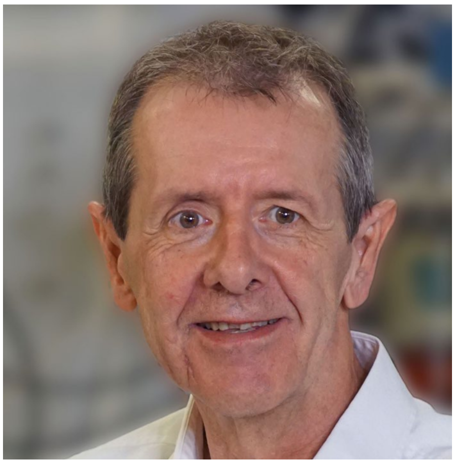
University of Basel
Swiss Nanoscience Institute

SNI Swiss Nanoscience Institute
Eine Initiative der Universität Basel und des Kantons Aargau

SNI update May 2017



Dear colleagues,

After a long absence, I am delighted to once again be actively focused on my research and the SNI. Your support over the last few months has been a great help in getting back on my feet, and I thank you from the bottom of my heart. I would especially like to thank all those who have filled in for me so well during my absence and have stepped in both in the laboratory and on the administrative side. At the SNI, our general manager Claudia Wirth in particular took on many additional tasks and executed them perfectly. Andreas Baumgartner, the new coordinator of the PhD School, also assumed numerous additional roles and proved an excellent representative at academic events.

My absence has meant that I had very little involvement in our annual report, which has recently returned from the printer. I would like to thank everybody who helped to compile this wonderful report. This summary of our activities over the past year is also available to read online. A surprise awaits visitors to the SNI website – nanoscience.ch – where our new web presence recently went live. I hope the new site will prove easy to navigate and that you will find all the information you need.

In April, our vice director Daniel Loss was awarded the coveted King Faisal Prize for Science for his development concept for a quantum computer. We congratulate him and have taken the opportunity of his success to cover the special phenomena of the quantum world in a little more detail in our title story. This issue of SNI update also contains a portrait of Sonja Neuhaus, a young materials scientist in the FHNW School of Engineering who has already conducted several successful Argovia projects. We also briefly report on various events from recent months and have summarized press releases published since the start of the year announcing the results of research by some SNI members.

I wish you a wonderful and productive spring and happy reading!

Kind regards,

Christian Schönenberger

SNI Director, University of Basel

Different rules – new applications

Quantum mechanics opens the door to new technologies

In April, SNI deputy director Professor Daniel Loss was awarded the 2017 King Faisal International Prize for Science in recognition of his groundbreaking theoretical work on spin physics, a field with potential applications that include the development of a quantum computer. Back in 1998, Daniel Loss and his colleague Professor David DiVincenzo proposed using the intrinsic angular momentum – or spin – of electrons as the smallest memory unit in the computer of the future, inspiring researchers worldwide to turn their attention to this field. The work being done by Loss and his colleagues makes use of the laws of the quantum universe. These laws, which are quite distinct from those governing our everyday lives, hold the key to game-changing applications – not just in computing, but also in fields such as communications technology and sensors. Several teams in the SNI network are focussing their research on these areas of quantum technology.

In April, Daniel Loss was awarded the 2017 King Faisal International Prize for Science in recognition of his groundbreaking theoretical work on spin physics. (PRNewsFoto/King Faisal International Prize)

