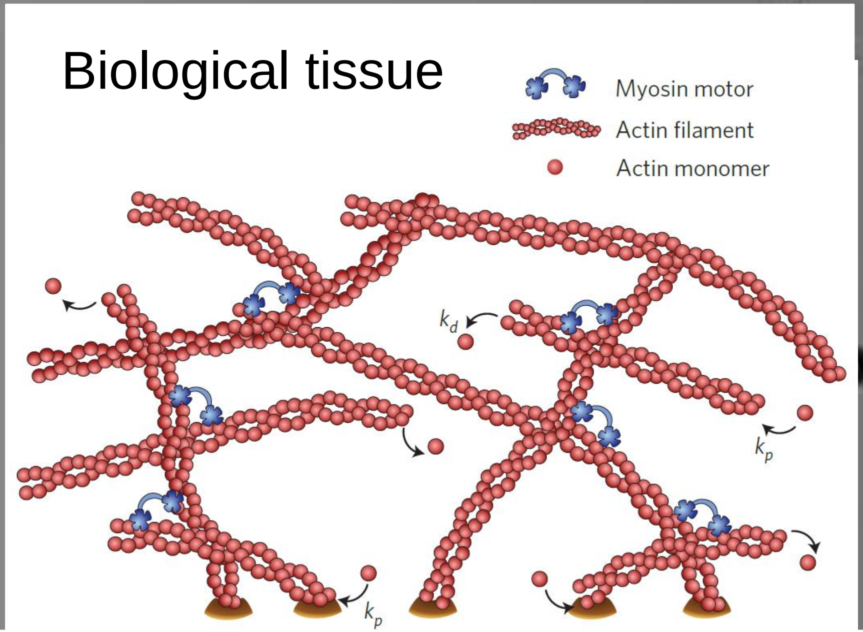


We use highly efficient nanocrystals to convert the sun light spectrum for most efficient photosynthesis

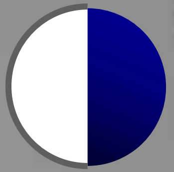
Contact: Peter Schall, p.schall@uva.nl

Project : Active Architectures





Non-equilibrium Physics: Understand biological matter



Background:
Self-propelling, active particles that imitate bacteria & motor protein motion

Contact: Peter Schall, p.schall@uva.nl

Physics of Volcanic Eruption

Your Research

In collaboration with a team of volcanologists in Durham University and computational scientists in University of Strathclyde, we are aiming to reveal the long-standing secrets of volcanic eruptions! We know the process of eruption is controlled by bubble dynamics. However, the difficulties in field measurements have limited our understanding of the underlying physics.

We will address the problem by making a (simplified) ***volcano in the lab*** and also making ***computer volcanoes***.

Question

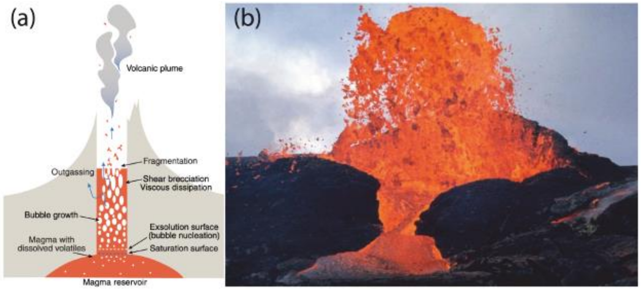
How does a gas bubble grow in a volcano's conduit and collapse at the free surface of a complex fluid?

Methods Involved

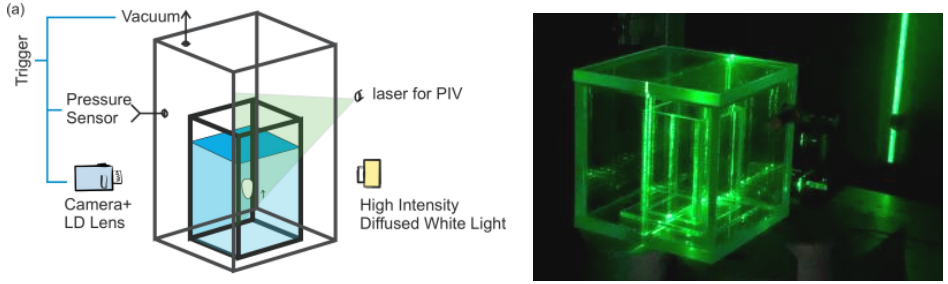
High-speed imaging,
Particle Image Velocimetry (Using Laser sheets)
Image Analysis
Numerical solution of hydrodynamics equations (if doing computations)

Literature

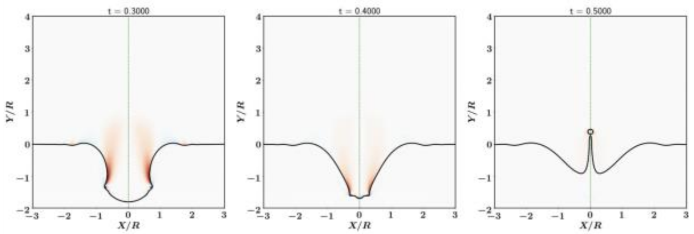
Gonnermann & Manga, Ann. Rev. Fluid Mech. 2007
Sanjay, Lohse, Jalaal J Fluid Mechanics 2021



(a) A schematic showing the role of bubble in a volcanic eruption (Gonnermann & Magna, 2007). (b) a real-life image showing the hydrodynamics of volcanic eruption (google image)



Experimental setup, developed by the help of the previous bachelor student, Marieke Beerepoot. Left: Schematic of the setup. Right: The setup during imaging.



The simulation of the collapse of the cavity formed by bursting of bubbles at the magma-air interface (on the right).

Supervisor / Contact
Mazi Jalaal (m.jalaal@uva.nl)

iop.fnwi.uva.nl/scm
fluidlab.nl

Surface Motors out of Equilibrium

Your Research

You will work in a team of experimentalists and theoretical physicists to understand the dynamics of "*surface motors*". These motors (although large, ~1cm) have no mechanical parts and are self-propelled due to molecular-scale interaction with the environments around them. This is one major step towards making new class of biologically-inspired machines.
Using experimental methods, you will study the motion of the motors in different conditions to understand the exact physics of propulsion and finding an optimal working condition.

Question

How does a self-propelled surface robot move on a surface of a liquid? What are the emergence behavior when motors interact with each other?

Methods Involved

Imaging & Image Analysis
Particle Image Velocimetry (Using Laser sheets)
Theory of hydrodynamics / soft matter physics

Literature

[1] The hydrodynamics of water strider locomotion, Hu, Chan, & Bush Nature 2003
[2] Emergence of bimodal motility in active droplets, Hokmabad *et al.* PRX 2021

Supervisors / Contacts

Jackson Wilt (j.k.wilt2@uva.nl)
Mazi Jalaal (m.jalaal@uva.nl)

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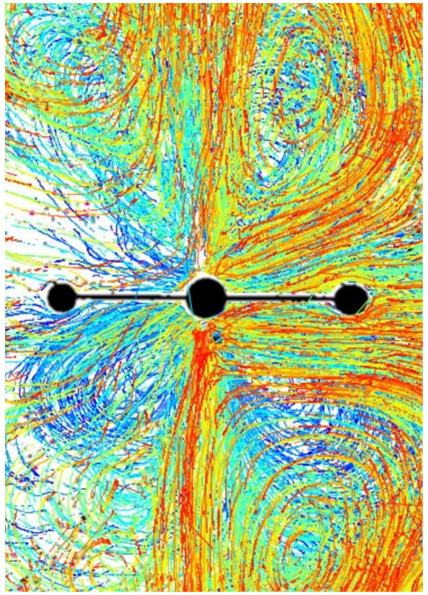
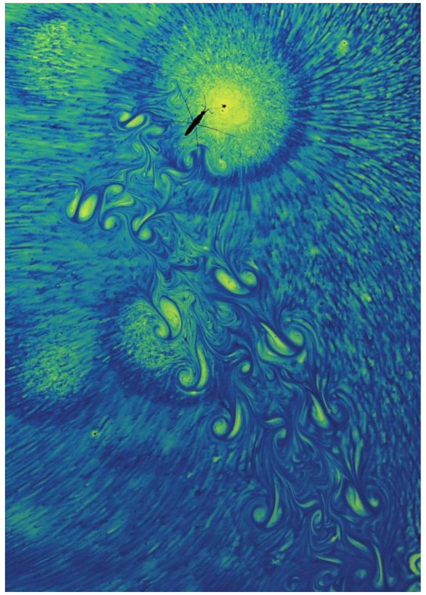
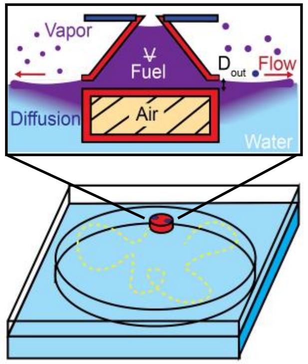


