University of Basel

Swiss Nanoscience Institute

Swiss Nanoscience Institute
Center of Excellence supporte
by the University of Basel
and the Canton of Aargau

# SNI Annual Meeting 2022

## 7 - 9 September
## Lenzerheide

**Swiss Nanoscience Institute**
**University of Basel**

Klingelbergstrasse 82
4056 Basel
Switzerland

**www.nanoscience.ch**

Cover image: Scanning electron microscopy image of the skin (horny keratin scales) of slowworm (*Anguis fragilis*) found dead and dry in Oberwil BL (photo), Switzerland. (Massimo Trifone and Sina Saxer, NanoLab FHNW)

***Contents***



Bildquelle: outdooractive.com

## *Welcome Words*

Dear colleagues,

This year's Annual Event is a very special one. It is the last time that the SNI community meets in Lenzerheide and it is also the last Annual Event under my leadership as SNI director. As you probably all know, I handed over my responsibilities to Martino Poggio at the end of July.

I think, we all enjoyed the atmosphere in Lenzerheide a lot in recent years, but often didn't take the time to enjoy the beautiful surrounding. We have therefore extended the meeting by one day – that will allow us to spend some time outside the meeting room and also provide even more chances to get to know each other better and to network.

The highlight of our meeting is still the diverse and exciting scientific program. In the keynote lectures Alexander Grimm (Paul Scherrer Institute) will talk about his work in quantum information processing and Sebastian Hiller (Biozentrum, University of Basel) will provide an insight into his research on NMR spectroscopy to unravel biomolecular mechanisms. In addition, Dr. Walter Riess from the IBM Zurich Research laboratory, a long year member of the Argovia Ausschuss, will tell us about his career path and insightful lessons to learn. We also have the pleasure to welcome Martino's father, Tomaso Poggio (MIT, Massachusetts, USA), to our Annual Event. He will give the late-night lecture and will introduce us into the world of artificial intelligence.

In addition, PIs from the Nano Argovia program and PhD students will present their latest findings in talks and during the poster session. There is quite a large number of new SNI members on the participants list. I am sure that the Annual Event is the perfect occasion to start the SNI membership and to connect to many people in the network.

We once made a survey to find out what you see in the SNI, what added value it brings to you. While some of you, not too surprisingly, stated that the SNI is another opportunity for funding, most however told us that they see the strong network within Northwestern Switzerland as the major added value. In fact, this was the mission that was formulated in the contract between the canton Aargau and the University of Basel when the SNI was founded in 2006. Since then, this was the guiding line for me as the director. Personally, I am very satisfied to see that the SNI succeeded to become a catalyst for stronger active collaborations between major scientific partners and industries in the region. I wish that the SNI will run many more years, that we will get our "own building" with a state-of-the-art cleanroom and develop further under the guidance of the new director Martino Poggio.

I thank you all for your enthusiasm for the nanosciences and the excellent work in recent years and wish us all an exciting, informative meeting with numerous fruitful discussions.

Best wishes,

Christian Schönenberger

## *Program*

### Wednesday, 7 September 2022

| | |
|---|---|
| 18:15 | Registration open |
| 18:30 | Opening words: Christian Schönenberger |
| 18:30-20:00 | Poster session und Apéro |
| 20:15 | Dinner |

### Thursday, 8 September 2022

| | |
|---|---|
| 07:00 | Breakfast |
| **Session 1** | |
| 08:40–09:20 | Keynote: Alexander Grimm |
| 09:20–09:40 | Annika Huber |
| 09:40–10:00 | Fabian Züger |
| 10:00–10:20 | Maria-Elisenda Alaball Pujol |
| 10.20-10:50 | Coffee Break |
| **Session 2** | |
| 10:50-11:30 | Invited talk: Walter Riess |
| 11:30-11:50 | Samuel Treves |
| 11:50-12:10 | Iris Martyn |
| 12:10 | Announcements for the afternoon, distribution lunch packages |
| **Afternoon activities:** | |
| | bike tour, hike easy, hike middle, hike active, art museum, train museum, spa |

| | |
|---|---|
| 19:00-21:00 | Dinner |
| 21:30 - 22:30 | Late Night Lecture : Prof. Dr. Tomaso Poggio |

### Friday, 9 September 2022

| | |
|---|---|
| 07:00 | Breakfast |
| **Session 3** | |
| 08:40–09:20 | Keynote Speaker: Sebastian Hiller |
| 09:20–09:40 | Shichao Jia |
| 09:40–10:00 | Melissa Carrillo |
| 10:00–10:20 | Jacopo Oswald |
| 10:20–10:50 | Coffee Break |
| **Session 4** | |
| 10:50-11:20 | Invited talk: Bojan Resan |
| 11:20-11:40 | David Jaeger |
| 11:40-12:00 | Josh Zuber |
| 12:00-12:20 | Joachim Köser |
| 12:20–12:30 | Closing Remarks: Martino Poggio |
| 12:30 | End of Meeting |
| 12:30 | Distribution lunch packages |

***Summary Talks***

| Last name | First name | Title | Date | Time | Page |
|---|---|---|---|---|---|
| Alaball Pujol | Lis | Quantifying bacterial responses to antibiotics at the single-cell level | 08. Sep | 10:00 | 11 |
| Carrillo | Melissa | Fixed-targets for time-resolved serial protein crystallography at SwissFEL | 09. Sep | 09:40 | 18 |
| Grimm | Alexander | Bosonic quantum information processing with Schrödinger cat qubits | 08. Sep | 08:40 | 8 |
| Hiller | Sebastian | Integrative structural biology of molecular nanomachines | 09. Sep | 08:40 | 16 |
| Huber | Annika | Self-assembling platinum (II) complexes from molecular nanowires towards amplified chiral recognition | 08. Sep | 09:20 | 9 |
| Jaeger | David | Towards hybrid optomechanics with hexagonal boron nitride | 09. Sep | 11:20 | 21 |
| Jia | Shichao | Ultrasound actuated acoustic rotors in air and in water: from protein crystallography to mechanobiology applications | 09. Sep | 09:20 | 17 |
| Köser | Joachim | Microstructured and biofunctionalized hydrogel-based periodontal LIGAment RECOnstitution device | 09. Sep | 12:00 | 23 |
| Martyn | Iris | Automatic design of heteromeric supramolecular nm-sized molecular containers | 08. Sep | 11:50 | 14 |
| Oswald | Jacopo | Graphene-organic semiconductor interfaces for vertical organic transistors | 09. Sep | 10:00 | 19 |
| Poggio | Tomaso | The science and the engineering of intelligence | 09. Sep | 21:30 | 7 |
| Resan | Bojan | Blue laser diode pumped Titanium:Sapphire sub 100 fs laser amplifier for nanomachining | 09. Sep | 10:50 | 20 |
| Riess | Walter | A brief reflection about sections of my life A journey which I did not expect to happen | 08. Sep | 10:50 | 12 |
| Trevers | Samuel | Observation of metastable skyrmion lattice in NdMn2Ge2 at room temperature | 08. Sep | 11:30 | 13 |
| Zuber | Josh | Towards all-optical single spin magnetometry | 09. Sep | 11:40 | 22 |
| Züger | Fabian | Towards electrically conductive dual-scale cell culture nano-scaffolds mimicking anisotropic cardiac tissue | 08. Sep | 09:40 | 10 |

## *Summary Posters*

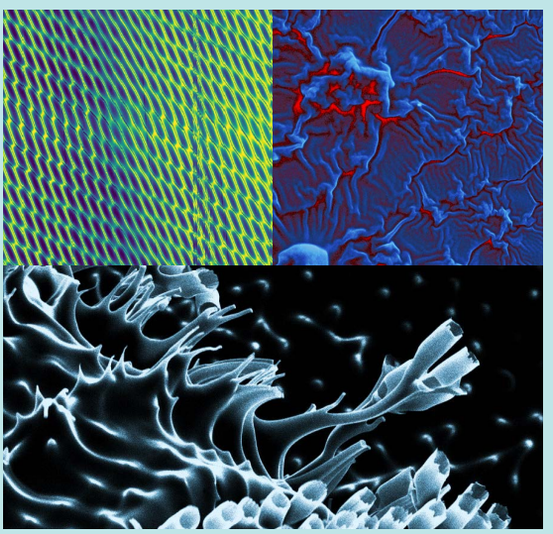
# Nano Image Award

Whether in the Annual Report, in a flyer or on postcards, fascinating images from the micro and nano worlds make our communication materials particularly striking.

We are therefore once again looking forward to receiving your beautiful images submitted for the Nano Image Award.

Please send your images together with a title and a short description (including size bar) by November 22, 2022 to: c.moeller@unibas.ch.

The three most outstanding images will receive prize money of 300 Swiss francs each and might become the cover image of one of our brochures.



# Nano Argovia program: Call for proposals

We are looking forward to receiving your project proposals in the applied research program Nano Argovia.

Please submit your application containing all documents in the required form by 30 September 2022 latest to admin-sni@unibas.ch

**Further information:**

https://nanoscience.ch/en/research/applied-research/

**Forms and guidelines:**

https://nanoscience.ch/en/research/applied-research/call/

***Late Night Lecture***

*Thursday, 8 September 2022*
*21:30-22:30*

# The Science and the Engineering of Intelligence

Tomaso Poggio

Eugene McDermott Professor
Director Center for Brains, Minds and Machines (CBMM)
Core founding scientific advisor, MIT Quest for Intelligence
McGovern Institute, CSAIL, Brain Sciences Department
M.I.T.

In recent years, artificial intelligence researchers have built impressive systems. Two of my former postdocs – Demis Hassabis and Amnon Shashua – are behind two main recent success stories of AI: AlphaGo and Mobileye, based on two key algorithms,both originally suggested by discoveries in neuroscience: deep learning and reinforcement learning. Recent engineering advances of the last 4 years – such as transformers,perceivers and MLP mixers – prompt an interesting question: will science or engineering win the race for AI? Do we need to understand the brain in order to build intelligent machines?

A deeper question is whether there exist a theoretical explanation – a common motif– to the various network architectures, including the human brain, that perform so well in learning tasks. I will discuss the conjecture that this is a property of our physical world in which functions of many variables must effectively be compositional functions with constituent functions each depending on a small number of variables.

***Keynote lecture***

*Thursday, 8 September 2022*
*8:40 - 9:20*

# Bosonic quantum information processing with Schrödinger cat qubits

Alexander Grimm
Paul Scherrer Institut, LNQ, Bosonic quantum information group, Forschungsstrasse 111, 5232 Villigen

**Abstract**
Quantum two-level systems are routinely used to encode qubits but tend to be inherently fragile, leading to errors in the encoded information. Quantum error correction (QEC) addresses this challenge by encoding effective qubits into more complex quantum systems. Unfortunately, the hardware overhead associated with QEC can quickly become very large.

In contrast, a qubit that is intrinsically protected against a subset of quantum errors can be encoded into superpositions of two opposite-phase oscillations in a resonator, so-called Schrödinger-cat states [1]. This "Schrödinger-cat qubit" has the potential to significantly reduce the complexity of QEC. In a recent experiment, we have demonstrated the stabilization and operation of such a qubit through the interplay between Kerr nonlinearity and single-mode squeezing in a superconducting microwave resonator [2].

In this talk, I will review some key concepts of QEC and situate our approach within the field. Then, I will give an overview of the cat qubit, followed by an outlook on different applied and fundamental research directions it enables. Finally, I will highlight the nanofabrication aspects that are relevant to the implementation of this type of qubit.

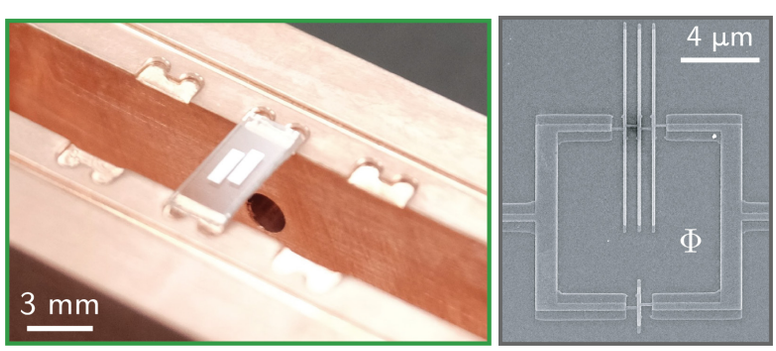



Fig. 1: Left panel: a sapphire chip holding the circuit used to implement a Schrödinger-cat qubit inside a microwave cavity. Right panel: Nonlinear inductor built from nanofabricated Josephson junctions used in our device (adapted from [2]).

**References**
[1] Mirrahimi, M. **et al. New J. Phys. 16**, 045014 (2014)
[2] Grimm, A. , Frattini N.E., **et al. Nature 584**, 205–209 (2020)

*Thursday, 8 September 2022*
*9:20–9:40*

# Self-assembling platinum (II) complexes from molecular nanowires towards amplified chiral recognition

SNI PhD Project P1908

Annika Huber, Oliver Wenger, Christof Sparr
University of Basel, Chemistry Department, St. Johanns Ring 19, 4056 Basel

**Abstract**
Our main ambition is to create a molecular material with sensing properties for volatile organic compounds (VOC) and chiral recognition. This conceptually new class of nanowires, chiral-nose-type chiral superstructures, will be based on self-assembled platinum complexes. Square-planar Pt(II) complexes have a strong tendency to aggregate with short metal-metal contacts. This can lead to extended one-dimensional structures exhibiting high electric conductance, vapochromism, and photoluminescence (Fig. 1)[1]. Recent research suggests that nanowires from chiral Pt(II) complexes give access to helical superstructures with unusual properties [3, 4]. By combining axially chiral organic molecules [5] with square planar Pt-coordination complexes, we hope to achieve unique photophysical and new macromolecular sensing properties.

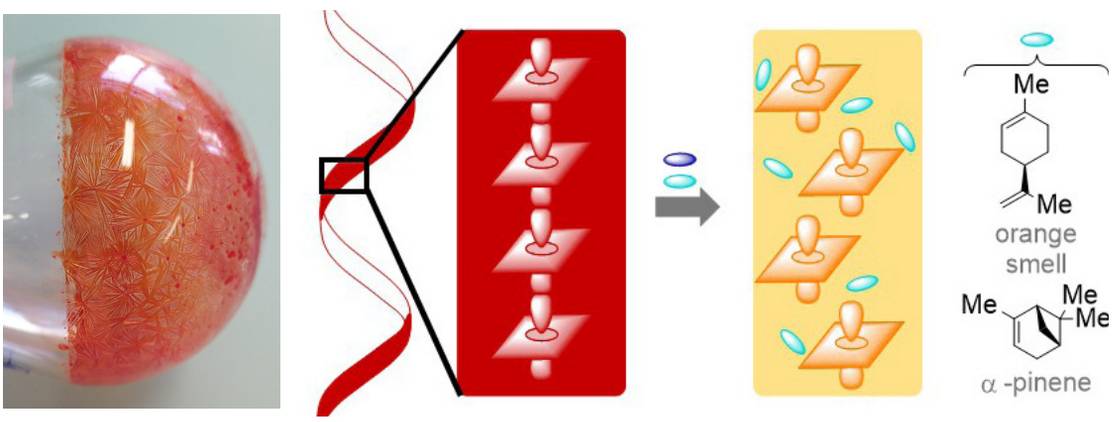



Fig. 1: Colourful Pt-complex material (left). Sensing principle of nanowires from stacked Pt(II) complexes (middle). Potential chiral VOC analytes (right).

In parallel, we started a second project, in which we investigate interaction-induced stereoselective chromium (III) complex formation. One key goal is to generate circularly polarized luminescence [6, 7]. These parallel investigations furthermore consolidate the photo-physical characterization techniques and analysis.

**References**
[1] O. S. Wenger et al., Chem. Rev. **113**, 3686-3733 (2013)
[2] H. B. Gray et al., Inorg. Chem. **36**, 913-922 (1997)
[3] Y. You et al., Inorg. Chem. 60, **11**, 7738-7752 (2021)
[4] J. Krämer et al., Chem. Rev. **122**, 3459–3636 (2022)
[5] C. Sparr et al., Angew. Chem. Int. Ed. **57**, 17189-17193 (2018)
[6] J. R. Jiménez et al., J. Am. Chem. Soc. **141**, 13244–13252 (2019)
[7] J. R. Jiménez et al., Dalton Trans. **49**, 13528-13532 (2020)

*Thursday, 8 September 2022*
*9:40–10:00*

# Towards electrically conductive dual-scale cell culture nano-scaffolds mimicking anisotropic cardiac tissue

SNI PhD Project P1902

Fabian Züger, Anna Marsano, Martino Poggio, Maurizio R. Gullo
FHNW Muttenz, Institute of Medical Technology and Medical Informatics, 4132 Muttenz

**Abstract**
Cardiovascular diseases are one of the most common causes of hospitalization and death in the industrialized world becoming a leading global threat of the 21st century. Myocardial infarction, followed by a loss of cardiac tissue, causes an impairment of heart functionality. This impairment coupled with a very low intrinsic regenerative capability of the cardiomyocytes (CM) and their sophisticated electrophysiological properties, urges the need for novel biofabrication methods to generate new cardiac tissue models and human tissue substitutes[1, 2].
In this project, a combination of 3D-bioprinting along with electrospinning is used to generate and stack different length scale scaffold features, an important attribute of extracellular matrix (ECM), essential for cell organization and tissue maturation [3]. Electrospun nanofibers (NF) are layered on a 3D-printed micro fabricate resulting in a dual scale construct. To mimic the electronic coupling of cardiac cells, which is a crucial element for proper maturation of the neonatal cells, the NFs are conductive [2].

