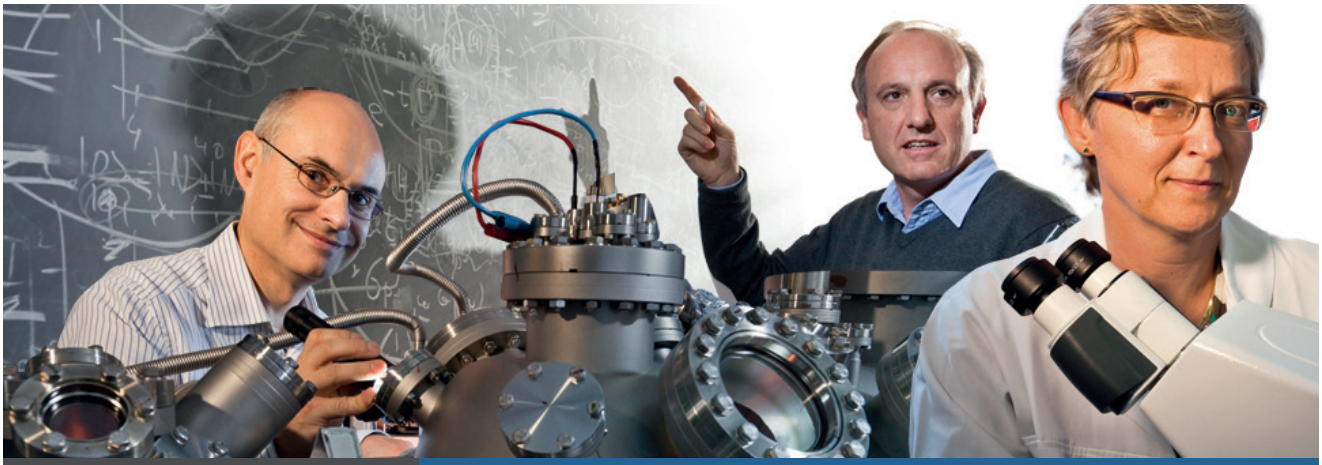


SNI
SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SNI update Oktober 2012

Words from the Editor

Dear colleagues

After a relaxing summer break, we had a busy start in the fall season and brought forward some of the important SNI projects that lie ahead of us. In mid September, the first workshop of our planned graduate school took place. Twenty-one enthusiastic PhD students were selected and used the chance to learn more about different aspects of intellectual property rights and to get to know instruments for the identification of personal strengths.

Additionally, previous PhD students reported on their careers in industry and thereby demonstrated how diverse career paths as a young scientist can be.

Currently, we are all busy writing the final report summarizing the twelve years of the NCCR Nano. We have to submit this document to the Swiss National Science Foundation along with our last annual report. I am confident that we will put together an impressive compilation of our success stories und appreciate your support in this endeavor. The finalization of our NCCR will take place simultaneously with next years Swiss Nano-Convention, which we will host in Basel from 22nd – 23rd May.

These current activities demonstrate that we are ideally prepared for the time after the NCCR. As planned since the beginning in 2001, the NCCR Nanoscale Science will be terminated by the end of May 2013 - but the Swiss Nanoscience Institute will continue to exist! We will focus on the education and support of young scientists as well as on applied research projects in the framework of the Nano-Argovia program. An exciting path is waiting for us - let us continue to tackle the route together.

