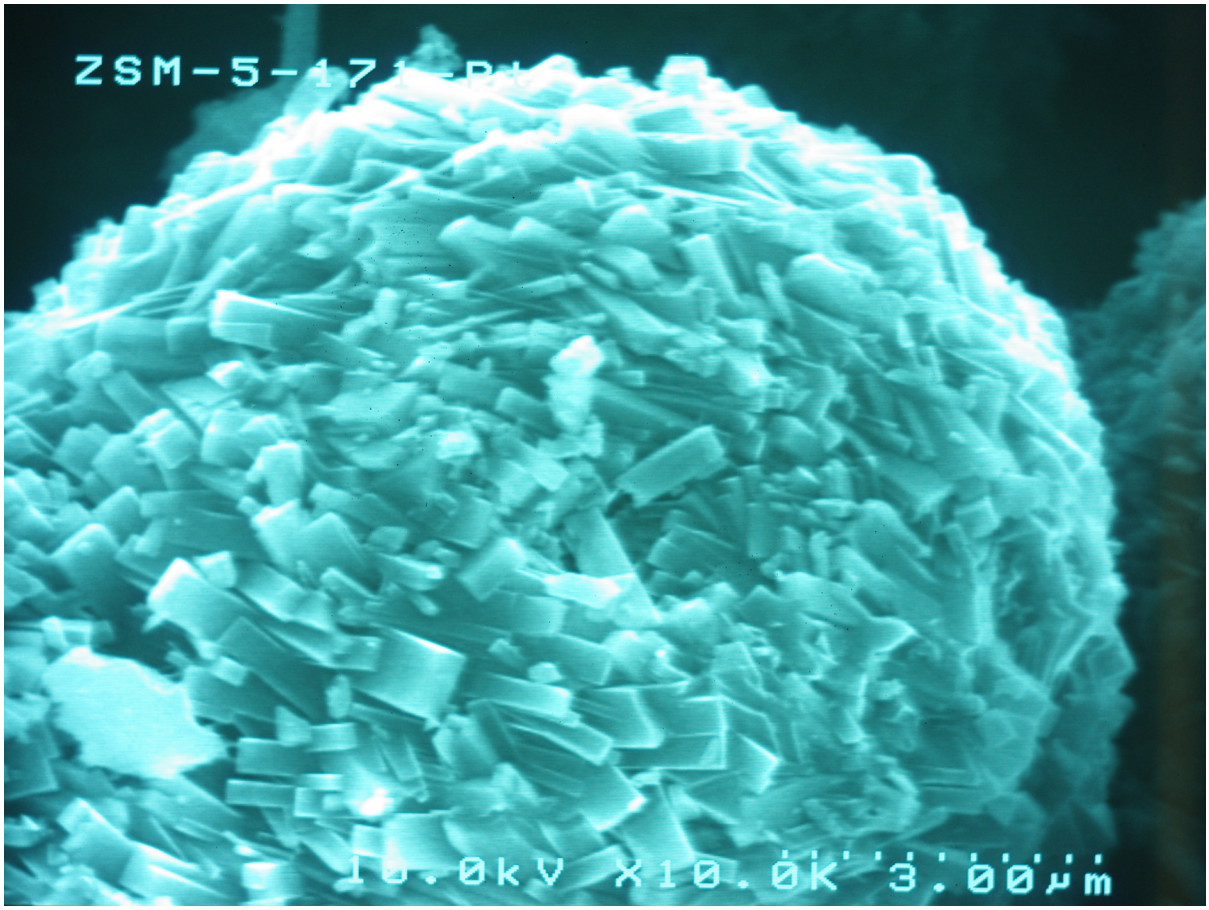
CINSaT

Center for
Interdisciplinary Nanostructure
Science and Technology

Newsletter No. 12 (August 2022)



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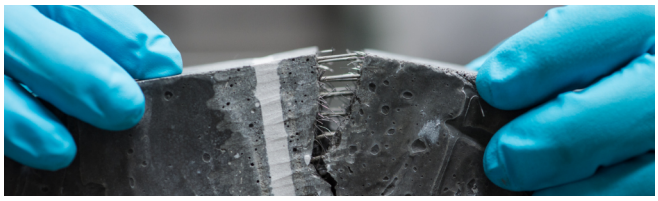

Cover Image
Ramizraza Saiyed (Technological Electronics) for Nano Diamond Group: SEM image of zeolite particles. The material is provided by the group of Prof. Yuri Kalvachev (Institute of Catalysis, Bulgarian Academy of Sciences) in the frame of a Humboldt Project with apl. Prof. Popov and plasma modified in INA.

Preface

Dear reader,

The beginning of this year marks for us in some way the return to normal conditions. Although knowing that the pandemic is still not over, meetings can be held in person and colloquia can be organized outside of the university again. So, it was possible to organize our annual Spring Colloquium in the AHORN Berghotel Friedrichroda once again on March 3rd to 4th, 2022, after a one-year timeout. With 72 participants the colloquium was well received and nearly 50 posters were presented. You can find more details in the *Latest Reports* section. In general, the CINSaT organized quite a few events in the first six months of the year from small ones to larger ones that took months of preparations to realize.

This year, we were also celebrating the 20th anniversary of CINSaT, which was founded in 2002. Related to it, an international 3-days workshop was organized from Wednesday, 30th of May till Friday, 2nd of June, in the *Tagungszentrum Südflügel* of the Kassel central station. Prestigious and well distinguished speakers could be invited from all over Europe and beyond, which allowed to create a highly exciting scientific program with interesting talks related to the focal points of the CINSaT. Over 120 participants of the workshop were listening to the 19 talks showcasing the interdisciplinary nature of the CINSaT and the numerous breaks in between the sessions gave enough opportunity for further discussion on the topics. More information and pictures of the workshop you can find the section *Latest Reports*. Related to the anniversary, we edited also a Festschrift with contributions from all active members and congratulatory notes from politics and university representatives. Many thanks to all of you who contributed to it.

Beside this, another important event, in particular for the future of CINSaT, happened. The architectural competition for the new physics and nanostructure science building ended by warding prices for the best designs. In particular, the planned clean room facilities for the new Nanotechnology Center (NTC) will be the first key lab of CINSaT. CINSaT will be directly involved in the planning and later operational organization. A brief report will be given in this newsletter.

Beside many external speakers in the workshop and in the autum colloquium, we had also a special visit of CINSaT in June by Prof. Dr. Alexey Niktin from the Donostia International Physics Center (DIPC), San Sebastian (Spain). Prof. Nikitin used the opportunity of his visit to Kassel to give an interesting special lecture on 23rd of June 2022 and to discuss with some CINSaT members possible collaborations. Some more informations are given in a brief report.

In the Education section we report about the visit of pupils from the *Internat Solling* and the *Lichtenberg Gymnasium* in Kassel on 21st June 2022. Over 30 forthcoming school graduates listened to three talks given by our members (Prof. Stengl, Prof. Fuhrmann-Lieker and me) and had afterwards the opportunity of a guided tour in the related laboratories. Furthermore, we report about the statewide junior scientist competition *Schüler experimentieren* for which the CINSaT donated prizes.