Different rules apply in the nanoworld

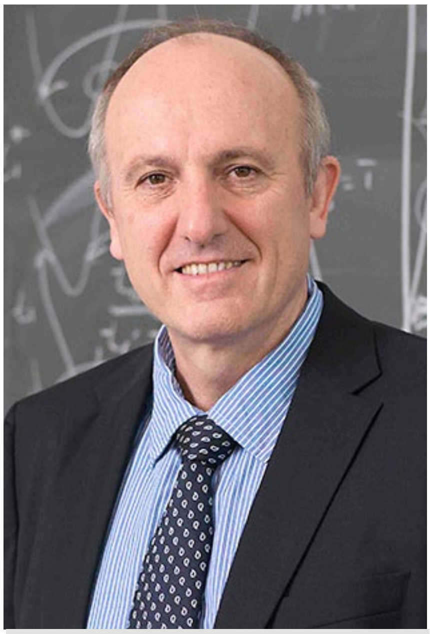
There have been a number of approaches to developing a quantum computer. All of these rely on the laws of quantum mechanics, a branch of physics dating back some 80 years which seeks to describe the properties and governing principles of matter – i.e. molecules, atoms and elementary particles. The realm of minute particles is subject to its own set of rules, which are different to those we know from everyday life. For example, entities observed at the quantum scale can behave as both particles and waves. The famous double-slit experiment demonstrated that an electron traveling towards a screen with two tiny slits in it can pass through both slits at once as a result of its wave-like nature, creating an interference pattern on the other side of the screen. In the quantum world, tiny particles can exist in a state of superposition. In the case of an electron's spin – which can be compared to the needle of a compass – this means that the spin direction is initially undetermined, pointing in different directions at once.

Particles only manifest these strange properties when they are in a system that is isolated from outside influences. As soon as researchers interfere, for example by taking a measurement, their state becomes determined – almost as if the particles wished to conceal their diversity and variability from us. But it gets even more amazing: Researchers are able to entangle two or more particles, creating a new kind of link between them. The state of entangled particles remains correlated, even if they are physically separated after entanglement. This phenomenon was known to Einstein, who described it as "spooky action at a distance".

In the macroworld we live in, we do not realize the outlandish rules of quantum mechanics – they describe phenomena that we cannot see or experience. Nevertheless, they are there, controlling the interactions of photons, electrons, atoms and molecules.

Electron spin as a memory unit

Daniel Loss and colleagues all over the world are now seeking to harness the laws of the quantum realm to research fundamental physical principles and develop new technologies. One of their most ambitious goals is the creation of a quantum computer. A model for a quantum computer proposed by Loss uses electron spins as its smallest memory unit, the qubit – analogous to a bit (0 or 1) in digital computing. Similarly to a compass needle, an electron spin can point up or down, or in other directions as well, meaning that a qubit does not just have two different states, but several, each associated with a specific probability. It is only when a measurement is taken that the spin state is determined as up or down.



The model for a quantum computer proposed by Daniel Loss uses electron spins as its smallest memory unit.

In Loss's model, electrons are trapped in semiconductor materials to create devices known as quantum dots. Quantum dots are nanoscale objects measuring between 10 and 100 nanometers. They behave in a similar way to atoms, but are around 1000 times larger. Even so, they are still small enough that 100 million of these electrons can be arranged on a single square centimeter and controlled electrically. The spin of an electron can be entangled with that of neighboring electrons. Manipulating one spin state alters the other entangled spin states. Whereas in digital computing, operations can only be completed sequentially, these phenomena would enable a quantum computer to perform them in parallel, accessing the results simultaneously. Accordingly, a quantum computer would be able to carry out calculations and simulations involving vast amounts of data that are beyond the scope of current computers.

Spin-based computing has yet to become a reality. One of the problems it faces is that interference from the surrounding environment in the solid-state device immediately determines an electron's spin state. The group led by Professor Dominik Zumbühl of the University of Basel's Department of Physics is exploring ways to delay this process, known as decoherence, for as long as possible. "My colleagues have made huge progress in this regard in recent years," reports Loss in an interview. Whereas coherence times – the length of time for which different states can be kept stable – were initially measured in billionths of a second, Zumbühl's group currently holds the world record of one minute.

A further as yet unsolved problem is scaling the computer. In order to compete with a current conventional computer, a quantum computer would need around 10^8 spin qubits. Based on current knowledge, each qubit would have to be controlled by a wire, posing a major challenge in terms of space. Accordingly, new ideas are needed before the first working quantum computer can be built. Another open question concerns the choice of material. While most research groups worldwide work with gallium arsenide (GaAs), Intel continues to use silicon.

What are quanta?