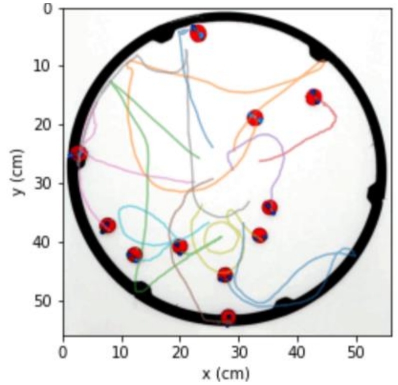
Flow around a surface Motor



Flow behind a surface bug[1]



Design principles



motor trajectories

Fluid Mechanics of 3D Printing

Experiments on printing ultra-soft materials

Many engineering and geophysics problems feature the free surface flow of elastoviscoplastic fluids (materials with both solid and liquid properties). Although negligible at large scales, capillary forces may become significant at small scales. Focusing on the process of 3D printing, we will study the dynamics of droplets of complex fluids spreading on a surface.

Your Research

Fluid physics of multi-phase flows with non-linear material properties; a combination of rheology, continuum mechanics, and small-scale fluid mechanics.

Research Question

How does a droplet of a complex fluid spread on a surface or another droplet and how can we control this process?

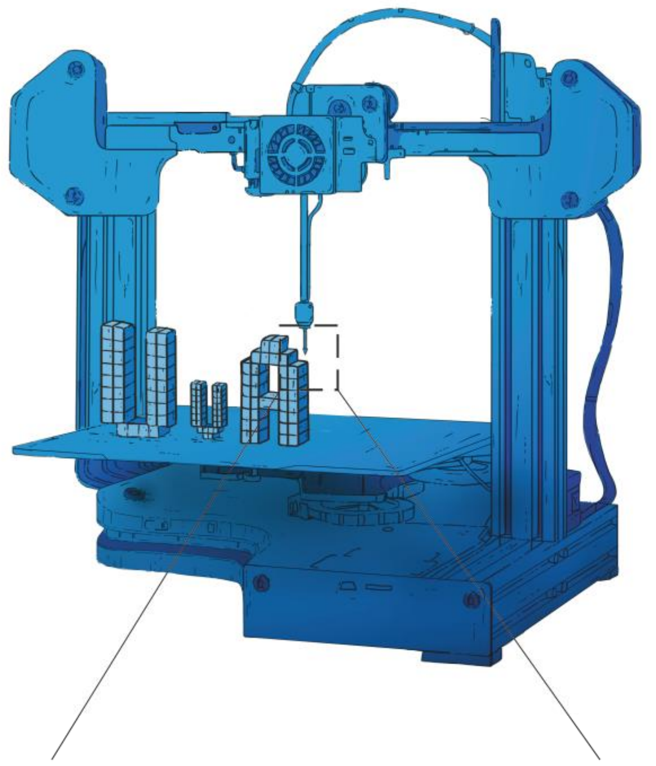
Methods involved

High-speed Imaging, Image Processing, Electron Microscopy
Optical Coherence Tomography, Interferometry.
Rheology of soft matters

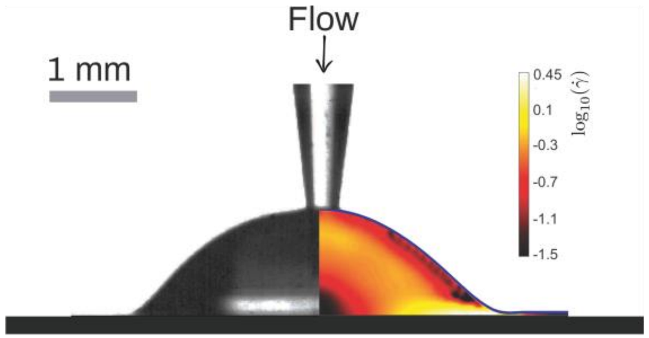
Literature

Balmforth et al. Ann. Rev. Fluid Mech. 2014. 46: 121-146
Jalaal et al. arXiv preprint arXiv:2010.02894
Jalaal et al. Journal of Fluid Mech. 2018. 837:115-128.
Jalaal & Balmforth J. of Non-Newtonian Fluid Mech. 2016. 238: 100-106

Contact:
UvA — Institute of Physics — Soft Matter Group
Dr. Mazi Jalaal (m.jalaal@uva.nl)
iop.fnwi.uva.nl/scm
fluidlab.nl



Spreading of yield stress droplets during the 3d printing process. Experiments (left) and theory (right):



UNIVERSITY OF AMSTERDAM
INSTITUTE OF PHYSICS

Helical Locomotion in Mud:
Design of a search and rescue robot

Background

The design of robots for various environmental conditions is challenging. The previous research has offered many solutions in designing robots that propel in liquid (swimmers) and on solid surfaces (rovers). But what if the environment is neither a liquid nor a solid? Examples of these environments include snow, sand, and mud. It is obvious alternative surface mobility strategies are required for such settings, as classic solutions (mainly wheel-based methods) fail. However, we are far from finding an optimal solution for robotic motility in harsh environments such as muddy materials. This project aims to tackle this problem.

Your Research: Helical Locomotion

You will work on the design and optimization of helical propellers for a robot. Such a system provides a non-reciprocal directional motion in both liquids and solids (think about a wine corkscrew).

The research includes the following steps:
1- Literature review and Design Plan
2- Design and 3D Printing the Helical wheels
3- Assembly of the Robot (based on KeyStudio Car Kit V3.0)
4- Experiments on different muddy surfaces (using synthetic muds in our lab)
5- Experimental Analysis (Image Processing)

Question

How to design a robot with helical propellers?
What is the optimal design in helical propulsion?

Methods Involved

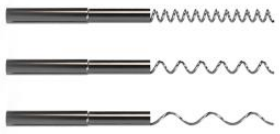
3D Printing
Imaging & Image Analysis
Robotic/Electronics

Contact

Mazi Jalaal (Assistant Professor, Institute of Physics)
m.Jalaal@uva.nl fluidlab.nl

design

→



prototyping

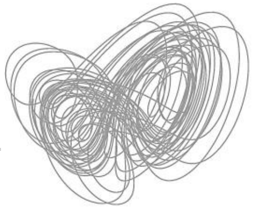
→

implementation

→

test

→



analysis

→

optimization

Sound of Flowing Iron

In the production of iron the furnace is tapped regularly by drilling a hole in the wall. The flow of liquid iron from the tap hole is stopped just before hot gas and slag floating on the iron starts to escape.

The stream that emerges from the tap hole just before the breakthrough makes 'plopping' noises most likely caused by the formation of bubbles and droplets. We have developed an end-of-tap detection system based on this sound emission. The sound recording is done by e.g. an ultrasonic acoustic camera.

The physics behind the sound formation is still ill understood. As part of the Bachelor project laboratory experiments and (numerical) modelling will be performed to understand the origin of the sound.

