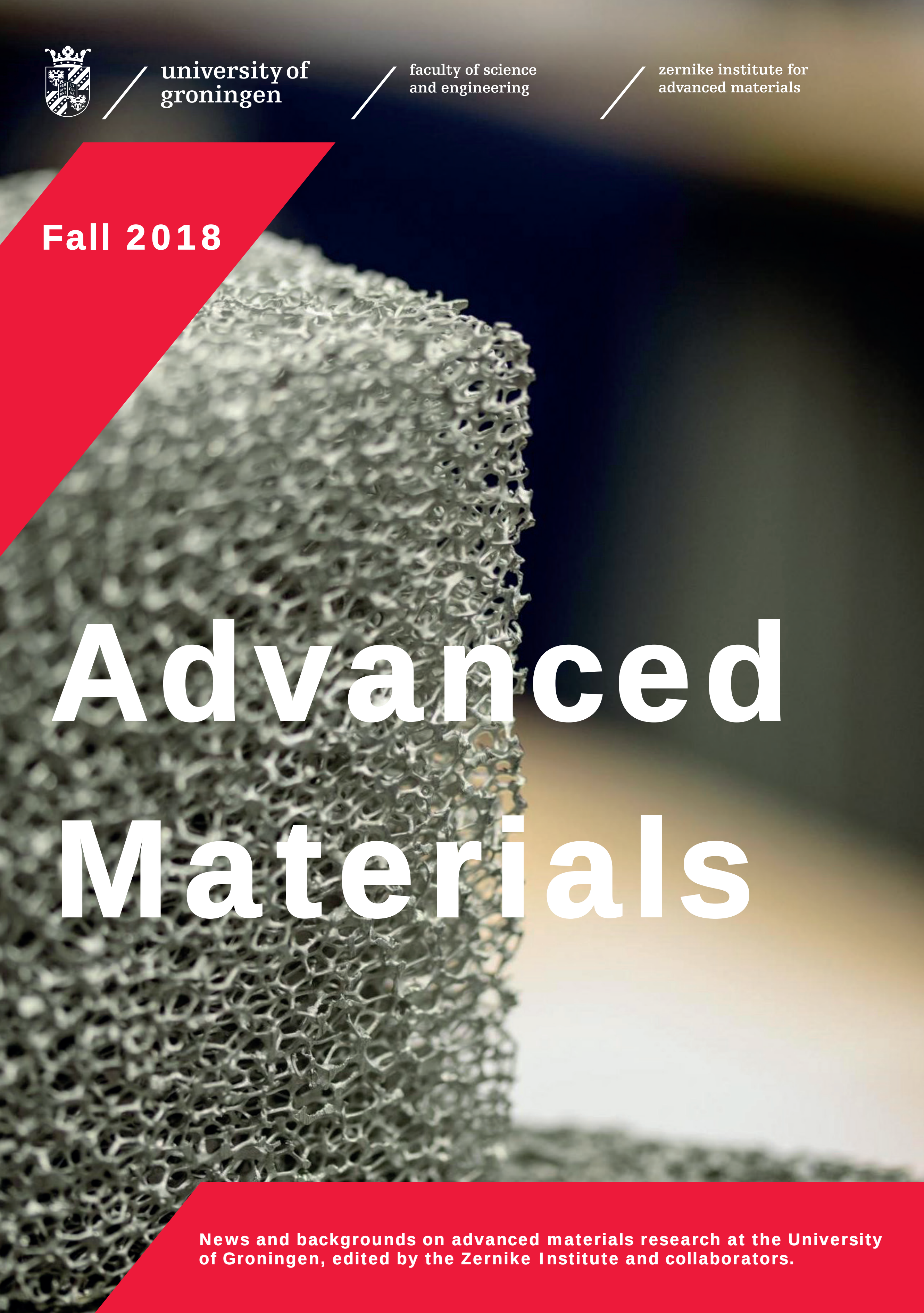


university of groningen / faculty of science and engineering / zernike institute for advanced materials

Fall 2018

Advanced Materials

News and backgrounds on advanced materials research at the University of Groningen, edited by the Zernike Institute and collaborators.

Preface

Within the Advanced Materials program at the University of Groningen we develop and study new materials, and these show new phenomena. We enjoy a revolution day after day, that will not stop any time soon. The undiscovered territory that you enter when you can combine elements, crystals and molecules at the nanoscale is vast. Our team of physicists, chemists, and bioscientists shares a passion for nanoscience. We are obsessed with fundamental understanding, intertwining theory and experiment, and designing novel concepts, models, and devices. This results in revolutionary new materials and nano systems.

In this newsletter you find a glimpse of the latest scientific developments and other news from the institutes that investigate Advanced Materials at the University of Groningen for a large part also represented as a faculty theme. In this first issue, the majority of news items focus on the Zernike Institute, but in the next issues we aim to present the entire breadth of the Advanced Materials program with all its beautiful facets. Today, we highlight the Physics Prize that was awarded to Maria Antonietta Loi; feature Meike Stöhr who was recently promoted to full professor; introduce our new research center CogniGron; briefly reflect on the very positive evaluation of the research quality in the Stratingh Institute, Zernike Institute and GBB and tell you the story of our former graduate student Vincent Voet.

Caspar van der Wal

Scientific director Zernike Institute for Advanced Materials

Appointed professor

New Professor of Materials Chemistry at the Zernike Institute of Advanced Materials

Chemist Moniek Tromp has been appointed Professor of Materials Chemistry at the University of Groningen. "My research into the characterization of materials lies on the boundary of physics and chemistry and fits well within the Zernike Institute of Advanced Materials, where I will work." Tromp will commence her activities in Groningen on July 1.

