Nanoscience Symposium
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NANOSCIENCE
SYMPOSIUM

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PUSHING THE BOUNDARIES OF NANOSCIENCE

NANO4SOCIETY
ECOSYSTEM FOR NANOTECHNOLOGY

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About

Nanoscience program

The Top master program in Nanoscience aims at interdisciplinary training in modern materials science, with a focus on nanoscale phenomena. The Zernike Institute for Advanced Materials is responsible for the program. Teachers and supervisors associated with the program represent the excellent research groups taking part in the research program of the Zernike Institute. The courses are taught by top international scientists, and a large part of the program consists of actually conducting high-level scientific research. Students are submitted to a challenging and highly demanding curriculum, combining both the broadness and depth necessary for a successful research career in modern materials science.

Nanoscience symposium

The symposium is organized by the First year students of the Top Master Nanoscience program. This symposium is part of the course of Small Research and Symposium, in which the students give an oral presentation on their topics of research.

This is a booklet for print use for the 2024 edition of the annual Nanosymposium, organised by the Nanoscience Master Programme, under the Zernike Institute for Advanced Materials.

More information can be found at:
`https://nanosymposium.nl/`

Timetable

9:00–9:25	**Walk-in with coffee**
9:30–9:55	**Symposium opening**
10:00–10:15	**Alwin Jansen**
10:20–10:35	**Rozemarijn Kooij**
10:40–10:55	**Yieon Park**
11:00–11:15	**Break**
11:20–11:35	**Kamila Handke**
11:40–11:55	**Maria Perraki**
12:00–12:15	**Nicolás Monreal**
12:20–12:35	**Leandro Mosquera Meztra**
12:40–13:10	**Lunch (sign up)**
13:15–13:50	**Dirk J Broer** Liquid crystal networks, a special class of materials with soft robotic functions
13:55–14:10	**Darius Pacurar**
14:15–14:30	**Sergio Alvarruiz Campos**
14:35–14:50	**Pedro Ortiz Costa**
14:55-15:10	**Break**
15:15-15:30	**Miranda Buil Contreras**
15:35-15:50	**Clifford Biame**
15:55-16:10	**Ayush Gupta**
16:15-16:30	**Ahmad Dibajeh**
16:35–16:55	**Teacher of the year award**
17:00	**Symposium closing**

Day Chair

Dr. Loredana Protesescu, University of Groningen

Dr. Protesescu has been an assistant professor since 2019 at Zernike Institute for Advanced Materials, University of Groningen. She is an inorganic chemist with solid expertise in the chemistry of (novel) nanomaterials, their structural particularities, and their surface chemistry in relationship to self-assembly, and their properties. Dr. Protesescu uses chemical design to achieve functional materials at the nanoscale with applications in energy, extreme environment, and bio-applications. She has a vast experience in the development of tailored semiconductor nanocrystals with applications in opto-electronic devices. Her contribution to the perovskite semiconductors nanocrystals is reflected by her extensive work with lead and tin halide perovskites with 2D and 3D structures and morphologies.

Dr. Protesescu has published more than 50 papers and contributed to the development of two patents, and she is the scientific advisor of Peafowl Plasmonics, a Sweden start-up company. Furthermore, Dr. Protesescu won the Nanomaterials 2020 Young Investigator Award, a Veni NWO grant (2019), and an OTP NWO grant (2024). She was selected as an Early Career Board member for Nano Letters starting 2022. Starting 2023, I am chairing the ECB.

Further information: https://www.protesesculab.com

Guest Speaker

Professor Dirk Broer, TU Eindhoven

Prof. Broer is Professor Emeritus at Eindhoven University of Technology, fellow at the Institute for Complex Molecular Systems and distinguished professor at South China Normal University. His research field is polymer science with an emphasis on responsive polymers, self-organizing systems, liquid crystals, and their applications in the field of optics and soft mechanics. Prof. Broer started his professional career in 1973 at Philips Research Laboratories in Eindhoven where he became Vice President Research in 2003 and specialized in data storage, communication, and display systems. In 1985 he introduced the process of in-situ photopolymerization of liquid crystal monomers, presently being used by many academic and industrial groups, for instance for optical and soft robotic components. In 2010, he became professor in Eindhoven to chair the Department Functional Organic Materials and Devices. Prof. Broer is member of the Royal Dutch Academy of Arts and Sciences. He has around 350 publications in peer-reviewed journals and more than 120 US patents.