The term "quanta" is often used to describe elementary particles, i.e. particles that cannot be divided into smaller components, as well as the smallest possible transferable units of energy. Quanta can act both as particles and waves, changing their position without traveling through space, surmounting obstacles in ways that are not fully understood, or appearing in different places at once. The laws of quantum mechanics were defined in the early 20th century by physicists including Albert Einstein, Niels Bohr and Erwin Schrödinger. However, it is only in the last decade that researchers have found ways to work with individual quanta to experimentally test and apply different theories.

Despite the many unresolved issues, Loss remains convinced that his model can succeed. “Theoretically, the spin-based quantum computer ticks all the most important boxes,” he explains. “It is fast, small and integrable.” That said, he makes no predictions as to when the first prototype will become available.

Wide range of applications

Computing is not the only field in which quantum mechanics has a great deal to offer. Other applications include more secure data encryption, new developments in electronics and optics, or revolutionary sensor technology. Several working groups at the University of Basel’s Department of Physics within the SNI network are actively researching these areas in collaboration with Loss. For example, the team led by Professor Richard Warburton is dedicated to producing hardware for the transmission of quantum information, which involves emitting and receiving single photons. The team is working on a single photon source, as well as the use of individual spin qubits as optically addressable memory units. Their research relies primarily on quantum dots. Quantum dots, as described above, are self-organizing nanostructures, made from semiconductor materials, in which the mobility of charge carriers is restricted. They are also sometimes referred to as artificial atoms due to their similarities with the real thing. However, unlike natural atoms, they allow fine-tuning of their properties, making them ideal for research purposes. Here too, quantum effects play a key role, enabling new electronic and optical applications.

The research groups let by Professor Patrick Maletinsky and Argovia Professor Martino Poggio are busy developing groundbreaking sensors. Patrick Maletinsky’s team focuses primarily on nitrogen vacancy (NV) centers. NV centers contain single electrons that can be excited or manipulated, and react to magnetic or electrical fields. Their spin also changes according to the surrounding fields, a process that can be detected easily using various measurement methods. Maletinsky’s team leverages these principles to develop quantum sensors for nanoscale magnetic imaging, which it uses to investigate new materials. This innovative quantum-based measurement technique offers enhanced sensitivity, enabling imaging of previously invisible magnetic fields. In Poggio’s lab, meanwhile, the main focus is on using nanowires as sensors. These tiny filamentary crystals, with an almost defect-free crystal lattice structure, can serve as a robust source of quantum light, and are able to measure both the size and direction of forces. Nanowires offer great potential as sensors for biological and chemical samples, and can be used as pressure or load sensors.

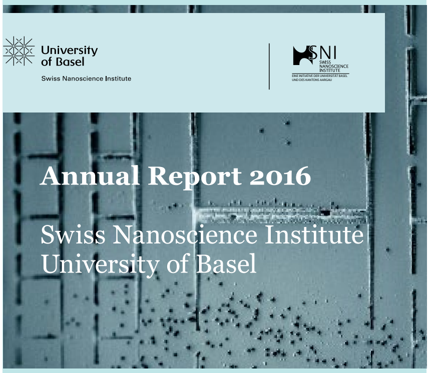
Examining minute structures such as electrons or their spin is a painstaking process, and the laws that govern them are highly complex. However, they open the door to entirely new applications, leading some experts to speak of a second quantum revolution. The first quantum revolution took place decades ago, when the laws of quantum mechanics were first described. Today, researchers at the SNI and worldwide have reached the stage of being able to apply them in technological breakthroughs.

New projects at the SNI PhD School

Proposals for new projects in the SNI PhD School can be submitted until May 31, 2017. Please send your applications to claudia.wirth@unibas.ch and do not hesitate to contact us if you have any questions.

For more information, see: nanoscience.ch/en/forschung/phd-programm/

Annual Report



The annual report 2016 has recently been completed. It summarizes the scientific findings of all projects in the PhD School and the Nano Argovia program and provides an overview of the highlights from the entire SNI network in 2016.

You can download the report at: nanoscience.ch/media
nanoscience.ch/media

Functional surfaces for fascinating effects

Sonja Neuhaus heads research group in the School of Engineering

Dr Sonja Neuhaus is fascinated by the possibilities offered by functionalized surfaces. In several Argovia projects, she has used her enthusiasm and knowledge of modified polymer surfaces to achieve different effects depending on the application. The young materials scientist is also a good example of how a flexible employer can help its staff to achieve a good balance between work and family.