Moniek Tromp (Apeldoorn, September 7, 1977) used to work as Professor at the Technical University of Munich in Germany. Four years ago, she and her family moved to Amsterdam, where she became Associate Professor at the Van 't Hoff Institute for Molecular Sciences at the University of Amsterdam. "I worked on the boundary of physics and chemistry, developing techniques for the characterization of materials and catalysis. In Groningen, there are many more researchers who are active in related fields, and with whom I can collaborate. That is why I appreciate the opportunity to work in Groningen." Tromp won the Athena Prize 2017 of the NWO. This prize awards excellent female chemists who are a role model for researchers. She received the prize for her original and creative work in her field of research, and for her persistent and courageous efforts for gender equality.Tromp's research aims at the understanding and characterization of materials. "We developed our own spectrometer for this purpose, specially geared toward experiments with X-rays. This allows us to do the research in Groningen instead of going abroad. We also develop devices to take measurements in varying conditions, for instance at high pressure and temperature."
Tromp's work addresses relevant issues. "For example, I have current projects with BMW, VARTA, and Volkswagen, but also with smaller Dutch companies such as E-Stone. In our collaboration we search for new materials to develop better batteries for electric cars, so that those cars can drive farther and charge faster without exploding."
Tromp also works with the Rijksmuseum in Amsterdam. "Together, we look for ways to clean pieces of art without damaging them, and we try to understand why paintings fade and paint corrodes."
For the coming years, Tromp has plenty of scientific ambition. "I want to be able to perform more specialized researched techniques in our own laboratory. We also continue to pursue the question what precisely is the active site of specific catalysts. We see that they do something, but we don't always know how they do it."
But the ultimate challenge lies in the field of energy. "I think that we have reached a theoretical limit for the storage of lithium batteries. At some point, there simply is no more room for improvement. In the years to come, we must look for other ways to store energy. A new kind of battery, or an entirely different approach to the usage and storage of energy. What that will look like, I don't know yet; there are many possibilities which are currently being investigated, and we hope to find out more in the near future."

NEWS New Research center

Outsmarting silicone – Materials that can learn

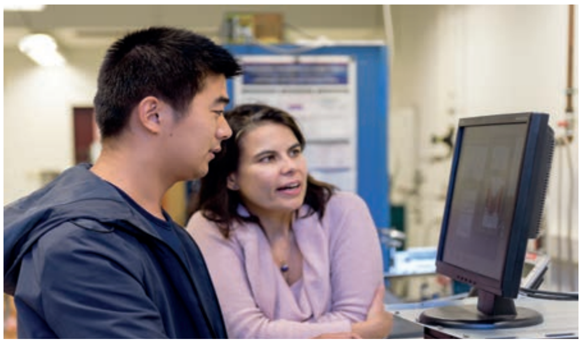
On February 1, the University of Groningen has founded a research initiative: the Groningen Cognitive Systems and Materials Center - CogniGron. "Our purpose is to create materials that form nanoscale networks that are as adaptable and efficient as neurons in our brains," explains Beatriz Noheda, the director of the center. "These systems may form the basis for a new kind of computer, which uses less energy and is good at pattern recognition." This entirely new approach requires a close collaboration between researchers from material science, mathematics, computer science and artificial intelligence.

"Computers are currently better at arithmetic operations than our brains, but they are less equipped for the recognition of patterns and the assessment of complex situations," says Noheda. Our brain can evaluate a situation very quickly and take the corresponding decision, or it can recognize voices and images effortless. In contrast, Google needs expensive and energy-devouring supercomputers to convert speech into text or to recognize images. Our brains can do these tasks much faster, better, and more energy-efficient. "More importantly, efficient pattern recognition is key to efficiently classify, filter and analyze heterogeneous and complex data sets that modern society generates and remain underutilized" Within the field of artificial intelligence, scientists have been busy for years building so-called neural networks, inspired by the brain. Lately, there are efforts all over the world to implement neural networks in hardware (neuromorphic chips) using adaptable electronics that emulate the plasticity of the brain. "The main problem is that current solutions cannot be made as dense as required, so in order to tackle complex enough problems, one will end up with a very large artificial brain that would require too much power. We believe that we can produce materials that could form such a neural network at the nanoscale."

> "We believe that we can produce materials that could form a neural network at the nanoscale."

Efficient brains

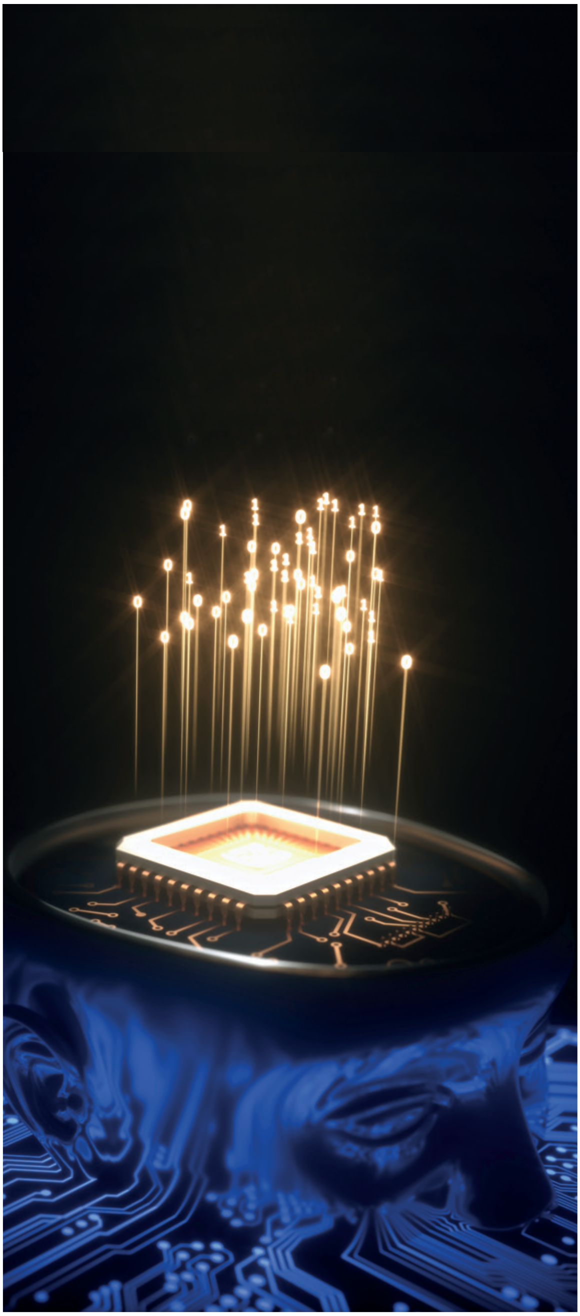
Brains are complex structures of neurons that are connected in complex networks and communicate with each other through those networks. "Brains



