University of Basel

Swiss Nanoscience Institute

SNI

Swiss Nanoscience Institute
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SNI INSight

Showcasing research and activities at the Swiss Nanoscience Institute

December 2022

Entangled

Worthy of a Nobel Prize – a current topic in the SNI network

Awarded

Excellent work by young researchers

Honored

Christian Schönenberger becomes SNI honorary member

Narrated

Nicolai Jung talks about his time at Harvard University

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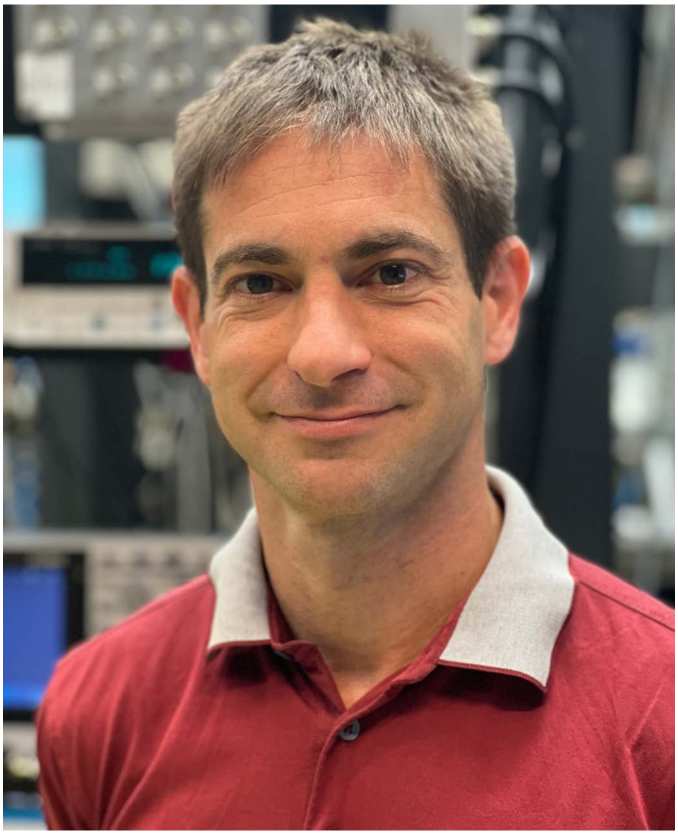
Editorial



Dear colleagues and interested parties,

In August 2022, I took over as director of the Swiss Nanoscience Institute from Christian Schönenberger. The weeks that followed have been very exciting indeed.

In my first official act as director, I had the pleasure of extending honorary membership in the SNI to my predecessor, Christian Schönenberger. Over the past sixteen years, Christian's commitment to the SNI has been unmatched; he made the institute what it is today – a recognized interdisciplinary center of excellence for nanosciences and nanotechnology. In the portrait included in this edition of SNI INSight, we take a look back at his career as a scientist and as SNI director.

You probably followed the news that this year's Nobel Prize in physics was awarded to three experimental physicists for their work on entangled photons. Entanglement is studied by many teams in our network, too. So, in this edition, we explore a few examples of the phenomenon, which Albert Einstein referred to as "spooky action at a distance", that are being studied in our labs.

You will also learn about the work of several young, up-and-coming scientists in our network who have earned different awards over the past six months. Starting in this edition of SNI INSight, we will also be including a new guest column written by a nanoscience student. In this first column, Nicolas Jung writes about his time at Harvard University.

The dedication of our students and doctoral researchers is nowhere more evident than in the commitment of the group of students currently planning an international nanoscience student conference (INASCON), which is set to take place next year in Basel. I am also pleased to see that our efforts to generate interest in the nanoscience degree program have met with success. A survey of students revealed that the new specialization in nanomedicine is proving to be a real asset to the nanosciences master's program.

Over the past few months, many of us have enjoyed the opportunity to gather together again in larger groups at conferences and meetings. We were also able to host a wonderful Annual Event at the SNI, convene for a Nano-Tech Apéro with industry representatives and hold numerous outreach events at which the SNI invited a wide audience to explore the exciting world of nanosciences.

At the moment, my new position has me learning constantly. I am having fun diving deeper into the organization of our unique network, and I am looking forward to working together with you in the years to come.

First. however I would like to wish everyone a relaxing holiday season and a great start to a healthy, peaceful and successful new year.

Prof. Martino Poggio, SNI Director

Entanglement

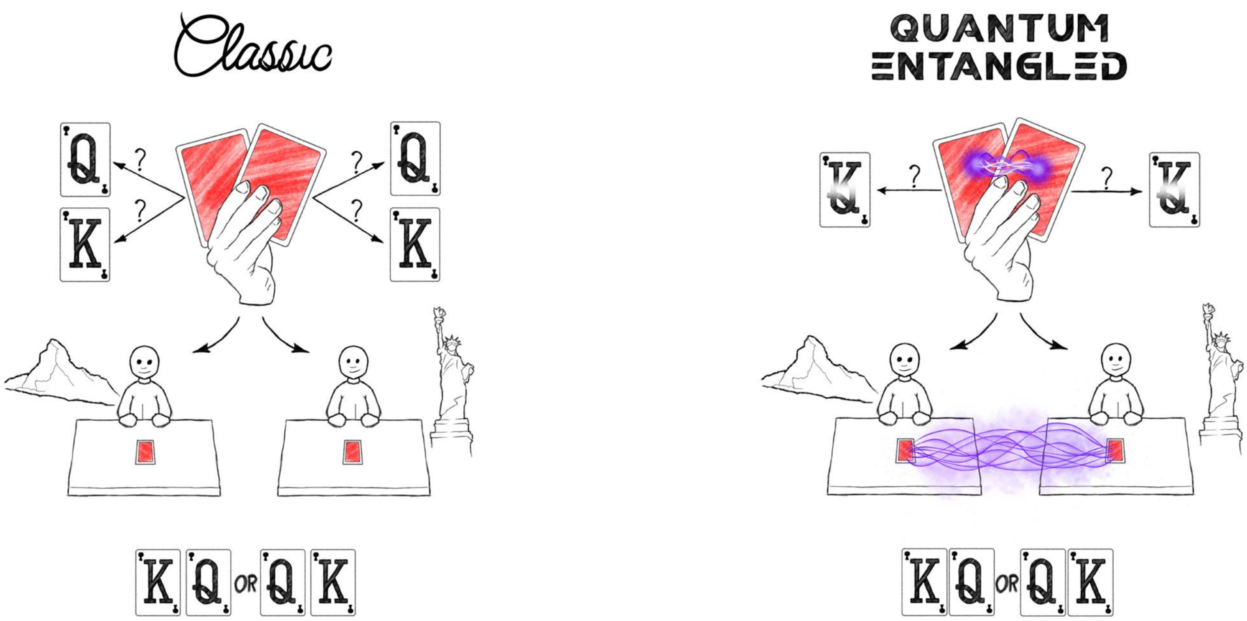
A fascinating topic of research in the SNI network – and worthy of a Nobel Prize

In October, the Nobel Prize Committee announced that Professors Alain Aspect, John Clauser and Anton Zeilinger were to be awarded this year's Nobel Prize in Physics. Their pioneering experiments with entangled photons have laid the foundations for fundamental physical experiments and various quantum applications of quantum mechanics. Within the SNI network, various research groups have also been working on experimental investigations of entanglement and have set their sights on specific applications. Here, we look at several examples that illustrate how researchers at the Department of Physics of the University of Basel are also investigating this quantum phenomenon, which is so hard to reconcile with our experiences of the macro world.

A close connection even over long distances

Entanglement is a quantum physical phenomenon in which certain properties of particles are closely connected with one another, even if the particles are separated by thousands of kilometers. The relationship between them remains intact, provided they are not disturbed. The entangled properties can involve the wavelengths of photons or the orientation of magnetic moments (spins) of particles.

The fact that a connection like this works without some kind of communication going on in the background is impossible to reconcile with our experiences of the macro world. Albert Einstein is among the researchers who have studied the phenomenon of entanglement – and rejected the idea that a strong correlation between two particles could exist in this way. He described the phenomenon as "spooky action at a distance" and assumed that it must be underpinned by hitherto unknown classical variables.



To illustrate the complex quantum world and entanglement, let's imagine that two people living far away from each other each gets a playing card (namely a queen or king) and inspects it at the same time. In the classical world, one of the persons gets a queen, and the other gets a king. It is clear who obtained which card when the cards were distributed. In the quantum world, however, when the playing cards are sent out, they can be both queen and king at the same time – a quantum mechanical superposition. Only when these "magic" cards are revealed, it is decided by chance whether it is a queen or a king. If the magic cards were entangled before being distributed, there is a close connection between them that remains – even over a long distance. If one person reveals a queen, the other person always possesses a king – and that, although for both cards it is decided whether they are queen or king only at the moment when the cards are turned face up and they both have the potential to be queen or king. (Image: SNI and Scixel)

Further information:

Research group Philippe Treutlein
https://atom.physik.unibas.ch/en/

Uni News
https://www.unibas.ch/en/News-Events/News/Uni-Research/Einstein-Podolsky-Rosen-paradox.html

Uni News
https://www.unibas.ch/de/Aktuell/News/Uni-Research/Verschr-nkte-Atome--berwinden-Grenzen-der-Messgenauigkeit.html

Correlations demonstrated experimentally

In experiments, however, the three Nobel laureates have demonstrated that this entanglement actually exists – at least in the quantum and nano world. The basis for their analyses are so-called Bell tests, in which researchers initially assume that particle properties exist independently of one another and at a specific location. A measurement of one particle should not therefore have any influence on that of another – in other words, one revealed card should be independent of the other (see image 1) – as we're familiar with in the macro world. Based on these considerations, it's possible to derive an inequality that the measurement results should fulfil.

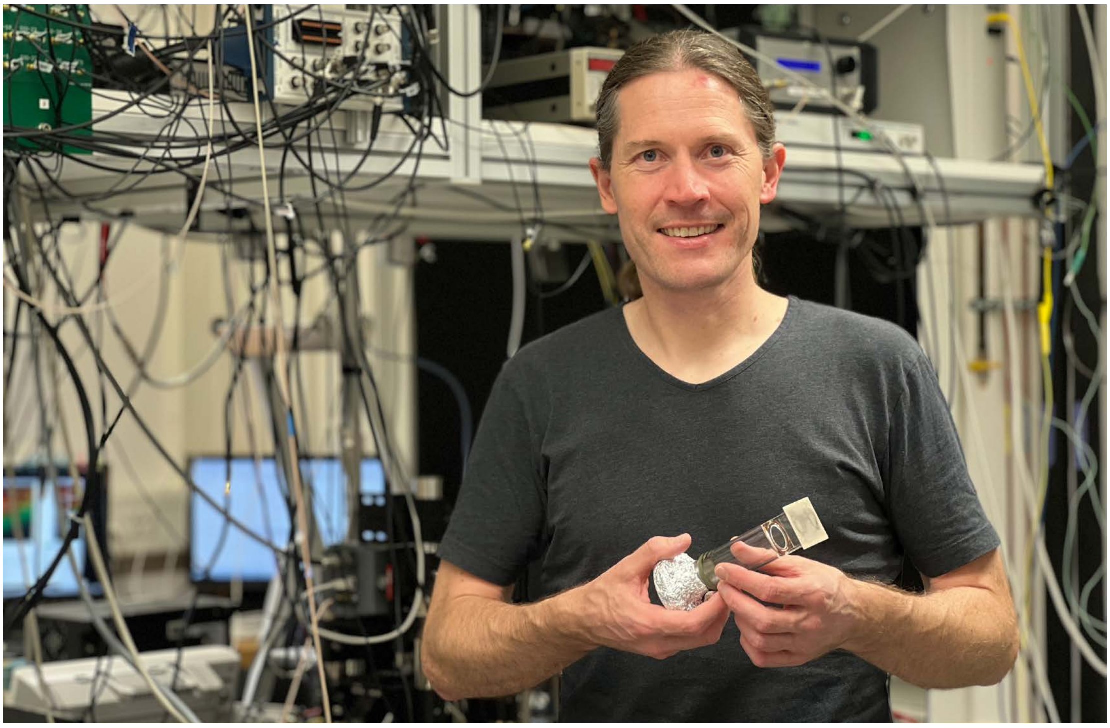
Yet the Nobel laureates' experiments with entangled photons that were sent to spatially separate measuring stations showed that it is possible for this "Bell inequality" to be violated. The properties of the photons in the experiments depend on one another – in other words, there is a "Bell correlation" between them. The particles don't assume their properties until a measurement is taken, contradicting our experiences in the macro world – after all, if we cast our minds back to our thought experiment in the macro world, the card was already a queen or a king before it was revealed.

These fascinating phenomena are also the subject of research by several research groups at the Department of Physics at Basel University, which forms part of the SNI network. The various teams pursue very different strategies when it comes to creating and investigating entangled particles – and are also pursuing different objectives in their research. Common to all of the groups is a curiosity about the laws of the quantum world and an interest in understanding these laws in order to pave the way for future applications.

Does quantum mechanics stop working at some point?

Like the three Nobel laureates, Professor Philipp Treutlein and his team also study quantum mechanical phenomena in the context of basic science – albeit not using individual photons but rather many-particle systems containing more than a thousand atoms.