Sonja Neuhaus is group leader at the School of Engineering (FHNW).

Getting to the bottom of things

Sonja Neuhaus has been interested in science since she attended the cantonal school in Aarau. When she read about the degree in materials science in an issue of "Perspektiven", she was immediately hooked. Participating in "Jugend forscht", which led her to the Federal Institute of Technology Zurich, confirmed her first impression that this interdisciplinary program was the perfect choice. During her studies in Zurich, she was particularly fascinated by material-related subjects and polymer chemistry. She spent the third year of her Bachelor's degree at the EPF Lausanne. "That was a good change of scenery for me," Sonja remembers. "And it became clear during this time that what really interested me was getting to the bottom of questions and researching them in the lab." After completing her master's, she immediately began a doctoral thesis at the Paul Scherrer Institute (PSI) investigating the functionalization of polymer surfaces.

Ideal combination at the FHNW

Before she had even completed her doctorate, Sonja Neuhaus was using online portals to tackle the next stage in her career. It was not long before she found a position at Glas Trösch that sounded exciting and was a perfect fit. "After my PhD I wanted to work in industry – to see what research produces," she comments. From 2011 to 2013, she worked as a project manager on new glass coating procedures at Glas Trösch in Bützberg. However, she didn't find this work entirely fulfilling, and sometimes missed having the independence to make her own decisions in the industrial environment. Right on cue, a contact at the PSI told her about a vacancy at the Institute of Polymer Nanotechnology. The job seemed made for Sonja Neuhaus. "I switch between industry and basic research depending on the project. This is where I feel most comfortable," says Sonja about her recent years at the FHNW. Here, she can conduct research while maintaining links with the application side and contact with the industry.

Functionalized polymer surfaces are the goal

Most projects are conducted in collaboration with Swiss SMEs, and Sonja Neuhaus has also been involved in some SNI Argovia projects in the last few years. Her research projects generally revolve around modifications to polymer surfaces without altering volume properties. To achieve this, various procedures are used to bond molecules and polymers to the surfaces, resulting in chemical functionalization. Depending on the problem to be solved, the polymers acquire new properties such as a water-repellent surface.

As the manager of the RepAll project, she and her team investigated, for example, how polymer surfaces can be structured and chemically modified to ensure less adhesion and better run-off for various liquids. In the SurfFlow Argovia project, completed in 2016, the project team examined how the surface of polymer lenses can be smoothed for optical applications without altering the form or deeper layers.

Another project focused on preventing the surfaces of cable materials from sticking together when coiled. In one fascinating project, color effects in security features were achieved via micro- and nano structuring.

Totally new requirements

The 33-year-old scientist faced a very different challenge around a year and a half ago, when she became a mother. Despite becoming the group leader for surface functionalization around the same time, Sonja was able to reduce her workload, allowing her to find a good balance between family and work. As she says herself, she has found the right place for her and, with plenty of dedication and enthusiasm, has overcome all possible obstacles to drive her research forward and continuously identify innovative approaches to surface functionalization.

Sonja Neuhaus is fascinated by the possibilities offered by functionalized surfaces.

Awards and Prizes

Daniel Loss received the King Faisal International Prize

In April, King Salman of Saudi-Arabia awarded Professor Daniel Loss the King Faisal International Prize for Science 2017. Loss received the renowned science prize for his pioneering work in spin physics and spin coherence in quantum dots. He shares the prize with Professor Laurens Molenkamp of the University of Würzburg. Congratulations!

Link to the video: www.youtube.com/watch?v=qek7Y01Skgs

Daniel Loss receives the King Faisal International Prize (Image: kfip.org)

Basel team secures victory at first nanocar race

The University of Basel team has won the first international nanocar race, which was held on a gold racetrack on April 28 in Toulouse (France). The two pilots Dr. Rémy Pawlak and Tobias Meier from the group of Professor Ernst Meyer (Department of Physics, University of Basel) were the fastest at steering a single molecule along a miniscule gold track measuring around 100 nanometers during the race.