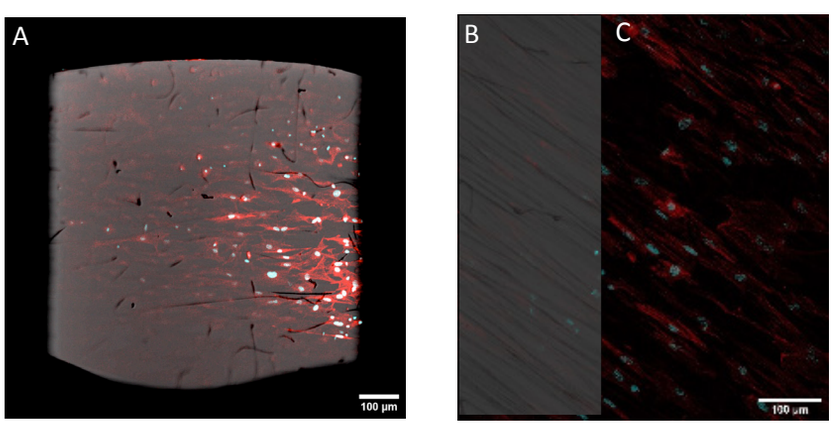



Fig. 1: A) Fluorescent micrograph of NRFBs grown for 3 days on the dual scale construct, 20X, TRITC (red) and DAPI (blue) staining; B) Brightfield image of NRCMs grown on aligned and conductive NF for 3 days, 20X; C) Corresponding fluorescent micrograph displaying the aligned NRCMs, 20X.

After successful production of conductive NF, by doping a polycaprolactone (PCL) solution with carbon nanotubes and cell experiments with neonatal rat fibroblasts (NRFBs) on the dual scale construct (Fig. 1A), first cardiac cell experiments, using neonatal rat CMs (NRCM) are being carried out on NFs in order to study cell alignment, growth and adhesion on conductive aligned NFs versus nonconductive NFs (Fig. 1 B/C). First results indicate that conductive NFs don't show any negative influence on cell alignment and proliferation compared to non-doped NFs. These results are a promising initial step towards electrophysiological and structural relevant cardiac tissue models. Further experiments on the aforementioned conductive construct, concerning cell maturation and proliferation, are currently under investigation.

**References**
[1] M. K. Baig et al., Am. Heart J., vol. 135, no. 6, Supplement, pp. S216–S230, Jun. (1998)
[2] Züger, F., Marsano, A., Poggio, M. & Gullo, MR. Advanced NanoBiomed Research **2**, 2100108 (2022)

*Thursday, 8 September 2022*
*10:00–10:20*

# Quantifying bacterial responses to antibiotics at the single -cell level

SNI PhD Project P1805

Maria-Elisenda Alaball Pujol, Michael Mell, Erik van Nimwegen, Thomas Julou
Biozentrum, Faculty of Science, Klingelbergstrasse 50-70 4056 Basel

**Abstract**
One of the main challenges in the treatment of bacterial infections is that current antibiotics often fail to eradicate the whole bacterial population. Even genetically identical cells can take on highly heterogeneous physiological states with slow or non-growing cells being less susceptible to the treatment. Most methods for the discovery and study of antimicrobial compounds are based on bulk population assays that assess the effects on the fastest-growing cells and slow or non-growing cells are outcompeted, making it difficult to identify new compounds. In recent years, more powerful methods have been developed to quantitatively measure behaviour and responses in single bacterial cells exposed to dynamically changing environments. We are developing a combined microfluidic, time-lapse microscopy, and image- analysis setup that allows us studying quantitatively the effects of antimicrobial compounds on single cells, to understand how their physiological and gene expression state determines their response to different antibiotics. Besides, we are developing new microfluidic designs that enable the study of multiple antibiotics and strains in parallel. Our methods will allow the identification of compounds that specifically target these subpopulations, which could in the future complement existing treatment strategies. This project has a potential impact on antimicrobial drug discovery and treatment design, by allowing screening for compounds that effectively kill slow or non-growing cell populations.

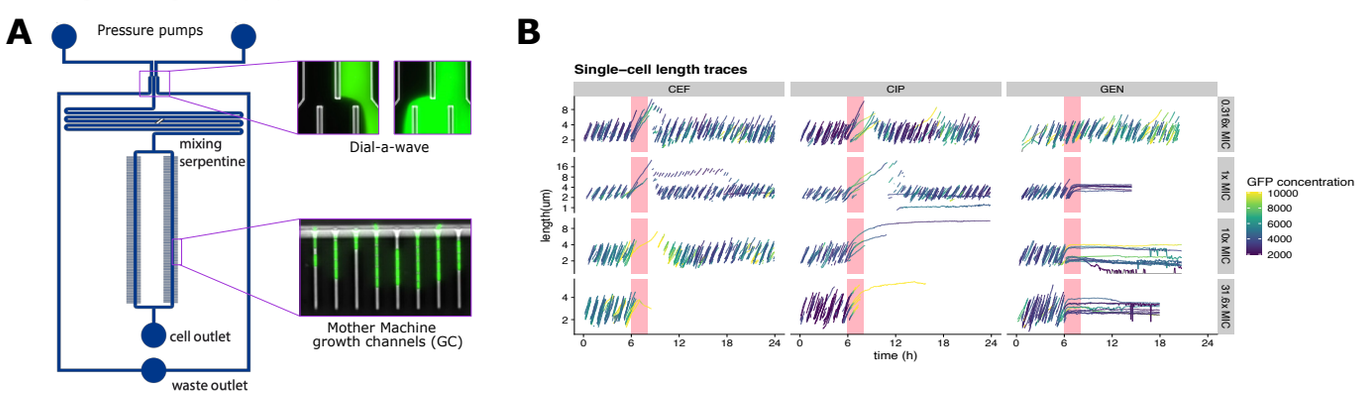



Fig. 1: A. The dual-input Mother Machine, a microfluidic device that allows long-term monitoring of growing bacteria exposed to controlled environmental changes. B. Single-cell traces of cell length, obtained after analysing the time-lapse videos of the Mother Machine experiments with DeepMoMA, a software for image analysis that enables segmenting and tracking individual cells across long experiments with controlled environmental changes. The red shadowed time interval represents the antibiotic treatment time.

**References**

[1] Kaiser, M. et al.Nature Communications, **9(1)**, 212 (2018)

*Thursday, 8 September 2022*
*10:50–11:30*

# How to be (and remain) successful in science and technology

Walter Riess

Department Head, Science & Technology, IBM Research – Zurich

ABOUT THE SPEAKER:
Walter Riess is Head of the Science & Technology department at IBM Research – Zurich and coordinator of the Binnig and Rohrer Nanotechnology Center. The research activities of the Science & Technology department include future device concepts, quantum computing, personalized medicine, mobile health, human body data interfaces and nanotechnology.

Dr. Riess joined IBM Research – Zurich as a research staff member in 1995, working on organic light-emitting diodes (LED). In 1998, he became manager of the display technology group for display applications of electroluminescent organic materials, which today are game-changing technologies used in many television displays and mobile devices.

Dr. Riess holds a PhD in Physics from the University of Bayreuth, Germany, where he habilitated in 1996. He has authored and/or coauthored more than 100 scientific papers and holds 70 granted patents. He is a senior member of IEEE, member of the German Physical Society, the Swiss Physical Society, and the Materials Research Society.

*Thursday, 8 September 2022*
*11:30–11:50*

# Observation of metastable skyrmion lattice in $NdMn_2Ge_2$ at room temperature

Sam Treves[1,2,3], Victor Ukleev[3], Andreas Apseros[2,3], Aki Kitaori[4], Naoya Kanazawa[4], Jamie Massey[2,3], Simone Finizio[3], Yoshinori Tokura[4], Valerio Scagnoli[2,3] and Patrick Maletinsky[1]
[1] Department of Physics, University of Basel, 4056 Basel, Switzerland
[2] Laboratory for Mesoscopic Systems, Department of Materials, ETH Zurich, 8093 Zurich, Switzerland
[3] Paul Scherrer Institute, 5232 Villigen PSI, Switzerland
[4] Department of Applied Physics, University of Tokyo, Tokyo 113-8656, Japan

**Abstract**
Recent discoveries of topological magnetic textures in centrosymmetric, rare-earth based materials have opened new perspectives for technological applications aimed at magnetic storage. Recent transport and Lorentz transmission electron microscopy (LTEM) measurements suggest that $NdMn_2Ge_2$ is a new room-temperature skyrmion host [1, 2]. Here we show varied field and temperature measurements which were undertaken for a 200 nm thick lamella of $NdMn_2Ge_2$ using scanning transmission x-ray microscopy (STXM) exploiting magnetic sensitivity via the x-ray magnetic circular dichroism (XMCD) effect. Our measurements show that it is possible to stabilise a metastable skyrmion lattice at room temperature and zero field. This lattice was stable from room temperature up until the sample's Curie temperature, and was recoverable when cycling between a negative and positive magnetic field in the out of plane direction. These results suggest $NdMn_2Ge_2$ to be an ideal candidate material for Skyrmion data and storage applications.

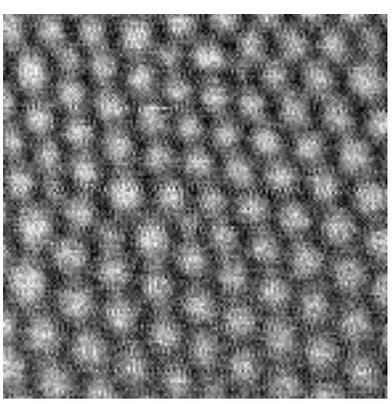


Fig. 1: A scanning transmission x-ray microscopy image of a metastable skyrmion lattice, which was stabilised from a random magnetic configuration using a 50 mT out of plane field whilst cooling from 330 K to 300 K.

**References**
[1] S. Wang, Q. Zeng, D. Liu, H. Zhang, L. Ma, et al. ACS Appl. Mater. Interfaces **12**, 24125 (2020)
[2] Z. Hou, L. Li, C. Liu, X. Gao, Z. Ma, et al. , Mater. Today Phys. **17**, 100341 (2021)

*Thursday, 9 September 2022*
*11:50 - 12:10*

# Automatic design of heteromeric supramolecular nm-sized molecular containers

SNI PhD Project P1906

Iris Martyn[1,2*], Konrad Tiefenbacher[1,3]
[1] Department of Chemistry, Mattenstrasse 24a, 4058 Basel
[2] Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel
[3] Department of Biosystems Science and Engineering, ETH Zurich, Mattenstrasse 24, 4058 Basel

**Abstract**
Self-assembled supramolecular capsules have exhibited promising behaviour as catalysts, due to their ability to encapsulate guests and stabilise reactive intermediates with non-covalent interactions, providing a lower energy pathway for reactions such as terpene cyclisation [1]. However, most known hydrogen-bonded capsules are homomeric (assembled from only one building block). Due to the high symmetry of their internal cavity, homomeric capsules are limited in their ability to impose specific conformations on the encapsulated substrate, resulting in limited product selectivity [2]. Few examples of homomeric capsules are to be found in the literature, and are generally curtailed in their catalytic applications due to small and still significantly symmetric cavities. A broad manual screening approach to search for homomeric assemblies revealed a strong preference for self-sorting among supramolecular building blocks. A new discovery method is proposed, making use of a Python framework for automatic generation of structures with machine learning property optimisation [3].

**References**
[1] Q. Zhang, L. Catti, K. Tiefenbacher, Acc. Chem. Res., **51**, 2107-2114 (2018)
[2] I. Némethová, L. Syntrivanis, K. Tiefenbacher, Chimia, **74**, 561-568 (2020)
[3] L. Turcani, A. Tarzia, F. T. Szczypinski, K. E. Jelfs, stk: J. Chem. Phys, **155**, 21402 (2021)

*Friday, 9 September 2022*
*8:40–9:20*

# Integrative structural biology of molecular nanomachines

Sebastian Hiller

Biozentrum, University of Basel

Modern structural biology combines multiple biophysical and biochemical techniques to resolve structure, function, and dynamics of biomolecular systems. Its cornerstones are the three atomic-resolution techniques cryo-electron microscopy, X-ray crystallography and solution NMR spectroscopy. I will introduce three large biomolecular systems studied in my lab and describe the integrative structural biology approaches we have used to resolve key functional questions for these systems. (i) The complex functional cycle of the molecular chaperone BiP, a central player in protein homeostasis [1]. (ii) The mechanism how the antibiotic darobactin inhibits the outer membrane insertase complex BAM [2]. (iii) The structure and mechanism of the protein Ninjurin [1] to rapture the cellular plasma membrane by a gigantic pore, as the endpoint of cell death pathways [3]. I will also discuss the integration and impact of the recent theoretical advance Alphafold [4] into our structural biology workflow.

**References**

[1] Gething. Semin. Cell Dev. Biol. **10** 465–472 (1999)
[2] Kaur et al. Nature **593**, 125–129 (2021)
[3] Kayagaki et al. Nature **591**, 131–136 (2021)
[4] Jumper et al. Nature **596**, 583–589 (2021)

*Friday, 9 September 2022*
*9:20–9:40*

# Ultrasound actuated acoustic rotors in air and in water: from protein crystallography to mechanobiology applications

SNI PhD Project P2007

Shichao Jia[1,2,3], Yohei Sato[3], Roderick Y.H. Lim[1,2], Soichiro Tsujino[1,3]
[1] Swiss Nanoscience Institute, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland
[2] Biozentrum, University of Basel, Spitalstrasse 41, 4056 Basel, Switzerland
[3] Division of Biology and Chemistry, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

**Abstract**
Recently, polymer thin film acoustic rotors have been successfully applied as sample holders for protein crystallography owing to the high positional stability during airborne levitation and rotation [1]. Nevertheless, the mechanism of generating the acoustic torque remains elusive. Thus, we fabricated acoustic rotors by UV lithography and investigated the impact of their size, shape, and the viscosity of fluid on the rotation characteristics. We found a way to determine the rotation direction in air and observed the characteristic scaling of the rotor size and ultrasound frequency in the water, which indicates the possibility to further miniaturize acoustic rotors as a unique tool to explore ultrasound mechanobiology.

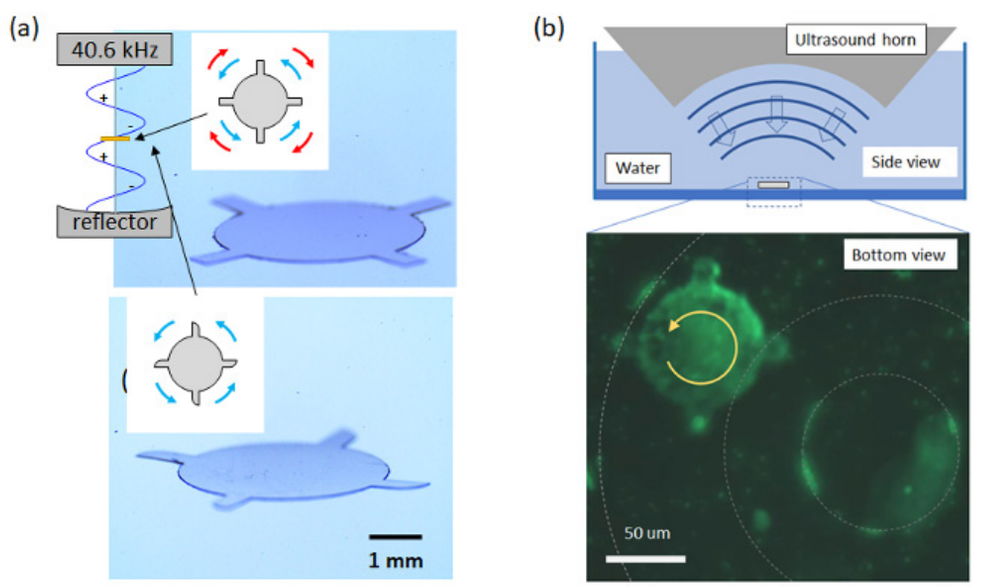



Fig. 1: (a) Snapshots and schematics of acoustic rotors with symmetric (top) and chiral blades (bottom). (b) Top: side-view schematic of the in-water acoustic rotor experiment. Bottom: snapshot of the rotation experiment of a 75-µm-diameter rotor under 13 MHz ultrasonic actuation.