"The fundamental question behind our research is whether these quantum mechanical phenomena are subject to a fundamental size limit, which ensures that the macro world obeys the classical laws we're familiar with in our everyday lives – after all quantum phenomena generally disappear in large systems. Alternatively, do the quantum laws that include phenomena such as entanglement also apply in the macro world, and is detecting them simply a question of effort and the techniques we use," explains Treutlein. "To explore this question, we're creating



Philipp Treutlein investigates the phenomenon of entanglement in many-particle systems containing over a thousand atoms.

entanglement and Bell correlations in increasingly large systems with an ever-greater number of particles."

Experiments with ultracold atom clouds

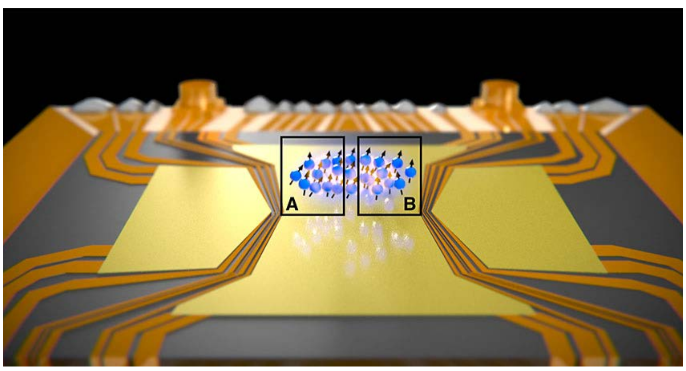
In their experiments, the researchers use laser light to cool a cloud of ultracold atoms to temperatures just a few billionths of a degree above absolute zero. Inside this cloud, collisions are constantly taking place between atoms – which in turn cause the magnetic moments (spins) of all of the atoms to become entangled with one another. "If we then take any two atoms in the cloud, they form an entangled pair – in other words, if the spin of one atom is pointing upwards, the other is automatically pointing downwards," explains Treutlein, although the direction is not defined until the magnetic moment is measured. Again, this is another of the unusual features of the quantum world.

In this cloud of ultracold, entangled atoms, the researchers can then study areas that are spatially separated from one another. To do so, they measure the correlation of spins in the separated areas and determine the precise position of the atoms. Based on the measurements in one specific area, Treutlein's team can then also predict the results in another area. "We recently managed to split the cloud and spatially separate the two parts," says Treutlein. "Here, too, measurements can prove that the spins of the two clouds are entangled with one another. Measuring the spin in one cloud influences the result of the measurement in the other – just as in the 'spooky action at a distance' that Einstein described."

Reduction of quantum noise

Through these experiments, the researchers demonstrate not only that the laws of quantum mechanics apply to the many-particle system in question, but also that these laws could potentially pave the way for numerous applications.

Potential applications include more accurate sensors and imaging techniques. Interestingly, entanglement can be used to determine – and even modify – the state of one particle by measuring the other. Treutlein's team is using this phenomenon to improve the measurement accuracy of devices known as atom interferometers, which are some of the most precise instruments for measuring gravitation, electromagnetic fields and other fundamental quantities.



A cloud of atoms is held above a chip by electromagnetic fields. The EPR paradox was observed between the spatially separated regions A and B (Illustration: University of Basel, Department of Physics)

In measuring an electromagnetic field, an atom interferometer takes the mean of the measurement results for a large number of atoms. Since the measurements of individual atoms are random in the quantum world, however, there are fluctuations in the measured values. Although these fluctuations are reduced by averaging the measurements, some "quantum noise" always remains. In the case of entanglement, however, the particles are no longer independent of one another and instead behave like a unit. The quantum noise of the individual atoms is correlated, and the measurement precision can be significantly improved by skillful selection of the measuring technique.

Greater security in communication

"Theoretically, entanglement could also be used to improve security in communication," explains Treutlein. This would involve encrypting the information to be exchanged using a key that was based on entangled quantum systems – generally photons. If someone intercepted this key, the sender and recipient would be able to tell immediately based measurement results of the partner photons. If no one had broken into the system, however, the message could be encrypted and sent.

Entanglement for better sensors

Professor Patrick Maletinsky also sees benefits in using entanglement when it comes to his research objectives. As well as developing sensitive sensors for tiny magnetic and electric fields, he is also working on quantum communication in collaboration with Professor Richard Warburton.

"Our research uses nitrogen-vacancy centers in diamonds. Within these vacancy centers, the spins of individual orbiting electrons change when the particles are exposed to an electric or magnetic field. The electrons can be excited and then emit individual photons that provide information about their spin state. This technique provides us with information on changes in individual spins based on the examined fields," says Maletinsky, explaining the principle underlying his research.

Maletinsky and his team are searching for ways to make measurements even more accurate by increasing the number of sensors and taking an average of the results – as with atoms in the atom interferometer. To obtain a measurement that is 10 times more accurate, he must increase the number of sensors from one to 100. If the spins of the sensors were all entangled with one another, however, a tenfold increase in the number of sensors would theoretically be sufficient to obtain 10 times the measurement accuracy. "At the moment, the problem

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Research group Patrick Maletinsky
https://quantum-sensing.physik.unibas.ch/en/

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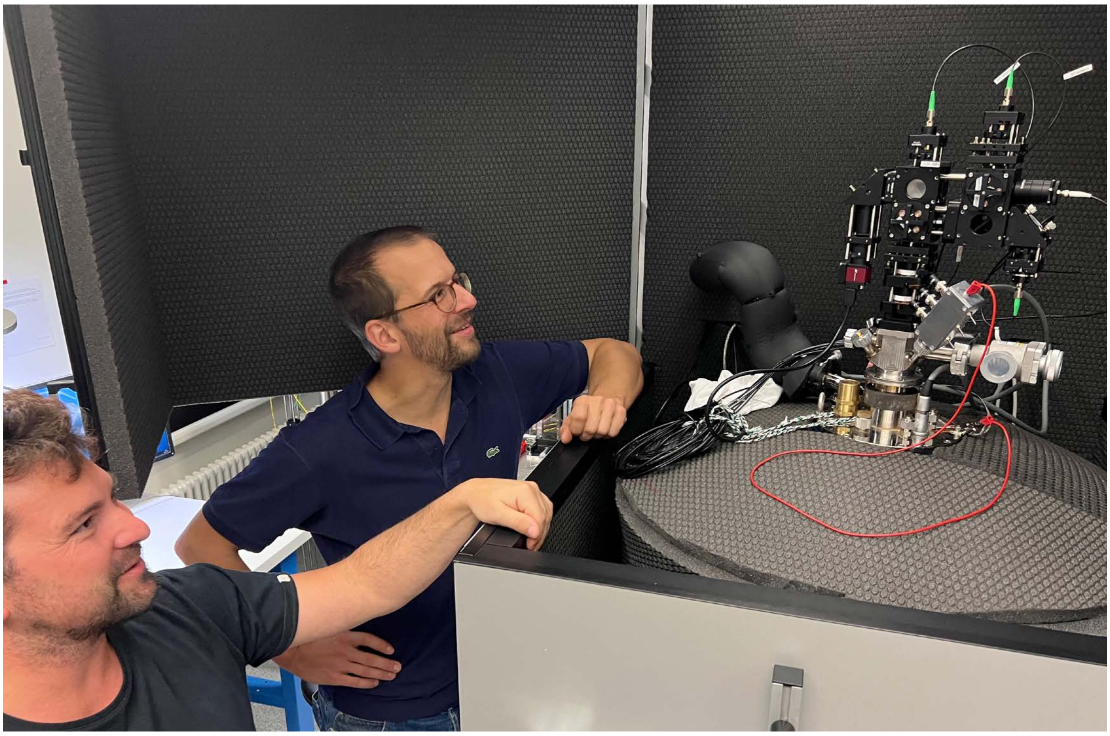


Patrick Maletinsky and his team are investigating ways to make their sensors, which are based on nitrogen vacancy centers in diamonds, even better using entangled spin. The measurements are carried out at very low temperatures in a cryostat.

with our experiments is that it still takes us far too long to entangle the spins and that we then have too little time to take the measurement. We need to solve this issue before we can make practical use of entanglement in our sensors," says Maletinsky.

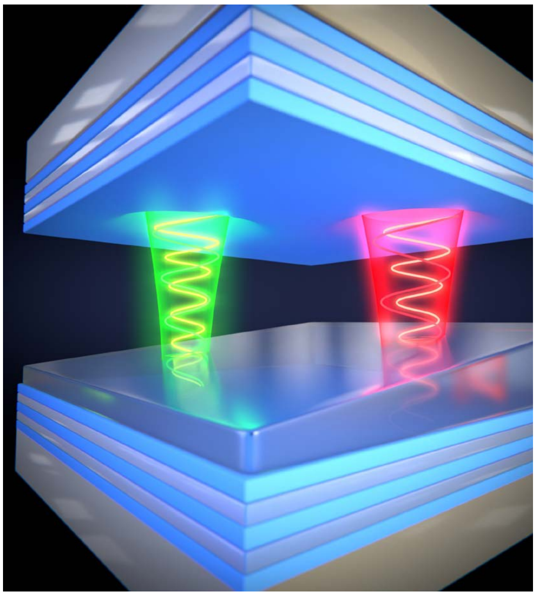
Mirror systems for better communication

In collaboration with Warburton's team, the group at Patrick Maletinsky's Quantum Sensing Lab also wants to apply the entanglement of electrons to diamond sensors for quantum communication.

To produce entangled spins, the researchers use tiny depressions, known as cavities, in which two parallel mirrors ensure that a photon is not lost but is instead reflected back and forth and can interact with quantum systems in between. In a cavity of this kind, a photon can couple two quantum systems, such as electrons, with one another and entangle their magnetic moments (spins). Another possibility is to equip multiple cavities with their own quantum systems. In each cavity, the photon can be entangled with the spin of another particle, such as an electron. A suitable experimental setup can cause the photons in the various cavities to interfere with one another, leading to "remote entanglement" between the separate spins. The researchers are still working on implementing this kind of entanglement within their system with a view to further increasing the efficiency of their approach.

Quantum dots as a source of quantum light

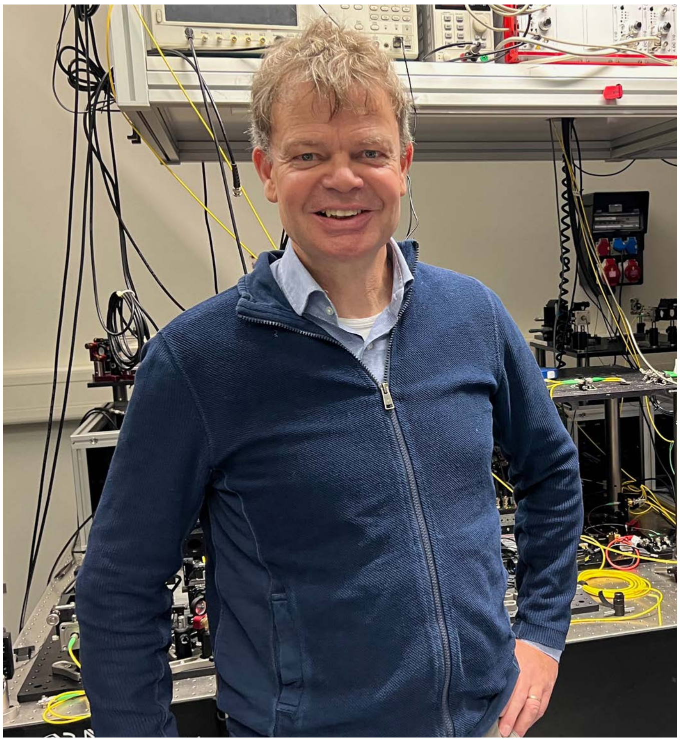
In addition to his collaboration with Patrick Maletinsky on nitrogen-vacancy centers, Richard Warburton also works on approaches involving quantum dots – tiny nanoscale structures in semiconductor materials in which "trapped" electrons can adopt only very specific energy levels. An electron can



Photons are not lost in the cavities, but are mirrored back and forth. (Image: Flågan, Riedel and Scixel) be promoted from the lowest energy level to a higher one with a laser pulse. A single photon is created when the electron drops back down again.

Recently, the Warburton team has succeeded in using this method to produce almost completely identical photons from two separate quantum dots. If these photons then strike a semi-transparent mirror, they become entangled and always react as a pair — as seen in the phenomenon of remote entanglement described above. The photons then either pass through the mirror together or are both reflected. In the macro world, which we are much more familiar with, it would also be possible for one of the two photons to be reflected and the other to pass through the mirror, but this is not the case with identical photons.

Aiming for cluster and graph states
"Above all, we're working on producing not only an entangled photon pair but rather chains of entangled photons called cluster states, subsequently also more complex graph states with entangled photons," says Richard Warburton. "These larger structures with multiple entangled photons could be used in quantum communication or even in a quantum computer."



Richard Warburton and his team use quantum dots as a source of quantum light.