Best regards

Christian Schönenberger

Director des Swiss Nanoscience Instituts, Universität Basel

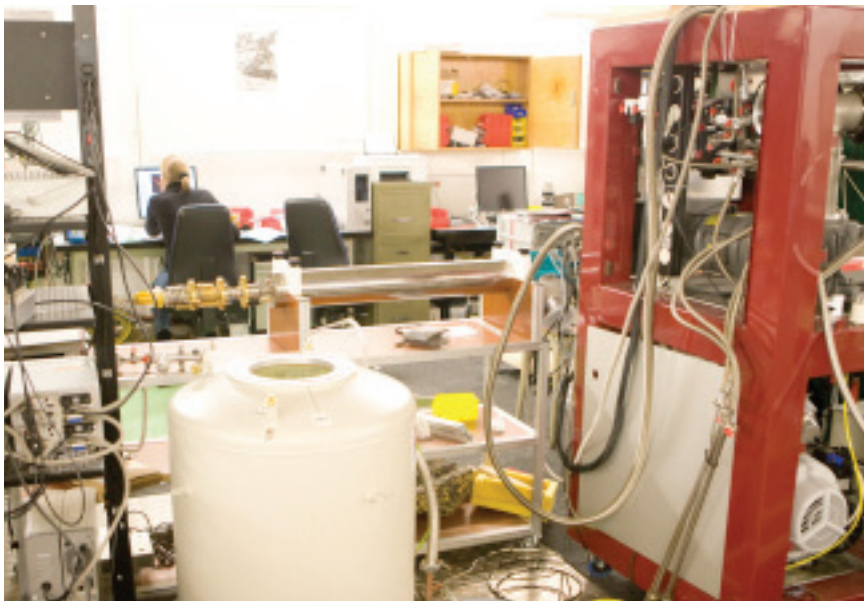
UNI BASEL

Cover Story

Breakdown of a natural law

The team of Professor Dominik Zumbühl from the Swiss Nanoscience Institute at the University of Basel recently demonstrated that at very low temperatures metallic Gallium-Arsenid behaves differently than was previously expected. These studies, which were carried out in close collaborations between researchers from the University of Basel and the IBM Research Laboratory in Rüschlikon, were recently published in "Physical Review Letters" and "Review of Scientific Instruments". The scientists proved that the Korringa law, which is important for metallic samples, is not valid for temperatures close to the absolute zero point. For the researchers it is quite a sensation to break down a universal natural law and in addition, the findings make the realization of a quantum computer a bit more likely.

Quantum computers depend on the laws of quantum mechanics. They will be able to perform much more complex calculation than current computers. Computers have been impressively improved within the last years. However, it is becoming more and more elaborate to locate even more switching elements on minimized chips. And still, calculations with huge data sets are problematic. A quantum computer could be the solution for these complex calculations. For tasks that current computers can only master within billions of years, the quantum computer would only need a couple of minutes. Simulations of climate or decoding would not be an issue any more. However, before such a super computer for these immense data sets can exist a lot of research still needs to be done. Quantum computing science has moved forward a lot in previous years and the Swiss Nanoscience Institute is one key player in that field.



Before a quantum computer can be utilized for complex calculations numerous theoretical hypotheses and practical experiments are necessary.

Neither zero nor one

For the realization of the quantum computer, several different approaches exist. All of them do not use – in contrast to current computers - zeros and ones as units of information. Instead, they work with qubits, which can display one as well as zero and are therefore in a hybrid state. Already in 1998, Professor Daniel Loss (University of Basel) and Professor David DiVincenzo (IBM) suggested using the spin of electrons as a carrier of these qubits. They developed this theory, as the electron spin normally is not determined and behaves similarly to an oscillating compass needle. The spin, the magnetic momentum of an electron, can be directed upwards or downwards and will only be defined by a measurement or by interactions with the surrounding structure. Another special feature of electron spins is the fact that the spins of different electrons can be dependent on each other. If one spin is measured, the spin of the other is immediately fixed. These phenomena, called superposition and coherence, do not occur and do not have an equivalent in our macroworld. They are difficult to understand, but they are the reasons that a quantum computer will be able to deliver immense processing power.

Stable as long as possible

On the path to the realization of a quantum computer there are numerous hurdles that researchers need to overcome. So it is essential to keep an isolated spin

stable as long as possible in order to save calculations or results. Therefore, it is necessary to cool down the electrons extremely. Here as well, scientists move in a range that is not known to us in our daily life. They aim for temperatures close to the absolute zero point. In recent years, the team of Professor Dominik Zumbühl at the SNI has provided major input to this problem and has overcome several obstacles. Whereas several years ago the electron spin could be maintained only for a couple of milliseconds, the group of Dominik Zumbühl managed to keep the spin stable for one second four years ago. Recently, the group together with researchers from the IBM Research Laboratory in Rüschlikon published studies, that show the potential for much longer time spans and therefore make the development of a quantum computer a bit more feasible.

Cooled faster than expected

In these experiments scientists made use of the fact that electrons in metallic Gallium-Arsenid are coupled with the nuclei of atoms in the semiconductor. The coupling can be applied to lead thermal energy from the electrons into the semiconductor and thereby cool the electrons.

According to a law postulated by Korringa in 1950, the efficiency of this cooling process increases linear to the temperature. In measurements, which were recently published by the team of Professor Zumbühl, the researchers were able to prove that the coupling is stronger than expected. At temperatures lower than 1 K, the relaxation time is shorter than it should be according to the Korringa law. This means that the nuclei take energy from the electrons faster than expected and that the electrons cool down more rapidly. For practical applications, these results imply that at temperatures close to the absolute zero point, electrons in a nanostructure can be cooled faster than anticipated. These findings are of high relevance for the realization of a quantum computer, as the system needs to be rapidly cooled down in order to keep it stable as long as possible. Thanks to the research of Zumbühl´s group, scientists in Basel now possess the coldest fridge worldwide that can be utilized for cool experiments in the quantum world.