**References**
[1] M. W. Kepa et al., Scientific Reports **12**, 5349 (2022)

*Friday, 9 September 2022*
*9:40–10:00*

# Fixed-targets for time-resolved serial protein crystallography at SwissFEL

SNI PhD Project P1904

Melissa Carrillo[1,3], John Beale[2,3], Celestino Padeste[1,3]
[1] Paul Scherrer Institute, Laboratory of Nanoscale Biology, 5232 Villigen PSI, Switzerland.
[2] Paul Scherrer Institute, Photon Science Division, 5232 Villigen PSI, Switzerland.
[3] Swiss Nanoscience Institute, 4056 Basel, Switzerland.

**Abstract**
Serial protein crystallography is a powerful method for obtaining room temperature structural data at an atomic level. This is performed with large numbers of individual micro-crystals introduced sequentially to the beam of synchrotrons or XFELs. XFELs have enabled the overcoming limitations of synchrotron serial crystallography by outrunning radiation damage with their highly coherent and brilliant femtosecond pulses. They provide the ability to perform serial femtosecond crystallography (SFX) and time-resolved serial femtosecond crystallography (TR-SFX) on protein micro-crystals [1], enabling new modes of structural biology. However, the constant need to refresh crystals in the beam path is a constant challenge and advances to its sample delivery can greatly improve experimental outcomes. Fixed-target (FT) sample delivery methods allow for a reduction of sample consumption, optimization of sample density without issues such as clogging and an increased ability to locate and position crystals. Microstructured silicon FTs are the most commonly used, offering an inert support for the immobilized crystals and a precise aperture array for rapid alignment strategies [2]. However, the silicon wafers are brittle, expensive and can give strong Si(111) reflections when misaligned [3, 4]. We present the fabrication and first experiment of our polymer-based fixed-targets developed for CristallinaMX, the FT-SFX end station at SwissFEL. Using silicon microfabrication and polymer replication technologies, we have designed inverted pyramidal shaped wells in 50 µm thick membranes. This design enables single crystals to funnel into predefined positions, optimizing the hit-rate of the probing X-ray beam.

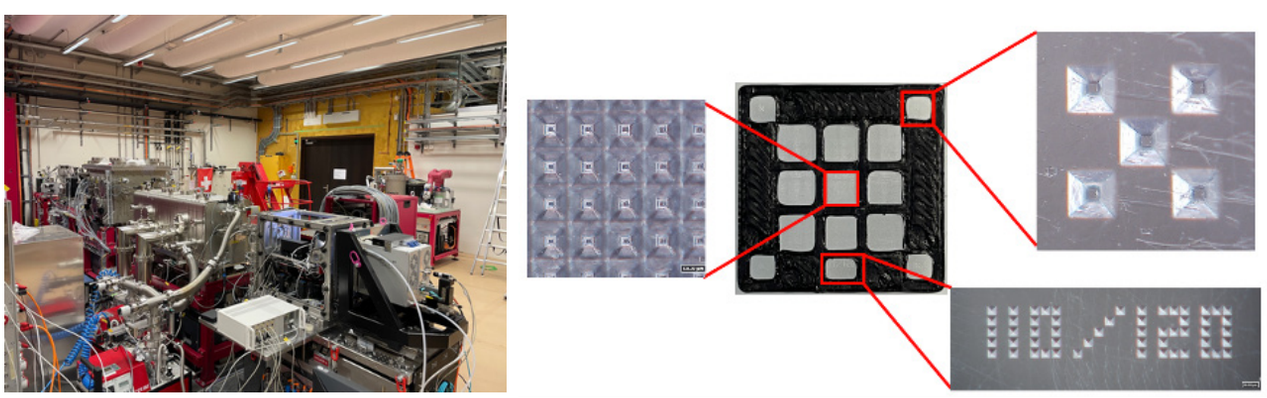


Fig. 1: Left: CristallinaMX. Right; 1st generation polymer-based fixed-target

**References**
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[2] Sherrell, Darren A., et al., Journal of synchrotron radiation **22(6)**, 1372-1378 (2015)
[3] Cheng, Robert KY., Crystals **10(3)**, 215 (2020)
[4] Martiel, I., et al., Structural Biology **75(2)**, 160-177 (2019)

*Friday, 9 September 2022*
*10:00–10:20*

# Graphene-organic semiconductor interfaces for vertical organic transistors

EMPA / SNI PhD Project P2009

Jacopo Oswald[1,2], Davide Beretta*[1], Michael Stiefel[1], Roman Furrer[1], Alessia Romio[1], Michel Daher Mansour[4], Dominique Vuillaume[4], Michel Calame*[1,2,3]
[1] Empa, Swiss Federal Laboratories for Materials Science and Technology, Transport at Nanoscale Interfaces Laboratory, Dübendorf, Switzerland
[2] Swiss Nanoscience Institute, University of Basel, Basel, Switzerland
[3] Department of Physics, University of Basel, Basel, Switzerland
[4] Institute of Electronic, Microelectronic and Nanotechnology, Centre National de la Recherche Scientifique, Villeneuve d'Ascq, France

**Abstract**
The great advantage of vertical organic transistors consists in having much shorter channel lengths and higher switching speeds than planar thin film transistors [1]. The organic permeable base transistors architecture is very promising to create complementary circuits operating in the MHz range [2][3]. Strategies to push the transistor performances in the GHz frequency range have already been presented [4].
In this context, we investigate the vertical charge transport and the injection mechanisms at the graphene/organic semiconductor interfaces. By incorporating graphene as a semi permeable base into the transistors architecture, we seek to improve the control over the electro statics of the device, and to enable the fabrication of flexible electronic devices operating at low-voltage and high frequency. In this preliminary study, we show the structural and electrical properties of vertical hetero-structures composed of graphene and P3HT.

**References**
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[2] Huang et al. Nature Electronics **4**, 544–545 (2021)
[3] Guo et al. Nature Electronics **4**, 588–594 (2021)
[4] Guo et al. Advanced Optical Materials, February 22, 2002058 (2021)

*Friday, 10 September 2021*
*10:50–11:20*

# Blue laser diode pumped Titanium:Sapphire sub 100 fs laser amplifier for nanomachining

Nano-Argovia Project A16.11 – NanoLase

Bojan Resan[1], Daniel Hug[1], Andreas Josef Dax[2], Alexandre Trisorio[2], Stefan von Wolff[3]
[1] Laser Group, Institute of Product and Production Engineering, School of Engineering, FHNW, Windisch
[2] Gun Laser Group, Paul Scherrer Institute, Villigen
[3] TLD Photonics AG, Bifangstrasse 29a, 5430 Wettingen

**Abstract**
Micromachining with femtosecond lasers enables structuring of various materials down to few microns in size. The method's inherent flexibility is very attractive for rapid prototyping, but optimized laser workstations are used also in large volume production of e.g. cell phone displays etc. Titanium doped sapphire-based lasers are generating 10 times shorter pulses than commercially available lasers, but are limited to scientific experiments due to complex, high-cost pump lasers. Recently, high power blue laser diodes are developed for displays and car industry, but are also promising for low cost, reliable pumping of Ti:sapphire lasers.
We present development of a novel, direct blue diode pumped Ti:sapphire ultrafast amplifier at room temperature, delivering ~50 fs laser pulses. By fast modulation of blue pump laser diodes, thermal issues in the diodes are minimized, the thermal lens inside the laser medium was reduced several times and peak pump power was increased few times, which enabled us to achieve a small signal gain of >27%. Such gain level is sufficiently high, and we are now building the compact, wall-plug efficient and low-cost amplifier, enabling sub-micron material processing in a fast and flexible way with a laser. This breakthrough from laser micromachining to nanomachining will be investigated on several types of materials including metals, ceramics, polymers etc..

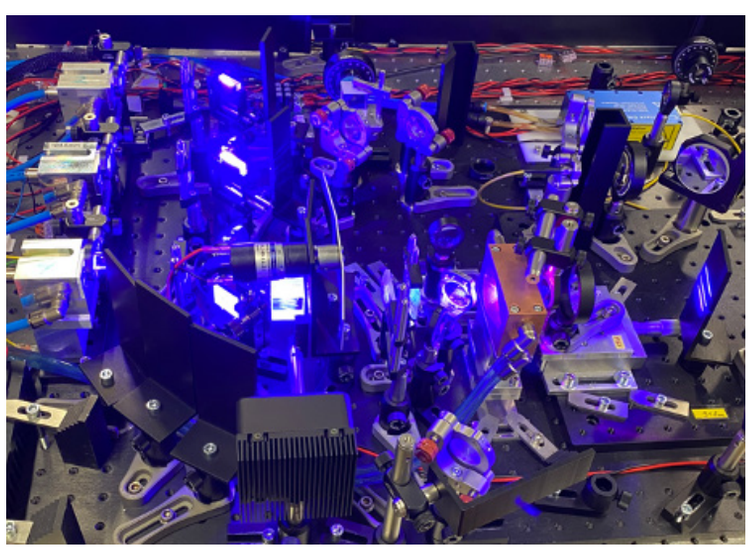

Fig. 1: Blue diode pumped amplifier setup

**References**
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[2] S. Backus et al. Opt. Express **25**, 3666 (2017)

*Friday, 9 September 2022*
*11:20–11:40*

# Towards hybrid optomechanics with hexagonal boron nitride

SNI PhD Project P1706

David Jaeger, Thibaud Ruelle, Francesco Fogliano, Floris Braakman, Martino Poggio
Poggio Lab, Department of Physics, University of Basel Klingelbergstrasse 82 4056 Basel

**Abstract**
Recent improvements in the fabrication and control of nanomechanical resonators have made cavity optomechanics a leading field in quantum information processing and the study of the quantum to classical crossover. Simultaneously, hybrid systems consisting of a two-level system (TLS) and a mechanical resonator have emerged as a new route towards quantum control of mechanical systems. Since not only the optomechanical interaction but also the optical control of a TLS is greatly enhanced in a cavity, a natural next step is to combine a TLS with a cavity optomechanics setup. Such devices are promising candidates to observe unique quantum phenomena. Particularly, a six orders of magnitude increase in the optomechanical coupling rate was demonstrated in a circuit cavity electromechanical implementation [1].
We are building an experimental setup [2] to study such systems, comprising a Fiber Fabry-Perot cavity (FFPC) within which a nanomechanical resonator with a TLS can be positioned, forming a membrane-in-the-middle system. 2D materials such as hBN can be exfoliated into membranes which have good mechanical properties and host defects that can serve as quantum emitters [3]. We are currently investigating the mechanical properties of these membranes and their optomechanical interatction with our FFPC (see Fig. 1).
Combining these constituents will allow us to create a fully coupled tripartite system. We plan on using this system to investigate three-body interaction effects arising from the coupling between the bipartite subsystems. We expect the combination of these effects to result in strong single-photon optomechanical coupling, giving us access to the regime of nonlinear quantum cavity optomechanics.

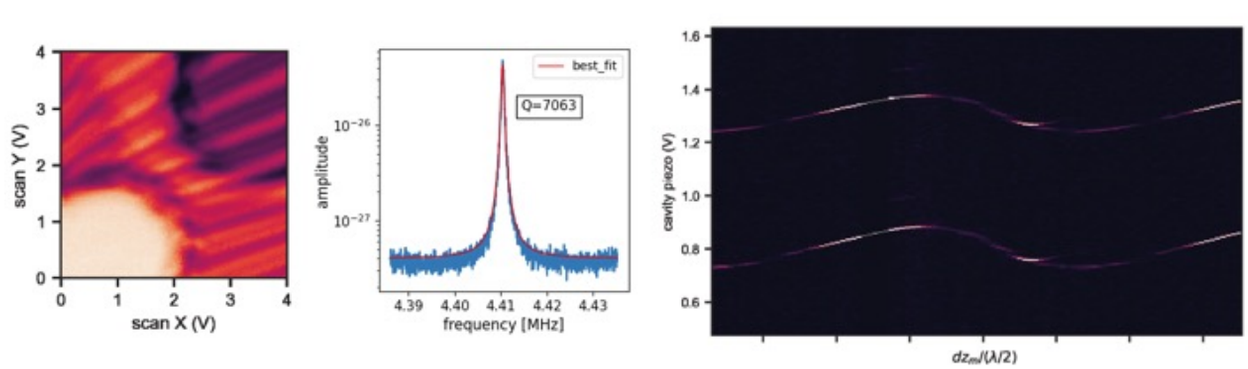


Fig. 1: Intra cavity scan of hBN flake placed on a SiN frame (left). A mechanical resonance of the resulting drum resonator (middle). Effect of the hBN membrane on the cavity resonance length as a function of the membrane position along the cavity axis, revealing a strong dispersive optomechanical coupling ($G/2\pi \sim 10$ GHz/nm) (right).

**References**
[1] Pirkkalainen et al., Nat. Commun. **6**, 6981 (2015)
[2] Ruelle et al., arXiv:2205.03038 (2022)
[3] Toan Trong Tran et al., Nat. Nanotechnol. **11**, 37-41 (2016)

*Friday, 9 September 2022*
*11:40–12:00*

# Towards all-optical single spin magnetometry

SNI PhD Project P2003

Josh Zuber[1,2], M. Li[1], M. Grimau[1], J. Happacher[1], B. J. Shields[1], and Patrick Maletinsky[1,2]
[1] Department of Physics, University of Basel, 4056 Basel, Switzerland
[2] Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel

**Abstract**
The negatively charged nitrogen-vacancy (NV) center in diamond has been widely established as a versatile magnetometer with possible applications ranging from 4K-300K [1,2]. Due to the NV's intrinsic properties however, the realm of ultra-low temperatures and strong magnetic fields has been largely inaccessible to this type of magnetometry. The negatively charged silicon-vacancy (SiV) center in diamond which, next to its exceptional optical features, is inherently less susceptible to its charge environment [3] presents an alternative. All-optical control of the SiV has been demonstrated down to 40mK [4] and thus it is natural to probe it as an alternative to the NV in these extreme conditions. We compare the two defects in their use as magnetometers and present compelling results concerning the SiV's optical coherence as well as single photon emission of shallow centers in diamond microstructures, paving the way to all-optical single spin magnetometry at ultra-low temperatures and high magnetic fields.

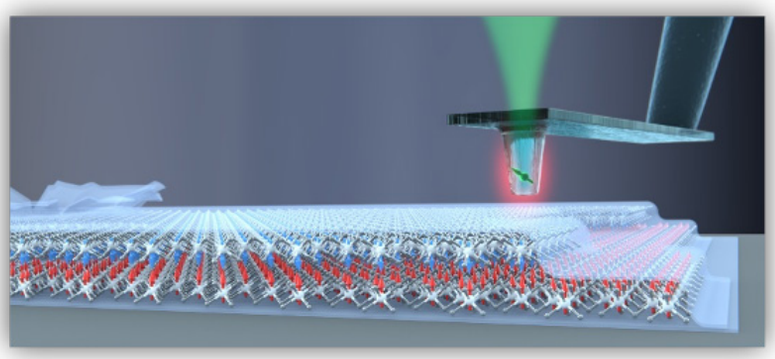

Fig. 1: Illustration of a diamond scanning probe containing a single NV scanning over a magnetic sample.

**References**
[1] L. Thiel et al., Science **364**, 973-976 (2019)
[2] N. Hedrich et al., Nature Physics **17**, 574-577 (2021)
[3] L. J. Rogers et al., Phys. Rev. B **89**, 235101 (2014)
[4] J. N. Becker et al., Phys. Rev. Lett. **120**, 053603 (2018)

*Friday, 9 September 2022*
*12:00–12:20*

# Microstructured and biofunctionalized hydrogel-based periodontal LIGAment RECOnstitution device

Nano-Argovia Project A16.07 LIGARECO

Joachim Koeser[1], Khaled Mukaddam[2], Tanja Naldi[1], Stefano Tugulu[3], Sebastian Kuehl[2]
[1] FHNW, ICB, Hofackerstr. 30, CH-4132 Muttenz
[2] Klinik für Oralchirurgie und Dental Imaging, Mattenstrasse 40, CH-4058 Basel
[3] Novonexile AG, Oberer Rainweg 32, CH-4414 Fuellinsdorf

**Abstract**
The prevalence of dental implants has increased about 10-fold in the last 20 years and with it the risk of bacterial infections leading to peri-mucositis/implantitis with effects ranging from bleeding of the mucosa to bone loss and possible implant replacement.
One of the strategies to address this clinically unresolved problem is to improve the soft tissue attachment to the implants, which by contrast to natural teeth are missing an arrangement of radially attached ligament fibers that mechanically prevent bacterial infiltration. The presented project explores a novel template-assisted strategy to promote the formation of radial ligament fibers around dental implants. The approach is based on the use of a biodegradable ring-shaped hydrogel device that can be implanted around the implant collar (Fig. 1).

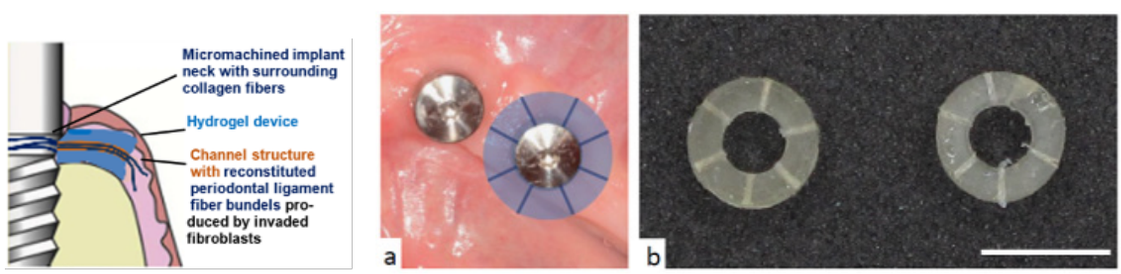


Fig 1: Left: Scheme of the proposed hydrogel device, a) and b) devices fabricated in the project. Scalebar: 8 mm.