Further information: https://www.tue.nl/en/research/research-groups/stimuli-responsive-functional-materials-devices

Student presentations

Simulating the biomolecular corona

Alwin Jansen **Pharmaceutical analysis**

The protein corona is an adsorbed protein layer that forms when a nanoparticle is exposed to a biological fluid. The protein corona plays a determining role in the interaction of the nanoparticle with the surrounding biological environment, providing its biological identity. Accurate modeling so far has been difficult due to its complex dynamics, depending on a variety of factors such as protein composition and environmental conditions. This research project aims to provide a start in modeling the formation of the protein corona on bear nanoparticles using diffusion-based simulations. Using the simulated coronas, the colocalisation of proteins was investigated to determine the possibility of short-range protein-protein interactions on the nanoparticle surface.

Applying tissue clearing for fluorescence-based intraoperative tumour margin evaluation

Rozemarijn Kooij **Molecular Biophysics**

Cancer is one of the most common causes of death globally. Since surgical removal of tumours constitutes a major part of cancer treatment, it is important to ensure that all cancer tissue is removed completely to prevent the need for further surgery or (chemo)radiotherapy. In intraoperative pathology-assisted surgery, fluorescence imaging can be used to detect tumour edges in excised tissue. If necessary, surgeons can remove additional tissue during the surgery. A tumour lights up by administering a fluorescent near-infrared tracer which accumulates in tumour tissue. However, the opaqueness of the excised tissue limits the imaging depth. To allow for margin evaluation from all directions, tissue clearing can be applied, enhancing the imaging depth by decreasing light scattering within the tissue. In this project, clinical samples were cleared with a new fast-clearing technique (< 1h) and imaged with confocal microscopy. The tracer distribution in healthy and tumour tissue was analysed as a step towards the development of intraoperative 3D tumour margin assessment.

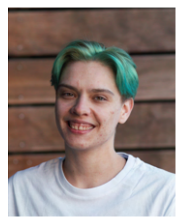
Energy Transfer Between Two Dimensional Sheets

Yieon Park **Theory of condensed matter physics**

Chlorosomes are the light-harvesting antennae that allow photosynthetic Green Sulfur Bacteria to survive under extremely low-light conditions. Owing to the evolutionary adaptation of the photosynthetic architecture, the energy transfer found between sheets rolled up within these chlorosomes are known to be most efficient among all natural light-harvesting systems. To understand the role of the relative orientation of the stacked sheets for the transfer process between the sheets, the energy transfer between Chlorosome type sheets depending on the angular relation has been modeled. This will provide insight into the role of stacking for the bacteria and if it can be used to create artificial systems with desirable properties either suppressing or enhancing energy transfer.

Mechanical deformation of stimuli-responsive liquid crystal elastomer thin films

Kamila Handke **Active Molecular Systems**



Soft robotics is a field that has evolved significantly in recent years, with the potential to revolutionize application in healthcare, sensors, electronics and wearable devices, relying on the flexibility and adaptability of smart materials. One of the driving forces in development of soft robotics are stimuli-responsive materials, which sense changes in their environment and adapt accordingly. Such materials are often used as building blocks for biomimetic and functional systems. Liquid Crystal Elastomers (LCEs) are lightly crosslinked liquid crystal networks, which exhibit anisotropic mechanical deformation upon stimuli application, owing to the alignment of the liquid crystal chains. Despite the recent progress, challenges still remain in designing and controlling the elastodynamic properties in the context of specific applications. The scope of this project involves investigating two different thin film LCE systems with differing response mechanisms. One system incorporates an azobenzene photoswitch moiety into the network, while the other relies on a photoactive dye to induce a thermal response. The optimization of the fabrication process included comparison of planar and splay structures, achieved through different alignment layers. Additionally, the project examined the impact of thickness and azobenzene content on the extent and rate of the mechanical response of the films. Lastly, in collaboration with RUG's Data Science team, efforts were made to develop and automate a protocol for efficient video analysis of thin film actuation due to applied stimuli.