Dr. Rudolf Sprik
Van der Waals-Zeeman Institute
Institute of physics
R.Sprik@UvA.nl

In collaboration with:

TATA STEEL

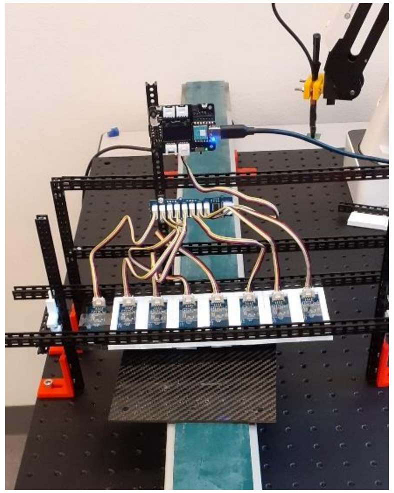
Eddy Currents in Carbon Composites

Carbon fiber reinforced polymer (CFRP) composites are very strong and light weight materials replacing metal parts in e.g. airplanes, windturbine blades, cars and bicycles.

The modern unidirectional carbon fiber tapes used in fabricating composite structures require testing the material in manufacturing and while in use.

As part of the Demonstrator Laboratory VU/UvA , Eddy Lite is exploiting the eddy current effect in the conducting carbon fibers to perform such new tests easy, fast and economically

In the Bachelor project unidirectional tapes with defects will be tested to assess the capabilities of the technique.
This requires accurate measurements in combination with a good understanding of the complex electrical conductivity of carbon fiber composites.



Dr. Rudolf Sprik
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R.Sprik@UvA.nl

D▶LAB AMSTERDAM

Eddy lite

Project: ***3D multistep metamaterials***

daily supervision: Wenfeng Liu(w.liu@uva.nl)
supervision: Corentin Coulais (coulais@uva.nl, coulaislab.com)

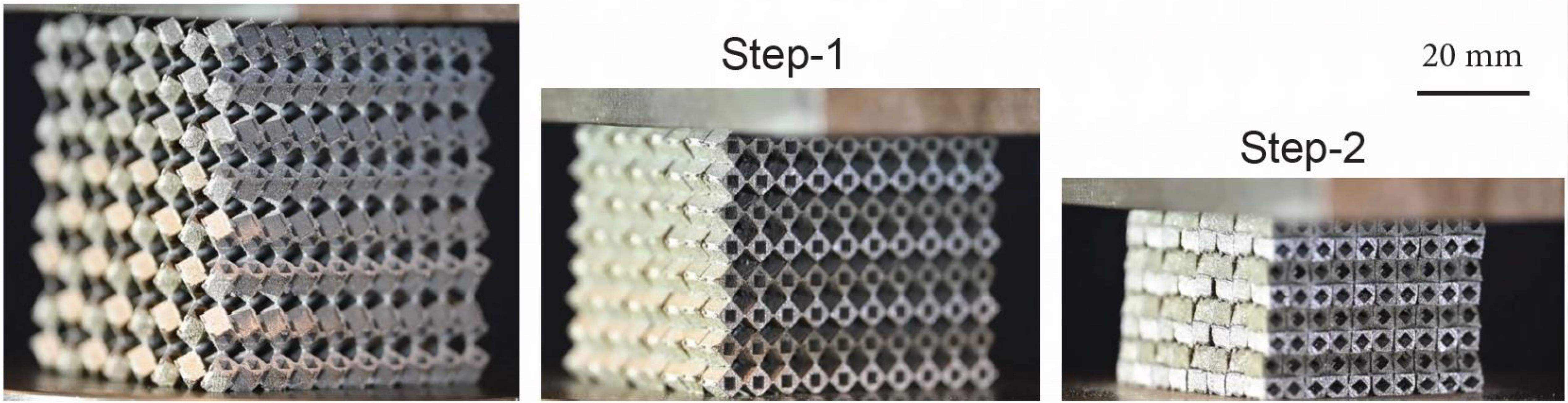


Fig.5 Multistep sequentail deformation in 3D metamaterials

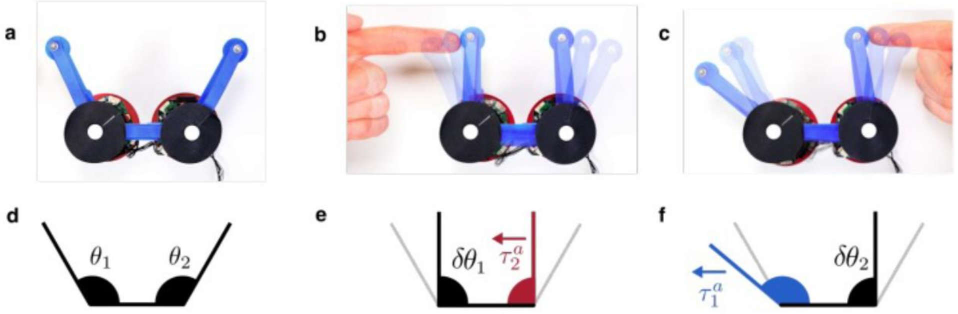
Pattern formation and topological defects in active metamaterials

Experimental/Theory/Computational

How to predict and design collective behavior in mechanical structures that do not conserve energy?

- **Experiment with distributed modular robots**
- **Numerically simulate out-of-equilibrium dynamics**
- **Use continuum mechanics and dynamical systems theory**
  - ➢ **To bridge the gap between materials and robots**

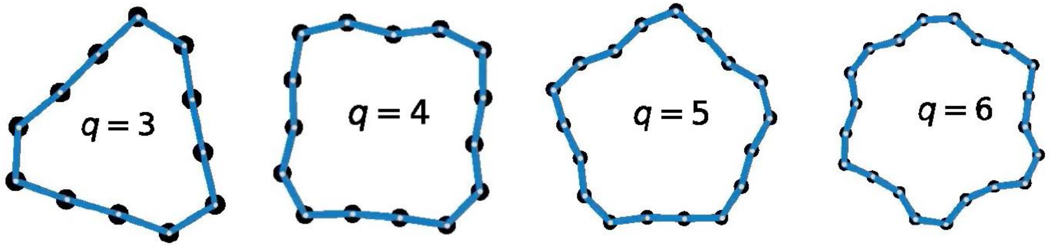
Out-of-equilibrium mechanics: **Energy injection at local level**



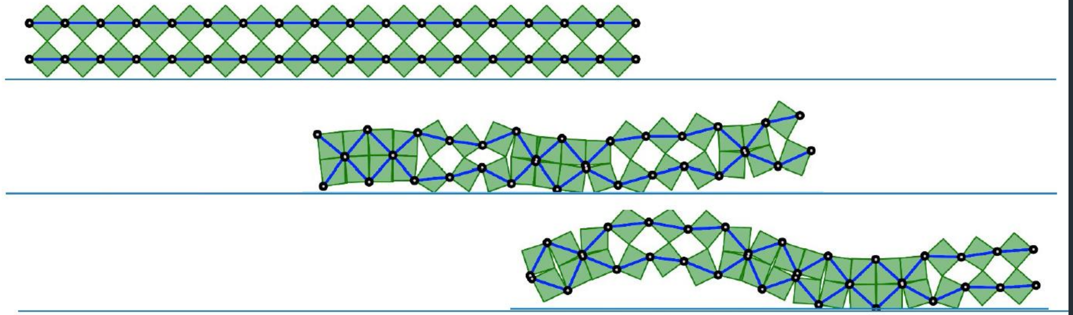
$$\begin{pmatrix}\tau_1\\ \tau_2\end{pmatrix} = \begin{pmatrix}-\kappa & -\kappa^a\\ +\kappa^a & -\kappa\end{pmatrix}\begin{pmatrix}\delta\theta_1\\ \delta\theta_2\end{pmatrix}$$

Literature:
1, 2, 3

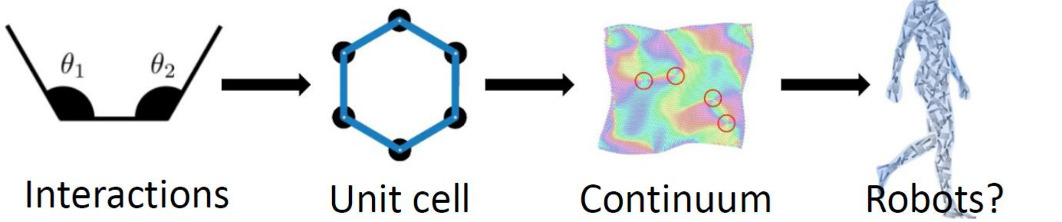
Discrete to continuum mechanics: **Pattern formation**