A defined arrangement of biofunctionalized microchannels within the device is used to guide the formation of periodontal-like ligament fibers around the implant by infiltrating periodontal ligament cells. For reasons of durability and biodegradability the device is made by crosslinking of multiarm PEG precursors which from the hydrogel. Suitable microchannel geometries were assessed by two main parameters which are a) the invasion of cells from the outside of the hydrogel and b) an elongated cell shape along the axis of the microchannel since cell synthesized extracellular collagen fibers are known to arrange along this axis (Fig. 2). All fibroblast cell lines investigated readily invaded the hydrogels, however certain cell types only elongated upon additional microstructuration of the microchannel sidewalls.

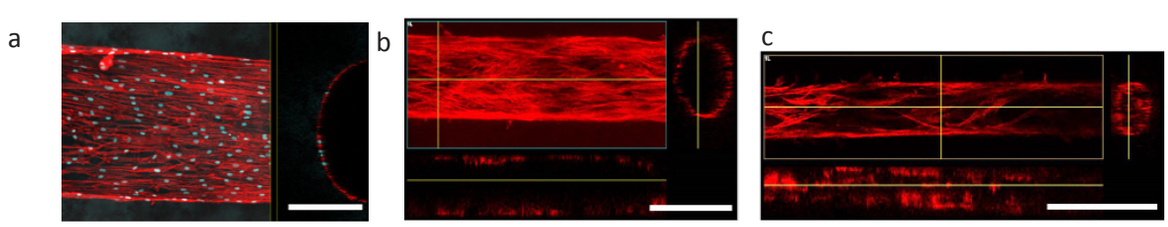


Fig 2: a) Actin and DNA fluorescence labelled PDL cells in 0.4 mm microchannels; b, c) actin labelled PDL cells in microchannels of 0.2 and 0.1 mm. Scalebars: 0.2 mm.

*Poster 1*

# Development of achromatic and apochromatic X-ray lenses

Nano-Argovia Project A16.01 ACHROMATIX

Joan Vila-Comamala[1], Umut T. Sanli[1], Peng Qi[1], Marie-Christine Zdora[1], Adam Kubec[1,2], Griffin Rodgers[3], Ana Diaz[1], Georg Schulz[3], Bert Müller[3] and Christian David[1]
[1] Paul Scherrer Institute, Villigen PSI, Switzerland
[2] XRnanotech GmbH, Forschungsstrasse 111, Villigen PSI, Switzerland
[3] Biomaterials Science Center, University of Basel, Allschwil, Switzerland

**Abstract**
X-ray optics are essential for X-ray imaging methods with many applications in biology, energy and materials science. Refractive and diffractive lenses suffer from strong chromatic aberration, only focusing X-rays from a narrow energy range at the same focal spot. An achromatic X-ray lens can be obtained by combining a diffractive and refractive element, as proposed in [1, 2]. Recently, we have demonstrated the first experimental realization of this concept [3]. Our achromatic X-ray lens was composed of a gold Fresnel zone plate, fabricated by electron beam lithography and electroplating, and a 3D printed polymer refractive lens, produced by two-photon polymerization. In this first realization, the two components were produced on separate substrates. Here, we also demonstrate that apochromatic X-ray focusing can be achieved by separating the two elements along the optical axis. Finally, we report on the current efforts in producing both elements as a monolithic device, i.e., on the same substrate (Fig. 1a). Such an implementation is very advantageous because it reduces the lens alignment complexity in the X-ray imaging systems. In recent experiments, we achieved X-ray focal spots down to 200 nm for scanning transmission X-ray microscopy using a monolithic X-ray achromat at 7.1 keV photon energy (Fig. 1b).

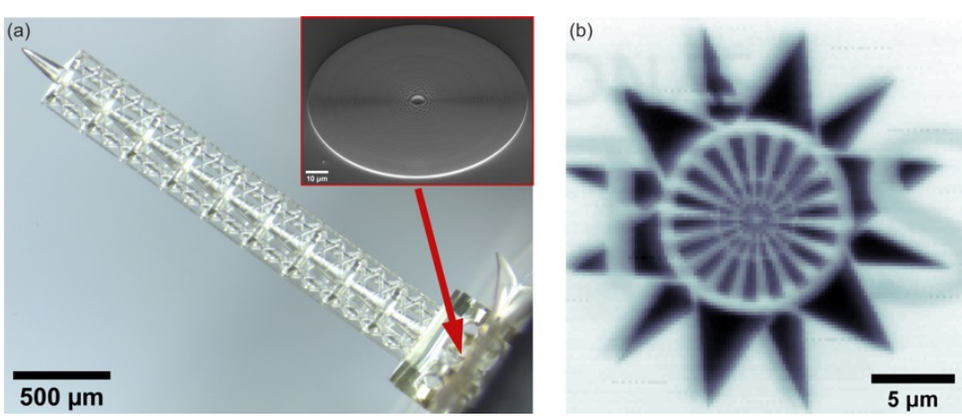


Fig. 1: a) Monolithic achromatic X-ray lens composed of 3D printed polymer refractive lens and a gold electroplated Fresnel zone plate. The polymer lens is printed on the top of Fresnel zone plate laying on the surface of the substrate. b) Example of scanning transmission X-ray microscopy image of gold nanostructures acquired with monolithic achromatic X-ray lens.

**References**
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[2] H. N. Chapman and S. Bajt, Proc. R. Soc. A **477**, 20210334 (2021)
[3] A. Kubec, M-C Zdora, U. Sanli, A. Diaz, J. Vila-Comamala and C. David, Nat. Commun. **13**, 1305 (2022)

*Poster 2*

# Nanocompass – A magnetic sensor based on a spin transfer torque magnetic tunnel junction

Nano-Argovia Project A16.10 Nanocompass

Hugo Nicolas[1], A. Inderbitzin[2], S. Gorenflo[2], M. Ulrich[3], R. C. Sousa[4], A. Mora-Hernández[4], I.-L. Prejbeanu[4], L. Hebrard[5], J.-B. Kammerer[5], Joris Pascal[1]
[1] FHNW, School of Life Sciences, Muttenz, 2FHNW, School of Engineering, Brugg-Windisch
[3] CAMILLE BAUER METRAWATT AG, Wohlen
[4] SPINTEC, Univ. Grenoble Alpes / CEA / CNRS, Grenoble, France
[5] ICube laboratory, UMR 7357, Univ. of Strasbourg / CNRS, Illkirch, France

**Abstract**
This paper presents the use of a nanometric spin transfer torque magnetic tunnel junction (STT-MTJ) as a magnetic sensing element [1]. This sensing element has the shape of a pillar with a diameter of 50 to 100 nanometres, making it one of the smallest magnetic sensing elements ever reported. The performances of the demonstrated sensor (Fig. 1a, c) almost completely outperform the magnetoresistive commercially available on-chip magnetic sensors in terms of miniaturization, measuring range and bandwidth. Further improvements on both signal processing electronics and stack of the junction will significantly increase the sensitivity and reduce the noise. In addition, the electronics required to operate the junction includes only a limited number of standard microelectronics components such as resistors, capacitors, and operational amplifiers. This makes the system fully compatible with future compact monolithic integration. The developed sensor system is currently implemented as a discrete version on a printed circuit board (PCB) (Fig. 1b). This system, including an analog-to-digital converter typically consumes 28 mW making the sensor compatible for low power applications and exhibits a range of up to ± 46 mT. The sensor bandwidth can reach 200 kHz and can possibly be increased to several MHz, making it particularly promising for new current sensing requirements in power networks.

a) b) c)

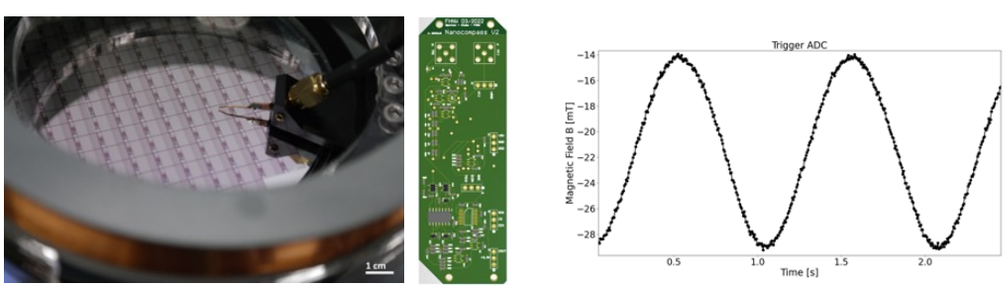


Fig. 1: a) MTJ under test within a Helmholtz coil, b) PCB of the signal processing electronics, c) measurement of a 1 Hz, ± 8 mT sine wave external magnetic field

This sensor can find applications in various domains and addresses several markets, ranging from the industrial and medical field to physics experiments. The nanometric dimension of the junctions also offers the possibility to arrange MTJs as an array with high density. This could result in a magnetic camera with an unprecedented density of tens of sensing units per square micrometres.

**References**
[1] A. Timopheev, R. Sousa, M. Chshiev, L. D. Buda-Prejbeanu, and B. Dieny. Physical review B (2015)

*Poster 3*

# Electrochemical vertical flow for C-reactive protein detection

Nano-Argovia Project A16.13 PEPS

Stefano Del Giovane[1], Hui Chai-Gao[1], Nicolas Glaser[1], Christopher Wood[2], Dominik Meinel[2], Mathias Wipf[3], Felix Kurth[1], Silvia Generelli[1]
[1] CSEM
[2] FHNW Muttenz
[3] MOMM Diagnostics GmbH

**Abstract**
In the Nano-Argovia project PEPS, we are developing an electrochemical sensor for the analysis of protein biomarkers at the point-of-care (POC). Such a digital device could increase the convenience and effectiveness of the monitoring and diagnosis of various diseases on par with today's testing of diabetes with glucose meters. However, the industrialization of such sensors is hampered by problems related to unspecific surface fouling, low POC compatibility of the device and expensive sensor fabrication. To address these limitations, we developed a laser perforated sensor functionalized by a polymer with strong antifouling properties, that can be prepared using cost-effective and highly scalable printing processes. A vertical flow system has been designed for user -friendly evaluation of the assay procedure. We present our progress regarding the sensor performances, the effect of the perforation and the first results, obtained by coupling the sensor with a vertical flow platform for the C-reactive protein detection (Fig. 1).

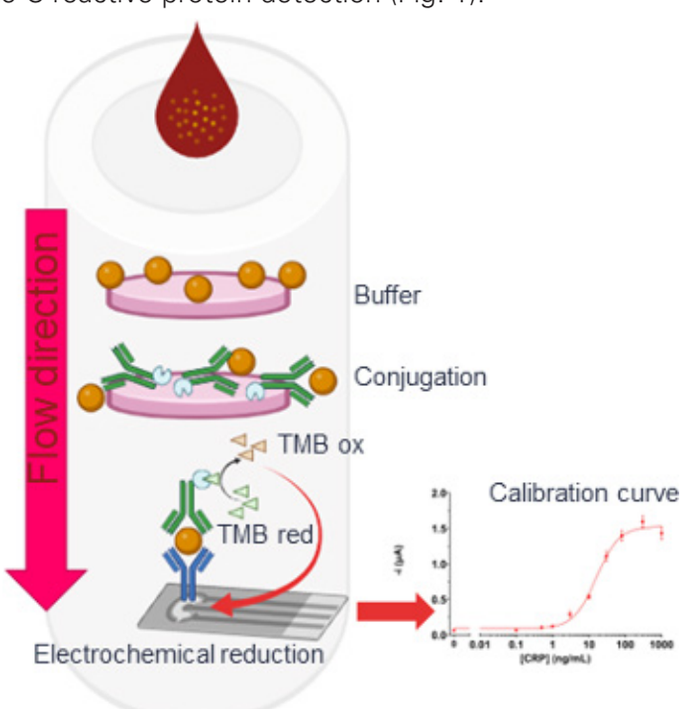


Fig. 1: A scheme of the electrochemical vertical flow device is presented above. A dropped sample flows through the sample pad, loaded with a buffer to tune the pH and salts content. Successively, the solution enters a conjugation pad, containing the detection antibody-enzyme conjugated, where the analyte is bound. The sandwich immunoassay is formed on this layer of the sensor. An enzymatic substrate is then added after the incubation time. Here, electrochemical reduction occurs on the sensor surface, applying a cathodic potential.

*Poster 4*

# Nanoimprinted metasurfaces for foldable and rollable displays

Nano-Argovia Project A17.4 META-DISPLAYS

Dimitrios Kazazis[1], Jakoba Heidler[2], David Pires[3], Richard Frantz[3], Benjamin Gallinet[2]
[1] Paul Scherrer Institut, Forschungstr. 111, 5232 Villigen PSI
[2] CSEM SA, Tramstrasse 99, 4132 Muttenz
[3] ROLIC Technologies Ltd, Gewerbestrasse 18, 4123 Allschwil

**Abstract**
Future displays – tablets, smartphones - will be foldable or rollable to simplify the consumer use and storage. These displays must be extremely thin to have the flexibility of a foil. The reduction of back reflection from ambient light is crucial to maximize contrast, and it is currently handled with a polarizer and a waveplate. Metasurfaces have a very large potential to overcome the limitations of phase retarding materials, as they can strongly alter the phase of the electromagnetic field within a single micrometer [1-2]. In this work, dielectric metasurfaces are designed and fabricated for phase retardation of the electromagnetic field. The main challenges to overcome are the wavelength and angular stability of the phase retardation. The nanoimprint lithography technique is used to manufacture the metasurface elements, which can be upscaled to the needs of the display industry. The generation of the nanoimprint master is performed with electron beam lithography in crystalline silicon, from which a copy in a soft stamp material is generated. The metasurfaces technology has a potential to be applied in other segments of the consumer electronics market, for example as flat imaging elements in smartphones.

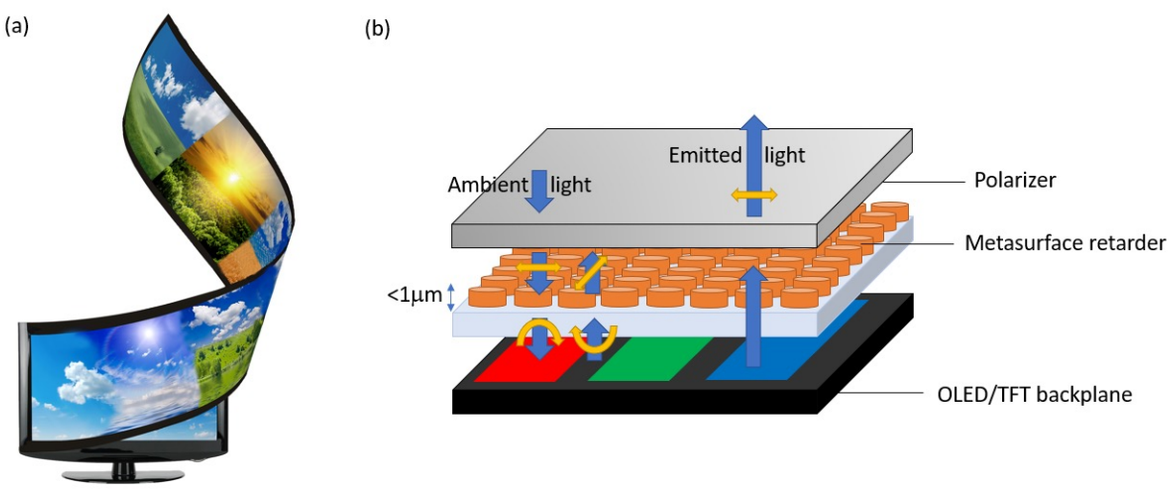


Fig 1: a) Rollable display concept. b) Metasurface retarder for minimization of reflected ambient light and maximization of contrast.