have a number of special l properties that are difficult to imitate. First, they can send multiple signals in parallel. That is difficult to accomplish in our current computers where there is no parallel signal processing and signals are sent through transistors in a sequential fashion. Moreover, neurons can send, process and store signals. In computers, however, there is a separate ocation for the memory, which requires a constant exchange of signals between the processor and the memory. A third characteristic of the brain is that it uses signals in short pulses so a large part of time the brain uses no energy." Remarkably, the brain does all of this on an extremely small scale: the human skulls houses approximately 100 trillion (100 million million) neurons that interact in this manner.

Adaptable networks

In their attempt to mimic such networks, scientists run into a number of problems. "The transistor chips we currently use are too rigid: they are designed to send a signal from A to B and then to C, while neurons in the brain sometimes send a signal from A to B, but at other times from A to C, depending on the stimulus and the history. We must, therefore, look for materials that form networks of devices with tunable conductivity, so that signals can be re-routed in multiple directions in an efficient way."



Small scale

Another problem is the scale of the networks. "We have been trying for years to reduce the size of computers, but it turns out that there is a limit. Making them even smaller leads to overheating and increased vulnerability. If you are going to work at the nanoscale, at the molecular level, then the system must learn to deal with failure: a molecular defect is now not much of a problem. However, when the size of device is reduced even further, this can lead to total failure of the circuit. Therefore, the system must be able, like the brain, to solve those problems by itself, that is, to have a work-around by re-routing the signals."

Looking for the right materials and build the system around them

There already exist synthetic materials whose conductivity can be controlled and which can be used to store information: so-called memristors. But Noheda sees other possibilities. "In Groningen we will focus on networks because we believe that is the next biggest challenge and because we have quite a unique set of expertise already in-house. At the Zernike Institute for Advanced Materials, various scientists work with materials that form nanoscale networks. Additionally, we have experience with adjusting conductivity. We are searching for materials that unite these properties naturally." In this endeavor, Groningen materials scientists work closely with scientists of other disciplines. Once the material is found, we need to train it and to integrate it in a computer architecture, making this a truly cross-disciplinary effort at all levels. "Here we have several research groups that study networks in other contexts. In artificial intelligence and computer science, they are building artificial neural networks; in mathematics, they know how to perform statistics on dynamical networks. The mathematicians also study order and chaos, which is very relevant because the brain learns most efficiently at the so-called "edge of chaos". We can combine all this knowledge to work on neural networks based on real materials that we can build in our lab."

Ambitions

CogniGron has formulated goals for the next seven years. "We can appoint twelve professors as linking pins between these various disciplines. We also hope to share about twenty PhD positions and we are in close contact with our colleagues at IBM and with other well renowned and respected institutions in the field of cognitive computing, some of which we have the honor to host in our Scientific Advisory board. Together we want to proof in the next seven years, that there are, indeed, new materials solutions that can emulate some of the useful functionality of our brains. Hopefully, the next step is to build actual complex systems as the basis of a new kind of computer." Noheda does not expect that an entirely new computer can be built in those seven years. "But I do think that we are in a position to contribute significantly to the next generation of neuromorphic chips."

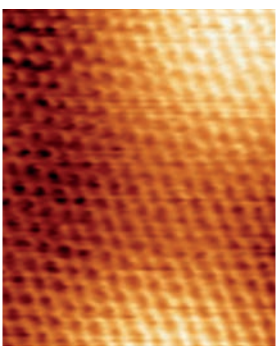
Interview

New Professor of Surface Science: Modifying the electronic properties of surfaces by molecular patterning

On February 1, former Associate Professor Meike Stöhr has been appointed as Full Professor of Surface Science. Together with her research team, she studies conducting surfaces covered with molecules. She changes these surfaces by adding molecules, and investigates how this affects the electronic surface properties of the materials. In this interview, she tells more about her work and her new position.

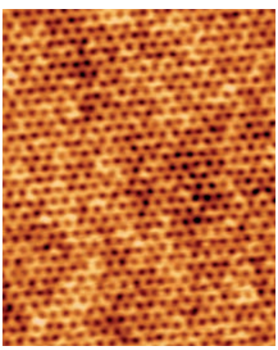
You are Professor in surface science. What exactly do you study?

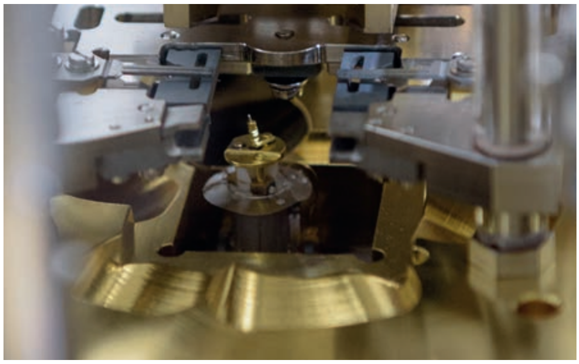
"Our studies mainly focus on two topics. On the one side, we use metal surfaces and investigate their interaction with organic molecules. The experiments are carried out under ultrahigh vacuum to reduce contaminations to the minimum. We would like to understand better how molecules interact with each other as well as with the substrate in order to learn the design rules for building certain functional structures. The molecules we employ have functional groups, which help them recognizing each other. This process, in which the molecules arrange in a certain pattern without human intervention, is called molecular self-assembly: the molecules spontaneously bond to each other, as if they are Lego bricks that connect on their own. This results in supramolecular nanostructures with a regular pattern, for example a honeycomb structure. The pores of such a honeycomb structure can then be used to trap the "surface" electrons; this results in the formation of quantum dots. Their interaction gives the material a new electronic structure. In this way we can influence the properties of these materials, such as their electric conductivity."