For more information, please see: nanoscience.ch/de/2017/05/01/basler-team-holt-sieg-beim-ersten-rennen-mit-nanoautos/

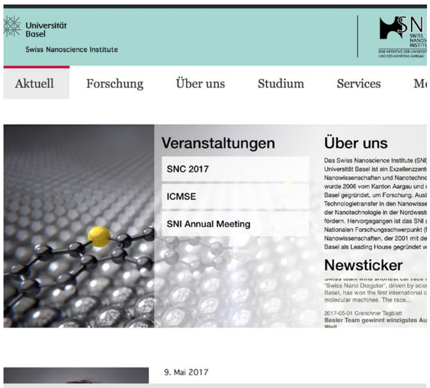
The Swiss Team wins the first international nanocar race. (Image: Nathalie Lambert / CNRS))

News from the SNI

New website

The SNI's new website went live in mid-April. Over the past few months, Colin Carter, Dr Katrein Spieler, and Dr Christel Möller have prepared this new online presence with the support of IT Services (ITS). To do so, the SNI used EasyWeb lite – a package provided by ITS that is based on WordPress and implements the University of Basel corporate identity guidelines. This has allowed us to replace our old website, which served us reliably for over ten years but had become outdated. We would like to thank everyone who has helped us to provide up-to-date information over the years.

If you have a suggestion or feel that something is missing from the new site, please send us your feedback (c.moeller@unibas.ch).



Since April, the SNI has a new online presence.

Andreas Baumgartner appointed to run PhD School

Since the SNI PhD School was founded in 2012, its various activities have been coordinated by Dr Michel Calame. On January 1, 2017, Michel Calame left the University of Basel to manage the newly established "Nanoscale Transport Phenomena" group at Empa. Dr Andreas Baumgartner, research assistant in Professor Christian Schönenberger's group in the Department of Physics, has been managing the SNI PhD School since the start of the year. He is the new contact for calls for proposals for new projects within the PhD School and will coordinate its activities.

Since January, Andreas Baumgartner runs the SNI PhD School.

Events

Open laboratory for politicians

On February 6 and May 15, the Departments of Physics and Chemistry and the SNI invited Basel's politicians to Klingelbergstrasse 82 for an insight into their research. Department heads Professor Dominik Zumbühl, Professor Marcel Mayor, and SNI Director Professor Christian Schönenberger began with brief reports on the various research facilities before the fascinated visitors embarked on three laboratory tours to learn about some aspects of research in more detail. The subsequent reception gave all involved the opportunity to ask further questions and talk with the scientists from chemistry, physics, and the SNI.

Politicians from Basel listen to the interesting presentations during the laboratory tours.

Nanoscience in the snow

At the end of January, in beautiful wintry weather, the doctoral students from the SNI PhD School met at Hotel Schwarzsee, 1,000 meters above Zermatt, for the "Nanoscience in the Snow" Winter School (NiS). After a short welcome reception, the first presentations began before everyone satisfied their hunger with a cheese fondue. Lively discussions continued late into the night by the posters displayed on all available walls and windows.

"Nanoscience in the Snow" is always a highlight for the SNI PhD students.

A heavy storm during the night prevented the three invited speakers from leaving the valley to talk to the doctoral students. Dr Michel Calame, coordinator of the SNI PhD School until the end of 2016 and the organizer of NiS, added to the program with a presentation about his own research over the last few years. The storm kept all participants indoors for the whole day, allowing Dr Oren Knopfmacher from Avails Medical to give even more detail about his journey as the founder of a start-up company. Along with contributions by the doctoral students themselves, this provided plenty of discussion topics. In the evening, the attendees bid farewell to Michel Calame as coordinator of the SNI PhD School and thanked Tomaž Einfalt for his work over the last two years as the PhD School representative. Shubham Singh was elected as the new representative for PhD students and Paolo Olivia received the prize for the best poster.