**References**
[1] Arbabi et al., Nature Nanotechnology **10**, 937- 943 (2015)
[2] Driencourt et al., ACS Photonics **7**, 444-453 (2019)

*Poster 5*

# Signs of frustration in a monolayer Fe-based Kagome antiferromagnet

SNI PhD Project P1602

Mehdi Heydari, Michael Brunthaler, Aisha Ahsan, Rejaul SK, Andrin Doll, Vladyslav Romankov, Muqing Hua, Nian Lin, Jan Dreiser and Thomas A. Jung
Swiss Nanoscience Institute and Department of Physics, University of Basel, 4056 Basel, Switzerland
Photon Science Department, Paul Scherrer Institut, 5232 Villigen PSI Switzerland
Department of Physics, Hong Kong University of Science and Technology, Kowloon, Hong Kong

**Abstract**
Kagome antiferromagnets (KAFM) are well-suited to study magnetic frustration due to their small coordination number (4 instead of 6) compared to other geometries such as triangular systems [1]. KAFMs show interesting ordering phenomena depending on the temperature and magnetic field such as nematic order, order-by-disorder and spin liquid behaviour and have been intensely studied in theoretical and experimental efforts earlier [2]. Such behaviour is critically affected by the pinning of local magnetic order at structural defects. However, it is challenging to obtain sufficiently defect-free Kagome lattices. The emergence of metal organic frameworks (MOFs) and coordination networks raised hope for their programmability by the coordination shell of the components. In the present work we self-assemble single sheets with Kagome structure including Fe(II) ions on a Au(111) surface by using benzene-1,2,3,4,5,6-hexaol (BHO) molecules as linkers. We characterize the structural integrity of this two-dimensional magnetic material by X-ray photoelectron spectroscopy and scanning tunnelling microscopy (Fig. 1a,b), and we investigate the electronic configuration and magnetic properties by means of X-ray absorption spectroscopy and X-ray magnetic circular dichroism (XMCD) as shown in figure 1c,d. The significantly low XMCD signal and the small net Fe magnetic moment extracted from sum rule calculations together with the negative Weiss temperature obtained from fits to inverse magnetic susceptibility data implicitly confirm the frustrated nature of the Fe magnetic moments in the system.

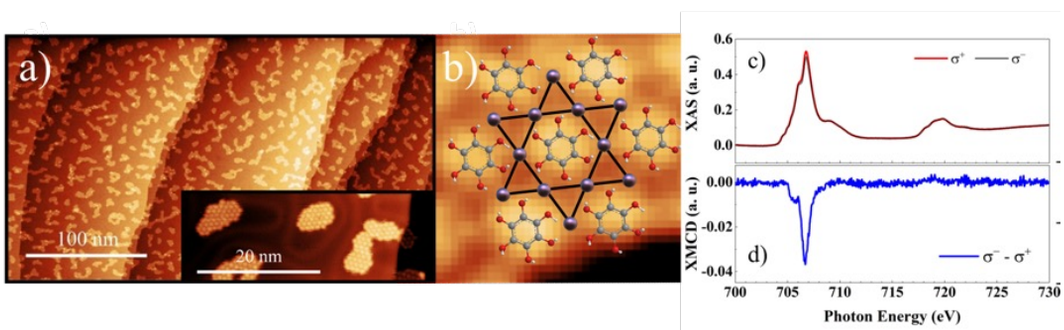


Fig. 1: a) Morphology of the Fe and benzenehexaol containing Kagome network. STM micrograph (T = 300 K) of the coordination network. b) Schematic view of coordinated Fe atoms. (Color code: violet, Fe; red, O; gray, C.) STM image of 2.4×2.4 nm c) Circularly polarized X-ray absorption spectra (black, red) and d) X-ray magnetic circular dichroism spectra both recorded in grazing incidence (θ = 60°) at low temperature (T = 2.5 K) and high field (B = 6.8 T).

**References**
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[2] Anghinolfi, L. et al.Nat. Commun. **6**, 8278 (2015)

*Poster 6*

# Hybrid lipid nanoparticle (hLNP) with improved gene delivery efficiency

SNI PhD Project P1801

Claudio Alter[1], Pascal Detampel[1], Claudia Lotter[1], Patrick Hauswirth[1], Cornelia Palivan[2], Tomaž Einfalt[*1], Jörg Huwyler[*1]
[1]Department of Pharmaceutical Technology, University of Basel, Klingelbergstrasse. 50, 4056 Basel
[2] Department of Chemistry, University of Basel, Mattenstrasse 24a, BPR 1096, 4058 Basel, Switzerland

**Abstract**
The interest in nucleic acid based nanomedicines increased in the last years, culminating with the worldwide COVID-19 pandemic and the two FDA approved lipid nanoparticles (LNPs) based mRNA vaccines from Pfizer/BioNTech and Moderna. However, current LNP formulations are composed of a simple 4 component lipid mixture and not optimized for organ or cell specificity, intracellular processing, and gene delivery efficiency. This can lead to off-target gene delivery, toxicity, and immunogenicity and thus lower the efficacy of a gene therapy treatment [1]. Extracellular vesicles (EVs) are membranous lipid vesicles, which are released from living and dying cells. They are known to have superior cellular uptake and intracellular processing based on their lipid composition in comparison to their synthetic counterparts [2]. Therefore, we decided to produce a hybrid LNP (hLNP) by fusion of EVs (i.e., nano plasma membrane vesicles (nPMVs)) with the standard 4 component LNP formulation in order to improve the gene delivery efficiency. Indeed, we observed a higher mCherry (reporter gene) expression in vitro and in vivo in zebrafish embryos (ZFE) (Fig. 1). These results suggest that incorporation of cell derived lipids/vesicles into the standard 4 component LNP formulation can be used to further optimize and fine-tune formulations for safer and more efficient gene therapies.

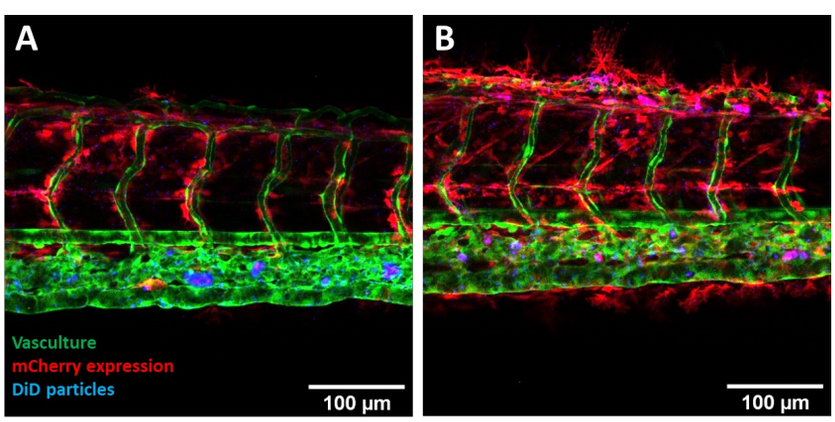


Fig. 1: In vivo zebrafish embryo (ZFE) experiment. The expression of a mCherry reporter gene in ZFE of LNPs (A) and hLNPs (B) was analysed by confocal laser scanning microscopy 24 hours after injection of the particles. Green: ZFE vasculature, red: mCherry expression, blue: DiD particle staining. Scale bar: 100 µm.

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*Poster 7*

# How do machines learn from proteins (and molecules)?

SNI PhD Project P1802

Vanni Doffini [1, 2], O. Anatole von Lilienfeld [3,4], Michael A. Nash [1, 2]
[1] Department of Chemistry, University of Basel, 4058 Basel, Switzerland
[2] Department of Biosystems Science and Engineering, ETH Zurich, 4058 Basel, Switzerland
[3] Machine Learning Group, Technische Universität Berlin, 10587 Berlin, Germany
[4] Berlin Institute for the Foundations of Learning and Data, 10587 Berlin, Germany

**Abstract**
This work focuses on how machine learning extracts useful information from discrete combinatorial spaces prone-to-mutations such as proteins or small organic molecules. To answer this question, we trained and evaluated kernel ridge regression machines using different amount of data generated computationally. Such data comprehend i) two naïve functions based on the many-body theory; ii) an estimation of the binding energies between a protein and a mutagenized peptide; and iii) the solvation energies of two 6 heavy atoms structural graphs. In contrast with what is commonly believed, our results showed non-linear patterns in the learning process (here referred as how the test error drops with the growth of training data). We called the two extreme behaviors saturated and exponential decays, and they are conditioned by the level of complexity enclosed in the training set, i.e. how many mutations are contained. Moreover, we presented the concept of mutant based shuffling, the idea of local clustering and global understanding and the fact that there might exists one or more specific sequences which strongly influence the learning paths. From a scientific perspective, our study could influence many future researches where machine learning is applied to mutagenizable discrete spaces arising from natural sciences. Examples can vary from chemical properties prediction to forecasting different protein characteristics. Not only that, this study could potentially impact more broad fields where the inputs are discretizable like in natural language processing.

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*Poster 8*

# Energy dissipation of $MoS_2$ monolayer surface under magnetic field

SNI PhD Project P1803

Alexina Ollier[1,2], Marcin Kisiel[1], Akash Gupta[1], Mehdi Ramezani[1], Andrea Baumgartner[1,2], Christian Schoenenberger[1,2] and Ernst Meyer[1]
[1] Department of physics, University of Basel, Klingelbergstrasse 82, 4056 Basel
[2] Swiss Nanoscience Institute, University of Basel, Klingelbergstrasse 82, 4056 Basel

**Abstract**

Understanding nanoscale energy dissipation is nowadays among few priorities particularly in solid state systems. Breakdown of topological protection, loss of quantum information and disorder-assisted hot electrons scattering in graphene are just few examples of systems, where the presence of energy dissipation has a great impact on the studied object [1]. It is therefore critical to know, how and where energy leaks. Pendulum geometry Atomic Force Microscope (pAFM), oscillating like a pendulum over the surface, is perfectly suited to measure such tiny amount of dissipation [2,3], since a minimum detectable power loss is of the order of aW.

Here we report on spontaneous spin polarization at the first-order magnetic phase transition in two-dimensional semiconductor gated monolayer-$MoS_2$ is detected by magnetic force spectroscopy. At low doping electron-electron interactions in $MoS_2$ lead to ferromagnetic spin order, whereas larger occupation of spin polarized energy bands results in paramagnetism. An abrupt and reproducible change of magnetic force was observed at doping concentrations equal to $n_c = 3.0 \times 10^{12}$ $cm^{-2}$ attributed to ferromagnetic to paramagnetic phase change. Local force detected by strong magnetic tip of the pendulum AFM confirms linear field dependence of the spin susceptibility in the paramagnetic phase which is a direct consequence of the nonanalyticity of the free energy.

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*Poster 9*

# Quantum dynamics of an ultracold ion coupled to a nanomechanical oscillator

SNI PhD Project P1808

Moritz Weegen, Panagiotis Fountas, Martino Poggio, Stefan Willitsch
University of Basel, Department of Chemistry, Klingelbergstrasse 80, 4056 Basel

**Abstract**
The trapping of ions in radiofrequency quadrupole traps [1,2] is a well-established technique for the realization of highly controllable quantum systems with many applications in the quantum sciences [3-6]. On the other hand, nanomechanical oscillators such as cantilevers are promising interfaces between the classical and quantum world as they provide quantum properties at very low temperatures. Their high sensitivity makes them excellent probes for precise measurements on the atomic level, as for example famously used in atomic force microscopy.
Theoretical studies have shown new possibilities of quantum state preparation [7] by driving the mechanical motion of the nanowire on and close to resonance with the ions' trapping frequencies. In order to achieve frequency-matching between the two systems, dynamic adjustment of applied voltages, depending on parameters such as the nanowire's exact position in the trap, is necessary. Here we report progress on the characterization of the ion-nanowire system, showing the nanowire's influence on the trap geometry and the resulting change in trap frequencies.

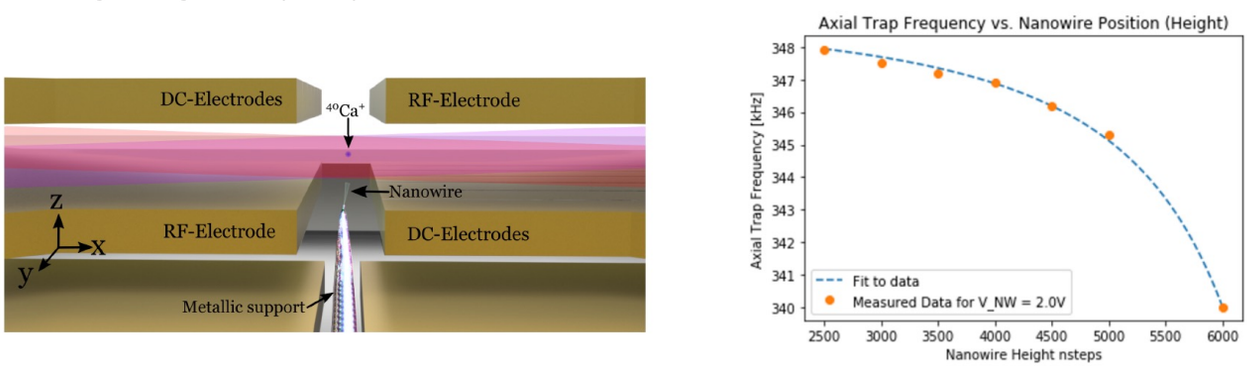


Fig 1: Left: Schematic of the ion-nanowire hybrid system [7]. Right: Change of trap frequency for different nanowire positions.

**References**

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*Poster 10*

# Prion-like spreading of amyloids: Single-cell structural proteomics

SNI PhD Project P1901

Andri Fraenkl[1,2], Larissa Glass[2], Michael Zimmermann[2], Maryam Mohammadi[2], Eline Pecho-Vriesling[3], Thomas Braun[1,2]
[1] Swiss Nanoscience Institute, University of Basel, Klingelbergstrasse 80, 4056, Basel
[2] Biozentrum, University of Basel, Spitalstrasse 41, 4056, Basel
[3] Department Biomedicine, University of Basel, Pestalozzistrasse 20, 4056 Basel

**Abstract**
The spreading of amyloid pathological lesions throughout the central nervous system is a characteristic of many neurodegenerative diseases such as Parkinson's, ASL, and Huntington's. However, the mechanisms whereby these pathological lesions spread are not well understood. The prion-like spreading model provides an intuitive explanation for the stereotypic propagation of the lesions [1-3]. However, the stochastic nature of biological systems and the rare pathological events make studying individual cells a necessity. The combination of microfluidics, enabling the handling and processing of single-cell amounts of material, and electron microscopy with its single-molecule detection limit, are a strong couple geared to analyzing changes in the structural proteome induced by the neurodegeneration [4-9].

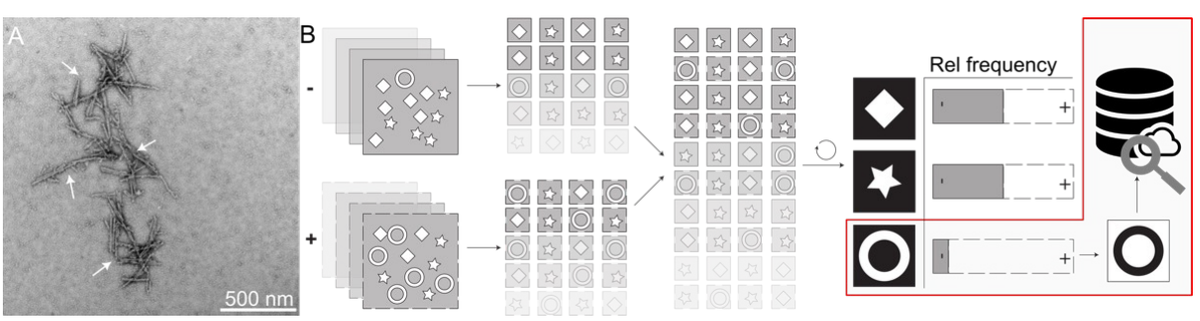


Fig 1: A) Negative stain electron microscopy image of lysate from an individual SH-SY5Y cell. α-synuclein filament fragments ("seeds") with attached proteins are visible (arrow). B) Differential visual proteomics algorithm [9] detecting changes in the structural proteome by comparing the proteome of two single cells.
Here we present a modular, microfluidic toolchain called cryoWriter for EM sample preparation. More specifically, the workflow of single-cell lysis and determining the proteomic content in mammalian neurons. First, a cell is selected under the light microscope and disrupted by electroporation while the cell content is aspirated into a microcapillary. Subsequently, the total cell lysate is prepared for electron microscopy and imaged. Finally, the imaged protein particles are subjected to a visual proteomics algorithm.

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*Poster 11*

# Neutron nanomediators: towards in-situ measurements

SNI PhD Project P1903

Antonia Ruffo[1,2,3], Pierre Boillat[1,3], Markus Strobl[1], Michel Kenzelmann[1,2]
[1] Laboratory for Neutron Scattering and Imaging (LNS), Paul Scherrer Institut (PSI), Villigen, Switzerland
[2] Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel
[3] Electrochemistry Laboratory (LEC), Paul Scherrer Institut (PSI), Villigen, Switzerland

**Abstract**
Polymer electrolyte fuel cells (PEFCs) are gaining more relevance as an alternative to batteries in the electrification of mobility, providing fast refilling and larger autonomy. However, durability and cost are still the major barriers to the commercialization. A possible approach to solve the described problematics is to understand the temperature distribution across the PEFCs structures, as its efficiency and durability depends on thermal management. Actual methods include using micro-thermocouples [1]: unfortunately, the invasiveness of the measurement causes an unreliable data detection.
Magnetic nanoparticles were proposed and studied as a non-invasive sensor within fuel cells. Neutron depolarization imaging (DNI) has been generically used to analyze the magnetic property of materials [2] based on the neutron precession. Here, the latter phenomenon has been used to detect the variation of temperature. In the current work are presented the DNI results of the first in-situ implementation of several nanomediators (Ni, Fe, NdFeB and NiAl), dispersed over gas diffusion layers (GDLs), porous materials used at the heart of the fuel cell structure. Freudenberg H23 GDLs samples were sintered with a fluorinated ethylene propylene (FEP) treatment [3], a well-known polymer used, for the following experiment, as a coater and disperser of nanoparticles. In figure 1 is confirmed a significant decrease of the depolarization coefficient ($\Sigma_{Dnorm}$) as a function of temperature – a promising result towards the targeted application of in-situ thermometry.