Of course, our members were also busy, and some of them were so kind to report here about their recent progress. Two new projects will be presented: the BMBF-funded DIQTOK project from Prof. Singer (Coordinator), Prof. Garcia and Prof. Popov explores the application of diamond as a material for quantum tokens and Dr. Wetzel reports about a DFG-funded project for fluorescence microscopy investigations on superplasticizer adsorption in alkali active materials. In the Research Highlights section, PD Dr. Neupert introduces an award-winning publication about transcriptomic, peptidomic and spectrometry imaging analyses of an ant brain and Dr. Wang shows us the optical tracking of single molecules in ultrahigh vacuum. Dr. Wang is a new associated member of the CINSaT which completed his application process in May 2022. He will introduce himself and his work in the New Members section.

Like always, I hope you enjoy the reading of this issue and stay healthy!

General

Latest information from the CINSaT management

Here we report briefly about key issues from the CINSaT committees, important discussions, and decisions from their meetings.

Member Meeting

The general assembly meeting of members took place on 22nd of February 2022. In the following, main issues discussed, and main decisions made are briefly listed, which are of general interest:

- The financial report was presented by the management and released by the general assembly.
- The CINSaT membership of Prof. Witzigmann and Prof. Brückner-Foit has ended due the move to the Friedrich Alexander university of Erlangen-Nürnberg and of retirement, respectively. We thank Prof. Witzigmann and Prof. Brückner-Foit for the support over the years and wish all the best for the future.
- Dr. Daqing Wang was approved as an associated CINSaT member.

New Members

We welcome three new members to the CINSaT:

- Dr. Daqing Wang is a post-doc in the group of Prof. Singer, Experimental Physics I - Light-Matter-Interaction. He applied in October 2021 for associated membership and gave his introduction talk during the autumn colloquium 2021. His application was accepted by the members during the member meeting on 22nd February 2022. He will present his work in the New Members section.
- Prof. Dr. Stefan Buhmann is the group leader of Theoretical Physics III - Macroscopic Quantum Electrodynamics. He applied in January 2022 for full membership and gave his introduction talk during the spring colloquium 2022. His application was accepted by the members via postal vote on 11th April 2022. He will present his work in a forthcoming volume of the newsletter.
- Prof. Dr. Claudia Backes is the group leader of Physical Chemistry of Nanomaterials. She applied in February 2022 for full membership and gave her introduction talk during the spring colloquium 2022. Her application was accepted by the members via postal vote on 11th April 2022. She will present her work in a forthcoming volume of the newsletter.

All three members were confirmed by decision of the presidential board on 23rd of May 2022.

Education

Learning without brain and oil recovery with bacteria

On Friday, April 1st and Saturday, April 22, 2022, the state competition of the junior science contest „Schüler experimentieren“ took place at campus Wilhelmshöher Allee in the faculty of Electrical Engineering. 28 Teams with members not older than 14 years qualified in various disciplines for this event. CINSaT donated a special prize on projects that are directed towards „a small world“ („Die Welt im Kleinen“). This prize was jointly awarded to two teams:

Annika Seuring and **Hendrik Ludwig** from the Rabanus Maurus school in Fulda investigated the learning behaviour of slime moulds, unicellular organisms with many nuclei that are able to learn without possessing nerve cells. The team demonstrated that the slime mould can couple stimuli according to classical conditioning experiments (also called Pavlov experiment). What at first glance sounds like science fiction may shed new light on the definition of intelligent organisms.

Alexander Ahrend from the Karl Popper school in Frankfurt measured the viscosity of oil with a variety of additives in order to find methods to extract raw oil more easily. Besides using metal powder he wanted to create gaseous thinning agents by the action of urease on compost materials such as beetroot peels. A creative idea that not many people would think of.

CINSaT congratulates all winners and encourages them to become the scientists of tomorrow.

Fig. 1: Annika Seuring and Hendrik Ludwig with their project presentation on slime moulds

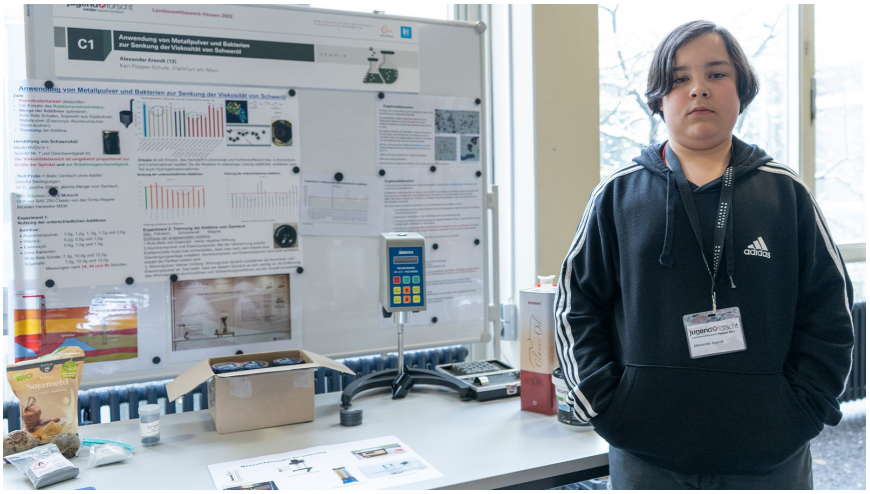

Fig. 2: Alexander Arendt with his project presentation on oil recovery

Pupils visit the CINSaT

Soon to be high school graduates visit – talks and laboratory tours present Nanoscience study course and current research in the CINSaT

On 21st June 2022 around 35 pupils and 5 teachers form the Internat Solling and the Lichtenberg Gymnasium in Kassel visited the CINSaT. Dr. Frank Hubenthal, MINT coordinator of the Internat Solling and alumni from the University of Kassel, initiated the visit for the second time after 2018. Three 30-minute talks and guided tours in three laboratories gave insight into the study course Nanoscience and some of the current research in the CINSaT.

The first talk was given by our member Prof. Monika Stengl from the Animal Physiology department telling the audience about her work to unravel the inner workings of the biological clock in animals and humans. She invited the pupils to ask questions about time and the feeling of what they perceive as time from the perspective of a chronobiologist which sparked a lot of questions that were readily answered by Prof. Stengl. The second talk was given by Prof. Thomas Fuhrmann-Lieker from the Physical Chemistry of Nanomaterials department which was more general about the dimensions of a nanometer, what nanostructures we can find in nature and how we can use nanostructures to create new materials with new properties that help us to overcome the challenges of the future. Furthermore, Prof. Fuhrmann-Lieker introduced the study course Nanoscience which excels in its interdisciplinary curriculum combining the physics, biology and chemistry of nanostructures in a unique way. The last talk was given by our Speaker Prof. Johann Peter Reithmaier from the Technological Physics department. In his talk he focused on the technological applications of nanoscience. He showed how we can grow thin layers of semiconductors on a substrate with atomic precision and how we can use these structures to create artificial atoms in quantum dots and their application as single photon emitters or in lasers with unmatched properties.

Fig. 1: CINSaT Speaker Prof. Reithmaier explains the principle of the clean room and the function of the devices stored in it to a group of pupils.

Surely not everyone could follow each detail of the lectures given, but the questions asked after each talk showed that the general understanding and concepts showed in the lectures were well understood by the audience. However, after 90 minutes of scientific lectures everyone could appreciate a short break, and everyone was looking forward to the guided lab tours. For this the visitors were divided into groups of 12 and shown around the laboratories in a 20-minute tour by PhD students and professors alike. After all tours were completed and all questions were asked – and mostly answered - the day ended.