Graphene_Cu111_10x10

Graphene_CuOx_7x7





"On the other hand, we do research on graphene. This material consists of an upper and a lower surface with no bulk between. It can also be considered as an indefinitely large and flat molecule with a thickness of only one atom. Graphene is a much-studied material because of its numerous outstanding properties. For graphene we also investigate how we can alter its properties by making use of molecular self-assembly."

In which way does your research cater the needs of society or drive technology?

"If we understand how we can modify the properties of materials, we can then controllably adjust them and apply them in various devices. Graphene is an especially interesting material. It only consists of carbon atoms which makes it light. It is one of the best electrical conductors and easy to manufacture. However, graphene also has disadvantages, one being the absence of an electronic band gap. Materials with a band gap are called semiconductors and can for instance be used as transistor material. With graphene, this is still a difficulty. We try to modify graphene in such a way that it exhibits a band gap, so that it can serve as a semiconductor."

What did you do before you became a professor here?

"Already since 2010, I have been working as Assistant and then as Associate Professor in the research group Surfaces and Thin Films. So I am not new here. I am from Germany and finished my studies in physics and mathematics at the University of Stuttgart. After obtaining my PhD at University of Essen, I became post-doctoral researcher in 2002, then Privatdozent (the German equivalent of Assistant Professor) at the University of Basel. When I arrived in Groningen, I entered the tenure track system as Assistant Professor, which eventually led to my appointment as Professor."

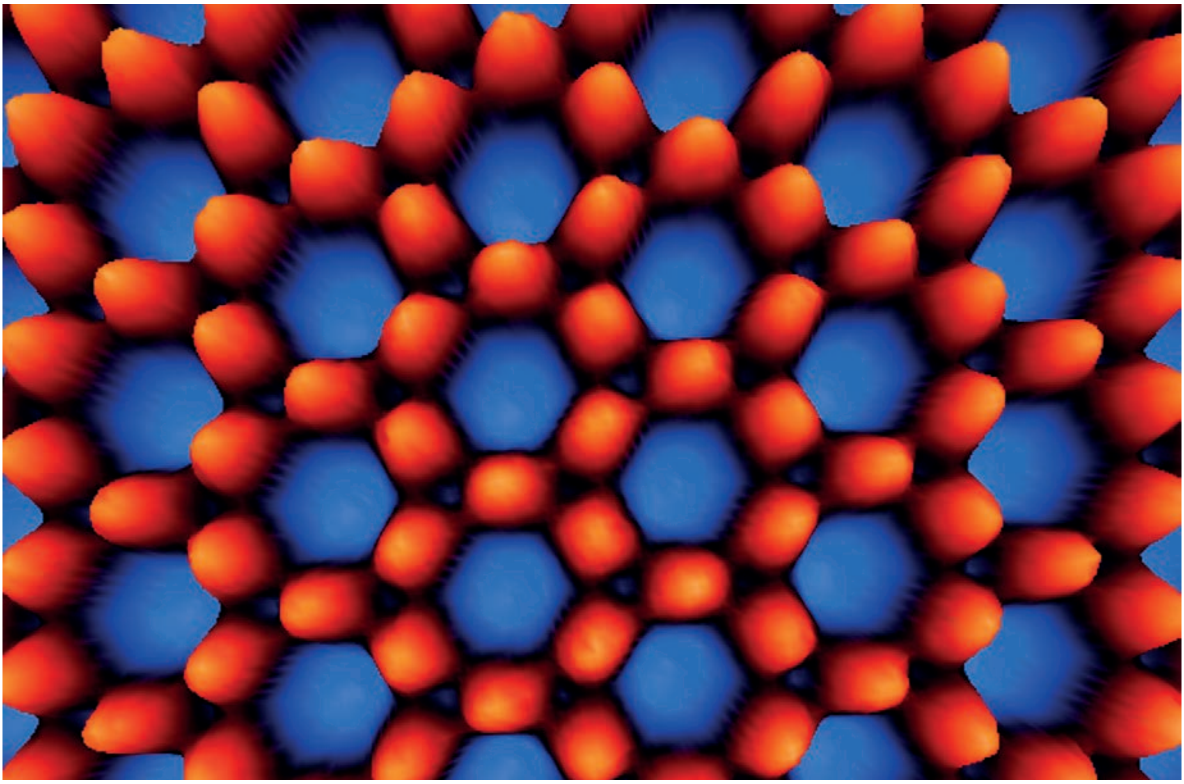
Can you tell more about the research group of Surface Science?

"At this time, our group consists of four PhD students, a technician and me. Since I just received a Vici grant from NWO, we can hire two more PhD students and two post-doctoral researchers and purchase additional equipment. In other words, at the moment we are small but we are going to grow again. The group size constantly varies depending on how well I am doing in acquiring third party funding."

"If we understand how we can modify the properties of materials, we can then controllably adjust them and apply them in various devices."

What are your plans for research in the years to come?

"I would love to discover how to introduce a band gap into graphene. I would also like to better understand which molecules we need to employ to controllably modify the material properties. Of course, we have some basic understanding, but sometimes you accidentally run into discoveries that have not been anticipated. I wish we were able to predict things better in advance." "Also, I plan to work with other 2D nanomaterials besides graphene, such as transition metal dichalcogenides (TMDCs). While they are a little bit thicker than graphene, they already have a band gap. These materials are on the rise, and it will be very interesting to find out more about them."



View of the scanning tunneling microscope through the viewport of the ultrahigh vacuum system.

Scanning tunneling microscopy image (18nm x 18nm) of a porous organometallic coordination network made from the perylene derivative 4,9-diaminoperylene-quinone-3,10-diimine and Cu atoms on a Cu(111) surface.