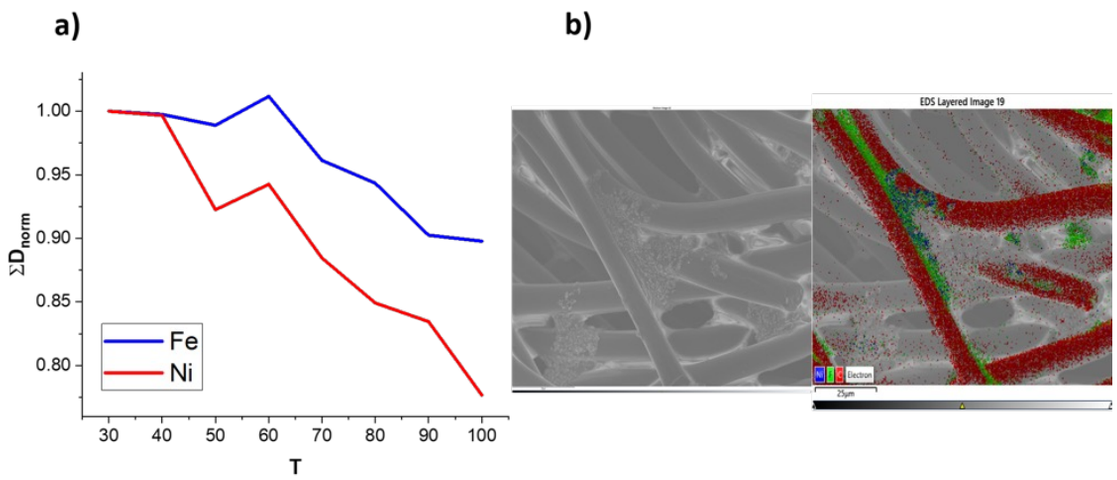


Fig. 1: a) Comparison of the depolarization coefficient variation respect the temperature of GDLs, coated with Ni and Fe nanoparticles. b) SEM image of a GDL coated with Ni (left) with its corresponding EDX data (right).

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*Poster 12*

# Functionalized nanowires as magnetic force transducers

SNI PhD Project P1905

Lukas Schneider[1,2], Hinrich Mattiat[1], José María De Teresa[3], Martino Poggio[1,2]
[1] University of Basel, Department of Physics, Klingelbergstrasse 82, 4056 Basel
[2] Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel
[3] Laboratorio de Microscopías Avanzadas, University of Zaragoza, 50018 Zaragoza, Spain

**Abstract**
Free standing nanowires (NWs) are sensitive mechanical force transducers. They have thermally limited force sensitivities of a few aNHz1/2. The main reason for the high sensitivity is their low mass. We use the NWs in a pendulum-type geometry as scanning force probes. Forces acting on a NW change its motion. The NW motion is detected optically with an interferometer.
While scanning a sample of interest below the tip of a NW the frequencies and amplitudes of the two first order in-plane modes of the NW oscillation are read out. They are influenced by the tip-sample interaction. Independent read-out of the two oscillation frequencies and amplitudes allows for simultaneous mapping of the in-plane force gradients.
Currently, we are working on finding optimal NWs for magnetic force sensing. In collaboration with J. M. De Teresa from the University of Zaragoza we explored two options. First, we grew NWs by focused electron beam deposition (FEBID). They are fully magnetic and exhibit an AC sensitivity to magnetic fields of about 3 nNHz1/2 [1]. Second, we grew Co tips at the free end of GaAs/AlGaAs NWs and Si NWs. The advantages and drawbacks of both options will be highlighted.

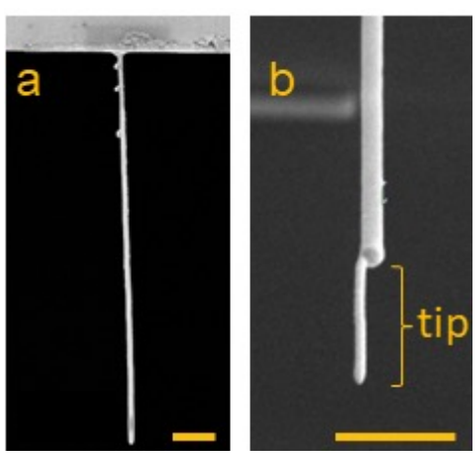


Fig. 1: Magnetic NWs. FEBID Co NW in a, FEBID Co tip on Si NW in b. Bars are 1 µm.

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*Poster 13*

# Coherent feedback cooling of a nanomechanical membrane with atomic spins

SNI PhD Project P1907 Spin-opto-nanomechanics

Gian-Luca Schmid, Chun Tat Ngai, Maryse Ernzer, Manel Bosch Aguilera, Thomas M. Karg, Philipp Treutlein
Swiss Nanoscience Institute and Department of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel

**Abstract**
Coherent feedback stabilises a system towards a target state without the need of a measurement, thus avoiding the quantum backaction inherent to measurements. In our experiment (Fig. 1), we employ optical coherent feedback to remotely cool a nanomechanical membrane oscillator using the collective spin of an atomic ensemble as controller [1]. Direct time-controlled manipulation of the spins allows us to tune the spin-membrane interaction from strong coupling to an overdamped regime. By applying a stroboscopic cooling, the cooling rate can be increased by a factor of two such that we can cool the membrane in a room-temperature environment to 216 mK (2.3x103 phonons) in 200 µs (Fig. 2). Furthermore, we observe and study the effect of feedback delay, which is inherent to the macroscopic distance between system and controller. Starting from a cryogenically pre-cooled membrane, this method would enable cooling of the mechanical oscillator close to its quantum mechanical ground state. The coherent feedback on the macroscopic membrane paves the way towards more elaborate quantum protocols such as the generation of non-classical states via state swaps as well as further studies of coherent feedback in the quantum regime [2].

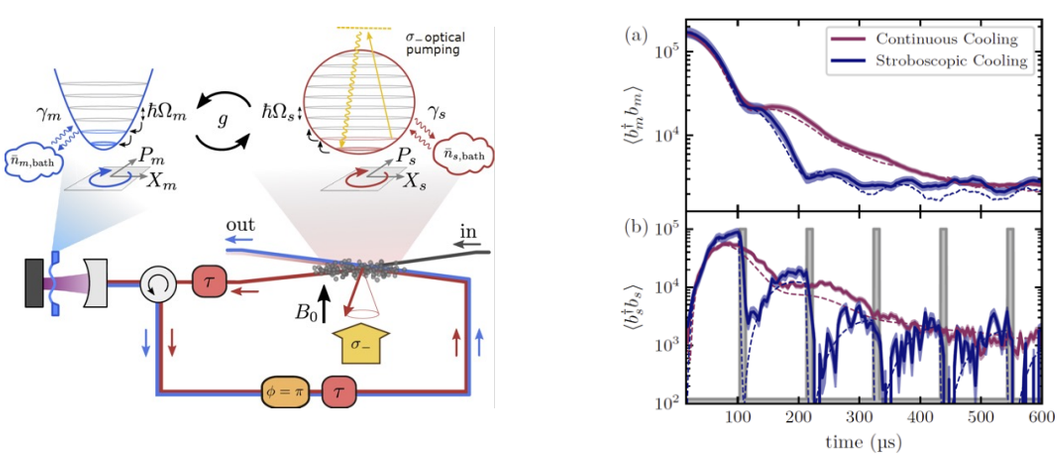


Fig 1: Left: Sketch of the light-mediated spin-membrane coupling. Light interacts first with the spin, then with the membrane, and then again with the spin. Right: (a) membrane and (b) spin occupation numbers for continuous cooling at $\gamma_s$=2g and stroboscopic cooling at $\gamma_s$=0.6 g. The gray shaded areas indicate the spin pumping pulses (where $\gamma_s \approx$ 60g).

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*Poster 14*

# Development of hafnium oxide nanocrystals as X-ray computed tomography contrast agents

SNI PhD Project P2001

Elizaveta Maksimova, Jonathan De Roo
Department of Chemistry, University of Basel, Mattenstrasse 24a

**Abstract**
In 2016, cardiovascular diseases were responsible for 31% of all global deaths (WHO). 2D histology (microscopic analysis of tissue) is the conventional technique to clinically assess the microstructure of cardiac tissue. For example, patients with a heart transplant regularly undergo an endo-myocardial biopsy (EMB). The removed cardiac tissue is then analysed for early signs of transplant rejection. On the other hand, Synchrotron Radiation X-ray Phase Contrast Imaging (SR X-PCI) is a non-destructive tomography technique, providing 3D information. While SR X-PCI measurements can provide 3D virtual histology, it is currently difficult to automatically identify early stages of rejection. Furthermore, for clinical implementation, X-PCI should be compatible with laboratory-source X-rays (having lower sensitivity). Therefore, we are developing here contrast agents that target immune cells to both improve cell differentiation and increase sensitivity.
Current contrast agents are mostly molecules with iodine (Z=53), but inorganic nanocrystals are an attractive alternative because of their low osmolality, easy functionalization of their surface, and dense packing of heavy metals. Besides, they have a longer blood residence time and reduced rate of renal clearance and "leakage" across the capillary vessels. While Au is most investigated, elements with Z=64-73 appear more suitable for clinical applications. In this project, we aim to develop hafnium oxide (Z=72) nanocrystals as novel contrast agents and apply them in cell-targeted 3D histology. Targeting the $HfO_2$ contrast agent to immune cells in cardiac tissue will enable future laboratory-source 3D histology, and the improved contrast could allow for semi-automatic segmentation by machine learning algorithms. Therefore, the clinical diagnosis will become more reliable, and automated, helping pathologists in their diagnosis.

*Poster 15*

# A death dealing nanomachine

SNI PhD Project P2002

Mitchell Brüderlin[1,2], Philip Cedro[1], Marek Basler[1], Roderick Lim[1,2]
[1] Department of Structural Biology, Biozentrum, 4056 Basel
[2] Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel

**Abstract**
Interbacterial competition has resulted in a multitude of ways bacteria are capable of killing their prey. One of these killing systems is the type six secretion system (T6SS). This highly regulated protein complex works almost like a harpoon and is used by various species as an effector protein delivery system that propels its cargo into neighbouring cells. However, what forces occur within the cell and within the complex itself is unknown. In this project we investigate both cellular response to external forces as well as intrinsic physical forces in the protein complex. To that end we use mechano-optical fluorescence microscopy coupled with atomic force microscopy (MOM-AFM). With this system we probe live cells of pseudomonas aeruginosa (PA) to examine their response to physical stimuli. In the meantime, we also investigate the individual parts of the protein complex such as the spike protein VgrG to test its physical stability and examine the forces exerted onto it during a firing event.

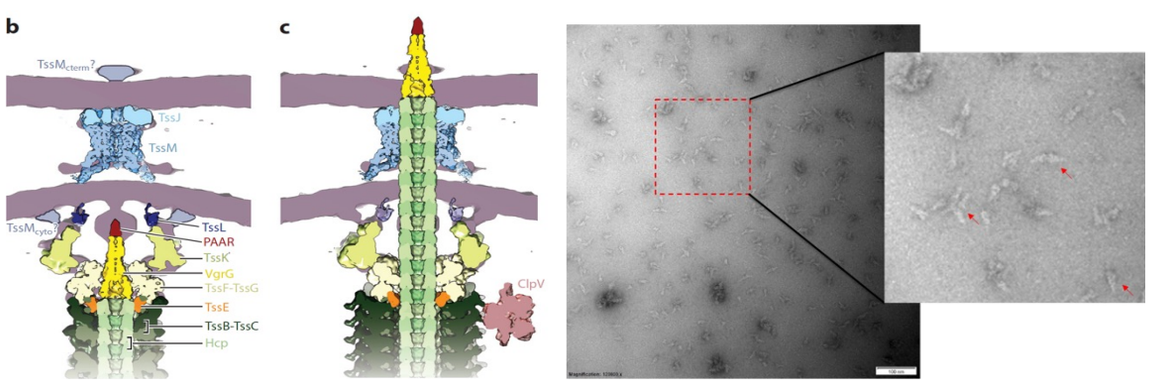


Fig. 1: Left: Overview of T6SS showing all the different proteins of the secretion machinery and their conformation during contraction [1]. Right: Display of a duelling event in pseudomonas aeruginosa imaged using fluorescently labelled sheath protein.

**References**
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*Poster 16*

# Nanoscale surface study of the multiferroic Rashba semiconductor $Ge_{1-x}Mn_xTe$

SNI PhD Project P2004

Martin Heinrich[1,2], Juraj Krempasky[3], Gunther Springholz[4], Thomas Jung[1,2], Matthias Muntwiler[1,2]
[1] Paul Scherrer Institut, Laboratory for X-ray Nanoscience and Technologies, 5232 Villigen PSI
[2] University of Basel, Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel
[3] Paul Scherrer Institut, Laboratory for Non-linear Optics, 5232 Villigen PSI
[4] Johannes Kepler University, Institute of Semiconductor and Solid State Physics, 4040 Linz

**Abstract**
GeTe is a IV-VI semiconductor compound with existing applications in optoelectronics and thermoelectrics. In addition to ferroelectricity and a large Rashba spin splitting in GeTe [1], doping with Mn atoms introduces ferromagnetism, which makes $Ge_{1-x}Mn_xTe$ a magnetoelectric multiferroic with coupled electric and magnetic polarization. Preliminary results indicate that the surface layers decouple from the bulk structure and that the polarization of surface spins via external electric fields is possible [2]. A thorough analysis of its surface atomic, electronic and magnetic structure is therefore of great importance for possible device applications such as spin-FETs or electrically controlled magnetic storage.
XPD and PhD measurements of GeTe (Fig.1a) compared to multiple scattering simulations allow us to gain information about the layer structure at the surface. In addition, STM measurements have been performed indicating triangular growth with local defects (Fig.1b). Here we study the size and role of domains, for example whether they are tied to grains in the morphology of the film. STS curves and Fourier transformed dI/dV maps are compared with (k-integrated) ARUPS measurements to match band structure features such as the Rashba splitting of surface bands with local electronic features. In this way we hope to gain a deeper understanding of the different interactions involved and how they translate from the local atomic to the larger averaged picture. In addition, we are preparing spin-polarized STM/STS [3] measurements with a magnetic tip to read out the local spin polarizations. We plan to test the magnetoelectric effect on the nanoscale by writing and reading a spin pattern using the electric field of the STM tip.

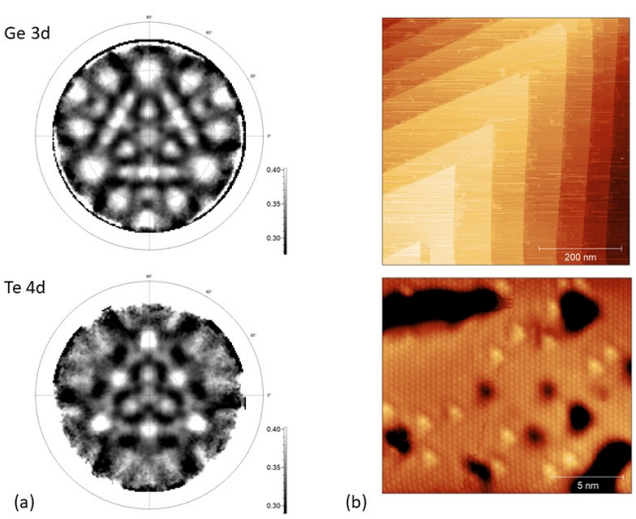


Fig. 1: (a) Measured XPD patterns for epitaxially grown GeTe fims. (b) STM pictures of GeTe showing triangular step growth and surface defects.

**References**
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*Poster 17*

# Transmembrane protein-mediated loading of synthetic compartments

SNI PhD Project P2005

Piotr Jasko[1,2,3,4], Cora-Ann Schoenenberger[1], Stephanie Gros[2,4], Richard Kammerer[3,4], Cornelia G. Palivan[1,4]
[1] Department of Chemistry, University of Basel, Mattenstrasse24a, 4058 Basel, Switzerland
[2] Department of Pediatric Surgery, University Children's Hospital Basel, 4031 Basel, Switzerland
[3] Department of Biology and Chemistry, Paul Scherrer Institute, Forschungsstrasse 111, 5232 Villigen PSI
[4] Swiss Nanoscience Institute, Klingelbergstrasse 82, 4056 Basel, Switzerland

**Abstract**
Compartmentalization, a prerequisite for the spatiotemporal control of biochemical pathways in cells, is an emerging concept in designing new materials for medical and technological applications. Synthetic nano- and micro-compartments (NCs, MCs), with their chemical versatility and superior stability provide the basis for developing catalytic compartments, artificial organelles, or cell mimics furnished with specific biomolecules [1]. However, a higher compartment loading efficiency and better permeability of the synthetic membrane remain hurdles that need to be overcome to increase the efficacy of in situ reactions. We aim to develop next-generation functional artificial compartments, modulate their composition by specific transmembrane proteins [2, 3] that deliver or selectively let molecules pass to the interior and test their activity in vitro, as exemplified in figure 1. Towards this aim, we genetically engineered fluorescent proteins onto the amino- or carboxy terminus of bacterial toxins and produced 8 fusion variants. Purified recombinant fusion proteins were used to scrutinize conditions that promote their surface interactions with the membrane and ultimately result in their integration into the membrane of synthetic compartments. Preliminary results obtained with one of these variants suggest that membrane insertion is strongly influenced by ionic conditions as well as the curvature of the membrane.