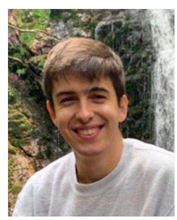
Motility of oil droplets in chiral lipid systems

Maria Perraki **Active Molecular Systems**

Movement is a hallmark of life, crucial from origin-of-life research to contemporary applications like drug delivery and reaction acceleration. However, the mechanisms by which controlled molecular movement can translate across length scales into purposeful motion have not yet been completely unravelled. Meanwhile, the study of droplet behaviour has become relevant in modern biology, due to the phase separation of contents that occurs within cells. It has been shown that a local inhomogeneity in interfacial tension is enough to generate movement of microscopic compartments like droplets, and that this so-called "Marangoni effect" is driven by the solubilization of the droplet by lipid molecules. The focus of this project was to study the interplay between chirality and the motility of oil droplets in lipid-rich water. At first, chiral lipids were synthesised and characterised in terms of their aggregation properties by Dynamic Light Scattering (DLS) and interfacial tension measurements. Subsequently, a series of oils were introduced in aqueous solutions of those lipids and the formed droplets were monitored using optical microscopy and a tracking software. This study provided insights into whether the chirality of lipids, active droplets, or their combination, can modify the trajectory, speed, or other characteristics of droplet motility, advancing our understanding of the parameters that affect conscious microscopic motion.

Chiral morphogenesis: from elastic droplets to helical filaments

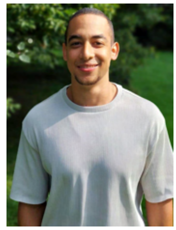
Nicolás Monreal **Active Molecular Systems**



The shape of cells is a key element of their function, such as the filaments growing in neurons that support intercellular communication. Many cells also have the potential to change their shape, for example during cellular division. Many of the fundamental physical and chemical mechanisms that drive cellular shape changes are still unknown, but they can be studied using fully synthetic model systems. Recently, it has been seen that in highly concentrated aqueous solutions of lipids, fluid droplets undergo morphogenesis as a result of inhomogeneity in the interfacial tension. Adding a chiral dopant to a nematic liquid crystal mixture during the synthesis of droplets induces a twist in the ordering of the liquid crystal molecules when the temperature is decreased, and the molecules arrange in a helical manner. In this project, a chiral molecule was synthetized and characterized that should induce the formation of a left-handed helix in a liquid crystal. Its properties were also compared to its chiral counterpart by studying how the droplets containing these chiral dopants respond to the drop of the interfacial tension by the change in temperature.

Niobium oxide prepared through a novel supercritical-CO_2-assisted method as a highly active heterogeneous catalyst for the synthesis of azoxybenzene from aniline

Leandro Mosquera Meztra **Product Technology**



High-surface area Nb_2O_5 nanoparticles were synthesized using a novel supercritical CO_2-assisted method and applied as a heterogeneous catalyst for the oxidative coupling of aniline to azoxybenzene, utilizing environmentally friendly H2O2 as the oxidant. The application of supercritical CO_2 ($scCO_2$) in the synthesis of the Nb_2O_5-$scCO_2$ catalyst resulted in a significantly enhanced catalytic activity compared to a reference catalyst prepared without $scCO_2$. Furthermore, the catalytic properties of Nb_2O_5-$scCO_2$ were evaluated in the oxidation reaction of ethylbenzene.

Low temperature magnetic imaging and spectroscopic investigation of van der Waals magnet CrSBr via SPLEEM

Darius Pacurar **Topological Quantum Materials**

Since their first discovery, the scientific interest in van der Waals (vdW) magnetic materials has been growing constantly. Such interest is justified by the layered nature of vdW materials. First, this allows for a magnetic order to emerge in truly two-dimensional systems just one-layer thick. Second, such layered nature makes them ideal for the formation of heterostructures with other magnetic/non-magnetic vdW materials, where novel magnetic and electronic properties can emerge given the strong interaction between the layers via clean/well-defined interfaces. In particular, a vdW magnetic material which is attracting much attention lately is CrSBr. CrSBr has been predicted and experimentally observed to be a layered antiferromagnet, where ferromagnetic mono-layers are coupled antiferromagnetically to the neighboring layers, making this material very promising for applications in 2D spintronics.