Fig. 2: Dr. Frank Hubenthal introduces Prof. Stengls talk about biological clocks.

Research Highlights

2nd place winner of the 2021 Mark A. Smith Award

for your paper: Habenstein et al. "Transcriptomic, peptidomic, and mass spectrometry imaging analysis of the brain in the ant Cataglyphis nodus

In July 2021 we published our comprehensive work on molecular imaging of the brain of the ant *Cataglyphis nodus* in the Journal of Neurochemistry with Dr. Jens Habenstein (University of Würzburg) as first author. In May 2022, the *Journal of Neurochemistry* announced that the paper was selected as the second place winner of the 2021 Mark A. Smith Award. This annual award, inaugurated in 2009, is granted by the International Society for Neurochemistry (ISN), *Journal of Neurochemistry*, and its publisher Wiley in recognition of the contribution of outstanding young scientists to an exceptional research paper published in the *Journal of Neurochemistry*.

Background:
Behavioral flexibility is an important cornerstone for the ecological success of animals. Insect societies operate as cohesive units, even though individual colony members may express very different behavioral phenotypes contributing to diverse tasks. These are often related to age. Age-related behavioral plasticity in social insects was shown to be associated with changes in diverse neuromodulators and neuropeptides (rev [1]). Neuropeptides represent a very large and diverse group of intercellular messenger molecules. They are processed from larger precursor proteins (preproproteins) by a set of dedicated enzymes that cleave the proprotein at specific sites (e.g. [2]). Neuropeptides plays a key role of in the flexible regulation of distinct behavioral phenotypes in social insects, such as for the transition from nursing behavior inside the dark nest to outdoor foraging. In thermophilic ants of the genus *Cataglyphis Foerster* (Hymenoptera, Formicidae) the stage-specific change in behavior provides an excellent experimental model to investigate the neuronal mechanisms underlying behavioral plasticity [3]. We propose that neuropeptides are responsible for the flexible modulation of distinct neuronal circuits resulting in stage-specific behavioral plasticity in individual ants.

As the neuropeptidome of *C. nodus* was unknown, we collected a comprehensive set of neuropeptidomic data obtained by transcriptome analysis of the ants' central nervous system combined with brain extract analysis by Q-Exactive Orbitrap mass spectrometry (MS) and direct tissue profiling by matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) MS of selected neuronal tissues (Fig 1).

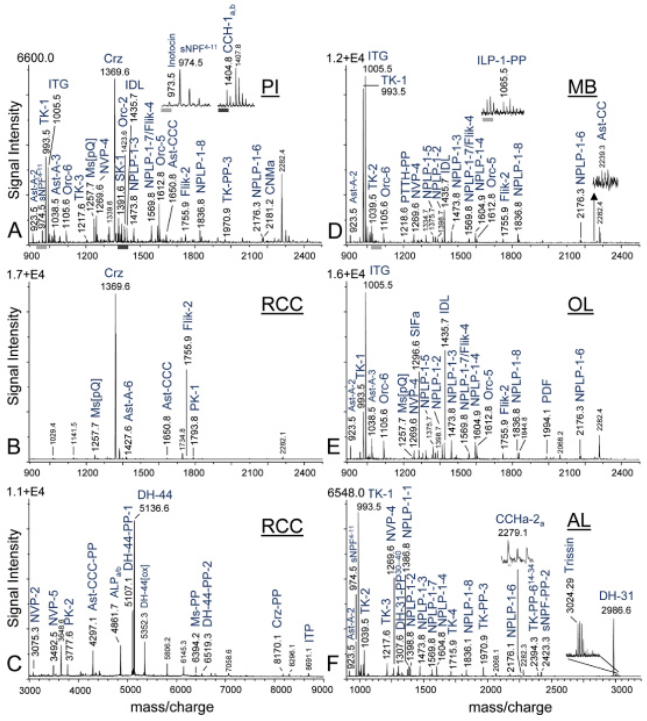

*Fig. 1: MALDI-TOF mass spectra (direct tissue profiling) obtained from preparations of **(A)** pars intercerebralis (PI), **(B,C)** retrocerebral complex (RCC), **(D)** mushroom body (MB), **(E)** optic lobe (OL), and **(F)** antennal lobe (AL). Ast-A, allatostatin-A; Ast-CCC, allatostatin-CCC; DH-31, calcitonin-like diuretic hormone-31; DH-44, corticotropin-releasing factor-like diuretic hormone-44; Crz, corazonin; IDL, IDL-containing peptide; ITG, ITG-like peptide; ITP, ion transport peptide; Ms, myosuppressin; TK, tachykinin-related peptide; NVP, NVP-containing peptide; NPLP-1, neuropeptide-like precursor 1; Orc, orcokinin; Flik, fliktin; PDF, pigment dispersing factor; PK, pyrokinin; PP, precursor peptide; sNPF, short neuropeptide F; SK, sulfakinin.*

In total, we identified 71 neuropeptides with likely bioactive functions, encoded on 49 neuropeptide-, neuropeptide-like, and protein hormone precursors, including a novel neuropeptide-like precursor (fliktin). In addition, we characterized the spatial distribution of a subset of peptides encoded on 16 precursor proteins with high resolution by MALDI MS imaging (MALDI-MSI) on 14 µm brain sections (Fig 2).

The accuracy of our MSI data was confirmed since immunostaining patterns for tachykinins matched with MSI ion images in consecutive brain sections (Fig 3).

The editors were impressed and fascinated by our comprehensive work that for the first time allowed to correlate a behavioral switch with a change in neuropeptide expression in respective neuropeptidergic brain circuits *in vivo*. In addition, our paper supplies a solid framework for future study of the functional role of neuropeptides that may be transferred to other animal species.

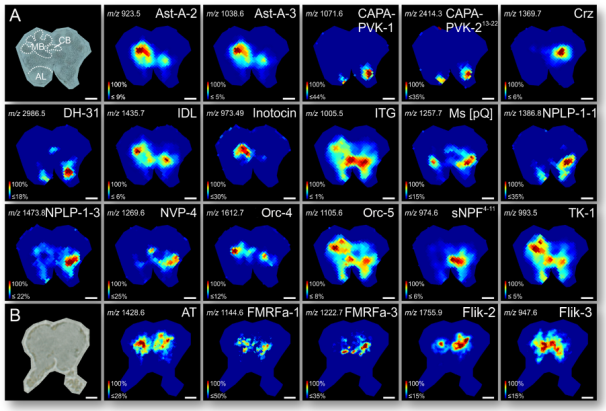

Fig. 2: MALDI-MSI ion maps show the spatial distribution of 22 peptides from 16 genes in two examplary ant brain sections including the novel neuropeptide fliktin. The accuracy of mass matching for peptide assignment was settled at ±0.05 %. Scale bars = 200µm.