Although the principle used to produce these larger entangled structures doesn't sound all that complicated in theory, it is a challenge to produce more than one entangled photon pair in practice. In their approach, the researchers use a quantum dot with a single electron. They excite this electron so that it emits a single photon, which becomes entangled with the electron's spin. Given that light moves very quickly, the photon disappears immediately after it is emitted — but its entanglement with the electron persists. The electron is then excited again, producing a second photon that becomes entangled with the first photon. "After the process is run for a third time, a short chain of three entangled photons can be formed. We could then extend this chain even further — and although the photons are at different locations, the close connection between them would persist," says Warburton, describing his team's approach. "Creating a graph state of entangled photons is a long way off, however."

Entangled pairs for free
Whereas it's very expensive for some lines of research to entangle photons or electrons with one another, the team led by Professor Christian Schönenberger and Dr. Andreas Baumgartner receives entangled electron pairs "for free." As electrons in superconductors are always entangled in pairs, the researchers from the Quantum- and Nanoelectronics group use superconductors as a natural source.

Some time ago, the team developed an electronic device component that can be used to extract such electron pairs, known as Cooper pairs, and then separate them spatially. This separation takes place in two spatially separate traps, known as quantum dots, in which the electrons are captured for a short time.

Only recently have the researchers then been able to demonstrate a negative correlation between the spins of the two separated partners of a pair — in other words, one partner is always "spin up," and the other "spin down." The researchers achieve this using two spin filters that can be configured to allow electrons with a specific spin orientation to pass. For example, if both spin filters are configured so that only spin up electrons can pass, the flow of current is suppressed. If the two spin filters are pointing in opposite directions, however, an electric current flows.

"The electrons in the Cooper pairs are not separated from one another by a sufficient distance, however, and the experiment can therefore not be considered as a Bell test with electrons — but we're working on it," says Andreas Baumgartner.

"Entangled electrons of this kind could be used in the realization of a quantum computer," explains Christian Schönenberger. "For example, a superconductor could be placed between two storage units (qubits) of the quantum computer to connect them via entangled Cooper pairs. Until now, the necessary interactions between two qubits only worked if they were very close to one another — which isn't ideal when it comes to implementing a larger system."

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Research group Christian Schönenberger
https://nanoelectronics.unibas.ch/

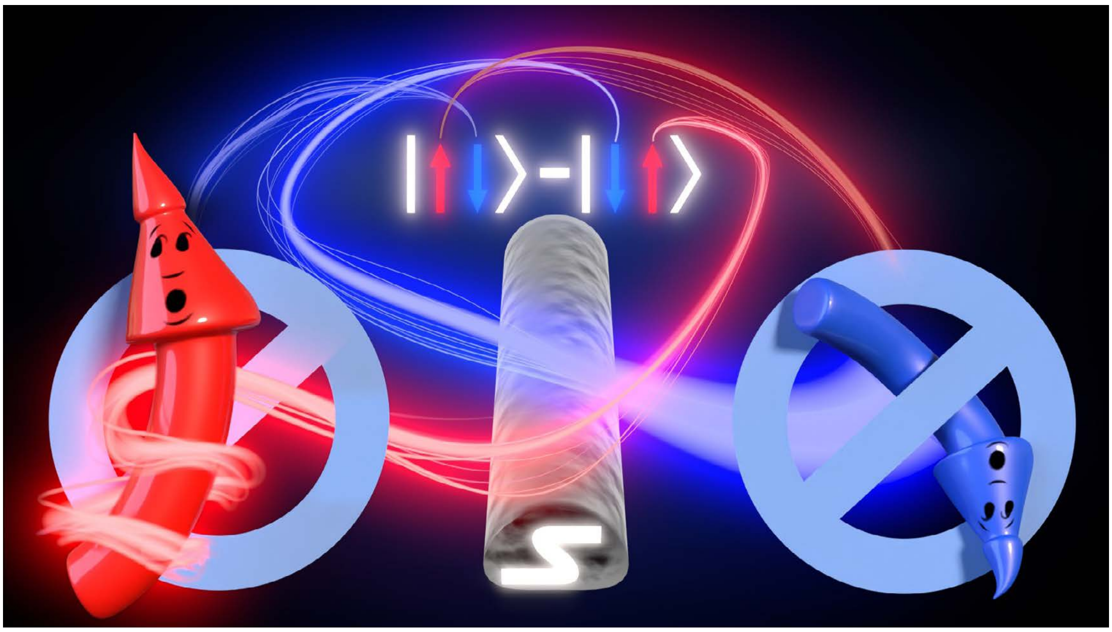
Uni News
https://www.unibas.ch/en/News-Events/News/Uni-Research/Spin-correlation-between-paired-electrons-demonstrated.html

Nature
https://www.nature.com/articles/s41586-022-05436-z

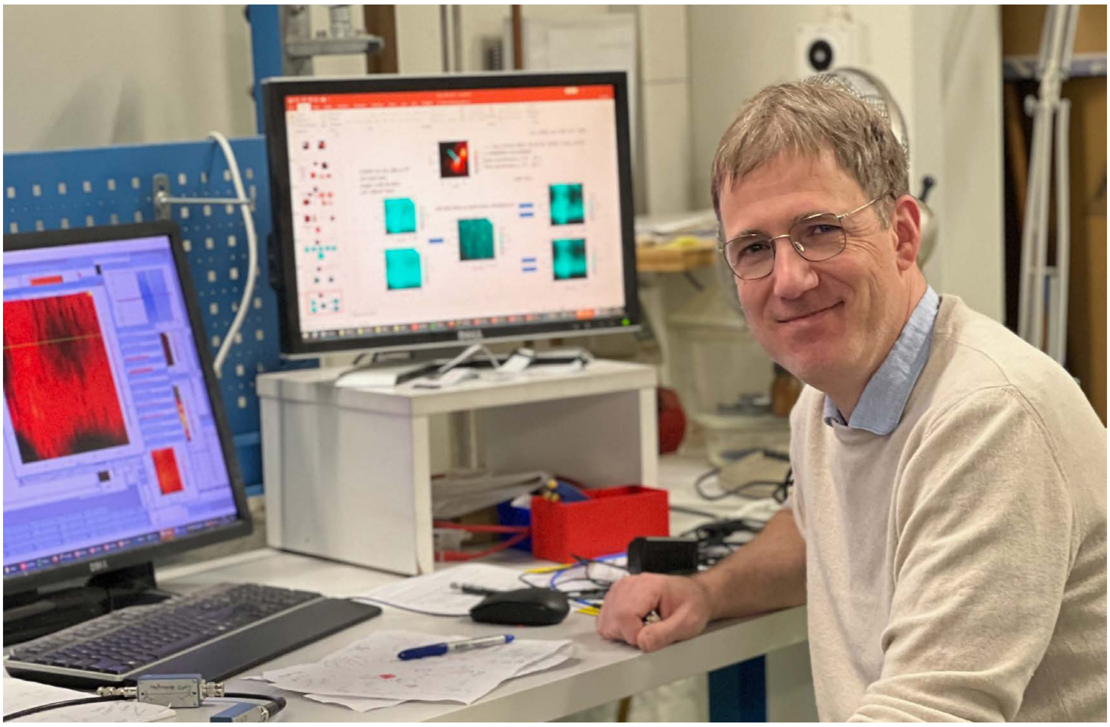
Spin down/spin up and spin up/spin down - Andreas Baumgartner and Christian Schönenberger use superconductors as a natural source of entangled electrons.

Elementary for quantum computing
For the development of a spin-based quantum computer, to whose development Professor Dominik Zumbühl's group is contributing, the entanglement of multiple spins is a basic requirement.

A quantum computer does not work with bits like a conventional computer, but with quantum mechanical states of suitable systems, so-called qubits. Various possibilities for the realization of qubits are being discussed worldwide. Researchers in Basel follow the approach to realize a qubit by the magnetic moment (spin) of an electron. Unlike a bit in a conventional computer, the spin of an electron can not only assume two states (0 and 1), but can point up, down and in numerous other directions simultaneously. These different states of the spin are superimposed and are



Electrons leave a superconductor only as pairs with opposite spins. If both electron paths are blocked for the same type of spin by parallel spin filters, paired electrons from the superconductor are blocked and the currents decrease. (Image: University of Basel, Department of Physics/Scixel)



Dominik Zumbühl and his team are researching the fundamentals of a spin-based quantum computer. This requires entangled qubits.

not fixed until they are measured - leading to the much higher computing power of a quantum computer compared to a conventional computer.

The Zumbühl team is investigating methods to realize such a spin-based computer in semiconductors. The difficulty here is to keep the electron spin stable and to control it. The researchers are already quite successful to control individual electrons by applying electric fields. In addition, however, several spins have to be coupled with each other - which in the quantum world is done by entanglement.

Researchers from Dominik Zumbühl's Quantum Coherence Lab recently succeeded in producing two qubits whose spins can be controlled arbitrarily and which are entangled with each other. "The two quantum systems are then no longer independent of each other, but react as a unit," explains Dominik Zumbühl. "With two qubits, this does not yet lead to a drastic acceleration in computing power. But if the number of qubits is increased, it makes a serious difference, since the computing operations can be executed in parallel rather than one after the other in the case of entangled qubits."

Collaboration is key to success

The projects described here always involve whole teams of people – not only from the University of Basel but also from research institutions all over the world. Close collaboration with theoretical physicists is also hugely important. In Basel especially, with the groups led by Professors Christoph Bruder, Jelena Klinovaja, Daniel Loss and Patrick Potts, there are some excellent theoretical scientists who work closely with researchers in the field of experimental physics and provide impetus for novel applications.

The awarding of the Nobel Prize to the three quantum researchers Alain Aspect, John Clauser and Anton Zeilinger has certainly helped even more to focus public attention on quantum research. Although it is still difficult for non-experts to imagine how the phenomenon of entanglement between particles works, the examples set out here demonstrate that this quantum mechanical coupling is a fascinating area of research – and one that paves the way for numerous potential applications.

All of the above approaches differ from one another and help to improve our understanding of the laws of quantum mechanics, as well as helping researchers learn to overcome the enormous technical hurdles. Despite huge advances in quantum research in recent years, there are still many question marks and technical challenges when it comes to controlling individual particles and these tiny structures.

Further information:

Research group Dominik Zumbühl
https://zumbuhllab.unibas.ch/en/

Uni News
https://zumbuhllab.unibas.ch/en/news/details/new-type-of-qubit-with-tunable-speed-and-frequency/

Uni News
https://www.unibas.ch/en/News-Events/News/Uni-Research/Hot-spin-quantum-bits-in-silicon-transistors.html%20%0D

New honorary member Christian Schönenberger

Always searching for answers

In September 2022, Professor Christian Schönenberger was awarded honorary membership in the SNI for his extraordinary dedication as SNI director. Many of us know about his contributions to the SNI, the aspects of the SNI that were important to him and where his academic interests lie. In this interview, he lets us in on a few details about his career that some of us may be less familiar with.

Professor Christian Schönenberger was SNI director for sixteen years. Together with many colleagues from the fields of physics, chemistry and biology, he made the SNI into what it is today – a recognized interdisciplinary center of excellence for nanosciences and nanotechnology. But back when he started his career, he could never have imagined this or another of his other professional achievements.

During the Annual Event 2022, Christian Schönenberger received honorary membership of the SNI.

Many different stations along the way

When Christian Schönenberger left high school in 1972, he had no intention of pursuing a Matura (high school diploma) or a university degree. Instead, he chose to apprentice as an electrician. Over the course of four years, he learned his trade at a small company and developed automatic film developing machines. Even back then, he was keen to understand how everything fit together and find answers to his many questions. In 1976, he started a three-year training program in electrical engineering at the Technikum in Winterthur, so that he could keep on learning.

After that, he took up a position as a technical assistant at ETH Zurich. There, he worked in molecular spectroscopy, where he helped build a UV laser for molecular excitation, a project that introduced him to quantum physics for the very first time. “I was working with two doctoral researchers, and that got me thinking that I would like to have a deeper understanding of the material, too,” recalls Christian. So, he decided to start all over again and study physics at ETH Zurich. “But that wasn’t quite so easy, because I didn’t have a Matura,” he says. So, Christian was forced to hit the German literature books and pass both an English examination as well as written and oral exams in German before he could get started.

Fascinating studies and starting a career at IBM

Christian truly enjoyed his time at university. But even after receiving his diploma, he still had not completely fulfilled his need to dig deeper into the subject matter, so he struck out in search of a topic fit for a doctorate. His search led him to the IBM research lab.

The lab, supervised by Professor Heinrich Rohrer, was working on some fascinating projects, and on top of that, he would need some industry experience later on when applying for jobs, so this opportunity was relatively secure. That was important for Christian because he had just become a new father.

For his doctoral dissertation, Christian built a magnetic atomic force microscope. He shared his lab – and many experiences and experiments – with Christoph Gerber, with whom he would again enjoy a close working relationship years later in Basel. In 1990, after completing his doctorate, Christian took up a position at Philips Research in Eindhoven (Netherlands), which at that time was one of the foremost industry research labs. His work there focused on low-temperature scanning tunneling microscopy and sensors that could be used to read out magnetic information in storage media.

"I had a great time at Philips," recalls Christian. "But then the company began restructuring and some very good and ambitious colleagues of mine quit to take up professorships."