Dynamics



Active mechanical metamaterials: **Turn materials into robots**

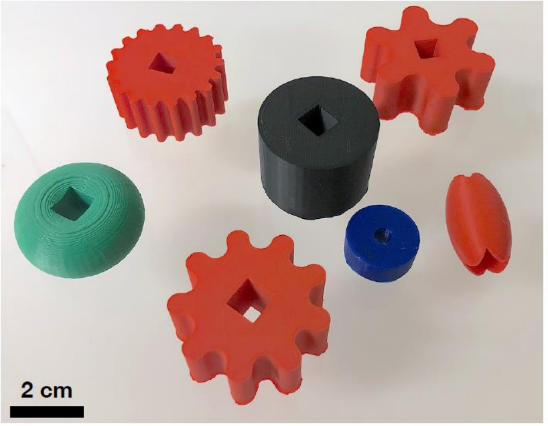


C.J.M.coulais@uva.nl
J.C.veenstra@uva.nl

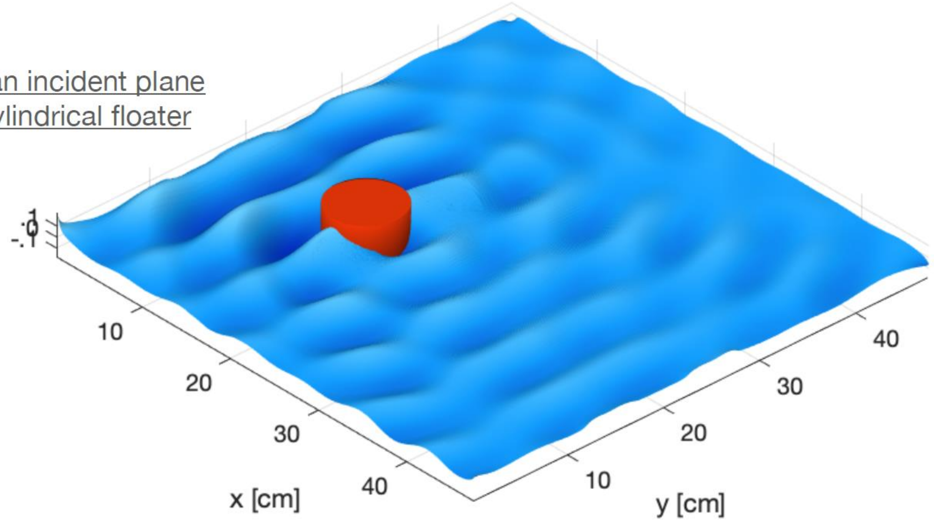
Designing floaters for water waves

Can we tune the resonance of floaters?

Several floater designs



Wavefield of an incident plane wave on a cylindrical floater



We want to fabricate **floaters** with a controlled **resonance frequency**. The **shape, weight and material** of the floater are the control parameters, with which we can tune the response of the object. Then, we will use arrays of these resonators to control waves.

OPEN QUESTIONS

- Can we control the frequency of floaters?
- How do 2, 3 floaters interact?
- Can we focus waves with an array of floaters?

YOUR JOB

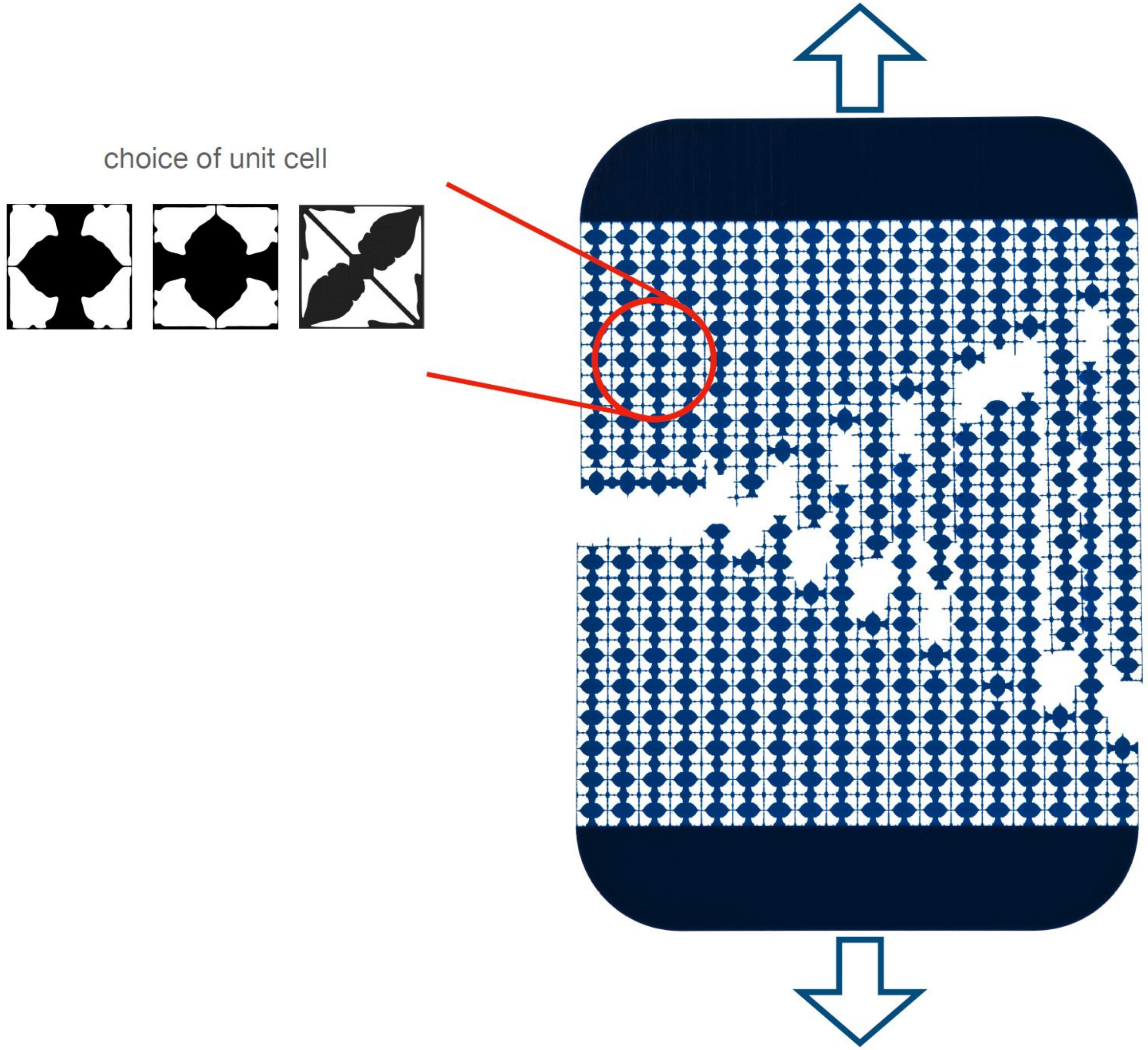
- Design of floaters in 3D
- 3D printing of plastic samples
- Measuring the floater's frequency and the waves around it

Contacts : Lucie Domino l.a.domino@uva.nl
Corentin Coulais coulais@uva.nl

Controlling crack paths with metamaterials

Can we make metamaterials that break in a controlled way?

We make metamaterials by tiling **unit cells** in square arrays, and we put the samples under **tension** until they break. We use several types of unit cells to make different **patterns**, and we observe the **crack paths** we obtain.



OPEN QUESTIONS

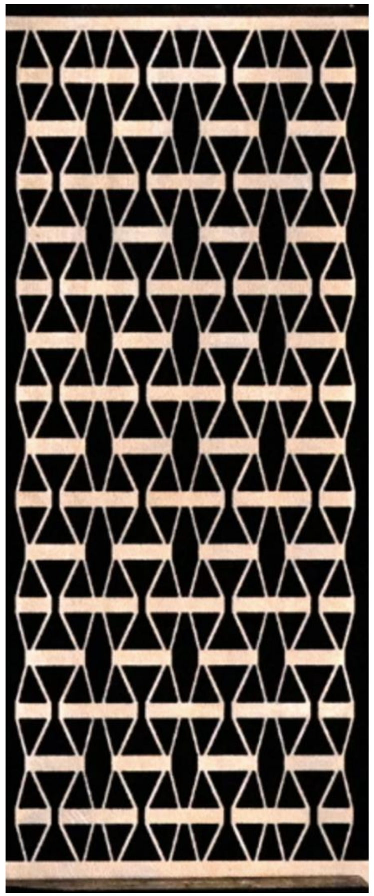
- What type of unit cells work best?
- Can we make any crack shape?
- What are the mechanical properties of the materials we obtain?