Different approaches

Besides the Zumbühl lab, there are other groups working on problems related to the quantum computer in Basel. For several years, the team of Professor Daniel Loss has held a leading position in theoretical quantum science using the electron spin as carrier of information. The Department of Physics at the University of Basel also acts as co-leading house for the NCCR QSIT, which studies these and other quantum phenomena.

Worldwide, other approaches exist to realize a quantum computer. Some groups are trying to utilize the energy level in atoms and molecules or the flow of a current in a circular superconductor. Which if any of these approaches will finally lead to the development of a quantum computer is currently not obvious. In any case, scientists from the Swiss Nanoscience Institute are delivering essential contributions to a better understanding of the quantum world and the optimal use of it.

Measurements in the Zumbühl group are “cool”.

We introduce…

Dominik Zumbühl, Professor of Physics at the University of Basel and project leader at the Swiss Nanoscience Institute (SNI) and at the Center for Quantum Computing and Quantum Coherence (QC2)

Fascinated by Physics and driven by the desire to explore nature – that is how Professor Dominik Zumbühl describes himself. Although not even 40 years old, he has been doing research with his own group for the last six years at the Department of Physics in Basel. During this time, he has not only built up his team and received research grants worth several million Swiss Francs, but also contributed considerably to a better understanding of quantum physics. Based on results generated by his team, he recently published the breakdown of a natural law in close collaboration with researchers from the IBM Research Laboratory in Rüschlikon (see cover story of this issue).

Looking at Dominik Zumbühl´s CV, people might wonder why he joined the University of Basel after having worked at prestigious places like Standford University, Harvard and MIT. However, he feels very fortunate to be Basel, and for good reason: for several years, Basel was the leading house for the National Center of Competence in Research Nanoscale Science and has been able to gain the critical mass to conduct successful quantum physics research. When Dominik applied for the professorship in 2006, the Molecular Electronics team of Professor Christian Schönenberger had already built up an excellent infrastructure at the Department of Physics and was open for collaborations. In addition, with the teams of Professors Christoph Bruder and Daniel Loss, outstanding theoretical physicists were close by under the same roof. “I was pretty young when I was looking for a position as assistant professor,” he remembers. “For me it was most important to find a place where good research is possible. It was good luck that Basel was looking for an assistant professor at that time. For me the situation here is optimal.”

Important milestones

In these last years, Dominik has achieved a lot. In 2008, the European Research Council (ERC) has chosen his project “Coherence of Spins in Semiconductor Nanostructures“ from among 9000 applications and granted 2.3 million Swiss Francs for his research. His recent publications (http://zumbuhllab.unibas.ch/pages/publications.htm) prove that the money was well invested. If asked for the greatest success stories of the last years, he names the set-up of his lab and infrastructure. These days, his team is well trained and has set up a worldwide unique infrastructure that allows them to carry out different quantum physics experiments in parallel. “Now, we have probably discovered a new material possessing novel magnetic properties,” he adds. A couple of years ago, this was already predicted theoretically by Daniel Loss and his team.

In this new material the interaction of the nuclear spins is regulated mainly by electron spins and is considerably stronger than in other systems. This process can be compared with the coupling of electrons in superconductors. There, quantums of lattice vibrations take over the strengthened connection. The resulting magnetism has novel properties. The nuclear spins are not aligned collinearly as in a ferro-magnet but show a continuous twist between the individual spins. The consequence is a helical magnet with a wavelength that is determined by the wavelength of the electrons.

A couple of years ago, Dominik was asked for his goals during an interview. He responded that ideally his research should contribute to the solution of the coherence problem and that he hopes to discover new physical phenomena at low temperatures. Until now, he was not able to completely eliminate the coherence issue. However, he dramatically increased the coherence time. In his recent paper, he proved that at low temperatures, close to absolute zero temperature, a well established law of physics is not valid. In addition, he hopes to have found a new material. It looks like Dominik is on track to successfully fulfill his search for new phenomena!