Christian started down a new path as well. He submitted an application to the Swiss National Science Foundation for an assistant professorship and subsequently received the position. Christian had intended to join the team led by Professor Hans-Joachim Güntherodt at the University of Basel, which had become the foremost research group for scanning probe microscopy, but before he could start on as assistant professor, Hans-Joachim Güntherodt advised him to apply for the recently announced professorship for condensed matter. Christian was appointed and started his new job in 1995.

The group led by Hans-Joachim Güntherodt at the University of Basel was a leader in scanning probe microscopy and therefore an attractive option for Christian Schönenberger when he returned to Switzerland from the Netherlands.

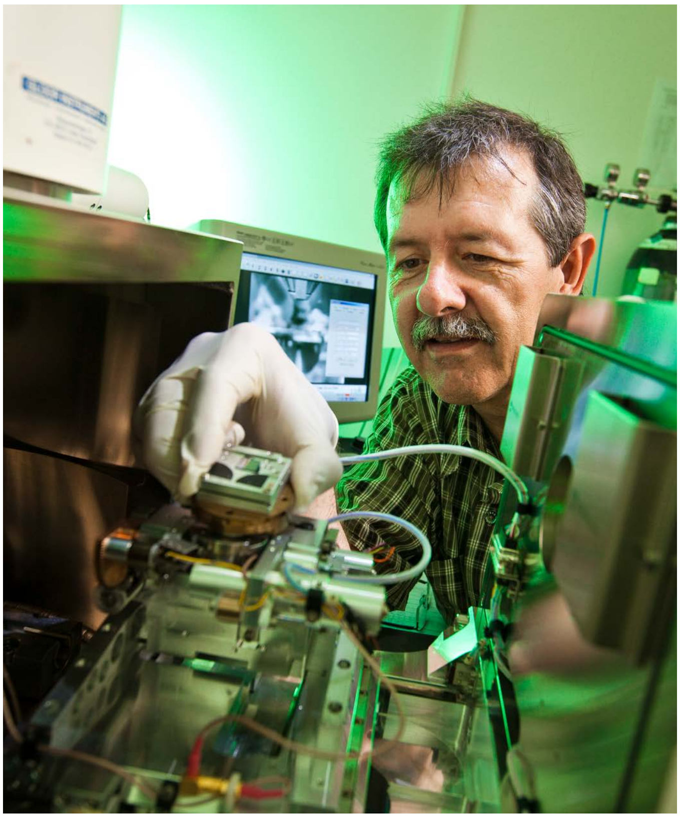
Switching to a new field of research

Hans-Joachim Güntherodt had expected to welcome another member to the scanning probe microscopy community, but when Christian returned to Basel, he was more intent on starting something new instead. His goal would not be to develop new microscopes, but rather to work on electronic components that could be used to study and reduce electrical noise.

His colleague Güntherodt, who, at the time, was Basel's only other professor for experimental condensed matter, supported his approach. Güntherodt advocated for Christian's project before the President's Board and made sure he received a second appointment credit. "In the beginning, there was no infrastructure in place here for my research approach, and I had to build it up piece by piece," says Christian. "Over time, as we gained new colleagues who needed similar equipment, it got easier, because we could work together to make larger purchases."

So began Christian Schönenberger's career at the University of Basel. The Department of Physics and his own Quantum and Nanoelectronics Lab both grew as the years went on. He has since produced over 230 publications, received numerous awards and raised 18 million Swiss francs in third-party funding.

Christian Schönenberger has always been dedicated to the education of excellent young scientists. From the very beginning, he was a proponent of establishing a bachelor's and master's program in nanosciences at the University of Basel – a program that would be unique in Switzerland – and he continued to support it over the course of its development. During his career, Christian supervised 72 doctoral students, some of whom are still working on their doctorates. And he always managed to find time in his busy schedule to hold outreach activities at the SNI for children and teens.



In Basel, Christian focused on developing and studying components for reducing electrical noise.

Always interested in new topics
When asked to share the highlights of his academic career, he mentioned a Hanbury Brown and Twiss experiment published in *Science* that was conducted with electrons on a chip. Together with his team, he demonstrated that the electrons behaved like fermions, excluding each other. Another highlight he mentioned was a project in which his team extracted and split entangled electron pairs (Cooper pairs) in a superconductor. This study, which was published in *Nature*, laid the groundwork for further experiments with entangled electrons from superconductors (for more information, see the other article on experiments involving entanglement in this edition of SNI INSight).

"When Hans-Joachim Güntherodt approached me with the idea of applying for selection as an NCCR together with the biology and chemistry departments, I knew right away that I wanted to support interdisciplinary research," explains Christian Schönenberger. "Through Hans-Werner Fink from the IBM Research Center, who worked in my lab at that time, I met the chemist Bernd Giese here in Basel, who was studying the conductivity of DNA using chemical electrodes. Through that connection, Michel Calame and I came up with the idea of incorporating smaller molecules into electrical circuits and studying them." Michel Calame, who spent many years working in the Schönenberger team, has continued this work for years now as head of a research group at Empa.

More information:

Research group Christian Schönenberger
https://nanoelectronics.unibas.ch/people/christian-schonenberger/

Selected publications

Science
https://www.science.org/doi/10.1126/science.284.5412.296

Nature
https://www.nature.com/articles/nature08432

Christian Schönenberger is dedicated to sparking young people's interest in the natural sciences.

Christian Schönenberger is looking forward to getting back into the lab himself.

A glance at Christian Schönenberger's impressive bibliography reveals many more approaches and findings that have attracted attention in the world of science. It is also notable, however, that his research topics keep changing over time. So with the inception of the National Center of Competence in Research (NCCR) Nanoscale Science in 2001, Christian began a new chapter in the field of nanoelectronics.

In Christian Schönenberger's lab, the team later began conducting physical investigations of two-dimensional electron gases, metallic nanowires and carbon nanotubes.

"When Konstantin Novoselov – who won the Nobel Prize together with Andre Geim for the creation of graphene – was visiting Basel, I, too, was bitten by the graphene bug and started doing research in the same field," recalls Christian. It was a short leap from graphene to other two-dimensional structures and then to van der Waals heterostructures, which he continues to study today.

Great dedication to the network
In addition to his academic pursuits, in the final stages of the NCCR, Christian Schönenberger, along with Hans-Joachim Güntherodt and other colleagues, showed a tireless commitment to ensuring the future of both the interdisciplinary network they had built and the academic exchange between institutions. Thanks to the support they received from the canton of Aargau and the University of Basel, their efforts succeeded and led to the founding of the SNI in 2006.

When asked to reflect on the high points of his time at the SNI, Christian answered: "I'm pleased that the concept we developed back then has stood the test of time. It means we were able to realize the three pillars of training, basic and applied research inlcuding knowledge transfer to industry and successfully integrate them in the canton of Aargau. Over time, with the addition of the Nano Imaging Lab, we established our services area, which we've now expanded with the founding of the Nano Fabrication Lab. We couldn't have predicted it early on, but it has really strengthened the SNI."

Still managing a busy schedule
In some ways, Christian Schönenberger bid farewell to the SNI at the last Annual Event, although as an honorary member, he will of course be welcome to attend all SNI events. However, he will not be saying goodbye to his research any time soon. Christian will continue to lead his group through summer 2024 and is looking forward to getting back into the lab himself as his coworkers finish their projects and the lab gradually begins to clear out.

Although he is now no longer managing administrative tasks for the SNI, his schedule is just as packed as ever. Several doctoral dissertations are waiting to be read, staff members want to discuss their projects, email inquiries need to be fielded – the list goes on and on. But every now and then, he has a free moment to climb onto his mountain bike and really work up a sweat.

One thing is certain: When Christian Schönenberger retires in 2024, he will be on the lookout for an exciting new project that he can pursue with all the same enthusiasm and commitment that we have come to know so well.

Swiss Nanotechnology PhD Award

The Swiss Nanotechnology PhD Award was created by the Swiss Micro- and Nanotechnology Network (Swiss MNT Network) and is presented at the Swiss NanoConvention in recognition of excellent first-author publications by doctoral students at Swiss research institutions. Every year, five such PhD prizes are sponsored by various companies.

Claudia Lotter received the award from the Hightech Zentrum Aargau. Thomas Mortelmans received the prize from the company Sensirion, and Simon Geyer — a doctoral student in the group led by SNI member Professor Richard Warburton — was awarded the prize by IBM Research Zurich.

A specific signal for improved uptake

Claudia Lotter receives PhD Award in recognition of her work

At the Swiss NanoConvention 2022, the former nanoscience student Claudia Lotter received the PhD Award – sponsored by the Hightech Zentrum Aargau – in recognition of a first-author publication in the *European Journal of Pharmaceutics and Biopharmaceutics*. Writing in the publication, Claudia describes how lipid nanoparticles developed for gene therapy can be optimized by tweaking the lipid composition.

Initial research into lipid nanoparticles, such as those used in mRNA vaccines against SARS-CoV-2, was aimed primarily at applications in gene therapy. In order to be used as a vaccine and in gene therapy applications, the lipid nanoparticles that package genetic material must achieve effective uptake into host cells. To ensure good uptake, researchers at the Department of Pharmaceutical Sciences of the University of Basel are working to optimize the composition of the lipid envelopes.

Marcus Morstein presented the Swiss Nanotechnology PhD Award to Claudia Lotter on behalf of the Hightech Zentrum Aargau. (Image: T. Byrne)

Solutions inspired by nature

As is so often the case in nanotechnology, nature provides some ideas as to how this can be accomplished. For example, dying cells use compounds on their surface to tell neighboring cells to absorb their constituents. One such signaling molecule is the phospholipid phosphatidylserine. Whereas this molecule is actively kept inside healthy cells, it appears on the surface of dying cells, where it springs into action. Viruses also have phosphatidylserine molecules on their surface and can therefore enter host cells, which then begin to produce the constituents of the virus.

Inspired by these natural processes, Dr. Tomaž Einfalt (formerly an SNI doctoral student in the groups of Professors Palivan and Huwyler group and now a lab head at Novartis) came up with the idea of integrating phosphatidylserine into lipid nanoparticles in order to improve the transport of genetic material into target cells. Claudia Lotter, who studied nanosciences at the University of Basel, subsequently put this approach into practice as part of her master's thesis. She completed the analyses in the first year of her doctoral dissertation and has now been awarded the Swiss Nanotechnology PhD Award 2022 for the resulting publication in the *European Journal of Pharmaceutics and Biopharmaceutics*.

Ideal concentration identified

As part of this work, Claudia showed that the integration of phosphatidylserine into the lipid envelope of the nanoparticles can boost the transfer of RNA and DNA in cell cultures by a factor of 10. "The optimum concentration of phosphatidylserine is 2% to 7% with respect to the total lipid concentration," she explains. "If the concentration of the integrated phosphatidylserine increases, the positive effect on uptake diminishes again."

Through their work, Claudia and her coauthors were able to show that the incorporation of defined quantities of phosphatidylserine into lipid nanoparticles opens up new approaches to efficient gene therapy that could be expanded to other therapeutic systems.

Selective uptake

In her doctoral dissertation, Claudia is now addressing another aspect of gene therapy. Known as "targeting", this technique aims to place specific markers on the surfaces of nanoparticles so that the particles can only be taken up by very specific cells. "We're focusing on specific breast cancer cells, which to a large extent possess human epidermal growth factor receptor 2 (HER2)," she says. "If the selective uptake of genetic material from these cancer cells is successful, it may be possible to develop a gene therapy for this form of cancer – in an approach that could be applied to other malignant tumors."

That possibility remains a long way off, however. Once Claudia has completed her doctoral dissertation, she would like to follow a development of this kind through to completion. "I can certainly see myself contributing to the development of gene therapies in a start-up or in industry," she says.

Interdisciplinary education

Her training as a nanoscientist certainly provides her with the ideal background for such a step. In the interdisciplinary nanosciences degree at the University of Basel, she received a broad grounding in the natural sciences and learned to interact with researchers from various disciplines. Now, as part of her doctoral dissertation, she is also gaining the necessary pharmaceutical knowledge.

Claudia feels that her degree was a demanding but very valuable experience. "All of the hard work was worthwhile," she says in the interview. "The team spirit among the nanoscience students was excellent, and I learned that you don't have to achieve everything alone – indeed, you can accomplish so much more as a team."

After her bachelor's degree, Claudia had thought for a long time about switching to ETH in Zurich, but she ultimately opted for the master's program in nanosciences with a focus on molecular biology – and she doesn't regret her decision. After all, she not only learned a great deal during her course of studies but also made some friends for life.

"Nanotechnology is playing an increasingly important role in drug research and development. Claudia Lotter's project therefore focuses on novel drug carriers that can be used for gene therapy. In the context of her doctoral thesis, Claudia has impressively shown that the lipid compositions of these nanomaterials significantly influence their interaction with biological systems. We are thus able to develop new strategies for gene therapy."

Professor Jörg Huwyler, Department of Pharmaceutical Sciences, University of Basel

Further information:

Research group Jörg Huwyler
https://pharma.unibas.ch/de/research/research-groups/pharmaceutical-technology-2253/

Publication in European Journal of Pharmaceutics and Biopharmaceutics
https://www.sciencedirect.com/science/article/pii/S0939641122000285

New principle for antibody tests

Thomas Mortelmans receives the Swiss Nanotechnology PhD Award

Dr. Thomas Mortelmans, a former doctoral student at the SNI PhD School, was presented with one of five PhD Awards at the Swiss NanoConvention 2022. He received the award, which is sponsored by Sensirion, in recognition of a first-author publication in the journal *ACS Applied Nanomaterials* in which Mortelmans described a novel functional principle for rapid Covid-19 tests. The principle can also be used to determine the status of the disease or to detect other viruses, such as influenza A.