YOUR JOB

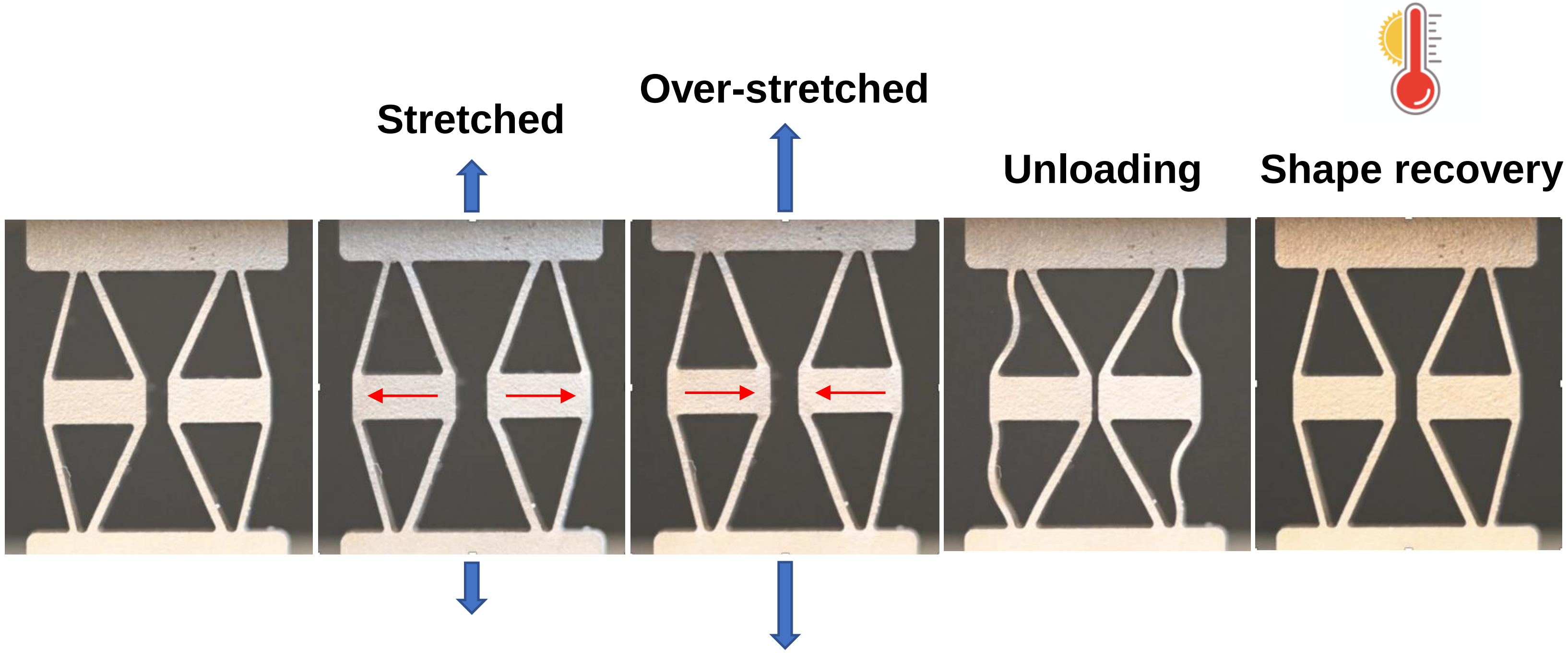
- Design of unit cells and metamaterials
- 3D printing or laser cutting of plastic samples
- Mechanical testing

Contacts : Lucie Domino l.a.domino@uva.nl
Corentin Coulais coulais@uva.nl

Shape memory meta-plates



In this project, we investigate the role of nonlinear material properties offered by shape memory alloys in tuning the nonmonotonic behavior of cellular meta-plates.



More information:
Shahram Janbaz, s.janbaz@uva.nl

UNIVERSITY OF AMSTERDAM

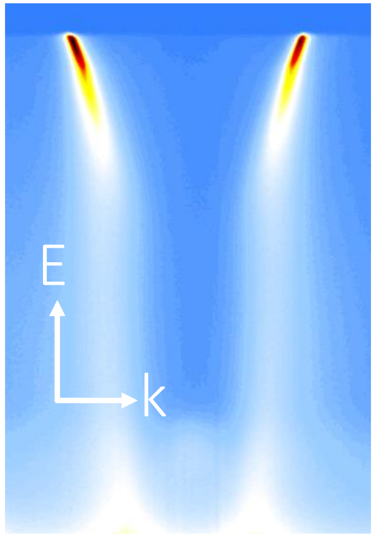
2022
Projects

Quantum Materials Group

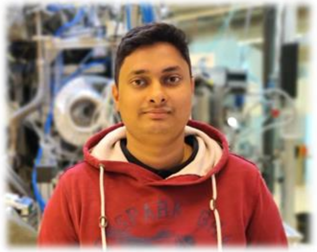
https://iop.fnwi.uva.nl/cmp/

Dive into k-space: ARPES BSc projects @Golden Lab

electrons meet AdS-CFT duality



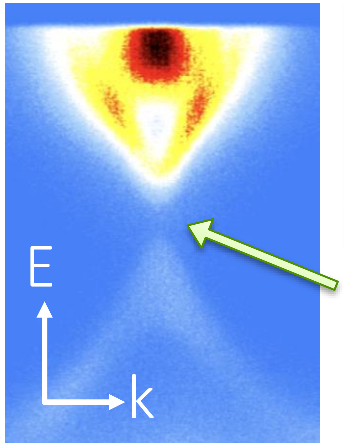
Join **Saumya** to measure the life-time of electrons in superconductors



Your research question: can **changes in the electron lifetime around the Fermi surface** explain electrical transport behaviour in copper oxide strange metals?

see: arxiv.org/abs/2112.06576 for direct use of AdS-CFT to simulate our experimental ARPES data

new spin on Dirac physics



Join **Sergio** to use laser-ARPES to explore magnetic topological insulators

Your research question: does this **gap close** when leaving the magnetically ordered state?

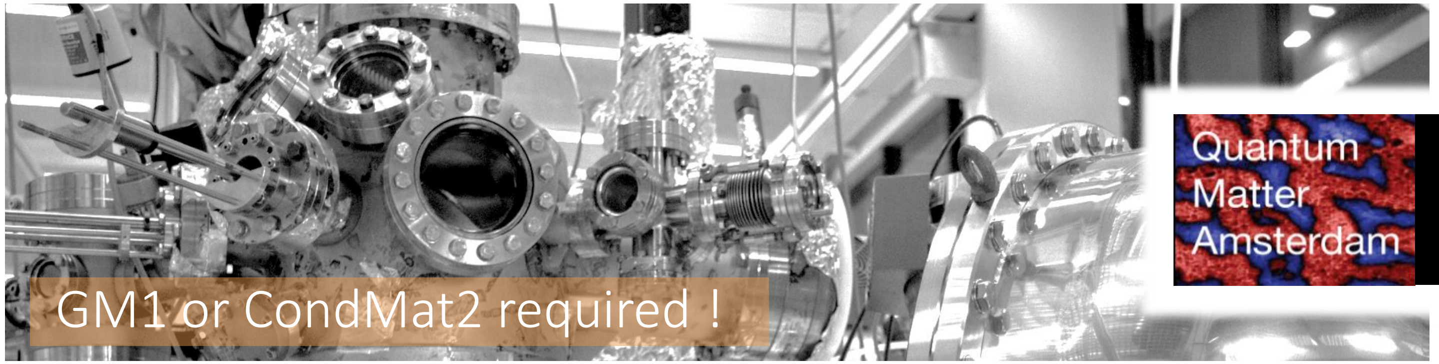
Collaboration with new group-leader @IoP-WZI Anna Isaeva →