Symmetry protected spin persistent texture in bulk non-magnetic materials

Sergio Alvarruiz Campos **Theory of condensed matter physics**

The field of spintronics seeks advancing past conventional electronics, based on electrical charge as the sole information carrier, by using the electron spin as an additional degree of freedom. In this field, materials with large spin orbit coupling (SOC) are very desirable, as this effect is at the center of many processes that lead to spin-charge conversion, essential to spintronics. Nevertheless, large SOC is also associated with shorter spin lifetimes. SOC results in a momenta dependent effective magnetic field that acts on the spin. As such, as an electron gets scattered, changing its momenta, also its spin will be affected, losing its coherence. As a solution: materials that present a spin texture fully polarized in one direction in momenta space. This will lead to carriers propagating in the real space in a persistent spin helix state, which is predicted to greatly enhance spin lifetime. For some bulk space groups, this persistent spin texture (PST) arises in certain regions of the Brillouin zone, imposed by the symmetry of the material. We propose non-magnetic materials that are predicted to present this symmetry-protected PST near the Fermi level and perform DFT calculations.

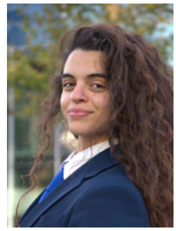
Keyword spotting with ferroelectric-based integrate-and-fire neurons

Pedro Ortiz Costa **Bio-inspired systems and circuits**

The ability to detect correlated events in the environment is an important feat of biological neural networks. Neuromorphic computing strives to mimic this ability for efficient sensory processing. This work explores the simulation of a HfO2-based ferroelectric capacitor (FeCap)-complementary metal oxide semiconductor (CMOS) leaky integrate-and-fire (LIF) neuron able to detect highly correlated events exploiting two different temporal dynamics. The possibility to exploit two time constants increases the versatility of the neuron and its dynamic adaptation while offering a compact and elegant solution for applications like coincidence detection of both transient and sustained coincidences. Moreover, the time constants are in biologically relevant time scales, which makes the neuron suitable to solve real-time tasks such as speech detection, including keyword spotting. Additionally, the use of FeCAP provides the neuron with dynamics similar to integrate and fire (I&F) neurons without leakage, which have proven to be beneficial in certain applications. An analysis of the leakage effect on the performance of the LIF neurons was conducted, together with a comparison with the FeLIF neurons, where a new methodology for training high temporal dynamics was used.

Towards the deposition of corroles on noble metal surfaces by organic molecular beam epitaxy

Miranda Buil Contreras **Surfaces and Thin Films**



Tetrapyrroles such as porphyrins and corroles are functional molecules with interesting properties. Whereas porphyrins are well-explored on surfaces, much less is known about corroles. Corroles present a different symmetry macrocycle compared to porphyrins and thus provide a different environment for the central metal atom, that dictates for example magnetic and catalytic properties of the molecule. Due to the modified shape of corroles, different self-assembled structures are expected in comparison to porphyrins. Additionally, employing temperature-induced coupling reactions, novel fused tetrapyrrole systems can be achieved on coinage metal supports. This project aims to prepare and study supramolecular assemblies of the selected tetrapyrroles on coinage metal supports, such as Ag(111). The deposition of three different corrole compositions was studied and characterized using scanning tunneling microscopy, x-ray photoelectron spectroscopy, and mass spectroscopy. However, the sublimation of the intact corrole proved challenging. The measurements suggest that the molecules decomposed before they could reach the substrate.