In recent years, almost all of us have taken numerous rapid tests to find out whether we're infected with SARS-CoV-2. The rapid antigen tests available on the market are not always reliable, however, and sometimes fail to return a positive result even with a high viral load – as demonstrated by a study from the Paul-Ehrlich-Institut (PEI) in Germany. Furthermore, these tests only ever give us a yes/no answer without providing information about the status of a disease or its progression.

The test developed by Thomas Mortelmans as part of his doctoral dissertation at the SNI PhD School is based on a different principle. It detects not only specific virus components but also antibodies produced by the human immune system in response to an infection with the virus. As the antibodies change over the course of an infection and as the number of them varies depending on disease progression, the test delivers other useful information. Moreover, the test principle developed by Mortelmans can also be used to detect antibodies against other diseases.

Thomas Mortelmans received the Swiss Nanotechnology PhD Award from Michel Despont (VP CSEM). (Image: T. Byrne)

Sensitive and straightforward to carry out

"The test could theoretically be carried out at medical practices using a straightforward technique," explains Mortelmans. "All it needs is a drop of the patient's blood. This sample is then mixed with a specially prepared liquid that contains not only nanoparticles with surfaces closely resembling those of coronaviruses, but also fluorescent particles that selectively bind to the antibodies from the patient."

If the blood sample contains antibodies specific to Covid-19, these will recognize the similar surface on top of the nanoparticles and bind to it. This adherence is visualized with the help of the fluorescent particles, which will specifically bind to the patient's antibodies.

Once processed in this way, the blood sample is dripped onto a Plexiglas plate that has been etched with a sophisticated pattern of nanochannels. There are several very narrow points along the course of these channels, which produce a strong capillary effect thanks to their specially developed shape. This effect draws the sample from the start to the end of the channel with no need for technical assistance. "As the antibody–nanoparticle aggregates pass through the nanochannels, they get stuck at particularly narrow points," explains Mortelmans. "The fluorescent appendages would allow physicians to observe this effect under a microscope and therefore to detect an infection with a high degree of sensitivity."

Thomas Mortelmans has now completed his doctorate at the SNI PhD School. He would come back to Basel at any time, as he recounts in a short video. (Image: T. Mortelmans)

"Based on the signal strength, it's also possible to identify whether the immune system is responding effectively and whether the disease is likely to be mild or severe," adds Dr. Yasin Ekinci, head of the Laboratory for X-ray Nanoscience and Technologies at the Paul Scherrer Institute PSI, who was one of the project leaders

Applicable to other tests

With this test principle, nanoparticles of a different size can also be added in order to bind to different antibodies. "These nanoparticles then get 'stuck' at a different point in the capillary, allowing us to detect a different disease using the same sample," says Mortelmans. In the prizewinning publication in *ACS Applied Nanomaterials*, he used influenza A viruses to demonstrate that the tests can be combined in this way.

Despite the positive results, further development of the system into a coronavirus test looks set to be discontinued due to a lack of reimbursement from health insurance funds. "With our work, however, the key thing is that we were able to prove that these kinds of tests can be used to detect various diseases. You could easily test for ten different diseases at the same time, detecting them quickly and reliably using different colors," explains Mortelmans.

Originally intended for mitochondria

When Mortelmans began his dissertation at the SNI PhD School in 2018, the focus was not initially on detecting SARS-CoV-2. Rather, the two project leaders Dr. Yasin Ekinci (PSI) and Professor Henning Stahlberg (then of the University of Basel; now at EPFL) had submitted a project proposal within the framework of the SNI PhD School for the development of a microfluidic diagnostic method for Parkinson's disease. The technique involved quantifying and determining the size of mitochondria, as the neurodegenerative disease is closely linked to the size and number of mitochondria in affected cells.

At about the same time, Mortelmans was in Belgium looking for a position as a doctoral student in the field of biomedicine. "I'd just completed my master's thesis at Hasselt University (Belgium) and was open to a new challenge," he recalls. "When I looked online for an interdisciplinary doctoral dissertation, the project at the SNI PhD School appeared right at the top of the list," he adds. "I was immediately drawn by the description, so I applied and quickly received an offer."

During this work, the test system was subsequently geared toward SARS-CoV-2 in early 2020, at which point Hennig Stahlberg had left the University of Basel and news of the first coronavirus cases had arrived from China. "Although I lost a couple of months as a result, it was very exciting to be working on such a topical issue," says Mortelmans.

Next step: the pharmaceutical industry

In July 2022, Mortelmans went on to receive the Swiss Nanotechnology PhD Award, which is sponsored by the company Sensirion, for the publication in which he, as first author, described the test system. He also completed his dissertation at about the same time, earning a top grade. Since September 2022, Mortelmans has been working as a trainee at Johnson & Johnson in Schaffhausen, where he's currently familiarizing himself with the various divisions of the global pharmaceutical company.

Further information:

Media release about the publication in ACS Applied Nanomaterials
https://nanoscience.ch/de/2022/01/24/neuer-schnell-test-koennte-parallel-corona-und-grippe-nachweisen/

Video
https://youtu.be/7VKskNZCoMc

Publikation in ACS Applied Nanomaterials
https://doi.org/10.1021/acsanm.1c03309

Video with Thomas Mortelmans about the SNI PhD School
https://youtu.be/9dqX_vimmcY

In his current role as a StepIn Trainee, he will undergo three rotations in various departments of the J&J site in Schaffhausen. Currently, he is assisting the Operational Support team of the Optical Inspection, Device Assembly and Packaging branch in various tasks, ranging from data analysis, to risk assessment and project development. The rotational program exposes Thomas to a lot of new technology and methodologies. “This requires that you are comfortable in communicating with people with different educational background. This is quite similar to being a PhD student at the SNI, where you are building the bridge between different scientific disciplines in the framework of an interdisciplinary project”, he reports.

Great time
Looking back, Mortelmans had a tremendous time at the Paul Scherrer Institute and the SNI PhD School. “I really enjoyed the interdisciplinary collaboration. Events such as the Winter School and the SNI Annual Event were real highlights and taught me a lot about different subject areas. Today, these insights allow me to consider problems from various angles,” he says. What’s more, it was no problem for him to belong to two institutions and two working groups at PSI and the University of Basel – actually, it turned out to be an asset.

Ending her doctoral dissertation on a high
Alexina Ollier receives an award for her presentation

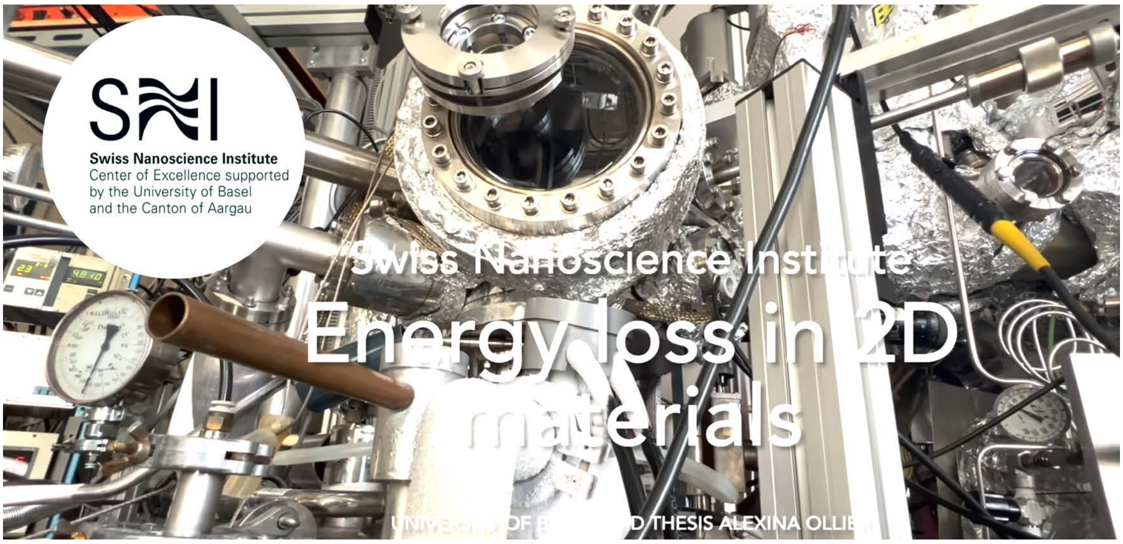
Former SNI doctoral student Alexina Ollier has been presented with the Young Researcher Award at the International Vacuum Congress 2022 in Sapporo (Japan). She received the award, which is sponsored by Canon Anelva Corporation, for her presentation on the electronic properties of single-layer free graphene sheets. As part of her SNI-supported doctoral dissertation, Alexina worked with atomically thin compounds of this kind and investigated energy losses in various two-dimensional materials.

Alexina Ollier received a Young Researcher Award at the International Vacuum Congress 2022 in Sapporo, Japan.

2D is unlike 3D
Two-dimensional materials such as graphene or molybdenum disulfide are the subject of worldwide research – including within the SNI network, where various groups are investigating the properties of these crystalline structures. Consisting of single atomic layers, the 2D materials have completely different physical properties from those of a three-dimensional crystal of the same material and are therefore of great interest for a wide range of applications – for example, in electronics or computer technology.

Over the last four years, Alexina Ollier has been working intensively with two-dimensional materials as part of her doctoral dissertation at the SNI PhD School, where she investigated energy losses and quantum effects in 2D materials of this kind.

Pendulum mode
Alexina carried out these investigations using a special atomic force microscope (AFM) that was developed in her working group, which is supervised by Professor Ernst Meyer at the Department of Physics of the University of Basel.



In a short video, Alexina explains how she studied energy loss in two-dimensional materials during her doctoral thesis at the SNI PhD School.

The AFM features a scanning cantilever probe that swings back and forth like a tiny pendulum. In order to carry out low-temperature measurements, the researchers position this oscillating pendulum perpendicular to the sample and then bring the sample and pendulum very close to one another. When an electric field is applied to the sample, energy losses lead to an interaction between the sample and cantilever probe, such that the oscillation of the probe decreases. Inside the AFM, this reduced oscillation can be offset by excitation to a higher energy level. The amount of excitation required is correlated with the energy loss, which can therefore be calculated.

Energy loss and quantum effects

This method is so sensitive that it can be used to investigate energy losses – also known as dissipation – in various two-dimensional samples. Researchers can also image quantum effects in order to obtain vital information and improve their understanding of 2D materials.

In the prize-winning presentation that Alexina Ollier delivered at the International Vacuum Congress 2022 in Sapporo (Japan), she specifically presented the properties of single-layer free graphene.

As part of her doctoral dissertation, Alexina also investigated molybdenum disulfide and a special double layer of graphene. This "twisted bilayer graphene" is made up of two graphene layers that are twisted relative to one another through the "magic angle" of 1.1°. What makes this material so special is that it exhibits various quantum mechanical phenomena – such as superconduction, for example, in which electric current can flow with no loss of energy.

Through her investigations with the AFM, Alexina was able to show that the three different 2D materials are very different from one another both in terms of energy loss and when it comes to quantum mechanical effects.

The free-floating single-layer graphene behaves in a similar manner to quantum dots. In other words, the movement of the electrons is highly restricted, and their energy cannot adopt continuous – but rather only discrete – values. In twisted bilayer graphene, Alexina observed that the energy losses oscillate as a function of the external magnetic field, probably as a result of quantum mechanical interference effects.

"Using pendulum AFM, Alexina Ollier was able to explore exciting questions relating to two-dimensional materials – and she discovered new physical phenomena in the process. It was amazing to see how she established numerous contacts within the SNI network, which was ultimately the key to her success."

Professor Ernst Meyer, Department of Physics of the University of Basel

Further information:

Research group Ernst Meyer
https://nanolino.unibas.ch/pages/intro.htm

Video with Alexina Ollier
https://youtu.be/gzIXDVMMDd0

Within an atomic layer of molybdenum disulfide, she then also identified a phase transition between ferromagnetism and paramagnetism. In paramagnetism, magnetization occurs only in the presence of an external magnetic field, whereas in ferromagnetism, magnetization persists for some time even without external magnets.

Deeper knowledge and greater confidence

In the meantime, Alexina has successfully defended her doctoral dissertation. The young researcher is keen to continue her research activity as a postdoc in another laboratory, and she is also excited to get to know another country and culture.

"When I came to Switzerland from France after my master's, I noticed a lot of differences," says Alexina. "In Basel, I enjoyed not only the freedom I had in my work but also the fact that my opinion really mattered."

All in all, Alexina thoroughly enjoyed her time in Ernst Meyer's team and at the SNI PhD School. She valued the numerous opportunities to present and discuss her work at the "Nanoscience in the Snow" Winter School and the Annual Event, and says she also learned a great deal at workshops such as the rhetoric course. "Because everyone got along so well, courses like these were also an opportunity to give each other open and honest feedback, which I found very helpful. As a result, I'm now able to present my work with certainty and self-confidence."