NEWS on Advanced Materials in Groningen

Shedding light on the mystery of the superconducting dome

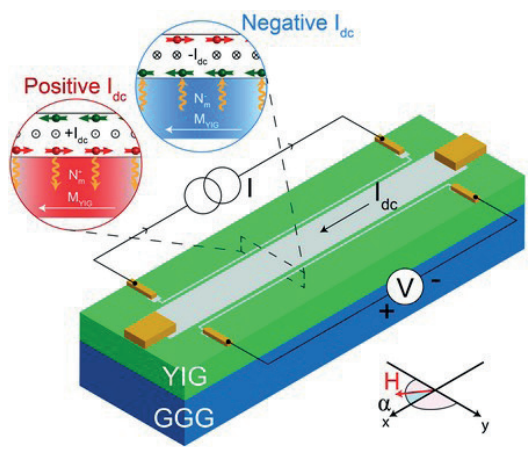
University of Groningen physicists, led by Justin Ye, and colleagues from Nijmegen and Hong Kong, have induced superconductivity in a monolayer of tungsten disulfide. By using an increasing electric field, they were able to show how the material turns from an insulator into a superconductor and then back into a 're-entrant' insulator again. Their results show the typical 'dome-shaped' superconducting phase, and finally provide an explanation for this phenomenon. The results were published in Proceedings of the National Academy of Sciences on 19 March.

Slow 'hot electrons' could improve solar cell efficiency

Photons with energy higher than the 'band gap' of the semiconductor absorbing them give rise to what are known as hot electrons. The extra energy with respect to the band gap is lost very fast, as it is converted into heat so it does not contribute to the voltage. University of Groningen Professor of Photophysics and Optoelectronics Maria Antonietta Loi has now found a material in which these hot electrons retain their high energy levels for much longer. This might make it possible to use more of their energy to obtain a higher voltage. Her results were published on 16 January in Nature Communications.

Practical spin wave transistor one step closer

Ludo Cornelissen, PhD student in The Physics of Nano Devices group of professor Bart van Wees, has managed to alter the flow of spin waves through a magnet, using only an electrical current. This is a huge step towards the spin transistor that is needed to construct spintronic devices. These promise to be much more energy efficient than conventional electronics. The results were published on 2 March in Physical Review Letters.

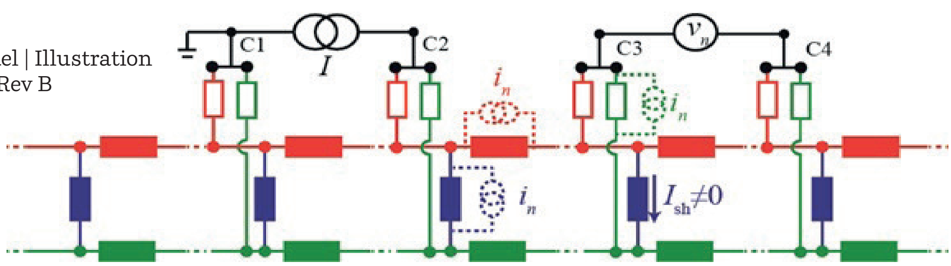


Schematic illustration of the magnon transistor
Illustration L. Cornelissen

New model brings spintronic transistor a step closer

PhD student Siddhartha Omar, working in Bart van Wees's lab, has analyzed the noise in spin transport in graphene. He used a theoretical model based on a circuit that he fed with experimental data. He concludes that impurities in graphene are the main hindrance to spin transport. His findings, which were published in the journal Physical Reviews B, pave the way to improving spin transport. This is necessary for building a transistor based on the principle.

The resistor model | Illustration Omar et al. Phys Rev B



NEWS on Advanced Materials in Groningen

Advanced Materials institutes praised for their quality

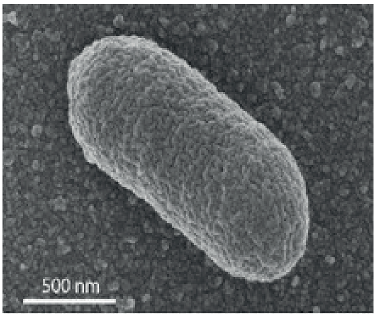
The Zernike Institute, Stratingh Institute & Groningen Biomolecular Sciences and Biotechnology Institute (GBB) have been evaluated by a panel of independent, international experts. The experts highlighted the research quality and the excellence of the researchers in the team. The scientific quality of all three institutes has been judged as 'world-leading'.

Every six years, all research Institutes in Groningen are evaluated by a panel of independent international experts, according to the Standard Evaluation Protocol (SEP) of NWO (Dutch national science foundation). In the summer of 2017, several of the institutes of the Faculty of Science and Engineering were visited by panels of international experts and evaluated according to three criteria: scientific quality, societal relevance and future viability. The evaluation committees graded these criteria on a four-point scale: excellent/world-leading, very good, good, and unsatisfactory. The three institutes that work for 20 years together under the umbrella of the National Research Center on Advanced Materials (Zernike Institute NRC) were all assessed as excellent/world-leading on research quality. For the Zernike Institute the panel was in particular impressed by the quality of junior staff, who already strongly contribute to the excellence of the Zernike research activities. The Stratingh Institute was considered world-leading institute at all levels, which consists of very strong researchers who are internationally leading experts in their fields and are recognized with many prestigious grants and awards. GBB was praised specifically for the work on lower eukaryotes, where GBB is one of the leading research institutes in the world.

"We are very pleased with the positive evaluation of Advanced Materials research in Groningen and the good advice provided by the committee." says Prof. Caspar van der Wal, Scientific Director of the Zernike Institute. "Preparing the evaluation with all staff was already an intensive and worthwhile process. With the positive and constructive feedback this adds up to a good basis for defining our future. We see a lot of opportunities for refining our actions with the reflections of the independent panel."