Excitation Energies of Erbium ion (Er^{3+}) in a Crystal Environment

Clifford Biame **Computational Chemistry**

This work uses upconversion to explore the erbium (Er^{3+}) ion's excitation energy in a crystal environment. Upconversion is a nonlinear optical phenomenon in which a higher-energy photon is emitted due to the successive absorption of two or more low-energy photons. Using spectroscopic techniques, the energy levels and transitions are accountable for the upconversion process. The optical absorption spectrum with a series of peaks helps to display the amount of excitation energies obtained when the electron is excited. The strength of each peak is given by the transition dipole moment. Different upconversion paths are identified by our data, most notably the one that involves the change from the ground state $^4\mathrm{I}_{5/2}$ to higher excited states such as $^4\mathrm{S}_{3/2}$ and $^4\mathrm{F}_{9/2}$. These transitions are facilitated through intermediate energy levels like $^4\mathrm{I}_{11/2}$ and $^4\mathrm{I}_{13/2}$. The interaction between the Er3+ ions and the surrounding crystal lattice produces the crystal field effect, which is essential for altering the electronic structure and, in turn, the ions' excitation energy. The results open the door for the construction of improved photonic devices, where exact control over emission wavelengths and upconversion efficiency is crucial, such as lasers, LEDs, and optical amplifiers. For a future perspective, the excitation energies should be calculated when the Er^{3+} ion is at the surface of the crystal.

New NMR methods for probing Photo-responsive materials

Ayush Gupta **Solid-state NMR**

Photo-responsive materials hold substantial promise for new applications in a range of areas, including functional nanogels and nanoparticles for biomedical and theranostic purposes. For such applications, light-responsive elements are combined with self-assembling (macro)molecules to attain nano-materials with controllable light-activated properties. Previous studies suggest that these materials could be utilised in drug-delivery systems to achieve improved control over the cargo release and distribution. Yet, there are many challenges in directly probing and measuring the rich atomic-level interactions of such light-activated transformations. In this light, solid-state NMR spectroscopy is an advanced spectroscopy technique based on nuclear spin interactions that is used to determine atomic-level structure in self-assembled nanomaterials. We demonstrate our development of novel methods and instrumentation to enable the use of magic-angle-spinning NMR to probe lipid self-assembling vesicles. We use the solid-state NMR technique to reveal atomic-level changes in structure and dynamics of lipid nanoparticles. Thus, helping to develop new techniques in order to demonstrate and implement novel measurements under light-irradiation, in situ and ex situ.

Topological spin texture in magnetic multilayers imaged via SPLEEM

Ahmad Dibajeh **Topological Quantum Materials**

The study of magnetic domains in computational device architectures allows for advancements in scalability and energy efficiency. This is especially possible in new architectures, which exploit topologically protected quasi-particles, magnetic skyrmions. Special skyrmions which exist in equilibrium under ambient conditions have been demonstrated through interlayer exchange coupling. Surface characterisation data is processed in this project; where In-Situ Spin Polarized Low Energy Electron Microscopy (SPLEEM) of Layer by Layer growth of alternating Ni and Co monolayers on Cu/Nb(110) was performed. Each layer's surface is characterized with respect to SPLEEM images pointing in-plane and out of plane. Out of plane skyrmions on Ni's surface are found to exist. Moreover, quantitative analysis of the skyrmion size and frequency is presented.

Sponsors

Nano4Society applies nanotechnology within the ecosystem to develop solutions for major social transitions and creating social impact and economic value. It does this by maintaining a well-functioning ecosystem with state-of-the-art nano-infrastructure, enabling fundamental and applied research through programs. Also, by helping companies to bring innovations to the market more quickly.

As a result, the Netherlands is able to occupy a top position within the ecosystem at an international level and to play a strong role in shaping the transitions around care, security, energy and agriculture, water and food.

‘More than a tech job’

Meet Pieter Smorenberg, a 2017 technology graduate who found himself back at the university, this time explaining to students how technologically fascinating his job is. Originally from Amsterdam, Pieter couldn’t have guessed that he would find so many technical and social opportunities in Veldhoven at ASML, the fast-growing tech giant.

Pieter studied precision and microsystem engineering, and now works as an applications engineer in customer support at ASML. He also spends some of his time as one of the ‘ASML Ambassadors’, giving guest lectures at his alma mater university or promoting STEM among school-aged children in the region.