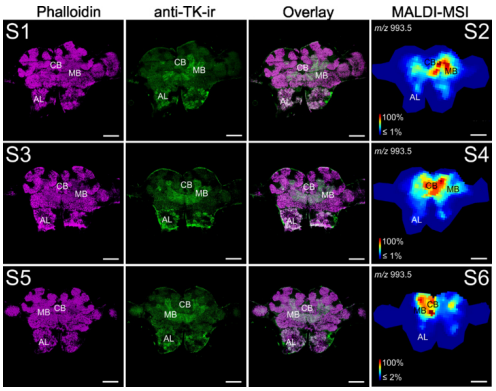

*Fig. 3: **Distribution of tachykinin-related peptides (TK) analyzed in six consecutive brain sections (S1-S6)** using immunohistochemistry (a-TK-ir, green) and MALDI-MSI. F-actin labeling with phalloidin (magenta) identified neuropil regions. Immunolabelled and detected molecules corresponding to TK shifted from the right to the left brain hemisphere in consecutive serial sections. Scale bars = 200 µm.*

Paper:

Habenstein J, Schmitt F, Liessem S, Ly A, Trede D, Wegener C, Predel R, Rössler W, Neupert S. (2021) Transcriptomic, peptidomic, and mass spectrometry imaging analysis of the brain in the ant *Cataglyphis nodus*. J Neurochem. 158(2):391-412. doi: 10.1111/jnc.15346.

Further information

[1] Hamilton A., Shpigler H., Bloch G., Wheeler D.E., Robinson G.E. (2016) Endocrine influences on insect societies. Non-mammalian hormone-behavior systems. Elsevier.

[2] Pauls D., Chen J., Reiher W., Vanselow J.T., Schlosser A., Kahnt J., Wegener C., (2014) Peptidomics and processing of regulatory peptides in the fruit fly Drosophila. EuPA Open Proteomics. 3, 114–127.

[3] Rössler W. (2019) Neuroplasticity in desert ants (Hymenoptera: Formicidae) – importance for the ontogeny of navigation. Myrmecol. News. 29, 1-20.

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Optical Tracking of Single Molecules in Ultrahigh Vacuum

Optical microscopy of single molecules is widely applied in studying dynamic processes with simultaneously high spatial and temporal resolutions. A prerequisite for achieving these high resolutions is to efficiently collect photons emitted from a molecule. In this work, we demonstrate that efficiency photon collection can be achieved for molecules on a surface in ultrahigh vacuum. This opens the possibility to combine optical microscopy with conventional surface science experiments.

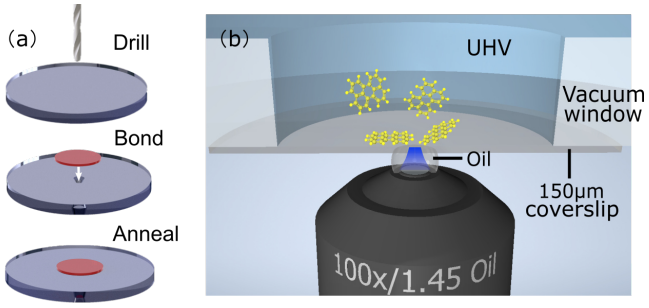


Fig. 1: (a) Fabrication of the thin vacuum window. (b) Illustration of the experimental setup.

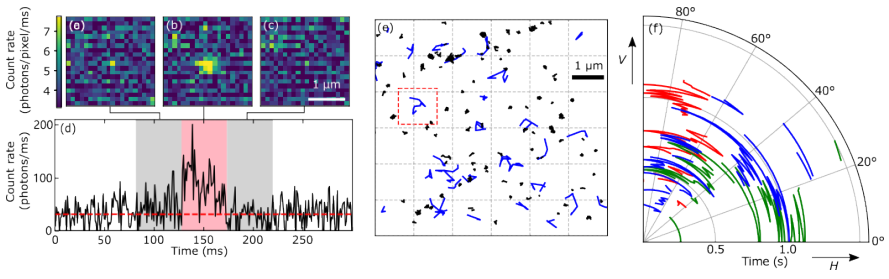
To achieve this, we adapt oil-immersion microscopy to a homemade vacuum window with 150-µm thickness. In this way, tracking the dynamics of single fluorescent molecules on the inner surface of the fused silica window is feasible. The fabrication of this vacuum window was carried out in collaboration with the glass-workshop and is illustrated in Figure 1. Based on this system, we demonstrate that the adsorption, translational and rotational diffusion of single perylene molecules on fused-silica surface can be resolved [see Figure 2]. Single molecules can be imaged with a time resolution of ≥ 1000 frames per second. The trajectories of translational diffusion of single molecules are tracked with a precision of ~ 24 nm. Besides, the orientations of molecules are also constructed with an average uncertainty of ± 8°. By measuring the temporal dynamics of the ensemble fluorescence intensity, we deduce two characteristic decay time scales for fluorescence signal, suggesting the coexistence of different adsorption states of perylene molecules.

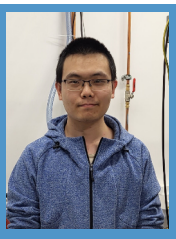
In the future, the system can be extended, e.g., by encapsulating the fused-silica window with thin conductive layers or two-dimensional materials to make it compatible for surface science studies. Such a system would also facilitate simultaneous correlative electron and light microscopy.

Further information

Tianyu Fang, Florian Elsen, Nick Vogeley, and Daqing Wang, ACS Photonics 2021, 8, 12, 3448–3454, https://doi.org/10.1021/acsphotonics.1c01279

Figure 2: (a-d) Fluorescence images showing the adsorption and desorption of a single perylene molecule. (e) Trajectories of molecules with high mobility (blue) and low mobility (black) obtained from tracking of their translational motion. (f) Reconstructed angular orientation of three exemplary molecules.





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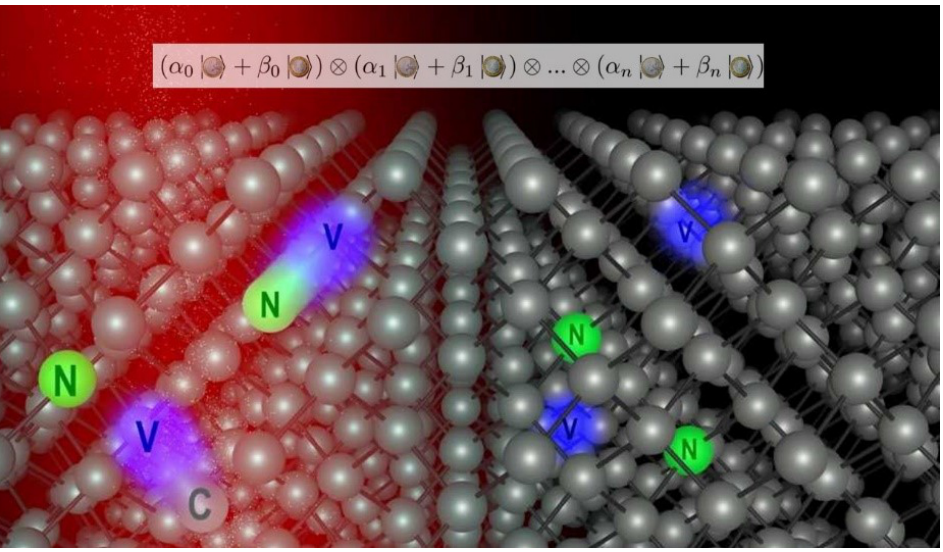
New Projects

BMBF Research Project: Diamond-based Quantum Tokens (DIQTOK)

Quantum communication will be an important building block in the future for the security of digital infrastructures in our society. In contrast to encryption methods commonly used today, it is based on fundamental physical laws, which means that it offers a level of security that remains guaranteed even in the event of attacks by quantum computers. In addition to secure data transmission, quantum communication also offers new possibilities for secure authentication of users of digital systems, protection of their privacy and secure storage of private data in a network. So-called quantum tokens could guarantee all these issues. Similar to security tokens commonly used today, such as bank cards, transponders or transaction numbers, quantum tokens can be implemented as an authentication solution using quantum physical properties. On the way to their implementation, it is important to improve further all key parameters of the envisioned quantum physical systems, in particular as a long-lived quantum memory, and to find efficient applications for them.