Although the storm had still not abated the next morning, Zermatt Lifts ran a few extra cable cars to gradually carry all NiS attendees down to the valley in safety. Zermatt was the last Winter School for Michel Calame and some of the doctoral students, who will be completing their dissertations this year. Dr Andreas Baumgartner, who took over as coordinator of the PhD School at the start of the year, will however continue NiS to encourage informal, interdisciplinary exchange between doctoral students.

Get on track, stay on track

In the fall semester 2017, the University of Basel will lend a hand to early career researchers with the "get on track" and "stay on track" programs. The "get on track" line of funding supports doctoral students who are also mothers and fathers with verifiable family duties. "Stay on track" is aimed at young postdocs in the early phase of motherhood, providing temporary, targeted relief to allow them to concentrate on their research despite the new challenges they face.

For more information, please contact
getontrack@unibas.ch
stayontrack@unibas.ch

International Conference on Molecular Systems Engineering (ICMSE)

NCCR Molecular Systems Engineering will be organizing the first International Conference on Molecular Systems Engineering in Basel on August 27–29, 2017.

For more information, please visit
www.nccr-mse.ch/en/events/international-conference-on-molecular-systems-engineering-icmse/

How does news reach the media?

The visit to the Basler Zeitung provided insight into the world of newspaper reporting. (Image: R. Stutzki)

Nanoscience students recently visited the Basler Zeitung newspaper as part of the Media Competence course for an insight into the world of current newspaper reporting. Editor-in-chief Markus Sonn welcomed the group of eight and clearly explained which news makes it into the paper and how.

The Media Competence course is available to Bachelor's nanoscience students and attracts considerable interest year after year. It was conceived by Dr Ralf Stutzki in 2014 and has been offered once a year ever since. In addition to lectures and exercises on the topic, the course includes a visit to the Basler Zeitung and a day at the Kanal K radio studios. During this course, the young scientists learn to present their own research to an audience of non-experts in a way that is entertaining and, above all, easy to understand.

10 steps to a job

A second careers workshop for SNI students and doctoral students was held on December 13, 2016. Dr Katrein Spieler, nano studies coordinator, organized the event together with Dr Birgit Müller of the Career Service Center at the University of Basel to assist young scientists with their further careers.

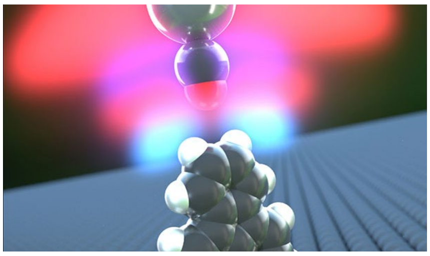
Around 30 students, doctoral students, and postdocs took the opportunity to gain tips on job searches and be inspired by the success stories of speakers Professor Jens Gobrecht (Paul Scherrer Institute), Dr Kaspar Renggli (D-BSSE), and Claudio Boller (KPMG AG).

Annual Meeting

This year's Annual Meeting takes place on September 7–8 at the Lenzerheide resort. Please put the date in your diaries!

Further information to follow.

Press releases and uni news from SNI members



University of Basel, May 15, 2017. Hydrogen bonds directly detected for the first time

For the first time, scientists have succeeded in studying the strength of hydrogen bonds in a single molecule using an atomic force microscope. Researchers from the University of Basel's Swiss Nanoscience Institute network have reported the results in the journal Science Advances.

University of Basel, May 9, 2017. Thomas Ward wins Royal Society of Chemistry award

Basel chemist Thomas Ward, Professor of Bioinorganic Chemistry at the University of Basel and Director of the NCCR Molecular Systems Engineering, is the Royal Society of Chemistry Bioinorganic Chemistry Award winner for 2017.

University of Basel, May 1, 2017. The University of Basel at the tunBasel 2017

The Swiss Nanoscience Institute and the Department of Physics participate in this year's tunBasel. They offer exciting experiments and games related to the two topics air and light. The tunBasel takes place at the Messe Basel from May 12 - 21.