leading maker of magnetic topological insulators and

← Irene Aguilera, new group-leader @IoP-ITFA

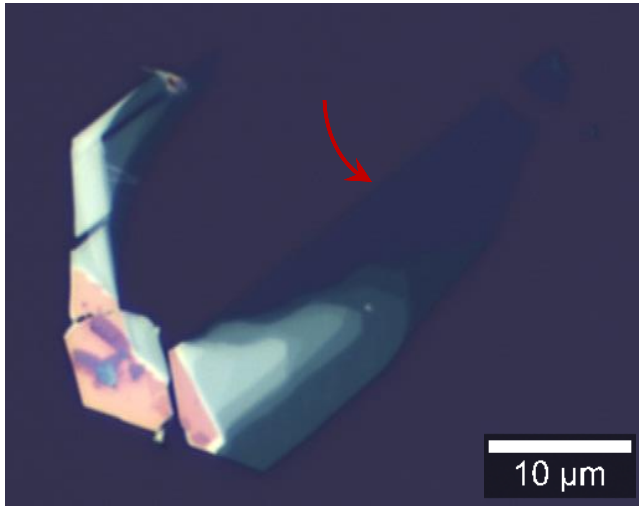
leading expert in ab initio theory of topological materials

→ there is space for 2 students @AMSTEL; one working on each of these projects

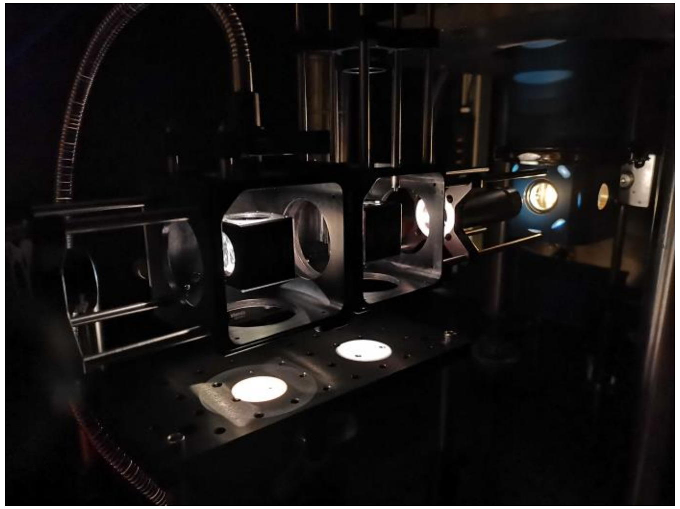


Quantum Matter Amsterdam

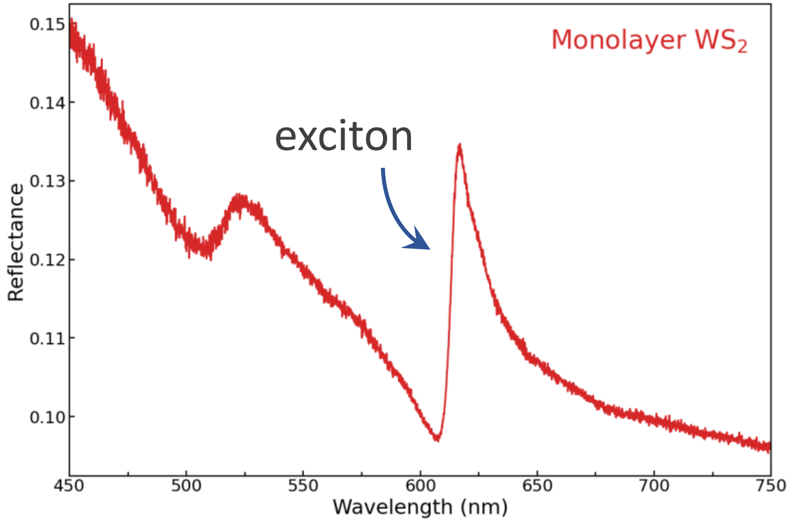
Low-temperature optical spectroscopy of 2D materials



Sample: single layer of atoms (2D material)



Experimental setup

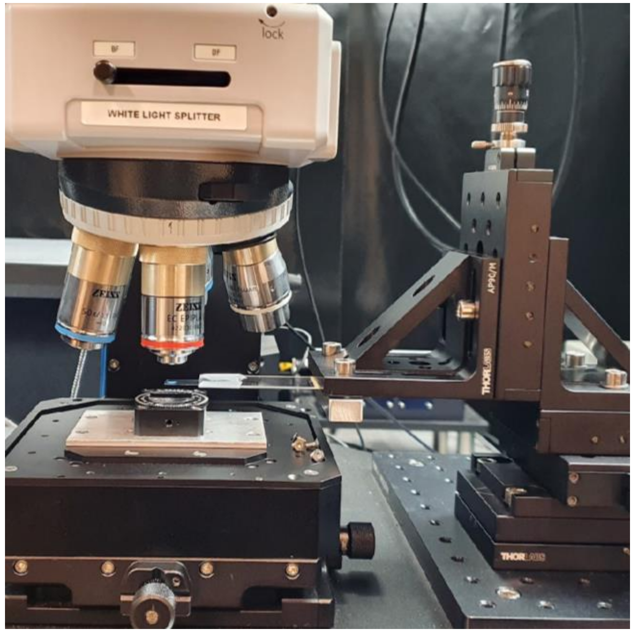


Unraveling line shape of quantum mechanical exciton resonance

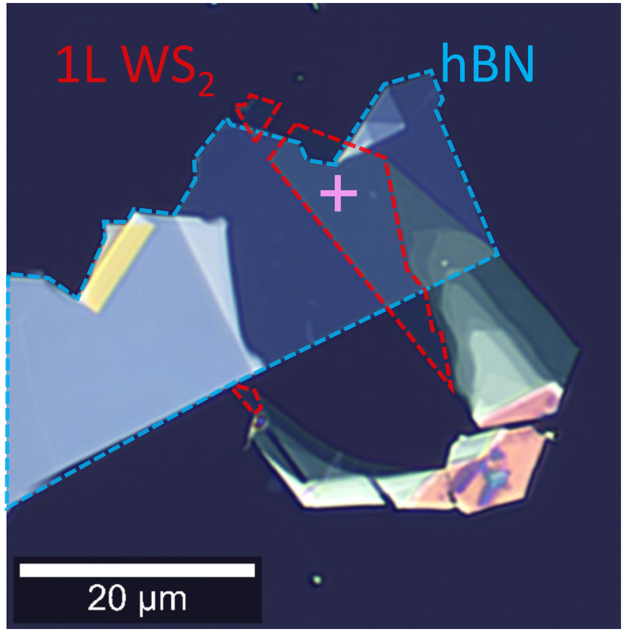
Project goal: Understand exciton line shapes as function of temperature

Contacts: Ludovica Guarneri (l.guarneri@uva.nl) and Jorik van de Groep (j.vandegroep@uva.nl)

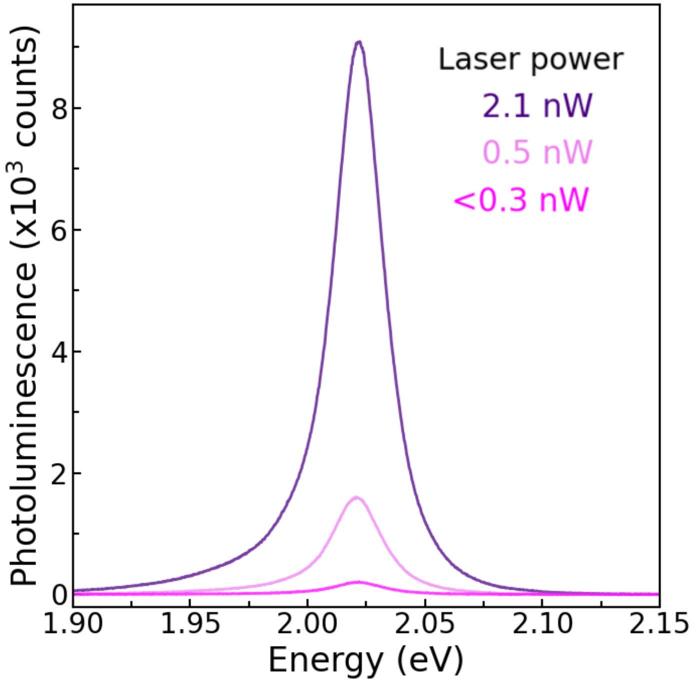
Lego with layers of atoms: heterostructure 2D materials