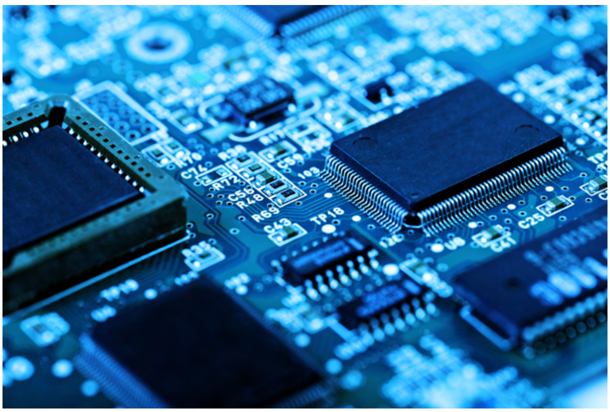
“The more I tell people about working here, the more things I realize I appreciate about the company,” he says. *“A lot of people don’t realize just how big ASML is in the semiconductor industry. You realize it when you visit the campus in Veldhoven. You see the big tower, the cleanrooms, the huge gardens and parking lots; it’s impressive. And then at the complete other end of the scale, almost all of the metrics we work with here are practically at an atom level – no other company is producing such advanced chip-making equipment.”* ASML is the world’s leading provider of semiconductor lithography equipment. All of the world’s top chipmakers are our customers, including Samsung, Intel, and TSMC.

Pieter has certainly found more than he expected in Eindhoven. *"I was a bit uncomfortable about moving to Eindhoven, but there’s a lot going on that you only discover after you get here. It’s not a ‘small city’. It’s a melting pot – people come from all over the world to live here.”*

Pieter has also found more than a career at ASML. *“There’s so much going on in our company, technically as well as socially. We have annual technology conferences where you can learn about what’s going on in your department, across the company – even across the world. This is really unique to ASML. You can develop your network and learn a lot about what other people are working on. It inspires, and you’ll get ideas for yourself. I’m like a kid in a candy store at these conferences.”*

Celebrating our technology isn’t the only way we have fun at ASML. *“I sometimes go for drinks with the ‘Young ASML’ group for young ASML professionals,”* Pieter says. *“You* *get to meet colleagues from all kinds of different departments. It’s a really open-minded atmosphere, because everybody is there for the same reason: to share a good evening with each other.”* The ASML campuses are like small cities – more than 19,000 people work just at the Veldhoven campus alone. Young, old, male, female, LGBTI+, living abroad, you name it – it’s easy to feel at home at ASML.

As a customer support engineer, Pieter also gets to travel a lot, listening to ASML’s customers and helping them to achieve their technology roadmaps. During his travels he experiences other cultures first-hand. *“You learn a lot – socially and culturally as well as technically. It’s been an eye-opener for me. We’re diverse, in terms of education, background, and nationality, but we’re all working together as one team because we all have the same goal: make this incredibly complicated technology a reality.”*



Are you interested to learn more about ASML? Visit www.asml.com/students for more information about our events, internships and scholarship program.