The recent award in Sapporo serves to confirm Alexina's appraisal. Not only has she produced some fascinating scientific insights in her doctoral dissertation, but she can now also present these findings in a clear and entertaining manner.

Medical nanosciences
A real enrichment of the nanoscience program

Since September 2021, the new specialization in medical nanosciences has been available to nanoscience students at the University of Basel. This offers a fascinating alternative to the existing specializations in physics, chemistry and molecular biology. We asked several students why they chose to major in medical nanoscience, what their initial experiences have been, and what subject areas they're working on as part of their master's studies.

A change was on the cards

In 2021, at the end of their bachelor's program in nanosciences, Alexa Dani and Tamara Utzinger considered switching to the master's degree program in biomedical engineering. After all, their interests lay in biological/medical issues, and they wanted their work to be as application-oriented as possible. When the medical nanosciences major became available in September 2021, however, switching was then out of the question and they both stayed on the nanosciences program.

The two young women are in agreement: "We definitely made the right decision! There's lots of scope for choice within medical nanosciences. We can register for lectures in both biomedical engineering and drug sciences, and the two project and the master's thesis we choose also give us insights into different areas – as well as teaching us to work across multiple disciplines," they say, summarizing the benefits of this specialization.

Application-oriented research

Alexa Dani, who came to Basel from Munich to study nanosciences four years ago, has experienced what it's like to work in an interdisciplinary field at the boundaries of medicine, biology and physics – especially during her project work at the start-up ARTIDIS. Indeed, she liked her work at the company so much that she's planning to do her master's thesis there. "I'm working toward approval of the ARTIDIS device, which can make rapid statements about the malignancy of a tumor and even provide

Tamara Utzinger, Michelle Arnet, Alexa Dani and Elaine Schneider are happy to be able to work on research projects that are close to a medical application with new specialization in medical nanosciences.

information relevant to a possible treatment," she says. As well as this direct impact of her work and the interdisciplinary nature of her task, she also enjoys the pleasant, familiar atmosphere at the company – whose roots go back to the group led by Argovia Professor Roderick Lim from the Biozentrum.

Tamara Utzinger would also like her research to make a concrete contribution to potential applications. Originally hailing from the Aargau, the young researcher began her master's thesis in Professor Andrew Yang's group at the University of California San Francisco in October 2022. There, she is investigating which immune cells can penetrate the blood–brain barrier and trigger inflammation in the brain in the event of neurodegenerative diseases. In the future, this knowledge may help physicians treat diseases of this kind.

Cells as the starting point for diseases

Master's student Philippe Van der Stappen was keen to gain some experience abroad and is currently carrying out research in Professor Alex de Marco's team at Monash University (Australia).

Right from the start of his nanoscience studies, Philippe was fascinated by the complexity of nature and its numerous "nanomachines" – such as human cells: "The interplay between these machines is beautifully coordinated and works perfectly in most cases. Due to the laws of physics and chemistry, however, the tiniest faults in these machines can give rise to diseases." Explaining his decision to major in medical nanoscience, the early career researcher says: "I think it's fascinating that we can improve our understanding of how diseases develop by studying cells in detail."

In his two projects so far, he was excited to use high-tech equipment for the detailed analysis of cell constituents. Now, he is using a plasma focused ion beam microscope that even allows researchers to remove individual regions of a cell. As part of his master's thesis, he is developing a procedure to isolate precisely the regions responsible for cell movement with a view to analyzing the proteins in those regions in their entirety. This research has implications for the investigation of cancer and degenerative and inflammatory diseases because tumor and immune cells are also mobile. Philippe enjoys this kind of research: "The work I do here is very exciting and varied – including everything from biology and engineering to programming and data analysis."

Alexa, Tamara and Philippe feel they are very well prepared for this demanding work thanks to the broad-based education they received not only in the nanoscience degree but also in lectures as part of the master's program – and they're pleased that they can always fall back on their interdisciplinary education.

Lectures provide orientation

Having only begun their master's studies in September 2022, Elaine Schneider and Michelle Arnet still aren't sure which area they want to focus on in their master's thesis – but both were so keen on the medical nanosciences course that it wasn't difficult for them to choose the specialization. Now, they want to get their bearings within the subject area by attending some lectures before deciding where to do their master's theses.

Elaine has already begun her first project. Having been interested in the neurosciences even before she started her nanoscience degree, she is now working with Professor Anne Eckert at the University of Basel's Department of Clinical Research. As part of this work, she is investigating changes in the bioenergetics of certain model cells for neurons under the influence of hormones.

In any case, the five students we asked agree that the specialization in medical nanosciences was an excellent way to expand the master's program in nanosciences. This new option means they can work on research projects that they find fascinating within the world of the nanosciences and that are, in some cases, highly application-oriented.

Further information

Master's program nanosciences, University of Basel
https://nanoscience.ch/de/studium/masterstudium

Make Nano Visible

In 2023, INASCON will once again be held in Basel

From 22 to 25 August, the International Nanoscience Student Conference (INASCON) will be held at the University of Basel. The event, which is expected to attract some 100 guests from all over the world, is being organized by a team of eight nanoscience students and doctoral researchers at the university.

A conference organized by students for students – that was the idea of the first International Nanoscience Student Conference (INASCON), which was held in Silkeborg (Denmark) in 2007. Since then, nanoscience students from Europe and further afield have come together for this conference 18 times in eight different countries. Under the motto "Make Nano Visible," the 2023 event will be the third time that the conference is hosted in Basel.

Alexa Dani is a master's student in Basel and is in charge of communication as part of the organizing team. "We're not only concerned with visualizing nanostructures using various microscopic methods," she explains. "Indeed, the effects and benefits of structures and phenomena on the nanoscale also make nano visible – and that's precisely what we want to talk about at the next INASCON."

In addition to eight scientific sessions addressing wide-ranging aspects of the nanosciences, the event will feature an "opportunity fair" at which companies and academic institutions can present themselves. There are also plans for excursions and communal dinners aimed at facilitating interdisciplinary discussions and networking between participants.

The organizing team still has a great deal to do before interested early career researchers come together for this interdisciplinary exchange at the University of Basel's Pharmazentrum in August. At present, Valerie Bendel, Mathias Claus, Alexa Dani, Timon Flathmann, Luca Forrer, Rahel Kaiser, Elaine Schneider and Lukas Schneider are meeting once a week to discuss details and make decisions. Between these meetings, the organizers work on the program and logistical questions such as accommodation and catering, as well as sponsoring, finances and communication.

The SNI team and Professor Christian Schönenberger are supporting them in these efforts, and we're very much looking forward to welcoming many dedicated young nanoscientists to Basel in summer.

Elaine Schneider, Lukas Schneider, Timon Flathmann, Alexa Dani, Luca Forrer, Rahel Kaier, Mathias Claus, and Valerie Bendel are organizing the next INASCON. (www.inascon.org)

"Organizing a conference is a feat of strength. The fact that a team of undergraduate and graduate students from the nanosciences is committed to INASCON for just this purpose is not a given. But the team will soon experience that the in-depth engagement with the content and the speakers is very rewarding."

Professor Christian Schönenberger

Guest article by Nicolai Jung
An unforgettable year at Harvard University

Since starting my degree, I had always planned to study at a university abroad in order to expand my horizons. I've now made this dream a reality by spending an amazing year at Harvard University in Boston, USA. This exciting time not only provided me with valuable scientific experience outside of Switzerland, but also taught me a great deal about founding a company and allowed me to expand my network. I even learned to play Quidditch.

Master's thesis was the ideal opportunity

Bearing in mind that the bachelor's program in nanosciences involves a busy timetable of lectures, internships and block courses, I decided to plan my stay abroad during my master's studies. This was relatively easy to do, as you only need to find one professor at the University of Basel who can supervise the research project as part of your master's thesis abroad.

A photo of me (left) and my closest friends from my time at Harvard in front of Harvard Medical School. (Image: N. Jung)

After completing various internships during the bachelor's and master's programs, I knew I wanted to write my master's thesis on malaria research and therefore searched online for research groups in that field. I wrote to 15 scientists in the USA, the UK and Australia and subsequently took part in numerous interviews. When I was offered a place in my first-choice research group, with Professor Manoj Duraisingh at Harvard University, I was ecstatic. I asked Professor Till Voss from the Swiss Tropical and Public Health Institute (Swiss TPH) at the University of Basel whether he would be prepared to supervise the project – and I applied for over 30 Swiss grants in order to fund my stay in Boston. Of these grant applications, five were ultimately approved – including the Argovia Travel Grant from the Swiss Nanoscience Institute.

A challenging endeavor

It was very exciting to arrive in the USA, and I found it very easy to settle in thanks to the well-structured and well-organized matriculation process set up by Harvard University for international students. I was given a warm welcome at the laboratory and quickly began work on my project, which involved developing a system for the protein expression of vaccine candidates to tackle the malaria pathogen *Plasmodium vivax*.

It is not yet possible to culture this eukaryotic single-celled parasite *in vitro*, and most of its proteins cannot be produced in other organisms by means of gene transfer. Accordingly, it's very difficult to develop vaccines against these parasites – which is one of the key objectives in the global fight against malaria.

My aim was therefore to design a new expression system that could transfer genes containing information about specific *Plasmodium vivax* proteins into malaria parasites that were genetically similar but, crucially, culturable. These pathogens would then produce the required proteins, which could be investigated with respect to their function, binding partners and structure. The proteins produced in this way could serve as the basis for developing a vaccine for the creation of therapeutic antibodies as well as nanobodies.

This work presented me with numerous challenges. Not only was I not used to that level of intellectual freedom when it came to solving a specific problem, but I was also solely responsible for the results. Although I suffered multiple setbacks and had to adapt the project several times, I ultimately learned a great deal and acquired many new skills.

Our Harvard Quidditch team at the national championships.(Image: N. Jung)

For me, the time spent at Harvard served as an excellent springboard into the world of research. Since November, I've had a position at the Walter and Eliza Hall Institute of Medical Research in Melbourne, Australia – once again in the field of malaria research. I might then go back to Boston next summer to do my doctoral dissertation, as I have only positive memories of the year I spent there.

Cultural differences

Over many long days, nights and weekends in the lab, I also saw how different the American and Swiss work cultures are when it comes to reconciling work and leisure time. Another cultural difference was the level of extracurricular commitment shown by my research colleagues, most of whom were involved in numerous sports and social clubs.

I, too, got involved in life outside the lab. For one, I joined the leadership team of Nucleate Boston, a student organization that supports the founding of companies in the life sciences. This taught me a great deal about the process of founding a company and about entrepreneurship, as well as allowing me to build up a large global network, as Nucleate is now represented at over 18 locations in the USA and Europe.

Initial laughter, then sweat

I also joined Harvard's official Quidditch team. Yes, that's right, Quidditch – the game from the Harry Potter books, in which players attempt to throw a ball into hoops or to catch the "Snitch." Not only is Quidditch a contact sport, like rugby, but it's also played while riding a broom.

When I first heard about it, I laughed, but I decided to give it a go because I wanted to try a sport I hadn't played before. This ultimately turned into quite an intensive commitment, with training sessions three times a week – but it was a great way to keep in shape, and the communal breakfasts or dinners afterwards were a good opportunity to meet new people and eat healthy. Our team even enjoyed some successes at the regional and national level.

Valuable experience

It's impossible to sum up a whole year of experiences and insights in the space of one or two pages. What has stayed with me the most, however, are the many talented people I met and how this year has furthered my personal development. I would recommend that all students do the same and spend some time abroad. It might involve some extra work at first, but it's definitely worthwhile!

Further information:

Research group Duraisingh:
https://sites.sph.harvard.edu/duraisingh-lab/

Nucleate Boston:
https://nucleate.xyz/locations/boston-ma/

Harvard Quidditch Team:
https://harvardquidditchclub.com

Walter and Eliza Hall Institute of Medical Research in Melbourne:
https://www.wehi.edu.au

More travel reports by students on the nanosciences program:
https://nanoscience.ch/de/studium/masterstudium/mobilitaet/

Events

In recent months, we've been able to make up for time lost over the last couple of years, as we've once again been able to hold large-scale events without elaborate safety measures – not only internally but also for an external audience.

Video: Highlights from the start of the Annual Event
https://youtu.be/4hBxGm0qSpM

Annual Event

This year's Annual Event was a very special occasion indeed. On the one hand, it was wonderful to have the opportunity to get together with colleagues again in a carefree manner in order to exchange ideas, learn about new developments in nanoresearch and discuss wide-ranging subjects. On the other hand, the event also reflected the change taking place at the top of the SNI. Christian Schönenberger was the host at the start of the meeting, but Martino Poggio assumed this role at the end of the second day. Martino took the opportunity to thank Christian for his enormous dedication to the SNI over the last 16 years and to nominate him as an honorary member of the institute.

This year, in response to requests from numerous SNI members, there was slightly more time for discussions with other members – a key aspect of this annual get-together of the interdisciplinary network. The topics of these discussions were as varied as those of the fascinating lectures and posters presented by doctoral students and project leaders, ranging from quantum communication to nanoelectronics and molecular nanomachines. Highlights included the late-night lecture on artificial intelligence given by Professor Tomaso Poggio (MIT, Massachusetts, USA) and the lecture by long-standing Argovia Committee member Dr. Walter Riess (IBM Research, Zurich), who shared some of his extensive experience in the world of research.