The Federal Ministry of Education and Research (BMBF) is funding the project DIQTOK with about 1.12 million euros over the next three years. Partners in the project are the University of Kassel and Helmholtz-Zentrum Berlin für Materialien und Energie. The University of Kassel is involved with three working groups of Prof. Kilian Singer (coordinator of the project), Prof. Martin Garcia and apl. Prof. Cyril Popov. The aim of the project is to produce efficiently long-lived quantum tokens based on nitrogen-vacancy color centers in diamond and to guarantee their security through fundamental laws of physics. The essential aspect that will contribute to the success of the project is the cooperation of various research groups with internationally recognized expertise in the field of quantum optics, optics and photonics with low-dimensional systems and diamond nanotechnology.



Nitrogen (N) - vacancy (V) centers in diamond can be the basis for long-lived quantum memories and mobile quantum token

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Superplasticizer adsorption in alkali activated materials – fluorescence microscopic in situ investigations

Alkali activated materials (AAM) are an alternative binder system, which shows advantages compared to ordinary Portland cement (OPC). Beneath the lower CO2-footprint, the durability might be increased due to the strength-forming phases in AAM which are different to the calcium silicate hydrate (C-S-H) phases forming from the hydration of OPC. AAM consist of alumo-silicatic precursors like ground-granulated blast furnace slag (GGBFS), metakaolin (MK) or fly ash (FA) and alkaline activators. Such activators can be alkali-hydroxides, -sulphates, -carbonates or -silicates (waterglasses). The combination of precursors and activators, which might be combined itself too, result in a broad variety of binders. Depending on this combinations, different properties in fresh (rheology, setting time) and hardened state (chemical composition, phase development, mechanical properties) result.

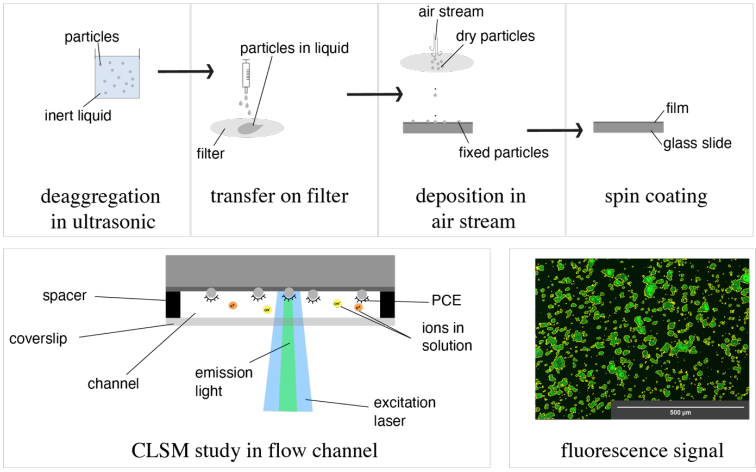

Fig. 1: Sample preparation procedure with resulting measurement setup.

Superplasticizer, mainly polycarboxylate ether (PCE), are effective admixtures for mineral binders to enhance the rheological properties. These PCE consist of a negative charged backbone and polyethylene glycol (PEG) side chains. But their typical chemical structure parameters regarding the side chain length and density, charge density or hydrophilic-lipophilic balance (HLB) are not suitable for AAM. Moreover, the decreased solubility and increased hydrolysis of the molecules in high alkaline environment are particularly challenging.

The working principle of PCE superplasticizers is based on the negative charged backbone consisting of deprotonated carboxyl groups in the alkaline environment of cementitious pastes. It results in adsorption of the PCE molecules on positive charged binder particle sites. This causes an increase of the Zeta potential and therefore an enhanced dispersion of these particles. Additionally, steric repulsion between the side chains increases this effect, while the effect of steric repulsion is influenced by the side chain conformation. These both parameters, the adsorption capacity and the conformation of the sidechains, depend on the availability of Ca-ions in the system which is known to be higher in cementitious systems in comparison to AAM.

With the objective of a broad application of AAM it is desired to find suitable superplasticizers concerning different types of precursors and activators. A promising method is the spatiotemporal detection of the PCE molecules on the binder particles by confocal laser scanning microscopy (CLSM). CLSM enables the localisation of PCE after coupling of the PCE molecules to fluorescent markers. Previous studies have shown this principle working on cement and concrete additives (J.Arend, 2019) (J.Arend, 2018). Hitherto, this method was limited to relatively large particles due to brownian motion of small particles and it was not possible to change the alkaline concentration in solution during the measurement. These experimental constraints are solved by fixation of the particles in a hard layer after spin coating and deposition in an air stream like shown in Figure 1.

To reduce the background fluorescence signal from the solution, the channel height could be reduced to about 10 microns by using a thin foil as a spacer. With a suitable casing in a flow cell, the liquid inside the channel can be modified or changed during the experiment. First preliminary studies showed well dispersed FA particles after deposition (Figure 2), the water to binder ratio in the flow cell has been estimated to be 1.6. The pH dependence of the fluorescence was taken into account by derivation of correction factors from fluorescence spectra. Fluorescence microscopic measurements showed that the average grey value of the taken pictures correlates with the flowability of the resulting pastes (Figure 3).

The relative adsorption of PCE molecules on the particles correlates with the flowability, the method will be used to investigate which parameters have to be varied for an application in AAM. For this reason, different types of PCE like methacrylate ester (MPEG), methallyl ether (HPEG) and isoprenol ether

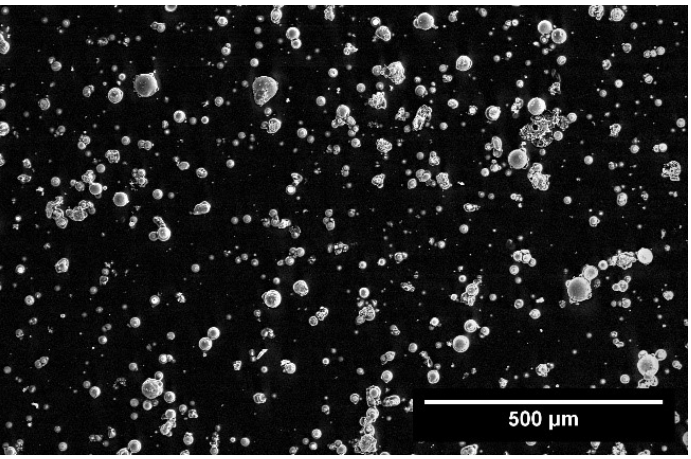

Fig. 2: SE SEM image of fixed FA particles in hard layer (false colour representation).