Infected by the physics virus

Dominik is not only an enthusiastic researcher but he is a motivating and stimulating teacher as well. It is important for him to take along his students on the discovery of the quantum world. “I am fascinated about physics and would like to infect my students with the physics virus as well. The fascination to explore new phenomena is enthralling and it keeps you at work even if it is getting difficult.” This message comes across during his lectures. Students have already acknowledged his engagement by awarding him the “Golden Chalk” – a prize for the best lecture.

Dominik does not stop sharing his enthusiasm when he leaves the university. He gets involved with public events like “Zuckerwelten” or “TecDays” in order to introduce people of all ages to the quantum world. When he talks about his motivation to advance the development of the quantum computer, he does not go into scientific details. He rather highlights which benefits such a computer will provide and how much faster it will be. It will not replace the computer on our desks but maybe some computers in large data processing centers. Climate simulations or other complex calculations will be possible that nowadays cannot be accomplished by any existing computer. “We live in an exciting world”, Dominik points out. “Quantum Physics is more than 100 years old. But only today do we have the technology to prove theories experimentally.”

For many years, Dominik finds the balance to his diverse research activities playing piano. During his time at the Stiftschule in Engelberg he played the organ, parallel to his studies at the ETH in Zurich he visited the conservatory and when he moved back from the United States he took with him many music notebooks. However, 16 months ago the piano has got a powerful competitor. Since then, his little daughter Nilufar has been waiting to play with him and to be put to bed. And it seems that Dominik Zumbühl is even more fascinated by this more lively part of nature!

Domink is not only an enthusiastic researcher but he is a motivating and stimulating teacher as well.

Successful finalization of the NCCR

As planned from the beginning in May 2001, the first National Centers of Competence in Research will be finalized by May 2013. This holds true for the NCCR Nano as well. In a final summary that is requested by the Swiss National Science Foundation, we have the chance to demonstrate how successful the NCCR Nano has been. A lot of information is already available in recent annual reports. However, for some material we need your support. Please provide Audrey Fischer with the data we have requested recently (audrey.fischer@unibas.ch).

First workshop for planned graduate program

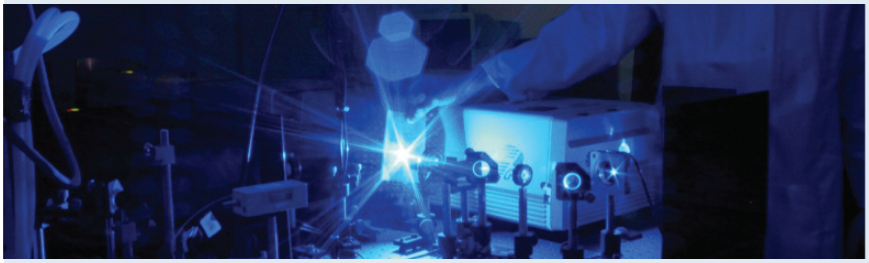
The SNI wants to provide a wide and diverse education for its graduate students. Therefore, we plan to implement a graduate program starting in 2013. The goal of the program is to provide excellent scientific supervision and additionally to teach other aspects of future careers.

Many PhD students only have a vague idea of their goals after their thesis. Stay in research, seek a job in industry or switch to marketing or communication instead? It is not clear to anyone where their own strengths lie and where these are needed. These and other topics were covered during the first SNI-workshop that took place from 11. – 12. September in Bad Ramsach. 21 selected PhD students had to opportunity to participate.

The first topic covered was Intellectual Property Rights. Wolfgang Henggeler, who is employed at Unitectra and works on patents of researchers from the University of Basel, gave some insight into the possibilities to protect intellectual property. Following the talk, the students themselves studied the possibility to protect a real invention and calculated possible earnings. They were surprised about the variety of details they had to consider during this exercise. Later during the day, Dr. Robert Sum, the founder of "Nanosurf AG", reported on the existing supporting possibilities for start-up companies, and on the role patents play for a KMU. He also explained how he became an experienced businessman on the job.

Invitation to information event

22th November 2012
4.15 pm – 6.30 pm
Aula of the University of Applied Science, Klosterzelstrasse 2
5210 Windisch



During the event, Regierungsrat Urs Hofman of the Canton Aargau will introduce the audience to the high-tech-strategy of the Aargau, which focuses on effective support of innovation and research. As one of the major pillars of this strategy, the Swiss Nanoscience Institute will present itself. A major part of the event will be covered by reports from industry representative who share their positive experiences during collaborations with universities.

Additional information at: www.nanoscience.ch

During the workshop students worked hard...