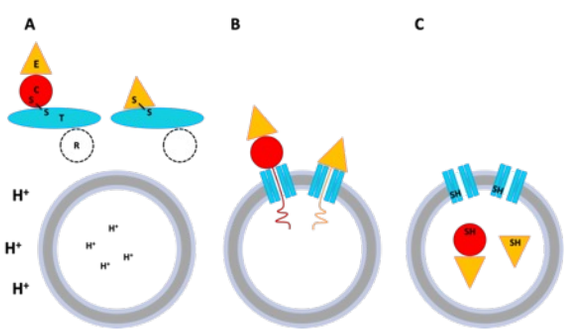


Fig. 1: Model of enzyme translocation across compartment membranes by bacterial toxin-based delivery vehicles.
A) Our adapted protein toxin molecules share a similar three-domain architecture: catalytic domain (C; red), translocation domain (T; light blue), and receptor-binding domain (R; white), which is absent in our constructs. B) The toxin variants are inserted into artificial membranes. C) Under specific conditions, e.g., acidification, C is translocated across artificial membranes without additional protein factors. Enzymes (E) fused to the N-terminus of C variants lacking the receptor-binding domain or directly to the translocation domain will be transferred. The reducing environment inside the compartment will release the enzymes, now confined by the liposome or polymersome membrane (gray).

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*Poster 18*

# Interaction of zirconium oxo clusters with amphiphiles at the air-water interface

SNI PhD Project P2006: RESTRAIN

Ajmal Roshan Unniram Parambil[1,2], Patrick Shahgaldian[1], Jonathan De Roo[2]
[1] FHNW, Institute of Chemistry and Bioanalytics, School of Life Sciences, U4132 Muttenz, Switzerland
[2] Department of Chemistry, University of Basel, 4058 Basel, Switzerland

**Abstract**
MOFs are organic-inorganic crystalline materials that consist of a regular array of metal clusters and rigid polytopic organic linkers [1]. Though MOFs are being extensively studied in catalysis, gas storage and separation, their practical applicability is held back by the difficulty of producing large MOF solids [2]. Researchers are also interested in developing two-dimensional MOFs through interface-assisted methods [3, 4]. Despite tremendous research on MOF design, it is remarkable that the current synthetic methods do not apply to 2D MOF nanofabrication and do not allow the production of large MOF single crystals.

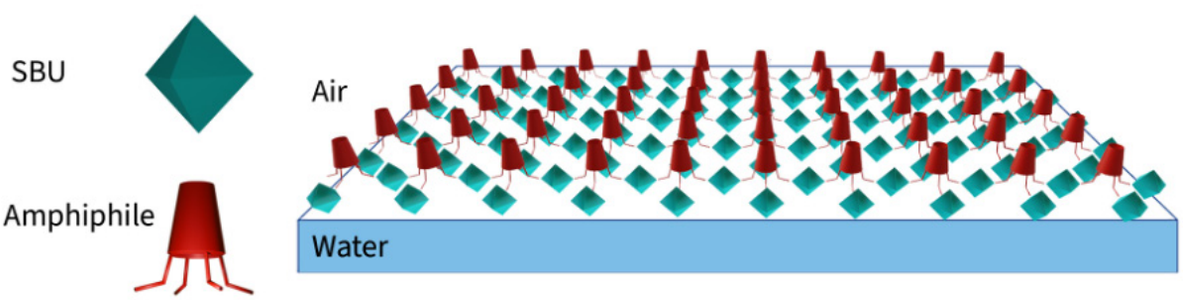


Fig 1: Schematic representation of the desired self-assembly of amphiphiles and secondary building units at the air-water interface

Here, we synthesized different $Zr_6O_8$ core-based oxo clusters as secondary building units (SBUs) and a series of amphiphilic organic linkers. The newly produced SBUs and amphiphiles are combined at the air-water interface to produce monolayer thin films in the form of 2D MOFs. The self-assembly properties and interfacial behavior of the layers were studied using the Langmuir balance method, Brewster-angle microscopy, and surface ellipsometry. The produced layers will be examined for their ability to template the growth of large MOFs.

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*Poster 19*

# Scanning nanowire quantum dot

SNI PhD Project P2008

Luca Forrer, Aurèle Kamber, Prof. Martino Poggio, Prof. Dominik Zumbühl, Dr. Floris Braakman
University of Basel, Department of Physics, 4056 Basel, Switzerland

**Abstract**
We are developing a new kind of scanning probe microscope, which employs gated quantum dots embedded in semiconductor nanowires, integrated on the tip of standard force microscopy cantilevers. Such sensor will be a sensitive scanning probe of charge and electronic density [1]. It will be used to characterize the spatial profile of charge noise, quantum dots, and electric fields [2]. Here we show our progress in fabricating electrical contacts on the cantilever using our floating resist coating recipe.

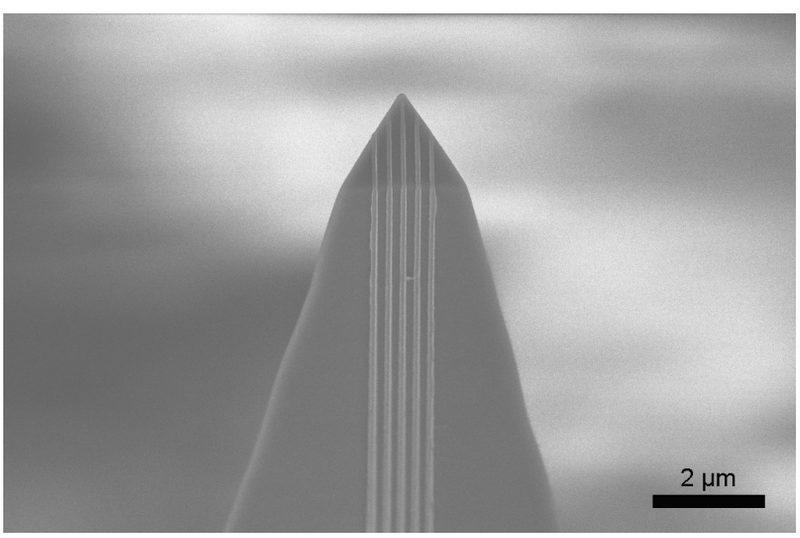


Fig. 1: Five 100nm wide gates made on a non-contact AFM cantilever using floating resist coating and electron beam lithography.

**References**
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*Poster 20*

# Bosonic quantum information processing with Schrödinger-cat qubits

SNI PhD Project P2101

Alessandro Bruno, Francesco Adinolfi, Tristan Kuttner, Alexander Grimm
Paul Scherrer Institut, LNQ, Bosonic quantum information group, Forschungsstrasse 111, 5232 Villigen

**Abstract**

Quantum two-level systems are routinely used to encode qubits but tend to be inherently fragile, leading to errors in the encoded information. Quantum error correction (QEC) addresses this challenge by encoding effective qubits into more complex quantum systems. Unfortunately, the hardware overhead associated with QEC can quickly become very large.
In contrast, a qubit that is intrinsically protected against a subset of quantum errors can be encoded into superpositions of two opposite-phase oscillations in a resonator, so-called Schrödinger-cat states. This "Schrödinger-cat qubit" has the potential to significantly reduce the complexity of QEC. In a recent experiment, we have demonstrated the stabilization and operation of such a qubit through the interplay between Kerr nonlinearity and single-mode squeezing in a superconducting microwave resonator [1].
In this talk, I will review some key concepts of QEC and situate our approach within the field. I will give an overview of the cat qubit, followed by an outlook on different applied and fundamental research directions it enables. I will highlight the nanofabrication and miniaturization aspects that are relevant to the implementation of this type of qubit [2,3].

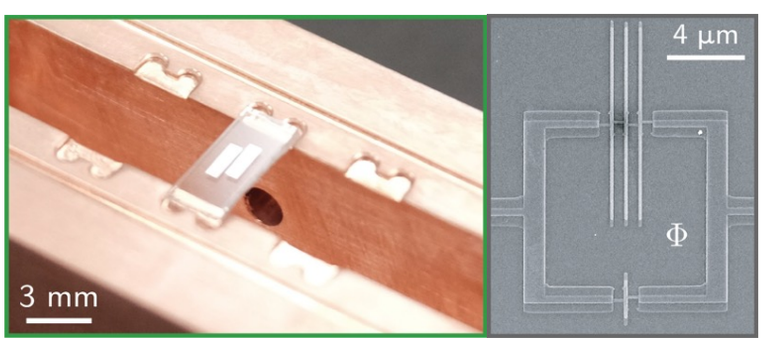


Fig. 1: Left panel: a sapphire chip holding the circuit used to implement a Schrödinger-cat qubit inside a microwave cavity. Right panel: Nonlinear inductor built from nanofabricated Josephson junctions used in our device.

**References**

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[2] Lecocq, F. et al. Nanotechnology **22**, 315302 (2011)
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*Poster 21*

# Gold nanoparticle assemblies for Raman visualization of ovarian cancer cells

SNI PhD Project P2103

Alessandro Stumpo[1,2,3], Francis Jacob[2], Viola Heinzelmann-Schwarz[2], Scott McNeil[3], Sina Saxer[1]
[1] University of Applied Sciences and Arts of Northwestern Switzerland (FHNW), Muttenz, Switzerland
[2] Ovarian Cancer Research, Department of Biomedicine, University Hospital Basel and University of Basel,
[3] Department of Pharmaceutical Sciences, University of Basel, Basel, Switzerland

**Abstract**
Ovarian cancer (OC) is the gynaecologic malignancy with the highest mortality. Several reports suggested that overexpression of the EGFR family play an important role in OC [1], leading to clinical trials of different EGFR inhibitors [2]. Nevertheless, the most common OC treatment approach remains the debulking surgery followed by chemotherapy.
Since patients with post-surgical residual tumour ≤1 cm have higher survival rates than those with more residual disease, a correct pre-operative visualization of the disease is necessary [3]. The current imaging techniques usually involves FGS (current gold standard in surgical guidance), CT, MR, PET, and laparoscopy, each of them with one or more hurdles [4]. Recently, Raman microscopy is emerging as a label-free, sensitive and non-invasive imaging and diagnostic technique [5]. In particular, a sensitive detection of specific cell types can be achieved coupling Raman microscopy with gold nanoparticles (AuNPs), exploiting the SERS measurement [6].
In the context of imaging and diagnosis, the SERS measurement needs the AuNPs surface to be functionalized with a proper mixture of inert and active targeting functionalities. In fact, a 100% surface coverage of Raman reporter achieves the strongest signal but result in non-specific binding. In order to achieve a perfect balance between Raman sensitivity, binding specificity and AuNPs stability/biocompatibility, an appropriate balance between Raman reporters, protective layer of PEG molecules and antibodies has to be obtained [7].
Compared to AuNPs, multiple AuNPs tethered together (AuNPs assemblies) allow the most intense SERS signal possible to be reached on the so-called "hotspots" between two very close gold nanoparticles. The ideal interparticle gap (~1 nm) can be obtained by linking particles together with small linker molecules such as Cucurbit[n]urils, as described by Jones et al.[8].
Thus, we aim to synthesize AuNPs assemblies capable of targeting tumor cells and with Raman active molecules placed on the "hotspots" to increase the Raman signal (Fig. 1). The AuNP assemblies are studied in vitro on ovarian cancer cell lines with different EGFR levels to prove Raman microscopy as a useful tool to distinguish healthy from cancerous cells.

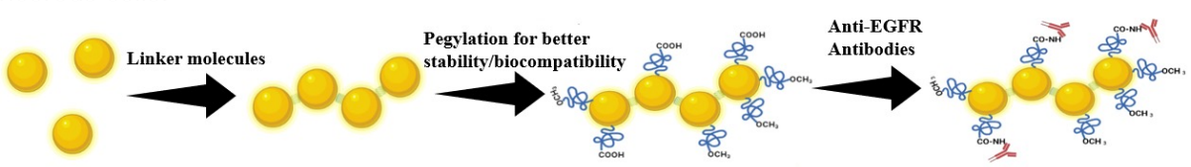


Fig. 1: Schematic illustration of the AuNPs assembly/functionalization.
Cucurbit[n]urils molecules will be used to assemble small AuNPs (<30 nm) in order to achieve an interparticle gap smaller than 1 nm, where the SERS effect is as strong as possible. Polyethylene glycol (PEG) will be used to prevent unspecific adsorption and enhance stability and biocompatibility. Anti-EGFR antibodies will be attached on carboxy group functionalized PEG surface to target cancer cells.

**References**
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*Poster 22*

# Low dose x-ray crystallography studies of FGE active site structure

SNI PhD Project P2104

Seseg Bolotova[1], John H. Beale[2], Florian P. Seebeck[1]
[1] Department of Chemistry, University of Basel, Basel
[2] Laboratory for Macromolecules and Bioimaging, Paul Scherrer Institut, Villigen PSI

**Abstract**
The formyl-glycine generating enzyme (FGE) is a mononuclear copper-dependent oxidase that catalyzes O2-dependent conversion of cysteine residues presented in specific amino acid sequence into formylglycine (fGly) [1]. The biological role of FGE is an endogenous activation of sulfatases, and a case of FGE misfunction in human cells leads to a rare disease known as multiple sulfatase deficiency. Aldehyde functional group in fGly produced by FGE is particularly interesting in terms of usage in biotechnology for protein conjugation.
The unique feature of the FGE active site is the coordination of CuI with two cysteines in near-linear coordination geometry, which is more characteristic for chaperone-like copper-trafficking proteins, rather than other copper-dependent oxidases. Upon binding the substrate, the formation of the tris-thiolate planar CuI complex with substrate peptidyl cysteine was observed [2]. FGE catalyzes O2 activation in an unusual way through binding O2 without coordination to the CuI and direct initiation of CuI/II redox reaction [3]. The crystal structure of FGE in complex with the substrate (S) and CdII as an unreactive CuI analog illustrates possible structural changes during the CuI/II redox cycle. A novel protocol for data collection at low x-ray intensities was used to obtain crystal structures with minimal radiation damage. In this presentation, I will discuss the structure of FGE:CdII:S and the latest lessons learned about the catalytic mechanism of this enzyme.

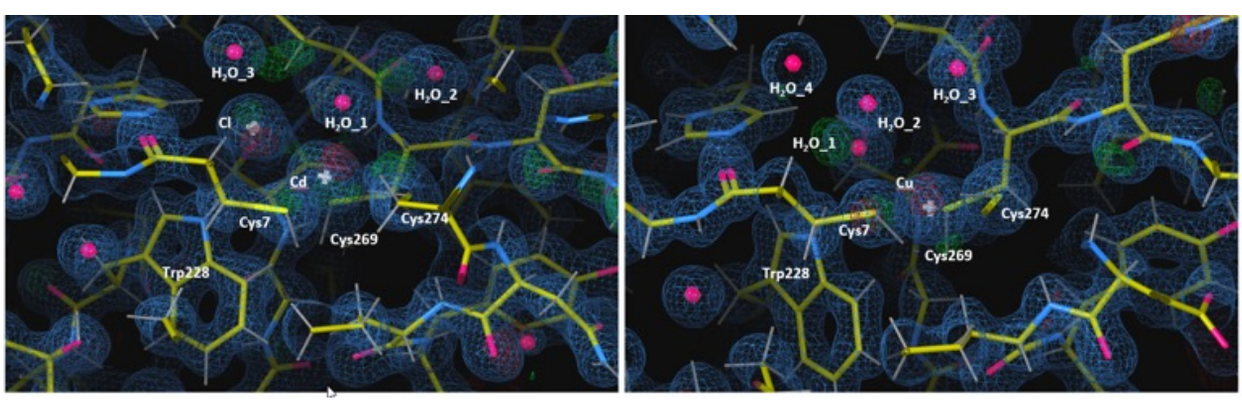


Fig. 1: View into the active site of FGE:CdII:Sub (left) and FGE N275D:CuI:Sub (right) and with electron density (2m|Fo|-D|Fc| omit map contoured at σ-level = 1.0).