Award-winning doctoral students
Josh Zuber, from Professor Patrick Maletinsky's Quantum Sensing Lab, received an award for the best talk by a doctoral student, and Ajmal Roshan, who works in the groups of Professor Patrick Shahgaldian (FHNW) and Professor Jonathan de Roo (Department of Chemistry), received an award for his excellent poster.

Perhaps another thing that made this year's Annual Event so special was that it was the last to be held in the Lenzerheide region. Next year, the SNI network will meet at the Hallwilersee (Lake Hallwil) in the Canton of Aargau. We're already looking forward to continuing in this tradition of a meeting focused on interdisciplinary exchange across institutional boundaries in a new setting.

Video:
Highlights from the Nano-Tech Apéro
https://youtu.be/OStiNm20suA

Nano-Tech Apéro

This year, the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) hosted a well-attended Nano-Tech Apéro that brought together over 60 guests from research institutions and industry at the end of October.

The event focused on findings from current applied research projects in collaboration with industrial companies from Northwestern Switzerland. Presentations and posters by project leaders and industrial partners demonstrated the sheer variety of projects supported by the SNI as part of the Nano-Argovia program, and the event also included fascinating tours of four laboratories at the FHNW School of Life Sciences.

We're very grateful to FHNW and all of the speakers for the insights into their varied applied research, as well as to everyone who made it possible for us to enjoy tours of these impressive labs.

The Nano-Tech Apéro offers an ideal opportunity to learn about ongoing applied projects in the Nano-Argovia program, to establish contacts and to develop ideas for new projects.

Water-related experiments, shimmering chocolate and much more

Over recent months, the SNI's outreach team has been out and about more than ever before. Barely a week went by without an event where the SNI team shared their fascination with the natural sciences through fascinating examples.

All about water

For example, the SNI delivered several workshops for school classes as part of a collaboration with Museum Burghalde in Lenzburg. Here, pupils had the chance to discover all kinds of facts about water and, above all, to experience its special properties for themselves through a series of experiments.

A special exhibition on energy and water inaugurated by Museum Burghalde this year incorporated a water lab, including numerous experiments, designed by the SNI. We also provided several explanatory videos presenting the special properties of water in an easy-to-understand manner.

A concept with various stations

At this year's Science Days at Europa-Park Rust (Germany), numerous visitors were attracted to the SNI stand by glittering chocolate. Specifically, the SNI team used ChocoFoil to produce biscuits known as Basler Leckerli covered with chocolate that shimmered in rainbow colors thanks to a special microstructure.

Once at the stand, children, young people and adults had the chance to learn more about topics such as nanostructures, the lotus effect and ferrofluid at various experiment stations and to win prizes by taking part in a quiz.

At the Rüeblimärt in Aarau, visitors to the SNI stand had the chance not only to win something but also to experiment and learn more about the SNI's activities. At the ECOC and the Science Days, the focus was on optical experiments. Also schoolchildren were able to experience the exciting properties of water through numerous experiments at a workshop at the Burghalde Museum in Lenzburg.

Different target groups

This year, the SNI once again had a stand at the Rüeblimärt in Aarau, where the primary objective was to provide visitors to this popular market with information about the nanosciences in general and to highlight the Canton of Aargau's commitment to this subject area.

In addition, school visits by the SNI team gave numerous pupils the chance to engage with fascinating nanoscience topics. The two outreach managers, Dr. Kerstin Beyer-Hans and Dr. Michèle Wegmann, also delivered courses on atomic force microscopy as part of project days, for example, as well as presenting various nanoscience topics at the TecDays organized by the Swiss Academy of Engineering Sciences (SATW). These school visits were attended by several nanoscience students from the University of Basel, who presented the bachelor's and master's degree programs in nanosciences, as well as various research projects, and were on hand to discuss and answer any questions about the course.

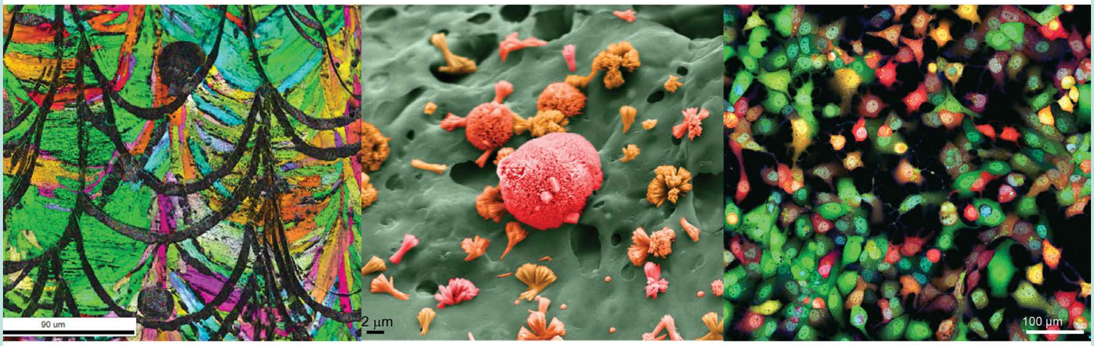
Teaching staff also benefited from various SNI programs. For example, physics teachers from Thun visited the Swiss Nanoscience Institute of the University of Basel for a program of continuing education where they gained insights into current research in physics through a series of lectures. The SNI's program at the European Conference on Optical Communication (ECOC) also gave numerous pupils a different perspective on the world of optics.

If you're interested in having the SNI team visit your school or would like to visit laboratories that form part of the SNI network, please contact us at:
sni-outreach@unibas.ch.

Nano Image Award 2022

We received a particularly large number of beautiful images this year and would like to thank everyone who participated in the contest. It was not easy to choose the three most beautiful images and we will try to use as many images as possible in our communication materials to share the beauty of the micro and nano world with a wide audience.

Winners of the Nano Image Award 2022



Additive Constructivism

Electron Backscatter Diffraction color crystal orientation map of a 3D-printed (additively manufactured) stainless steel, after etching the surface to reveal the melt pool tracks.

The materials is porous (pores seen as black dots at the tips of the melt pool tracks) which interrupts the epitaxial growth of the crystallites in the material during solidification. Therefore every melt pool consists of several small crystallites with different orientation.

Dr. Efthymios Polatidis and Christos Sofras
Laboratory for Neutron Scattering and Imaging (LNS), Paul Scherrer Institute

Spongy Nanoflowers

Grown crystals of fluoroapatite on a treated toothsurface.

The image was made in preparation of a publication that covers also results from the Nano Argovia project NanoCure.

Dr. Lucy Kind
FHNW School of Life Sciences, Muttenz

Lipid nanoparticles in transgenic cells

Analysis of human cells expressing a red fluorescent transgene by confocal microscopy. Cells were transfected using a lipid-nanoparticle (LNP) based gene delivery system.

Bright green signal: endosomal escape
Green signal: Galectin3-GFP,
Red signal: transgene RFP,
Cyan signal: cell nuclei
Blue signal: LNP

Claudio Alter, SNI PhD School,
Department of Pharmaceutical Sciences, University of Basel

Congratulations to all winners!

News from the SNI network

Portrait of SNI doctoral student Mitchell Brüderlin

The University of Basel recently portrayed SNI PhD student Mitchell Brüderlin as part of its summer series *In Focus*.

Mitchell Brüderlin, who comes from the Canton of Aargau, studied nanoscience at the University of Basel and was then so enthusiastic about one of the PhD School projects that he did not go abroad as originally planned, but stayed in Basel. In the portrait, he talks about his work at the Biozentrum and tells how he came to study nanoscience in the first place.

Link to article "Mitchell Brüderlin Is Sounding the Attack on Bacteria" (University of Basel)
https://www.unibas.ch/en/News-Events/News/Uni-People/In-Focus-Mitchell-Bruederlin-Is-Sounding-the-Attack-on-Bacteria.html

Mitchell Brüderlin at the SNI Winter School "Nanoscience in the Snow" 2022, where he won the Best Poster Award.

Nadine Leisgang and Thomas Karg win SPS awards for their doctoral theses.

Nadine Leisgang and Thomas Karg win SPS Awards for their PhD theses

The Swiss Physical Society (SPS) awards prizes to young physicists for outstanding research work in the early stages of their careers. In 2022, two former PhD students from the Department of Physics and the Swiss Nanoscience Institute received this prestigious award.

Short article
https://nanoscience.ch/en/2022/09/08/nadine-leisgang-and-thomas-karg-win-sps-awards-for-their-phd-theses/

Swiss Physical Society
https://www.sps.ch/preise/spg-preise/gewinner-2022

Uni News about paper (Nadine Leisgang)
https://nanoscience.ch/en/2020/08/12/a-highly-light-absorbent-and-tunable-material/

Uni News about paper (Thomas Karg)
https://nanoscience.ch/en/2020/05/08/laser-loop-couples-quantum-systems-over-a-distance/

SNSF Starting Grant for Murielle Delley

The Swiss National Science Foundation (SNSF) has awarded a Starting Grant to Prof. Dr. Murielle Delley from the University of Basel.

Murielle Delley has been an assistant professor at the Department of Chemistry at the University of Basel and a SNI member since 2021. Prior to that, she conducted research at Yale University, USA and ETH Zurich. With her SNSF project, Delley aims to pave the way for a more sustainable production of chemicals. To this end, she is researching heteroatomic defects in cobalt sulfides and oxides, which could be the key to a more efficient electrocatalysis.

Uni News, University of Basel
https://www.unibas.ch/en/News-Events/News/Uni-People/Seven-SNSF-Starting-Grants-for-the-University-of-Basel-.html

One new appointment and four promotions

The University Council has appointed Professor Murielle Delley as Assistant Professor of Inorganic Chemistry and granted four promotions in the Faculty of Medicine and the Faculty of Science.

In the Faculty of Science, Professor Sebastian Hiller and Professor Timm Maier will be promoted to full professor on February 1, 2023. Professor Dominik Zumbühl will be promoted to full professor at the Department of Physics as of the spring semester 2023.

Uni News, University of Basel
https://www.unibas.ch/en/News-Events/News/Uni-Info/One-new-appointment-and-four-promotions.html?mtm_campaign=UN_20221130_UR%20

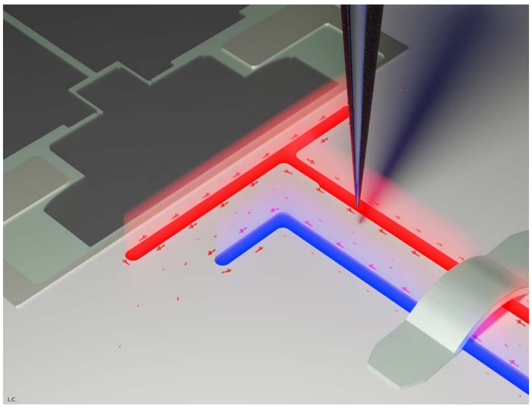
Prof. Murielle Delley. (Photo: Karissa Van Tassel)

Quantum interference device images current flow in qubit circuits

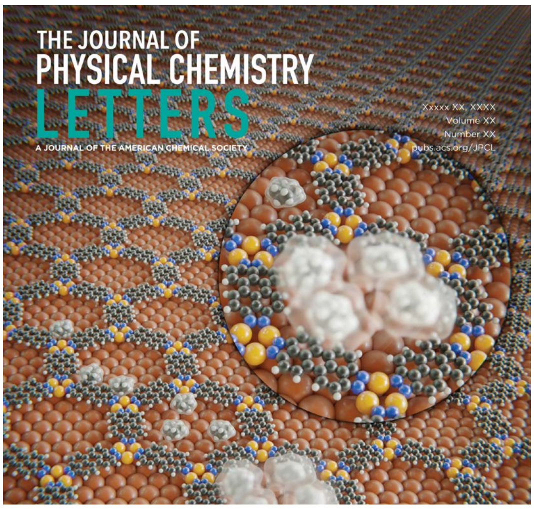
Physicists from the SNI network at the University of Basel and the ETH Zurich have used a scanning superconducting quantum interference device (SQUID) to image the current flow of a superconducting device developed for quantum computing. The data will help to optimize qubit control. The article was recently published in *Applied Physics Letters*.

Original publication Applied Physics Letters
https://aip.scitation.org/doi/10.1063/5.0103597

"Scilight" article summarizing the paper
https://aip.scitation.org/doi/10.1063/10.0013509



Map of the circuits magnetic field, showing the flow of current density within the device. (Image: Departement of Physics, University of Basel)



Cycloalkanes adapt their shape when trapped in tiny pores, researchers show on the cover of *The Journal of Physical Chemistry Letters*. (Image: Deptartment of Physics, University of Basel)

Dancing molecules

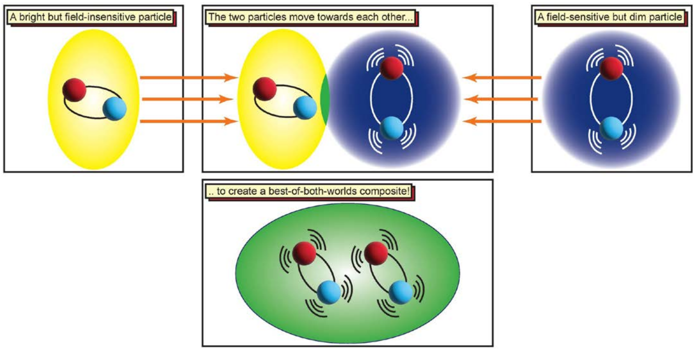
When cycloalkanes are enclosed in nanometer-sized pores, they adapt their shape – similar to the induced fit concept described in biochemistry. The molecules do not all behave the same way. With increasing lack of space and low temperatures below 5K, the molecules surprisingly start to move.