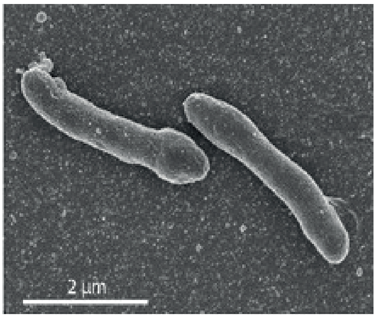
'New life form' answers question about evolution of cells

Bacteria and Archaea are two of the three domains of life. Both must have evolved from the putative Last Universal Common Ancestor (LUCA). One hypothesis is that this happened because the cell membrane in LUCA was an unstable mixture of lipids. Now, scientists from the University of Groningen and Wageningen University have created such a life form with a mixed membrane and discovered it is in fact stable, refuting this hypothesis. The results were published in the journal Proceedings of the National Academy of Sciences in the week of 19 March.
There are many ideas on how cellular life could have evolved billions of years ago. Protocells may have formed in clay minerals, or as simple lipid vesicles. In the latter scenario, something called the 'lipid divide' would have occurred, creating the separate domains of Bacteria and Archaea, explains University of Groningen Professor of Molecular Microbiology Arnold Driessen. 'The lipid membranes of both domains are different, composed of phospholipids that are each other's mirror image.'



The left panel shows: EM image of a normal E. coli cell. Right panel: an engineered cell with a mixed membrane, which shows an elongated form.

Photo's University of Wageningen / Van der Oost laboratory



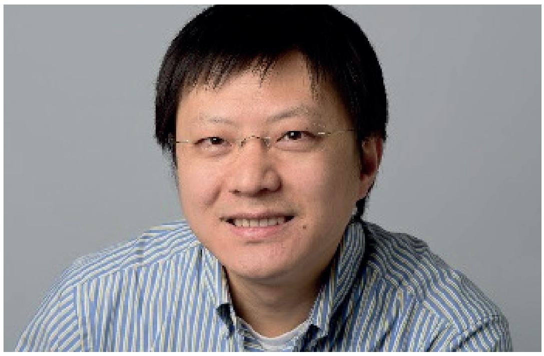
NEWS on Advanced Materials in Groningen

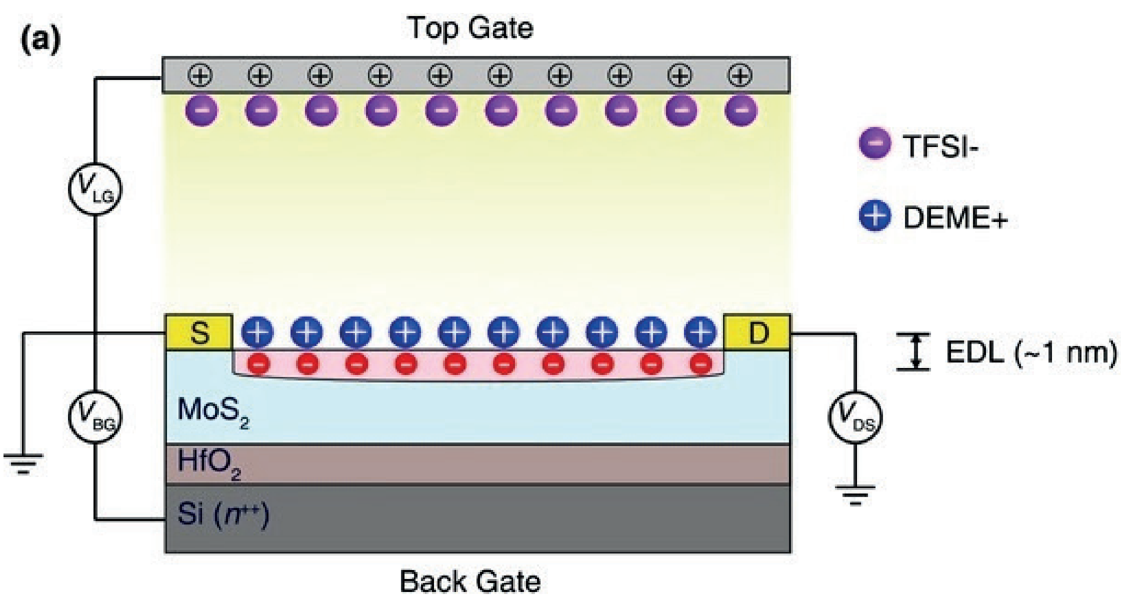
Professor Maria Antonietta Loi wins Physica Prize 2018

The Netherlands Physical Society (NNV) announced that Professor of Photophysics and Optoelectronics Maria Antonietta Loi received the Physics Prize 2018 on 13 April. The prize is for excellent physics research by a physicist working in the Netherlands. In winning the prize Loi joins the ranks of Nobel laureates Klaus von Klitzing, Gerard 't Hooft, Martinus Veltman, and famous physicists such as Robbert Dijkgraaf and astronomer Ewine van Dishoeck.

First superconducting transistor at practical voltage and temperature

A team of physicists from the University of Groningen led by Associate Professor Justin Ye has constructed a superconducting transistor that operates at a few Kelvin. The back gate which switches the molybdenum disulphide transistor from the metallic to the superconducting phase operates at a continuous low voltage. This type of transistor could be used in quantum logic circuits. The results were published on 28 May in the journal Advanced Materials.





Student of Nano Science wins Audience Award at FameLab NL

Can you explain a difficult scientific concept to a general audience in three minutes? Marcel Eleveld, student of Nano Science at the University of Groningen, can do it. He proved this at FameLab NL in Utrecht, where on May 9 he was awarded the Audience Award with his talk on Eigen's Paradox.
FameLab is the world's largest competition in scientific communication, with 31 participating countries. It is like "Idols" for scientists. The big question is: Who can best explain a difficult concept in three minutes and keep the audience captive? The listeners voted for Marcel, who explained Eigen's Paradox—you need information to make a system for copying information, but how can gather enough information to do that without such a system?—and how it relates to the origin of life. His award? On January 2019 he may deliver a TEDTalk at TEDx in Alkmaar.
According to the jury, the first prize was for Jaïr Santanna from the University of Twente. He will represent the Netherlands at the international FameLab in England.