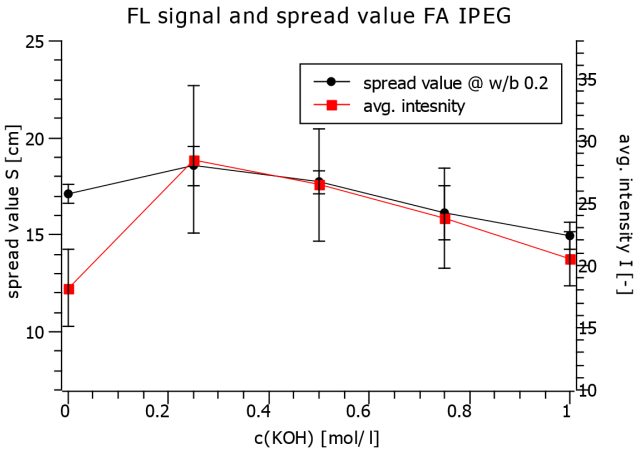

Fig. 3: Intensity signal and flowability of resulting pastes at different activator concentrations. An optimum point can be seen at 0.25 M KOH.

(IPEG) with different side chain length, charge density, molecular weight and HLB are used on precursor particles for empiric studies of the adsorption behaviour. This method will be checked with additional, indirect measurements like total organic carbon (TOC), dynamic light scattering (DLS) or spectroscopic determination of not adsorbed PCE molecules in solution. The aim of the project is to gain a deeper understanding of the mechanisms of action of PCE in AAM, which will enable the targeted development of superplasticizers for this type of binder.

Further information

J.Arend, A. B., 2018. In-situ investigation of superplasticizers: From fluorescence microscopy to concrete rheology. Cement and Concrete Research, November, pp. 178-185.

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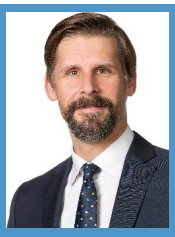

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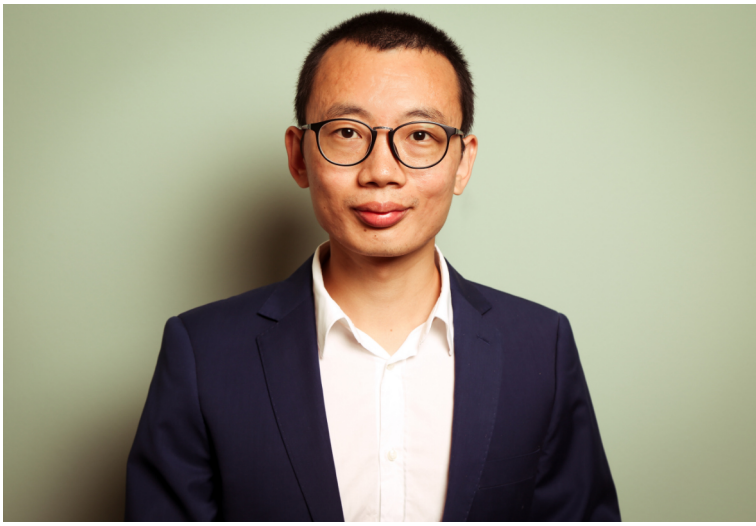
New Members
Dr. Daqing Wang



Dr. Daqing Wang is an experimental physicist working in the Department of Light-Matter Interaction at the Institute of Physics. He is currently leading the project “Enantiomer separation and matter-wave interferometry using discriminatory optical forces” within the framework of the collaborative research center ELCH. He became an associated member of CINSaT in February 2022.

Dr. Wang’s research focuses on understanding and controlling the interaction between light and molecules on the microscopic and quantum level. Molecules are ubiquitous in the everyday life and are of fundamental importance to a range of scientific disciplines covering physics, chemistry, and biology. The use of light to detect, measure and control molecules is an active field of research with far-reaching impacts in these various disciplines. Dr. Wang’s research addresses light-molecule interaction at the level of single photons (quantum particles of light) and single molecules. Here, the central research questions are, e.g., how the quantum states of a molecule can be controlled with photons, how the efficiency of the interaction can be enhanced and how the structural properties of molecules and light, such their handedness, manifest themselves in the interaction. The fundamental insights into these questions gained through this research could enable the application of molecules for quantum information processing and to fabricate sensitive optical sensors for detecting small amounts of biological molecules.

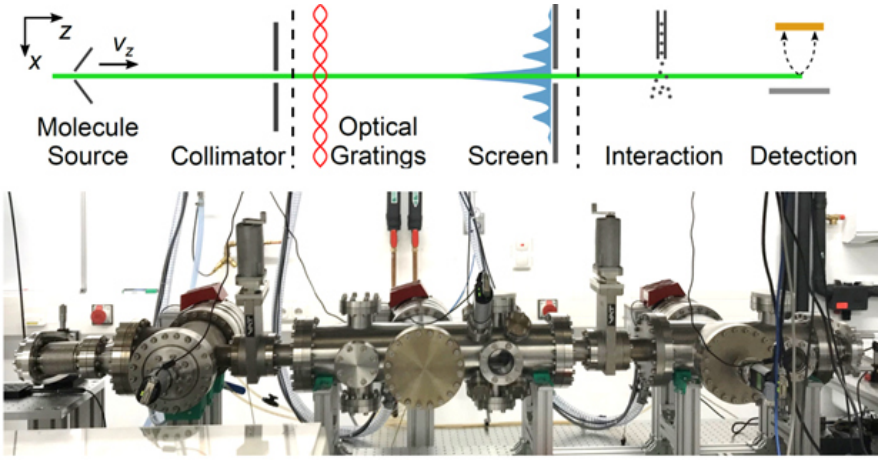


Fig. 1: Dr. Wang and co-workers showed that matter-wave diffraction can put chiral molecules into superpositions of left- and right-handed forms, enabling new studies of how the two states interact with their environment. The scheme illustrated in the upperpart of this figure opens the possibility for exploiting enantiomer superposition states for fundamental experiments with chiral molecules in the quantum regime [B. A. Stickler, M. Diekmann, R. Berger, and D. Wang. Phys. Rev. X 11, 031056 (2021)]. The lower part of the figure shows the experimental setup, which is been finalized to implement this scheme.

Research Groups
Biochemistry – Faculty 10

Prof. Dr. Friedrich W. Herberg is heading the Department of Biochemistry since 2002. He is a biochemist focusing on the investigation of mechanisms of intracellular signal transduction with special interest in the structure, function and regulation of protein kinases and established technology in biological interaction analysis (BIA). Most prominent subjects of our research are the cAMP-dependent protein kinase (PKA), cGMP-dependent protein kinase (PKG) and the leucin-rich repeat kinase 2 (LRRK2).

Protein kinases can be viewed as molecular “nanomachines” that regulate the function of downstream targets in signal transduction cascades. They mediate the process of protein phosphorylation and thereby, down- or upregulate cellular functions. Besides acting as a simple “ON/OFF”-Switch, distinct phosphorylation patterns can mediate more complex regulation processes. Aberrant phosphorylation can lead to developmental defects, diabetes, Parkinson’s disease, or cancer. We want to understand the influence of human mutations on kinase function and regulation. This information helps to understand disease mechanisms and facilitates the development of specific molecular tools to interfere with disease relevant signaling pathways. In a broader view, we want to understand the function of kinases in the context of their respective signaling pathways and how spatiotemporal regulation of ubiquitously acting kinases is achieved. In a cellular environment, specific signaling molecules must be restricted in time and space. This is achieved via precise timing of stimuli and via anchoring proteins, by forming membraneless compartments to limit diffusion.