Researchers from the SNI network led by Professor Thomas Jung from the Department of Physics at the University of Basel and the Paul Scherrer Institute have demonstrated this using scanning tunneling microscopy images and published their findings in *The Journal of Physical Chemistry Letters.*

Original publication
https://pubs.acs.org/doi/full/10.1021/acs.jpclett.2c01592

Coupling of electron-hole pairs

For the first time, physicists from the University of Basel have succeeded in coupling different types of electron-hole pairs (excitons) in the van der Waals material molybdenum disulfide. This successful coupling allows them to utilize and control the different properties of the two types of electron-hole pairs – and could pave the way for the production of a novel source of individual particles of light (photons). Moreover, the study and modeling of exciton-exciton coupling is key to gaining a better understanding of the underlying semiconductor physics. In collaboration with colleagues from the University of Toulouse, the researchers recently published their findings in the journal *Physical Review Letters*.



The coupling of two different electron-hole pairs leads to a fusion of their properties. (Image: L. Sponfeldner, SNI and Department of Physics, University of Basel)

Uni News, University Basel
https://nanoscience.ch/en/2022/09/05/coupling-of-electron-hole-pairs/

Video
https://youtu.be/Sq_KVBM_WzI

Original publication
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.129.107401

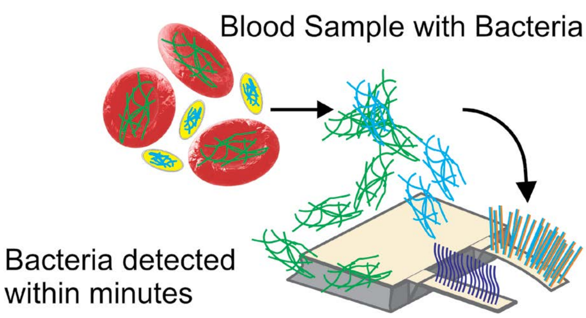
Ultracold circuits

Cooling materials to extremely low temperatures is important for basic physics research as well as for technological applications. By improving a special refrigerator and a low-temperature thermometer, Basel scientists have now managed to cool an electric circuit on a chip down to 220 microkelvin – close to absolute zero.

Uni News, University of Basel
https://nanoscience.ch/en/2022/09/22/ultracold-circuits/

Original publication
https://journals.aps.org/prresearch/abstract/10.1103/PhysRevResearch.4.033225

The cryostat used by the Basel physicists to reach a record temperature of 220 micro-Kelvin. The special thermometer along with a scale bar can be seen in the centre of the image (golden rectangle). (Image: University of Basel, Department of Physics)



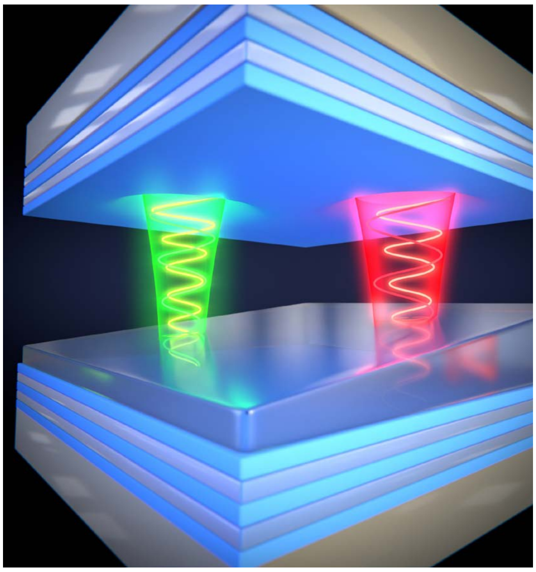
A nanomechanical sensor can detect bacteria in a blood sample (Image: Department of Physics, University of Basel)

Time-saving due to early diagnosis

Researchers from the SNI network have shown that nanomechanical sensors are ideally suited to quickly and reliably detect even a few bacterial germs in the blood. The interdisciplinary team describes in the scientific journal *Biosensors* that the method can be used to diagnose sepsis at an early stage – which gives more time for successful treatment.

Original publication
https://www.mdpi.com/2079-6374/12/11/994

Laser light of any wavelength



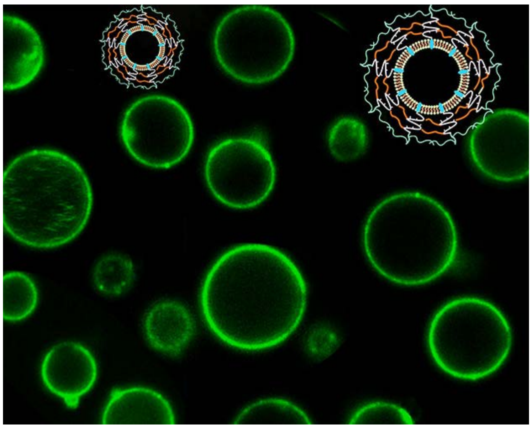
The platform with two closely spaced, highly reflective mirrors and a wedge-shaped diamond membrane paves the way for a universal, low-threshold frequency shifter for laser light. The paper was featured on the cover of the journal. (Image: Flågan, Riedel, and Scixel)

Researchers from the SNI network have developed a platform for the resonant enhancement for so-called nonlinear optical processes which could aid to produce laser light of any wavelength. They combine a wedge-shaped diamond membrane with two narrowly spaced, highly reflective mirrors (Fabry-Perot microcavity). In this way, the researchers can regulate the resonant frequencies of the microcavity, and thus the wavelengths involved in the nonlinear optical process, by the distance between the mirrors and by the thickness of the diamond membrane. In the scientific journal *Optica*, the team of scientists from Stanford, Calgary and Basel report that their approach can be applied to other material systems and nonlinear processes and could thus pave the way to a universal frequency shifter for laser light.

SNI News
https://nanoscience.ch/en/2022/10/24/laser-light-of-any-wavelength/

Original publication
https://opg.optica.org/optica/fulltext.cfm?uri=optica-9-10-1197&id=511097

Stable membrane for therapeutic carriers



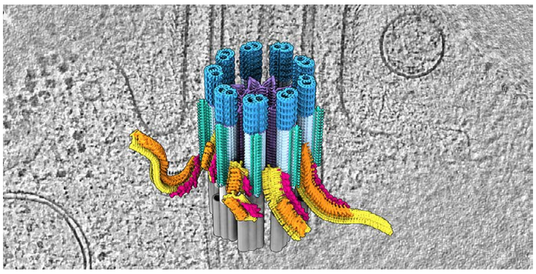
Giant Plasma Membrane Vesicles (GPMVs) under a Laser-Scanning Microscope. The membrane is colored green. The schematic shows the three domains of the cross-linked copolymer membrane. (Image: Department of Chemistry, University of Basel)

Cells can generate vesicles as a response to changes in their environment. Although such cell-derived vesicles have great potential for biomedical research, their membrane is fragile and they have tendency to cluster together. Researchers at the University of Basel have successfully introduced a strategy to overcome these issues by equipping the vesicular membrane with a stabilizing shell.

Uni News, University of Basel
https://www.unibas.ch/de/Aktuell/News/Uni-Research/Stabile-Membran-f-r-therapeutische-Transportvehikel.html

Original publication
https://onlinelibrary.wiley.com/doi/10.1002/adhm.202202100

Cilia in 3D: Miniature train station discovered

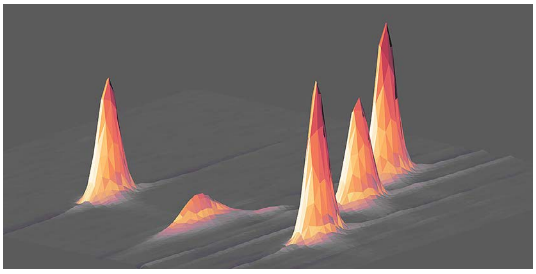


Cilia are highly complex transport hubs. Defects can lead to diseases, e.g. cystic kidneys or blindness.
(Image: Biozentrum, University of Basel)

Cilia are small hair-like organelles that extend from cells and perform many functions, including motility and signaling. Researchers have now revealed that cilia have a specialized transport hub at their base, where trains and cargos are assembled for transport throughout the cilia. Since defects in this cilia transport system can lead to, for example, cystic kidneys or blindness, the results published in *Science* also provide new insights into molecular basis for a variety of diseases.

Uni News, University of Basel
https://www.unibas.ch/en/News-Events/News/Uni-Research/Cilia-in-3D--Miniature-train-station-discovered.html

Original publication
https://www.science.org/doi/10.1126/science.abm6704

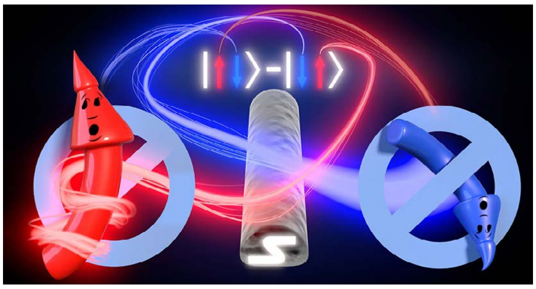


Detail of a three-dimensional representation of NMR measurement of a protein. (Image: University of Basel, Biozentrum)

Inauguration of the Swiss High-field NMR Facility

On 11 October 2022, the Swiss High-field NMR Facility was inaugurated with a scientific symposium at the Biozentrum of the University of Basel. The new technology platform is operated jointly by the Universities of Basel and Zurich and the ETH Zurich and offers researchers around Switzerland access to cutting-edge technology in the field of nuclear magnetic resonance (NMR) spectroscopy.

Uni News, University of Basel
https://www.unibas.ch/en/News-Events/News/Uni-Research/Inauguration-of-the-Swiss-High-field-NMR-Facility.html



Electrons leave a superconductor only as pairs with opposite spins. If both electron paths are blocked for the same type of spin by parallel spin filters, paired electrons from the superconductor are blocked and the currents decrease. (Image: University of Basel, Department of Physics/Scixel)

Spin correlation between paired electrons demonstrated

Physicists at the University of Basel have experimentally demonstrated for the first time that there is a negative correlation between the two spins of an entangled pair of electrons from a superconductor. For their study, the researchers used spin filters made of nanomagnets and quantum dots, as they report in the scientific journal *Nature*.

Uni News, University of Basel
https://nanoscience.ch/de/2022/11/23/spin-korrelation-zwischen-gepaarten-elektronen-nachgewiesen/

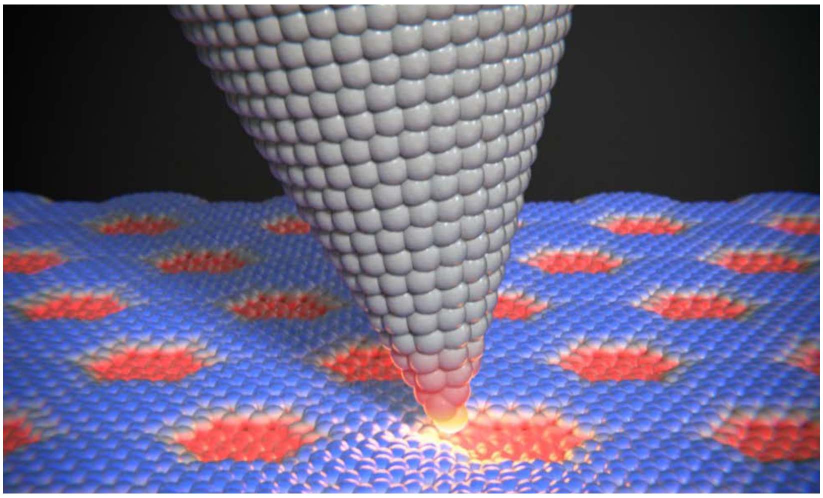
Original publication
https://www.nature.com/articles/s41586-022-05436-z

Unexpected speed-dependent friction

In the macro world, friction doesn’t depend on the speed at which two surfaces move past one another, but researchers from Basel and Tel Aviv have now observed precisely this effect in special graphene structures on a platinum surface.

Uni News, University of Basel
https://nanoscience.ch/de/2022/12/07/unerwartete-geschwindigkeitsabhaengige-reibung/

Original publication
https://pubs.acs.org/doi/10.1021/acs.nanolett.2c03667



Surprisingly, the friction between the tip of an atomic force microscope and the Moiré superstructures depends on the speed at which the tip is moved across the surface. (Image: Department of Physics, University of Basel and Scixel)

SNI INSight — Showcasing research and activities of the Swiss Nanoscience Institute

Concept, text and layout: C. Möller, M. Poggio
Translations and proof-reading: UNIWORKS (Erlangen, Germany)
Image: C. Möller and named sources

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