Jaïr Santanna (left, Jury Winner, Uni. Twente) en Marcel Eleveld (Audience Award, RUG). Photo Joost Weddepohl

Alumnus

The importance of a network

Vincent Voet

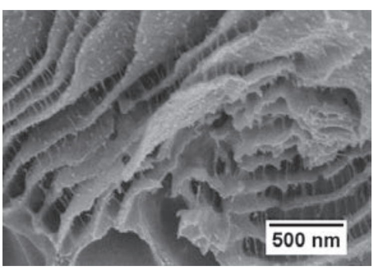
PhD date: January 2015
Subject: Block copolymers based on poly(vinylidene fluoride)
Promotor: Katja Loos and Gerrit Ten Brinke
Employer: NHL Stenden University of Applied Sciences
Education: Chemistry at RUG / University of California, Berkely, CA (semester)

How did you become a PhD student with Katja Loos?

"Already as a student I was fascinated by block copolymers, and I knew Katja from the classroom. I was aware of her research in this field together with Gerrit Ten Brinke (currently emeritus Professor of Chemistry). I simply applied for the job, asking if there was an opening for me. I wanted to stay in Groningen, because it is a nice city to live and work."

What made the work in the Loos group enjoyable?

"The atmosphere in the group was very good. Of course, high quality research is important, but so is a good working environment. I also appreciated getting much freedom to develop my research and to make my own choices. I was able to pursue my dreams in the lab. That made going to work a daily joy."

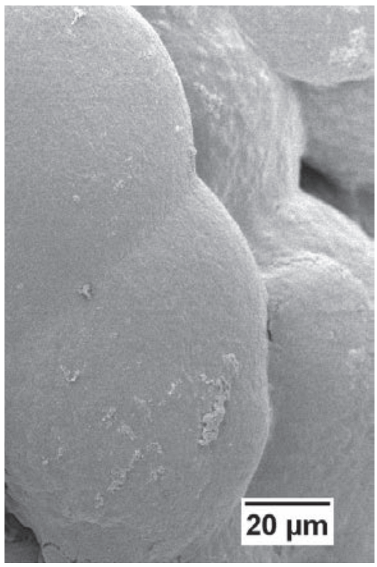


What is the most important thing you learned?

"I learned that having the right relationships is even more important than having the right knowledge. At the beginning of my PhD project, I was not very aware of this. But over the years I learned that networks are important. Because of a network you can collaborate, you can approach potential new partners, and you can also find new jobs."

How did you end up with your new employer, and what work do you do?

"Through my network. I sent an open application to the Professor Sustainable Polymers at the Stenden University, whom I know because he and Katja work closely together. There I work in the Professorship Sustainable Plastics. I have several tasks: I mentor and coordinate student research projects, communicate with companies, request subsidies, give lectures, and write publications. I think it is great that the research is applied and takes place in close collaboration with the industry."
"The Lectorate also collaborates with the University of Groningen. Currently, I even spend one day a week as guest researcher in the laboratory of Katja Loos to study the development of more sustainable materials for 3D printing."



The best memories

"The times with colleagues were good. For instance, I recall the many drinks in the hallway, but also volleyball tournaments, and frying oliebollen in the fume hood. Sometimes we did things we were not supposed to do, but this is not the time to elaborate on that."

Interview

Vision on Science:

More collaboration between science, technology, and industry

"Scientists, technologists, and industries should collaborate more." That is the conviction of Tamalika Banerjee, Associate Professor of Spintronics at the Zernike Institute for Advanced Materials in Groningen. She calls for more communication and guidance from scientific advisors and policy makers. "If we all do what we are good at and work closely together, we can create an ecosystem that uses technology efficiently for societal needs."

One of the reasons why Banerjee, born and raised in India, loves working as a physicist in Groningen, is the connection between fundamental science and applications. 'I find it important to translate our scientific knowledge into practice, much has been done but there is still a long way to go'.

Physics is everywhere

"Knowledge of physics is applied everywhere. If scientific knowledge was not applied in society then we would not have airplanes, for instance. Likewise, you see many applications of physics in the technology of health science. One example is the MRI scanner, but also the materials for protheses could be developed because of physics." This is also true for the subject of Banerjee's group: spintronics. "It has many applications in the semiconductor industry, for instance in the hard disks of your laptops and other such low power storage devices ."

Speak each other's language

But Banerjee thinks that more can be accomplished. "If science and industry learn to speak each other's language and listen better to one another, we can do much more." This can be stimulated by building more technology incubators and science parks around the Universities. This will encourage innovation and play a greater role in the collaboration between science and technology.

> "Scientists, technologists, and industries should collaborate more."

Tamalika Banerjee grew up in India. There she obtained her PhD in Physics in 2000 at the University of Madras. Then she had a post-doc position at MIT (Massachusetts, USA) working on spintronics. She joined University of Twente (Mesa+ Institute for Nanotechnology) and learnt new and unique probing techniques that enable nanoscience. Through a Rosalind Franklin Scholarship, she started in 2009 at the Zernike Institute for Advanced Materials and the RUG, where she developed her own research group, with a focus on new approaches in spintronics. Since 2013, she is Assoicate Professor in Spintronics of Functional Materials.

Do what you are good at

How, then, would you solve that problem? "One difficulty, I think, is that scientists do not always know how to implement their work in practice. They lack the necessary experience, training and time. We are always told that scientific publications are a good indicator of our success. We are good at it and we must do what we are good at: develop ideas and make prototypes. The translation from ideas to commercializing products are best done by industries. Both academics and industries have a different way of solving a problem and this is what we could bridge by building more technology incubators and strengthening our links with existing ones. We must take time to sit down and talk with the industry, for implementing clear strategies that exploits innovation and turns ideas into a profitable product." Here she sees a greater role in education. "In recent years, our students are being trained in different transferable skills in various courses offered by our Graduate School. They are better in communicating their research in different platforms including with the industry and to develop entrepreneurial skills. Perhaps this will help lower the threshold for future collaboration."

Appointed professor

New Professor of Solid-state NMR at the Zernike Institute for Advanced Materials (ZIAM)

Professor Patrick van der Wel used to utilize NMR spectroscopy especially to find answers to difficult biological questions. On August 1 he will enter a professorate at the Zernike Institute for Advanced Materials (ZIAM). He is full of ambition: "I would like to integrate solid-state NMR further into biophysics and material science, through collaboration with specialists in other fields."