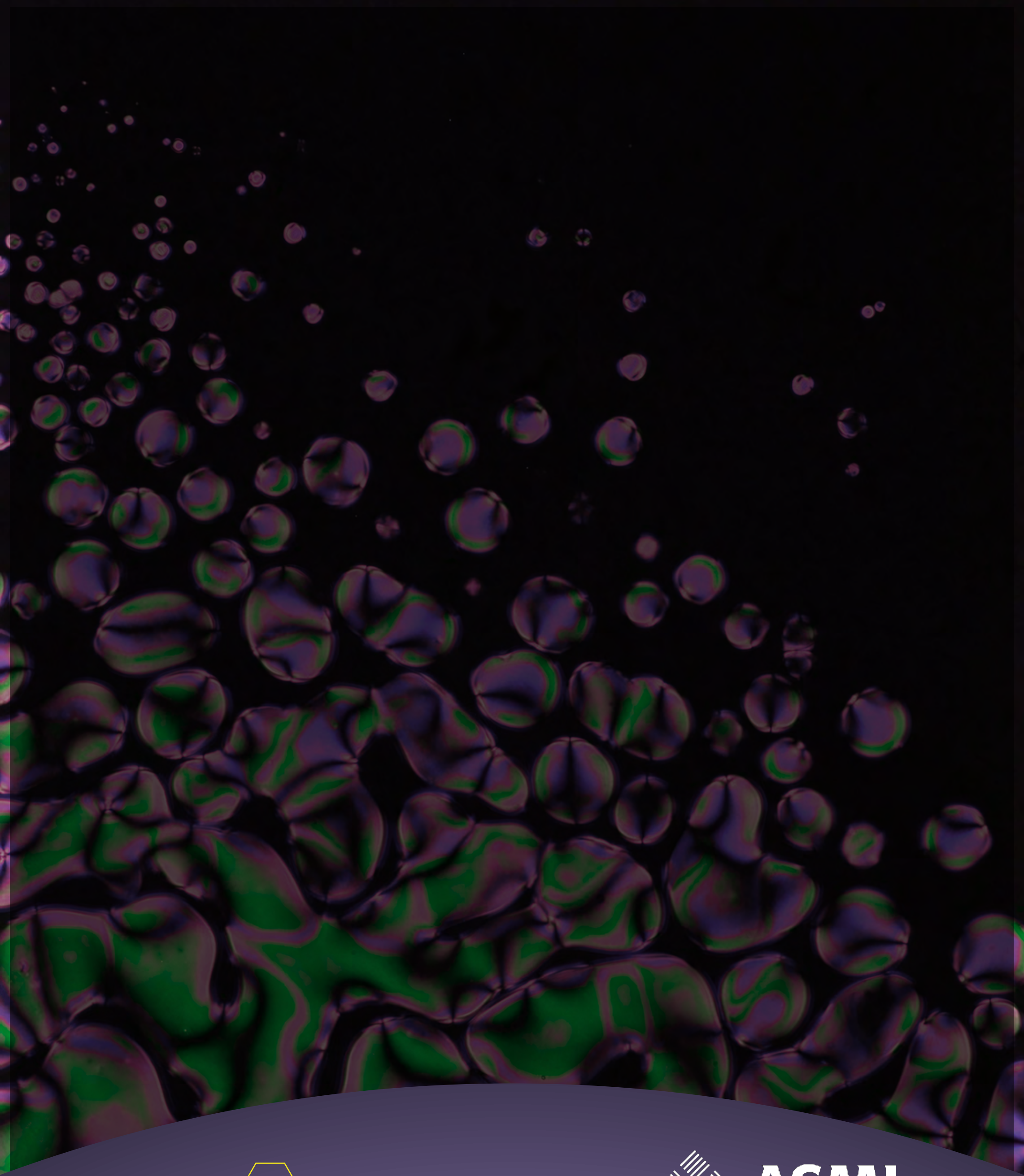
Groningen Cognitive Systems and Materials Center (CogniGron) is part of the University of Groningen and a globally recognised and unique multidisciplinary research centre in neuromorphic computing. We conduct fundamental research on self-learning materials and systems. Our mission is to design a blueprint for future-proof computers. In the end, our aim is to develop computer chips that are up to 10,000 times more energy efficient.

COGNIGRON: A UNIQUE MULTIDISCIPLINARY KNOWLEDGE INSTITUTE

Combining physics, material science, mathematics, computer science and artificial intelligence, the main goal of CogniGron is to create self-learning materials that will perform the tasks that are currently assigned to thousands of transistors and complex algorithms in a more efficient and straightforward manner. This introduces a new generation of computer platforms for cognitive applications, such as pattern recognition and analysis of complex data.

Our programme in cognitive systems and materials aims to discover and develop physical building blocks (i.e. materials) with intrinsic cognitive functionality via cross-linked networks at the nanoscale, allowing more efficient and denser circuits than those of state-of-the-art solutions. CogniGron will also investigate and design the optimal implementation of such new material structures at the system level.

The **Stratingh Institute for Chemistry** is a research institute at the Faculty of Science and Engineering of the University of Groningen. The Stratingh Institute for Chemistry aims to perform excellent research and teaching in molecular and supramolecular chemistry. The major activitie integrated in institute includes the chemical sciences such as bio-organic chemistry, organic chemistry, molecular inorganic chemistry, and molecular materials chemistry. The institute's research programs focused on synthesis, catalysis, functional materials, bio-organic chemistry/chemical biology, and systems chemistry/complex molecular systems.



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