Nachwuchsförderung in Technik und Naturwissenschaften.

tunBasel.ch

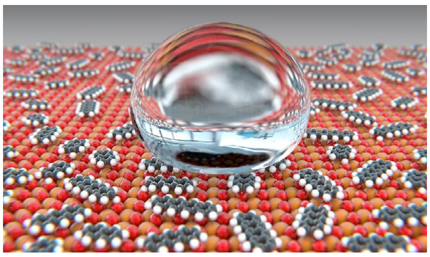
Wir tun etwas für die Zukunft.

University of Basel, May 1, 2017. Basel team secures victory at first nanocar race

The University of Basel team has won the first international nanocar race, which was held on a gold racetrack. The young scientists from the Department of Physics and the Swiss Nanoscience Institute at the University of Basel were the fastest at steering a single molecule along a miniscule gold track measuring around 100 nanometers.

University of Basel, April 7, 2017. Daniel Loss receives accolade from King Salman of Saudi Arabia

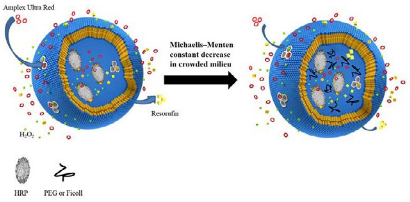
In early April, physicist Daniel Loss of the University of Basel received the 2017 King Faisal International Prize for Science in the Saudi capital of Riyadh. Loss was awarded the distinction in recognition of his pioneering work in the field of spin dynamics and spin coherence in quantum dots.



University of Basel, March 22, 2017. Rare earths become water-repellent only as they age

Surfaces that have been coated with rare earth oxides develop water-repelling properties only after contact with air. Even at room temperature, chemical reactions begin with hydrocarbons in the air. In the journal Scientific Reports, researchers from the University of Basel, the Swiss Nanoscience Institute, and the Paul Scherrer Institute report that it is these reactions that are responsible for the hydrophobic effect.

University of Basel, March 1, 2017. Researchers imitate molecular crowding in cells

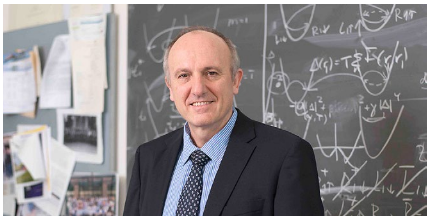


Enzymes behave differently in a test tube compared with the molecular scrum of a living cell. Chemists from the University of Basel have now been able to simulate these confined natural conditions in artificial vesicles for the first time. As reported in the academic journal Small, the results are offering better insight into the development of nanoreactors and artificial organelles.

University of Basel, January 23, 2017. University Council: One promotion and eight new Honorary Professors

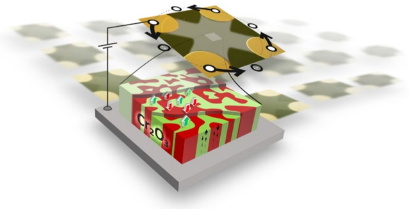
The University Council has promoted physicist Professor Patrick Maletinsky to Associate Professor, chosen eight new honorary professors, and adjusted several study regulations.

University of Basel, January 13, 2017. Basel Physicist Daniel Loss receives the King Faisal International Prize



Professor Daniel Loss from the University of Basel's Department of Physics and the Swiss Nanoscience Institute has been awarded the King Faisal International Prize for Science 2017. The King Faisal Foundation awarded Loss the renowned science prize for his discovery of a concept for development of a quantum computer based on the intrinsic angular momentum of electrons. Loss has further refined his theory over recent years and established a completely new field of research.

Helmholtz-Zentrum Dresden-Rossendorf, January 3, 2017. Random access memory on a low energy diet: researchers from Dresden and Basel develop basis for a novel memory chip



Memory chips are among the most basic components in computers. The random access memory is where processors temporarily store their data, which is a crucial function. Researchers from Dresden and Basel have now managed to lay the foundation for a new memory chip concept. It has the potential to use considerably less energy than the chips produced to date – this is important not only for mobile applications but also for big data computing centers. The results are presented in the latest volume of the scientific journal Nature Communications.

All media releases can be found under:
nanoscience.ch/en/media/recent-press-releases-2/

Please provide feedback:

Please send information for SNI update and feedback to c.moeller@unibas.ch.