Sample fabrication: deterministic stamping



2D heterostructures



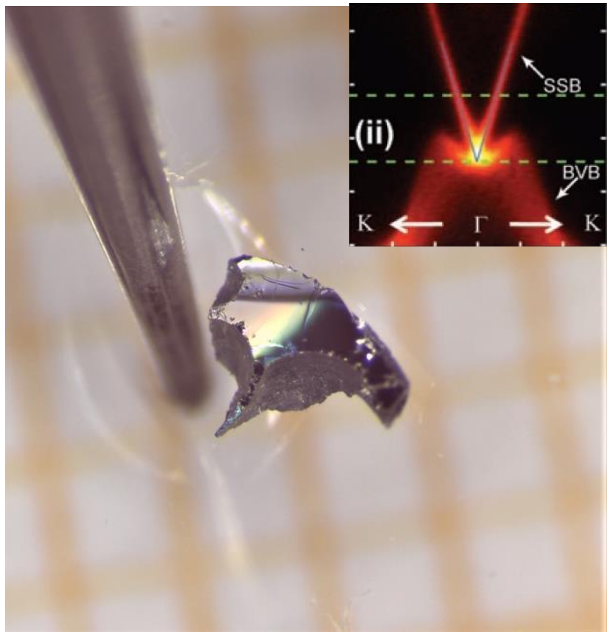
Photoluminescence and lifetime measurements

Project goal: Explore light-matter interaction of interlayer excitons

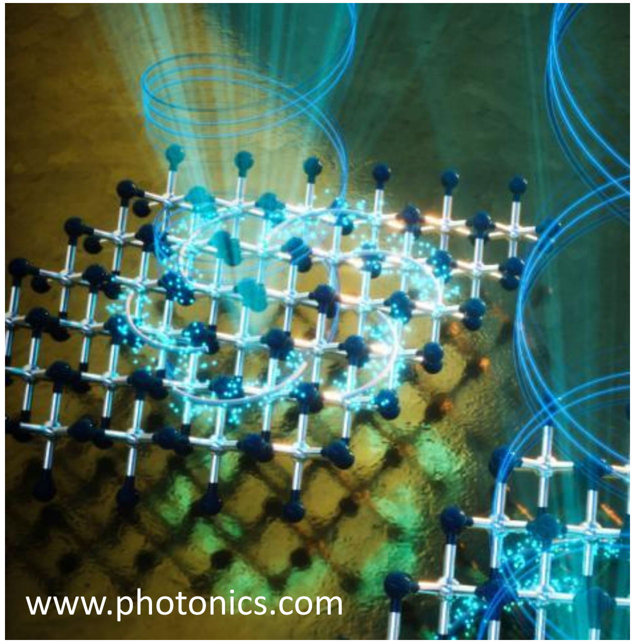
Contacts: Tom Hoekstra (t.hoekstra@uva.nl) and Jorik van de Groep (j.vandegroep@uva.nl)

Hunting chiral excitons on a topological surface

Experiment: make and study topological crystals



Bi-based layered quantum materials



Chiral photoluminescence measurement

Project goal: pinpoint chiral excitons for room-temperature quantum devices

Contacts: Olivier Renier (o.renier@uva.nl), Anna Isaeva (a.isaeva@uva.nl), Jorik van de Groep (j.vandegroep@uva.nl)

Strain tuning of quantum materials @ Q-mat group

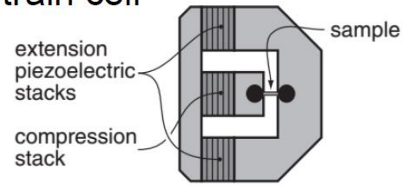
Anne de Visser

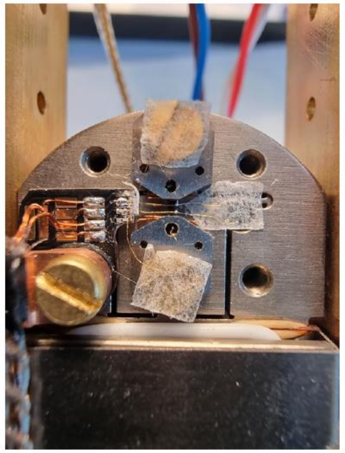
- Goal: investigate unconventional electronic states of topological / superconducting materials

with Jelle Lorenz
PhD student

- Method: use the new uniaxial strain device CS100 Razorbill cell

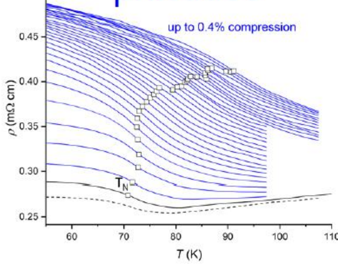
strain cell





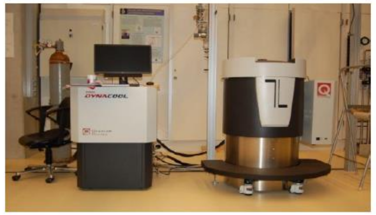
oriented ZrSiS crystals

large effects in pnictides



- Candidate materials:
  - pnictide superconductor $Ba(Fe,Co)_2As_2$
  - transition metal dichalcogenide $IrTe_2$
  - $BiCh_2$ superconductors
  - nodal line semimetal ZrSiS, ZrSiSe

Lab. D0.120 PPMS



Heliox

e-mail: j.p.lorenz@uva.nl or a.devisser@uva.nl --- lab location: WZI /IoP, rm. D0.120

2022 Projects

ARCNL Materials Department

BSc Project

ARCNL
ADVANCED RESEARCH CENTER FOR NANOLITHOGRAPHY

Quantifying laser-induced damage

Roland Bliem group, r.bliem@arcnl.nl" below the title (Quantifying laser-induced damage

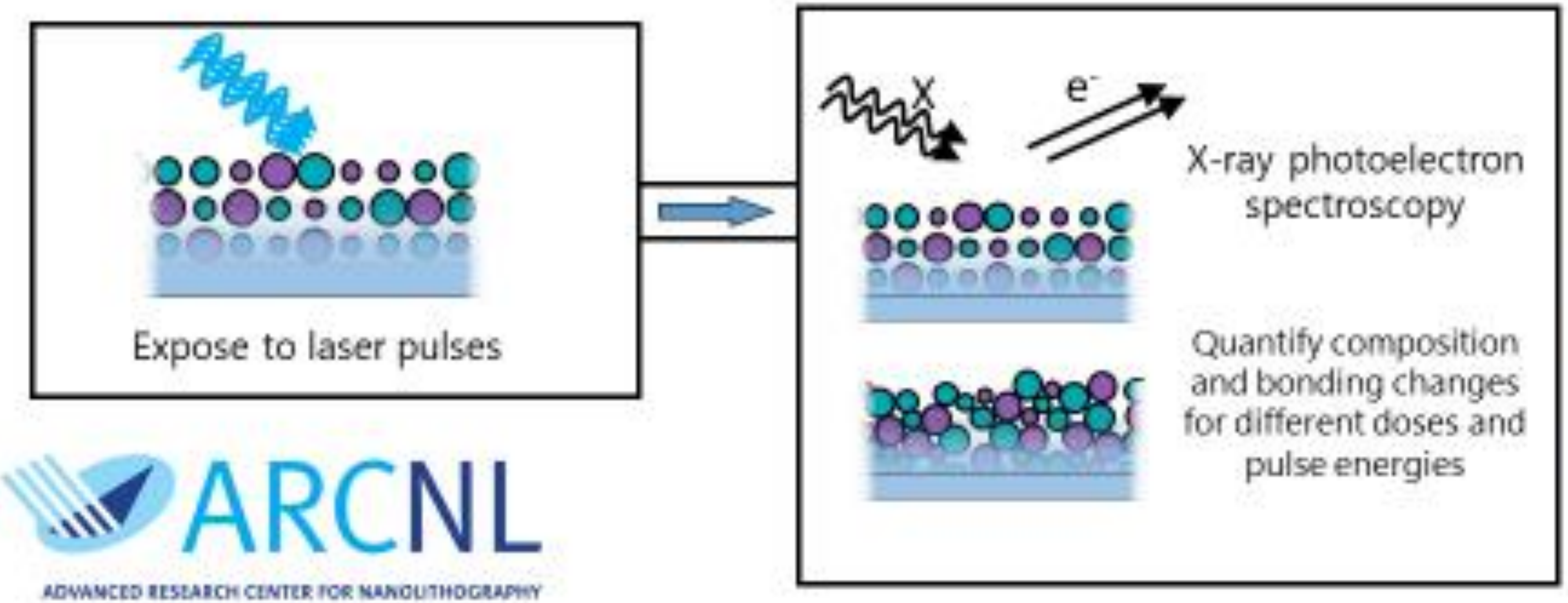
Very high intensity:
Local plasma for thin-film deposition