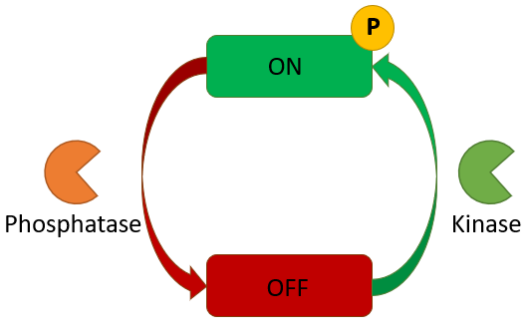


Fig. 1: Protein kinases act as a molecular switch to turn on/off downstream protein activity in signaling cascades, together with the antagonists, protein phosphatases.

Figure 2: Biochemistry group members in July 2022.

We employ a variety of methods to tackle these questions. We excel in BIA by surface plasmon resonance (SPR) to determine binding kinetics in real time, discriminating between association- and dissociation rate constants. In the CINSaT, we aim to improve existing platforms like SPR (AG Ehresmann) and develop new platforms for the detection of biomolecules (Popov, Merker). Other in vitro methods like switchSENSE technology, calorimetry and fluorescence techniques facilitate our understanding of complex protein interaction networks. Those are supported by in vivo approaches like bioluminescence resonance energy transfer (BRET) and live cell imaging of second messengers by molecular biosensors.

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Latest Reports

20 Years of CINSaT – International Workshop

To celebrate the 20th anniversary of CINSaT a 3-day international workshop with 19 external guest speakers from Germany and Europe was organized.

In July 2000, professors at the University of Kassel formed a loose association of scientist interested in the nanoscience. Here, the interdisciplinary nature of this field was already apparent since those professors came from physics, biology, chemistry, and electrical engineering alike. Over two years later, in November 2002, the University of Kassel founded the CINSaT with eight founding members, among them are four that are still members of the CINSaT today: Prof. Baumert, Prof. Hillmer, Prof. Maniak and Prof. Siemeling. In the following 20 years the CINSaT has grown considerably, and we are happy to report that the CINSaT has now 36 members which is more than ever before. Those members are publishing more articles, attracting more funds, and supervising more doctorates than ever before. For the celebration of the 20th anniversary of CINSaT, a 3-day international workshop was organized with high profile guest speakers, an interesting cultural program and a festive banquet which suits the occasion.

Group photo at Kassel central station

The workshop took place at the *Tagungszentrum Südflügel* which is a renovated part of the Kassel central station. 124 participants joined the workshops from Wednesday, May 30th to Friday, June 2nd, 2022. The first day started with the opening speech given by our current CINSaT speaker Prof. Reithmaier. He gave an overview over the history of the CINSaT and reminded of the first speaker and leading initiator of the CINSaT, Prof. Träger, who unfortunately passed away earlier this year. After the opening speech, Prof. Wachendorf, vice-president for research at the University of Kassel, brought greeting from the University administration and stated that the CINSaT will only be growing when it takes over the management of the newly build Nanotechnology Center (NTC), which is planned to be completed in the late 2020s at the main campus. After greeting notes by representatives of the faculties that have members participating in the CINSaT, the scientific program started with the *Nanophotonics* session. Opened by Prof. Vahid Sandoghdar from the Max Planck Institute for the Science of Light, followed by Prof. Dieter Bimberg (Bimberg Chinese-German Center for Green Photonics, GER/CHN) and Prof. David Gershoni (Technion, ISR). After a short lunch break the cultural program started.

Head of CINSaT

Vice President of the University of Kassel

The first part of the cultural program was a visit and guided tour of the UNCESO World Heritage Site *Bergpark Wilhelmshöhe* with the 300-year-old water features. Via bus transfer the workshop participants were brought to the Hercules statue where they met their guides for the afternoon. After a short visit to the Hercules statue, the water features started accompanied by an overwhelming noise produced by air that is forced through trumpets by the pushing water masses. The next 2 hours the participants were following the water down the *Bergpark* along the individual stations like the Devil's Bridge and the Aqueduct and listened to explanations of the guides. At the end the water was released for the last time in a 50-meter-high fountain

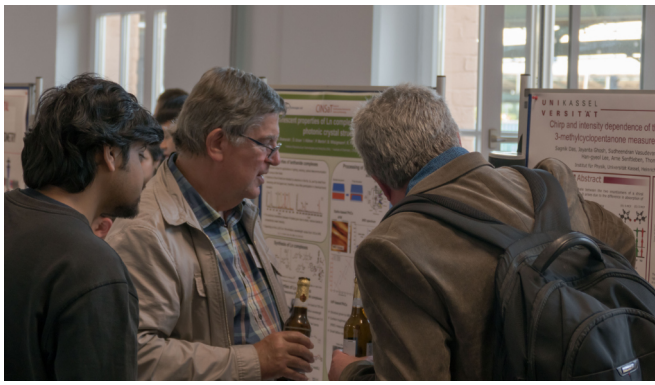
Impressions of UNCESO World Heritage Site

Bergpark Wilhelmshöhe

Impressions of the Banquett at the Alte Brüderkirche

The talks provoced a lot of questions and scientific discussion ensued which were often continued in the coffee breaks

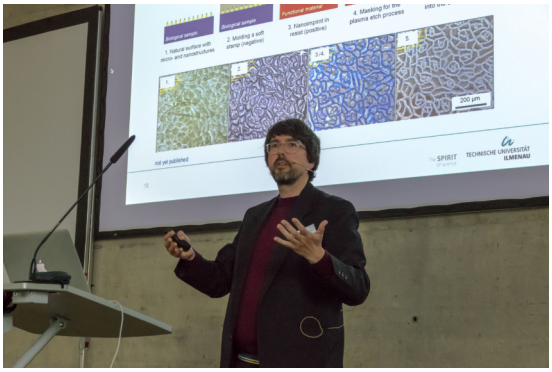
showcasing the sheer force that is produced only by gravity. After walking for more than 3 hours the participants were transported back and could relax for the next few hours until the festive banquet started at the *Alte Brüderkirche* in Kassel, a 700-year-old redundant church. The guests were welcomed in a reception with musical accompaniment by the XYjazZ Bigband of the University of Göttingen. After the three-course menu a concert by the XYjazZ Bigband was played which was very well received by all participants and late at night the first day ended.



Participants used the poster session as an opportunity for scientific exchange and building connections.

The second day was completely dedicated to science packed talks and a poster session in the evening where the co-workers of the CINSaT members presented their current research. Before lunch three sessions took place. First the *Chiral Structures* session featuring talks by Prof. Wörner (ETH Zürich, CH) and Prof. Powis (University of Nottingham, UK), followed by the *Characterization of Nano- and Microstructured Materials* session with talks from Prof. Schneider (HU Berlin & Helmholtz-Zentrum Berlin) and Prof. Gutmann (STFC, UK), and lastly the *Physics and Applications Based on 2D Materials* session with talks given by Prof. Bacher (University of Duisburg-Essen) and Prof. Molenkamp (University of Würzburg). After lunch the session 3D *Nanostructures* started with talks by Prof. Strehle (TU Illmenau) and Prof. Seifert (CIC nanoGUNE, ESP) followed by the last session fo the day called *Quantum Dot Devices* with talks from Prof. Eisenstein (Technion, ISR), Prof. Grillot (Télécom Paris, FR) and Prof. Gioannini (Politechnico di Torino, ITA). After sitting the whole day for 11 talks all participants enjoyed the good sunny weather, a cool beer and some pretzels while looking at the posters that show the current research of the CINSaT. As the last discussions ended, so did the second day of the workshop.