Dr. Lucia Grüter and Dr. Lars Zimmerli depicted how work in other companies looks like. They both finalized their thesis at the University of Basel a couple of years ago and were holding leading positions in different companies (Novartis, Glas Trösch, and Jendra Power).

...and exchanged experiences during the social activities in the rain.

The second day of the workshop concentrated on teamwork. In corporations, teamwork is often more complex than at universities. Deadlines are tighter and goals are rarely value-free. Therefore, scientific excellence is only one part of the recruiting process for positions in industry. It helps a lot to be prepared and to know ones own talents. Yvonne Ulrich (MeCoaching) introduced one of the widely used instruments to discover talents, the Gallup StrengthFinder. The StrengthFinder focuses on the talents of each individual and is used by many international companies as a management tool.

In the closing lecture of the event, the entrepreneur Klaus Nicklaus shared his experience with the audience and talked about his successful life. He covered his time as an apprentice and talked about the foundation and IPO of Esec AG. He impressively demonstrated how visionary ideas linked with enormous stamina lead to extraordinary results.

Press releases and Uninews

Basel, 10.10.2012. Milestone on the path to produce quantum-mechanically entangled electrons

In quantum physics, two particles sometimes occur in entangled states. This is crucial for future applications in quantum information processing. Until now, the controlled production of such particle pairs was difficult, especially for electrons, the basic building blocks of modern electronics. The research group of Professor Christian Schönenberger at the University of Basel, has recently generated a sufficiently high number of entangled electrons in an elegant process, which allows further experiments or applications. The work was recently published in the prestigious journal «Physical Review Letters».

Basel, 29.08.2012. Unexpected cooling effects

In experimental physics, the cooling down to very low temperatures can lead to the discovery of new natural laws. Together with scientists from IBM Research Laboratory in Rüschlikon, the group of Prof. Dominik Zumbühl of the University of Basel has recently observed the breakdown of a natural law in nanostructures at very low temperatures. These findings might have important consequences for the development of a quantum computer. Together with colleagues from the Aalto University in Finland, the physicists from Basel were able to develop the coldest fridge for nanostructures. Results were recently published in “Physical Review Letters” and “Review of Scientific Instruments”.

Basel, 10.6.2012. Constricted blood vessels: Researchers from Basel and Geneva develop nanocontainer

Scientists from the University of Basel and the University Clinics in Geneva developed so called nanocontainers in order to successfully treat constricted blood vessels in artheriosclerotic patients. These nanocontainers are able to transport drugs and to specifically release them close to the constrictions. Side effects will be decreased utilizing this targeted method. Results were recently published in "Nature Nanotechnology".

Basel, 2.5. 2012. Sustainable solar cells out of frequent metals

After the tragedy in Fukushima, the necessity to find alternatives to nuclear power became even more evident. Currently, many technologies are intensively investigated. However, the sustainability of the materials is often neglected. A process that uses expensive and rare resources will not be established in mass production. Recently, chemists of the University of Basel described a groundbreaking approach to build low-priced and sustainable, dye-sensitized solar cells. The original paper was recently published in the renowned science journal „Chemical Communications". The approach presented is based on zinc – one of the most frequent elements in the earth crust.

In the media

Aargauer Zeitung, 29.6.2012. Canton supports research because Nano and Aargau are siblings

The canton Aargau financially supports the Swiss Nanoscience Institute at the University of Basel with 5 Million Swiss Francs. In return, Basel waives his rights to ask for payments regarding equalization of burden (Kulturlastenausgleich).
http://www.aargauerzeitung.ch/aargau/kanton-aargau/kanton-unterstuetzt-die-forschung-weil-nano-und-argovia-geschwister-sind-124733609

Aargauer Zeitung, 22.8.2012. Approach between small and medium-sized companies and science

Experts of different disciplines met in the lecture hall of the University of Applied Science in Windisch to discuss contact points and financial support for collaborations between university and small and medium-sized companies. Large corporations already benefit from technology and know-how transfer with universities and research institutions. Partnerships like this offer great changes for smaller companies as well. The meeting in Windisch focused on "Support for innovation: opportunities for small and medium-sized companies". The Service Center of the region Brugg (Brugg Regio) and the Standortförderung Aargau Services organized the event and successfully brought together science and small and medium-sized companies.

Please contribute

Please give feedback and submit ideas, success stories and news that might be of interest for the SNI community to the editorial team:

Dr. Christel Möller (c.moeller@unibas.ch) and
Dr. Tibor Gyalog (tibor.gyalog@unibas.ch).