In the development of new materials, the properties of the building blocks are very important. Unfortunately, it is not easy to see these building blocks—molecules. Most of the available techniques require that the molecules are either dissolved in water or crystallized. But this alters their behavior compared to their "natural" environment. "With solid-state NMR spectroscopy, we can view molecules without first dissolving or crystalizing them," Van der Wel explains. "This allows us to study their structure or dynamics under almost any circumstances."

Nanostructures that shape gold particles into superstructures

Huntington

In recent years, Van der Wel worked at the medical department of the University of Pittsburgh in the United States. "I focused on neurodegenerative diseases, which are characterized by the-clustering of proteins in the brain. Those proteins form a kind of nanomaterial, which in the long run has devastating consequences for the brain cells. I especially studies the formation of these structures in Huntington's disease. This incurable disease, which is of great interest for researchers in Groningen and elsewhere in the Netherlands, will remain an active area of research for Van der Wel.

NMR in material science

This type of NMR spectroscopy has many applications in material science, according to Van der Wel. "For example, in the production of sensors and solar panels, it is important to know the exact properties of the materials. NMR measurements allow you to link atomic structure to function. This allows for more deliberate design instead of trial and error."

Collaboration

Van der Wel thinks of his appointment in Groningen as Professor of Solid-state NMR as an opportunity to learn and study new things. "It is an interesting challenge to apply solid-state NMR to new developments in biophysics and material science. There is much I could learn from that" He is already working hard at making new contacts. "I love to work with colleagues, not only within Zernike Institute, but also, for instance, with institutes that specialize in biological materials."

Expert in solid-state NMR spectroscopy joins Zernike Institute

Making gold with grease

The formation of supramolecular structures is also important outside of the human body. "They are used in the development of so-called 'smart' materials. Solid-state NMR spectroscopy can be helpful in the study of such materials." Van der Wel has some experience with this line of study. "For instance, in 2016 our group published an interesting article about biologically inspired nanostructures that shape gold particles into superstructures."

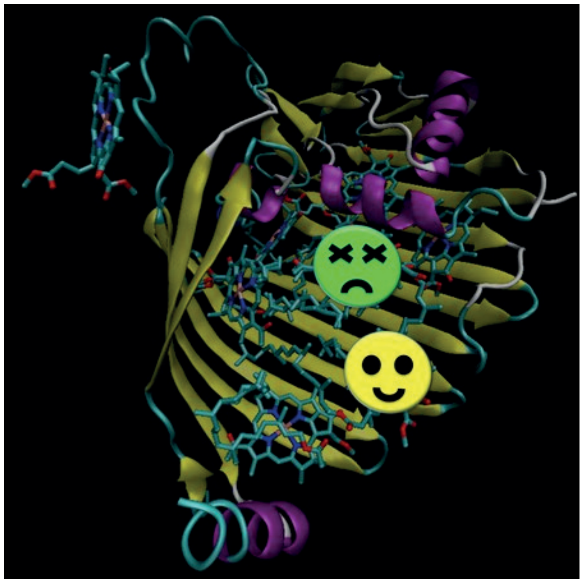
Quantum effects observed in photosynthesis

Molecules that are involved in photosynthesis exhibit the same quantum effects as non-living matter, concludes an international team of scientists including University of Groningen theoretical physicist Thomas la Cour Jansen. Quantum mechanical behavior was found at a temperature of 77 Kelvin, much too low to play a biological role. The interpretation of these quantum effects in photosynthetic systems may help in the development of nature-inspired light-harvesting devices and the present research may help identify quantum effect is other systems. The results were published in Nature Chemistry on 21 May.

For several years now, there has been a debate about quantum effects in biological systems. The basic idea is that electrons can be in two states at once, until they are observed. This may be compared to the thought experiment known as 'Schrödinger's Cat'. The cat is locked in a box with a vial of a toxic substance. If the cap of the vial is locked with a quantum system, it may simultaneously be open or closed, so the cat is in a mixture of the states "dead" and "alive", until we open the box and observe the system. This is precisely the apparent behavior of electrons.

Vibrations

In earlier research, scientists had already found signals suggesting that light-harvesting molecules in bacteria may be excited into two states simultaneously. In itself this proved the involvement of quantum mechanical effects, however in those experiments, that excited state supposedly lasted more than 1 picosecond (0.000 000 000 001 second). This is much longer than one would expect on the basis of quantum mechanical theory.
Jansen and his colleagues show in their publication that this earlier observation is wrong. "We have shown that the quantum effects they reported were simply regular vibrations of the molecules." Therefore, the team continued the search. "We wondered if we might be able to observe that Schrödinger cat situation."
"In the case of such a superposition, spectroscopy



The figure shows the photosynthetic complex of light-harvesting green sulfur bacteria the green and yellow circles highlight the two molecules simultaneously excited. | Illustration Thomas la Cour Jansen/University of Groningen

should show a specific oscillating signal", explains Jansen. "And that is indeed what we saw. Furthermore, we found quantum effects that lasted precisely as long as one would expect based on theory and proved that these belong to energy superimposed on two molecules simultaneously." Jansen concludes that biological systems exhibit the same quantum effects as non-biological systems. But at the normal operating temperatures for biological systems, like bacteria, the effects are too weak to determine the efficiency in the photosynthetic systems, which others have suggested.
The observation techniques developed for this research project may be applied to different systems, both biological and non-biological. Jansen is happy with the results. "This is an interesting observation for anyone who is interested in the fascinating world of quantum mechanics. Moreover, the results may play a role in the development of new systems, such as the storage of solar energy or the development of quantum computers."

Superposition

They used different polarizations of light to perform measurements in light-harvesting green sulfur bacteria. The bacteria have a photosynthetic complex, made up of seven light sensitive molecules. A photon will excite two of those molecules, but the energy is superimposed on both. So just like the cat is dead or alive, one or the other molecule is excited by the photon.

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