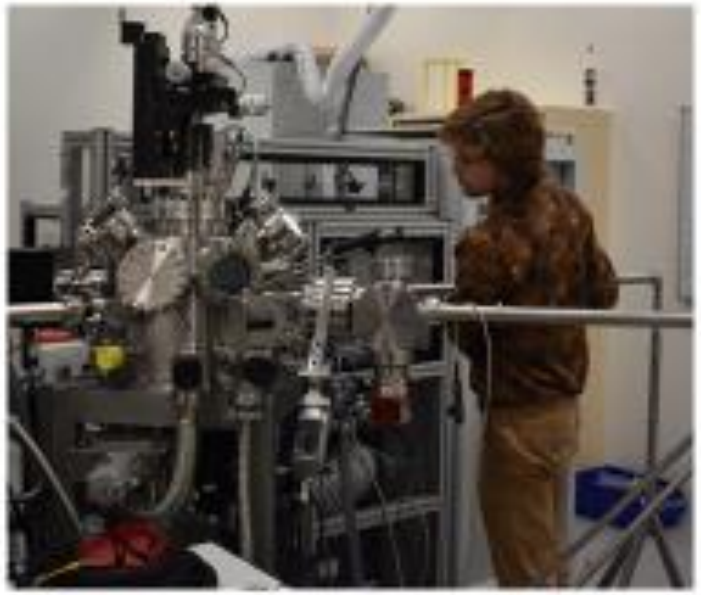
- High-intensity laser light creates damage

  What is the signature of laser-induced damage in spectroscopy?

  How much damage is required to see it in spectroscopy?

Project: Identifying Laser-Induced Damage using X-ray Photoelectron Spectroscopy





ARCNL
ADVANCED RESEARCH CENTER FOR NANOLITHOGRAPHY

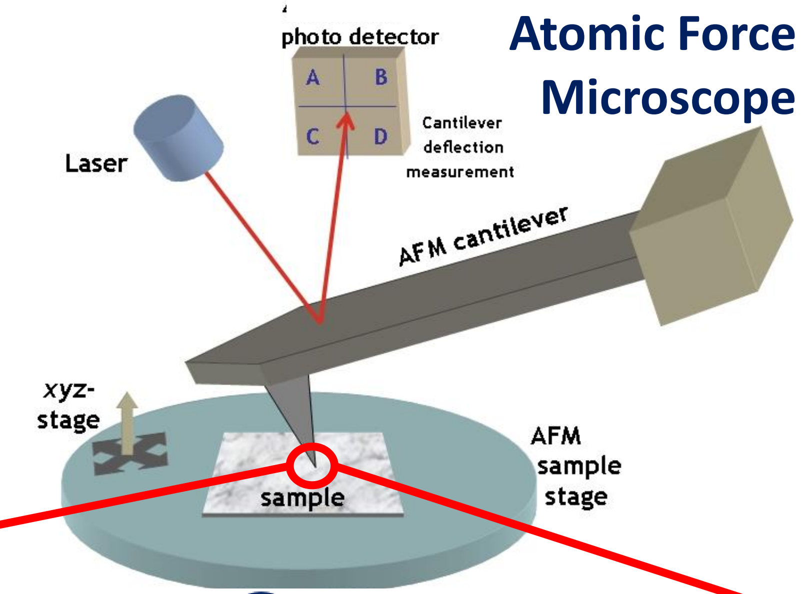
Capillary Adhesion in Different Environments

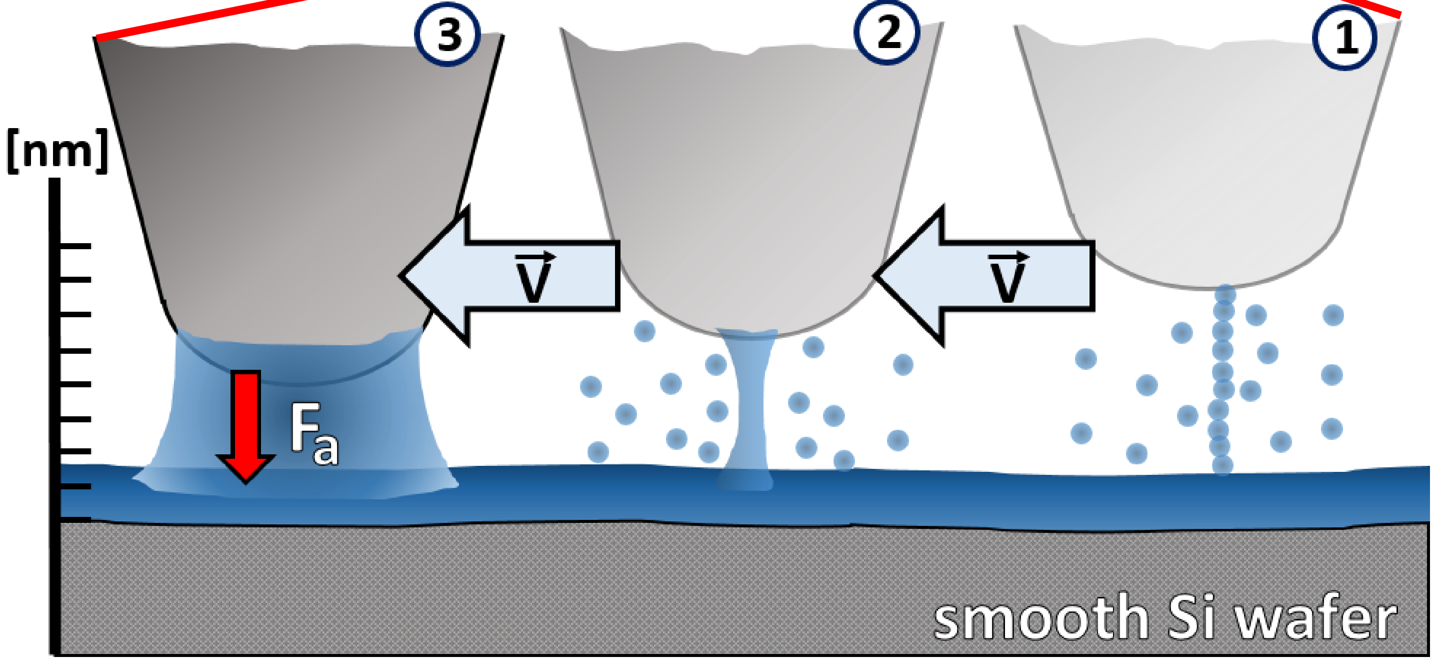
Friction and adhesion play a critical role in the precision positioning inside chip machines

Can capillary condensation occur at low relative humidity levels?

Can a water bridge form between hydrophilic and hydrophobic surfaces?

What influence does sliding velocity and tip-sample distance play?





Dr. Felix Cassin
PostDoc

Dr. Bart Weber
Group Leader