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*Poster 23*

# Ferromagnetism of mobile electrons in a two-dimensional semiconductor

SNI PhD Project P2105

Rahel M. Kaiser, Nadine Leisgang, Hinrich Mattiat, Lukas Schneider, Lukas Sponfeldner,
Martino Poggio, and Richard J. Warburton
Department of Physics, University of Basel, CH4056, Switzerland

**Abstract**
Felix Bloch suggested in 1929 that mobile electrons in a metal should form a ferromagnetic state at low density [1]. Ferromagnetism means in this context that the electron spins all point along a particular direction. The ferromagnetism is a consequence of the repulsion of the individual electrons via the Coulomb force. By aligning their spins, the electrons move apart on account of the Pauli principle, lowering the net energy associated with the Coulomb repulsion. This reduction in Coulomb repulsion comes with a cost: each state can accommodate two electrons (spin-up and spin-down), such that leaving one spin state empty increases the total kinetic energy. At low densities, the Coulomb repulsion wins over the kinetic energy. This is irrelevant for normal metals for which the density is so high that the kinetic energy is dominant. In contrast, for semiconductors the density can be made sufficiently small that the ferromagnetic state becomes a possibility. However, for conventional semiconductors, silicon (Si) and gallium arsenide (GaAs), the ferromagnetic state is predicted to occur only at very low densities where the electrons are no longer mobile – they become localised by disorder even in the cleanest samples. Ferromagnetism is elusive.

The situation changes radically in two-dimensional (2D) semiconductors, for instance in $MoS_2$. On the one hand, the Coulomb repulsion is stronger than in GaAs as the dielectric constant is smaller. On the other hand, the kinetic energy cost of aligning the spins is smaller than in GaAs as the electron effective mass is larger.

Optical experiments suggest that up to a certain density, mobile electrons in $MoS_2$ do indeed form a ferromagnetic state [2]. If true, this represents a new state of matter – complex physics (more complex than Bloch envisaged [3]) cause the electron spins to align spontaneously. In parallel, evidence was presented recently for Bloch ferromagnetism in AlAs. In both cases, the evidence for the magnetisation is at best indirect, coming either from complex optical processes (the exciton – Fermi sea interaction [2]) or from subtle signatures in quantum transport [4].

We discuss here the possibility of demonstrating the ferromagnetism of mobile electrons in $MoS_2$ by probing the magnetisation directly using a scanning nano-magnetometer. This is challenging for at least two reasons. First, there is only one electron per 104 atoms – the magnetisation is much weaker than that of a conventional ferromagnet. Secondly, 2D semiconductors are small in size and inhomogeneous – imaging on the nano-scale is crucial. Nevertheless, preliminary work suggests that the signal should lie above the noise for reasonable parameters.

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*Poster 24*

# Development of a new torque sensor with improved sensitivity for dynamic torque magnetometry

SNI PhD Project P2107 High-sensitive torque magnetometry for 2D materials

Mathias Claus, Boris Gross, Ilaria Zardo, Martino Poggio
University Basel, Department of Physics & Swiss Nanoscience Institute, Basel

**Abstract**
Nanomechanical resonators allow measurement of mass, force, and torque with excellent sensitivity. Their detection limit is determined by the transducer's size, internal dissipation and radiative losses as well as clamping losses near the supports. Together, these determine a resonator's quality factor (Q). By patterning the mechanical supports, a phononic band-gap can be engineered around the transducer's resonance frequency to reduce mechanical losses, and hence, boost sensitivity.
We intend to apply this technique to fabricate ultra-sensitive mechanical torque sensors made from silicon nitride and tailor their design especially for the study of 2D materials – including 2D magnets and van der Waals heterostructures. In a next step, electrical contacts are planned to be integrated in the sensor. Here, we report on current progress in fabricating these next generation torque sensors and discuss practical challenges in achieving high-Q devices. To this point, few prototypes have been made and tested.

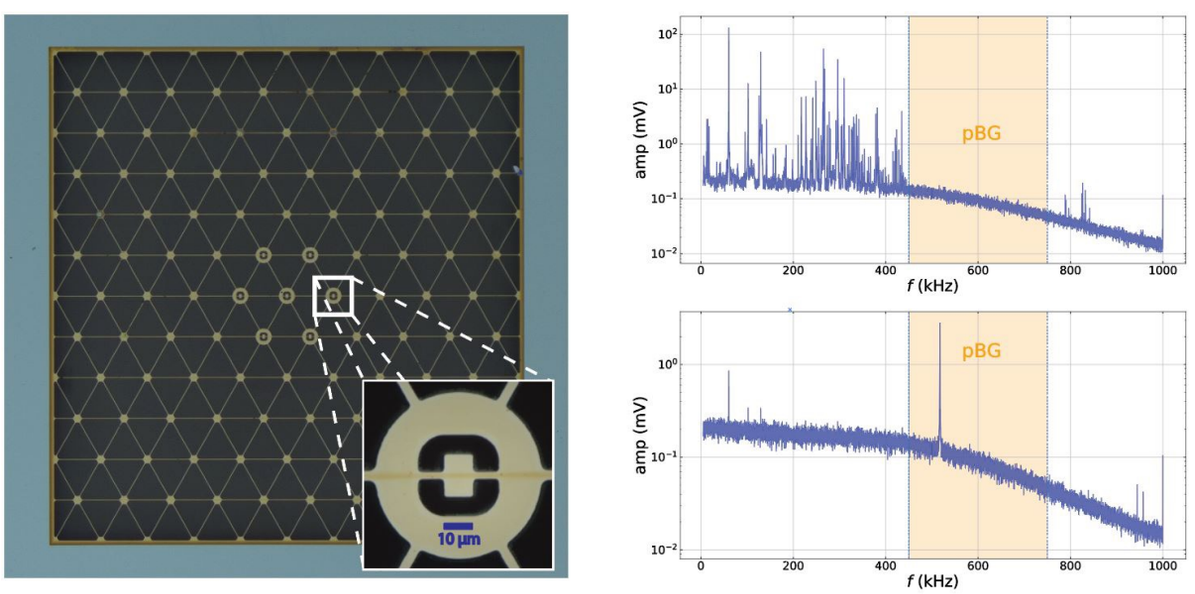


Fig. 1: 100 nm thick SiNx membrane patterned to feature a phononic band-gap (pBG) with seven torsional resonators located in the centre. The displacement spectrum of one of the torsional resonators shown on the right has a band-gap opening between ~450 – 750 kHz and the torsional resonance sits at 516 kHz.


**Informations- und Networking Event mit Nano-Argovia Partnern**

Donnerstag, 27. Oktober 2022

16.00 – 18.30 Uhr mit anschliessendem Apéro

Fachhochschule Muttenz
Hofackerstrasse 30
4132 Muttenz

Fachhochschule Nordwestschweiz
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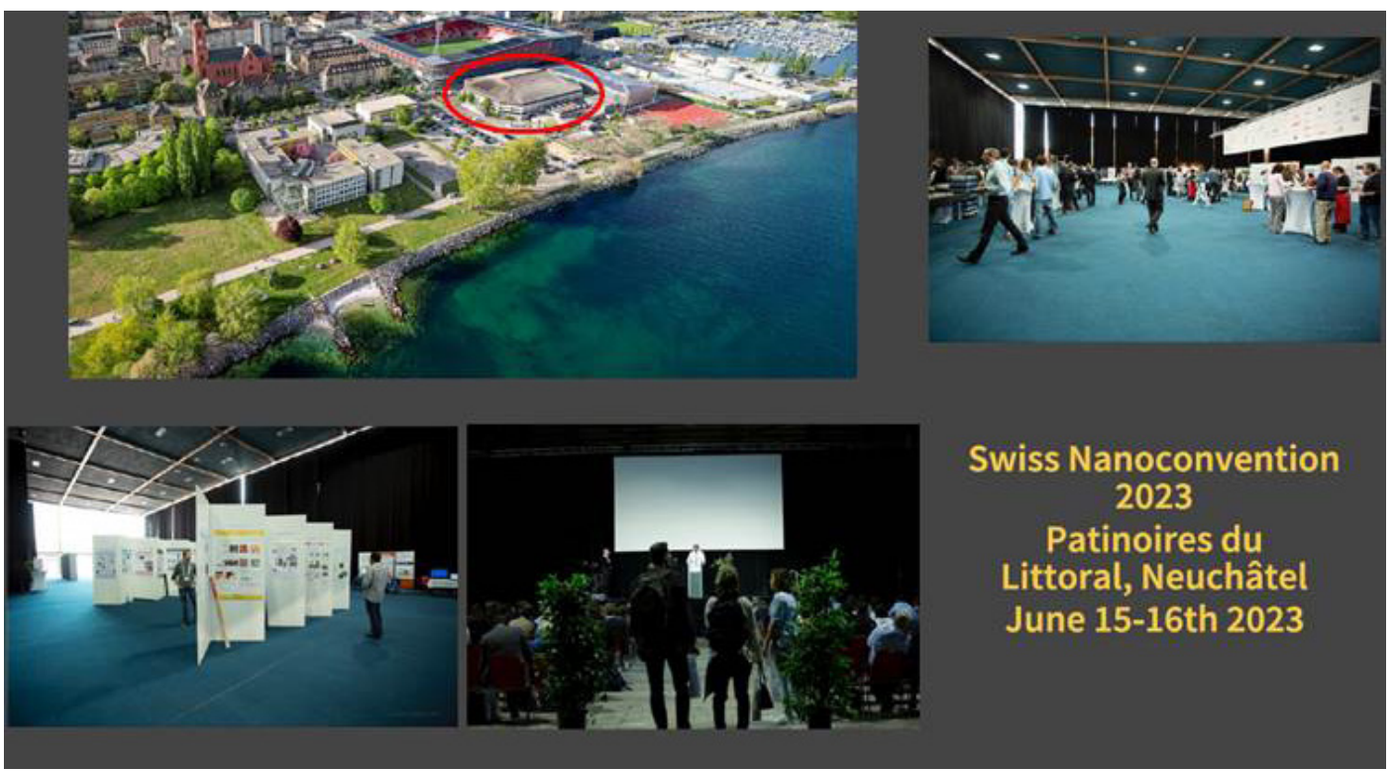
# Swiss NanoConvention 2023 in Neuchâtel Patinoires du Littoral on 15/16 June 2023




# SNI Annual Event 6 to 8 September 2023, Hotel Seerose, Meisterschwanden

*Announcement*


***Next year, the deadline for the PhD Call will be earlier, on April 30, 2023.***

**Timeline**

| | |
|---|---|
| April 30, 2023 | Deadline for project proposal |
| May - June | Review process |
| August | Information about acceptance |
| Sept. - Dec. | Search for PhD candidates |
| Jan. 1, 2024 | Earliest project start |

**More information**

| | |
|---|---|
| Web | phd.nanoscience.ch |
| Contact | andreas.baumgartner@unibas.ch |

## *List of Participants*

| Last name | first name | email | affiliation |
|---|---|---|---|
| Alaball Pujol | Maria-Elisenda | elisenda.alaball@unibas.ch | biozentrum |
| Alter | Claudio | claudio.alter@unibas.ch | pharma |
| Baumgartner | Andreas | andreas.baumgartner@unibas.ch | sni |
| Behe | Martin | martin.behe@psi.ch | psi |
| Beyer-Hans | Kerstin | kerstin.beyer-hans@unibas.ch | sni |
| Bieler | Evi | evi.bieler@unibas.ch | sni |
| Boillat | Pierre | pierre.boillat@psi.ch | psi |
| Bolotova | Seseg | seseg.bolotova@unibas.ch | chemistry |
| Braun | Thomas | thomas.braun@unibas.ch | biozentrum |
| Bruder | Christoph | christoph.bruder@unibas.ch | physics |
| Brüderlin | Mitchell | mitchell.bruederlin@unibas.ch | biozentrum |
| Bruno | Alessandro | alessandro.bruno@psi.ch | psi |
| Car | Anja | anja.car@unibas.ch | sni |
| Carrillo | Melissa | melissa.carrillo@psi.ch | sni |
| Chami | Mohamed | mohamed.chami@unibas.ch | biozentrum |
| Claus | Mathias | mathias.claus@unibas.ch | physics |
| Del Giovane | Stefano | stefano.delgiovane@csem.ch | csem |
| Doffini | Vanni | vanni.doffini@unibas.ch | other |
| Dürrenberger | Markus | markus.duerrenberger@unibas.ch | sni |
| Erpel | Susanne | susanne.erpel@unibas.ch | sni |
| Forrer | Luca | luca.forrer@unibas.ch | physics |
| Fränkl | Andri | andri.fraenkl@gmail.com | sni |
| Gadea | Gerard | gerard.gadea.diez@gmail.com | sni |
| Gerber | Christoph | christoph.gerber@unibas.ch | physics |
| Gerspach | Michael | mg@buhlmannlabs.ch | other |
| Gobrecht | Jens | jens.gobrecht@eulitha.com | other |
| Grimm | Alexander | alexander.grimm@psi.ch | psi |
| Gullo | Maurizio | maurizio.gullo@fhnw.ch | fhnw muttenz |
| Heinrich | Martin | martin.heinrich@psi.ch | psi |
| Heydari | Mehdi | mehdi.heydari@psi.ch | sni |
| Hiller | Sebastian | sebastian.hiller@unibas.ch | biozentrum |
| Huber | Annika | annika.huber@unibas.ch | chemistry |
| Hüni | Sandra | sandra.hueni@unibas.ch | sni |
| Jaeger | David | da.jaeger@unibas.ch | physics |
| Jasko | Piotr | piotr.jasko@unibas.ch | chemistry |
| Jia | Shichao | shichao.jia@psi.ch | biozentrum |
| Jung | Thomas | thomas.jung@psi.ch | sni |
| Kaiser | Rahel | rahel.kaiser@unibas.ch | physics |
| Kammerer | Richard | richard.kammerer@psi.ch | psi |
| Kazazis | Dimitrios | dimitrios.kazazis@psi.ch | psi |
| Koeser | Joachim | joachim.koeser@fhnw.ch | fhnw muttenz |
| Lim | Roderick | roderick.lim@unibas.ch | sni |
| Lücke | Arnold | arnold.luecke@unibas.ch | physics |
| Maksimova | Elizaveta | elizaveta.maksimova@skoltech.ru | sni |
| Maletinsky | Patrick | patrick.maletinsky@unibas.ch | physics |
| Martyn | Iris | iris.martyn@unibas.ch | chemistry |
| Mathys | Daniel | daniel.mathys@unibas.ch | sni |
| Meinel | Dominik | dominik.meinel@fhnw.ch | fhnw muttenz |
| Meyer | Ernst | ernst.meyer@unibas.ch | physics |
| Moeller | Christel | c.moeller@unibas.ch | sni |
| Muntwiler | Matthias | matthias.muntwiler@psi.ch | psi |

| Last name | first name | email | affiliation |
|---|---|---|---|
| Nicolas | Hugo | hugo.nicolas@fhnw.ch | fhnw muttenz |
| Ollier | Alexina | alexina.ollier@unibas.ch | sni |
| Oswald | Jacopo | jacopo.oswald@empa.ch | sni |
| Padeste | Celestino | celestino.padeste@psi.ch | psi |
| Palivan | Cornelia | cornelia.palivan@unibas.ch | chemistry |
| Pascal | Joris | joris.pascal@fhnw.ch | fhnw muttenz |
| Poggio | Tomaso | tp@ai.mit.edu | MIT |
| Poggio | Martino | martino.poggio@unibas.ch | physics |
| Poggio | Barbara | | |
| Resan | Bojan | bojan.resan@fhnw.ch | fhnw windisch |
| Riess | Walter | wri@zurich.ibm.com | ibm |
| Ruffo | Antonia | antonia.ruffo@psi.ch | psi |
| Saxer | Sina | sina.saxer@fhnw.ch | fhnw muttenz |
| Schmid | Gian-Luca | g.schmid@unibas.ch | physics |
| Schneider | Lukas | luk.schneider@unibas.ch | physics |
| Schönenberger | Christian | christian.schoenenberger@unibas.ch | physics |
| Schönenberger | Monica | monica.schoenenberger@unibas.ch | sni |
| Shahgaldian | Patrick | patrick.shahgaldian@fhnw.ch | fhnw muttenz |
| Stumpo | Alessandro | alessandro.stumpo@outlook.it | fhnw muttenz |
| Tagit | Oya | oya.tagit@fhnw.ch | fhnw muttenz |
| Tiefenbacher | Konrad | konrad.tiefenbacher@unibas.ch | chemistry |
| Treutlein | Philipp | philipp.treutlein@unibas.ch | physics |
| Treves | Sam | Samuel.treves@unibas.ch | sni |
| Unniram Parambil | Ajmal Roshan | ajmal.roshan@unibas.ch | fhnw muttenz |
| Vila-Comamala | Joan | joan.vila-comamala@psi.ch | psi |
| Warburton | Richard | richard.warburton@unibas.ch | physics |
| Weegen | Moritz | moritz.weegen@unibas.ch c | hemistry |
| Wegmann | Michèle | michele.wegmann@unibas.ch | sni |
| Wirth | Joachim | joachim.wirth@gmx.ch | other |
| Wirth | Claudia | claudia.wirth@unibas.ch | sni |
| Wyss | Marcus | marcus.wyss@unibas.ch | sni |
| Zardo | Ilaria | ilaria.zardo@unibas.ch | physics |
| Zuber | Josh | josh.zuber@unibas.ch | physics |
| Züger | Fabian | fabian.zueger@fhnw.ch | sni |

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