The third and last day of the workshop started with the session *Imaging and Assembly of Biological Systems on the Nanoscale* with two talks from Prof. Sundberg and Prof. Jussi Toppari (both University of Jyväskylä FIN) and a talk by Prof. Skruzny (EMPL Heidelberg). The last session was called *Quantum Optics* with talks by Prof. Sek (Wroclaw university of Science and Technology, PL) and Prof. De Rossi (THALES, FR). With this the scientific program ended and Prof. Reithmaier gave closing remarks to the audience, thanking all the speakers, all contributors, and all participants to make this workshop a success and a worthy event to celebrate 20 years of CINSaT. After lunch the workshop ended and we are looking forward to the next milestone, the 25th anniversary of CINSaT in 2027.



The 19 external guest speakers presented topics in several different areas of nanoscience and technology.

CINSaT Spring Colloquium 2022

First spring colloquium in Friedrichroda after hiatus due to the pandemic in 2021

After last years virtual spring colloquium using GatherTown software, the CINSaT invited all members and their co-workers once again to the AHORN Berghotel Friedrichroda from March 3rd to March 4th, 2022. Of course, some special preparations were necessary like an approved hygiene concept and a permission from the responsible health department. But apart from these organizational issues a meeting was possible and highly anticipated by the participants. The 2-day colloquium is the major opportunity for different CINSaT groups to get to know each other and their work and discuss questions in a broad interdisciplinary environment. This is only possible with the participation of as many groups as possible and the contributions of the participants like talks and posters.

This years colloquium attracted a large audience again.

The scientific talks are an opportunity to present recent results.

Our speaker Prof. Reithmaier opened the colloquium and welcomed all participants. Overall, 72 participants listened to 20 scientific talks, most of them were given by doctoral candidates that showed their recent results. Two 1-hour talks were given by CINSaT membership applicants Prof. Dr. Claudia Backes and Prof. Dr. Stefan Buhmann as part of their application process. Prof. Backes gave an interesting talk about her field of research entitled “2D materials in the liquid phase” and Prof. Buhmann told us about the quantum vacuum in his talk “You want it darker – Quantum vacuum, dispersion forces, and energy transfer”. Both have completed their application process in the meantime and are now full members of the CINSaT. After listening to the talks, the participants had the opportunity for a little bit of exercise in a 2-hour guided hiking tour in the surroundings of the hotel. Afterwards the poster session started with some cool beverages and a lot of intensive scientific discussion into the late evening. In total 46 posters were presented.

The second day started with a continuation of the scientific talks. The last talk was given via Zoom by our member Prof. Monika Stengl giving an overview to the DFG-funded research training group (RTG) “Multiscale Clocks” which aims to unravel the mechanism and constituents that are responsible for creation and maintenance the biological time. After lunch the participants were divided according to their research in six focal sessions giving the opportunity to discuss issues or problems in more detail with peers that work in the same area. The colloquium was closed by Prof. Reithmaier in the afternoon and we as organizers hope that all participants left with solutions to problems, new insights, and ambitious ideas. We will see us next year!

Group photo in front of the AHORN Berghotel Friedrichroda

Special Lecture by Alexey Nikitin

Ukrainian researcher Alexey Niktin visited CINSaT and gave a special lecture

On 23rd of June, 2022 researcher Prof. Dr. Alexey Y. Nikitin visited the CINSaT and gave an 1-hour lecture about his work with the title “Hyperbolic Light”. Prof. Niktin made his doctorate in theoretical physics in 2006 at the Institute for Low Temperature Physics and Engineering and the Institute for Radiophysics and Electronics at the University of Kharkiv. He gathered research experience at the University of Zaragoza and the CIC nanoGUNE research center in San Sebastian, Spain. Since 2018 he is an Ikerbasque Research Associate at Donostia International Physics Center in San Sebastian. His research is about the theory of optical phenomena in natural and artificial low-dimensional materials and metamaterials; hyperbolic light and near-field microscopy.

Despite the short notice around 30 interested researchers from CINSaT joined the lecture and participated in an extensive scientific discussion with Prof. Niktin. Following the lecture, a meeting between Prof. Nikitin and the CINSaT members Prof. Reithmaier, Prof. Hillmer, Prof. Backes, Prof. Fuhrmann-Lieker and Prof. Ehresmann was held in which the participants discussed various topics in more detail, including potential collaborations. A laboratory tour concluded the visit.

Architectural competition for new building for physics and nanostructure sciences

After more than a year of preliminary planning in preparation for an architectural competition, the construction project was put out to tender in December 2021. 20 interdisciplinary teams of architects and MEP planners had qualified to take part. 17 of them had submitted a contribution by the submission deadline on March 9, 2022. After a detailed preliminary examination by employees of the construction department headed by Ms. Beata Lejman, representatives of the users (including Dr. Guido Fuchs, Prof. Arno Ehresmann and Prof. Johann Peter Reithmaier), the LBIH (Landesbetrieb Bau und Immobilien Hessen) and the The office commissioned to carry out the competition procedure, FALTIN+SATTLER FSW Düsseldorf GmbH, held the meeting of the jury on May 3rd and 4th, 2022.

The jury consisted of 11 people with voting rights and was made up of independent architects and specialist planners as specialist judges, as well as representatives of the public building owner as material judges. The Hessian Ministry of Finance, the Hessian Ministry of Science and Art, the LBIH, the City of Kassel and the University of Kassel with its President Prof. Ute Clement were represented by judges. In the hybrid event (face-to-face event with the option of online participation), the people involved in the preliminary examination were available to answer questions.

Contrary to the fear that arose beforehand that the representatives of the departments would not have a say, or only to a limited extent, the application-related aspects were well received alongside the architectural requirements. Surprisingly, the user representatives were even asked to take part in the discussion of the shortlisted contributions and to support the jury in preparing an evaluation proposal. A total of 4 main prizes and 4 recognitions were awarded.

- 1st prize winner: Birk Heilmeyer & Frenzel Gesellschaft von Architekten mbH, Stuttgart
- 2nd prize winner: HeinleWischer Architects, Stuttgart
- 3rd prize winner: Staab Architects, Berlin
- 4th prizewinner: Wulf Architects, Stuttgart

Despite this decision, there is still considerable room for improvement, as there was no draft plan that satisfactorily satisfied all concerns. From the point of view of the university, physics and the CINSaT, however, it should be possible to realize a functional new building that implements all the essential usage specifications. However, considerable improvements or replanning are still necessary, particularly when it comes to clean room planning.

Fig. 1. Draft of the new building for physics and nanostructure sciences by the award-winner Birk Heilmeyer & Frenzel Gesellschaft von Architekten mbH from Stuttgart.

At the end of the award procedure, the award winners are invited to negotiations. Among other things, the first further developments of the drafts are to be presented here. The participants will receive a catalog of instructions based on the preliminary examination and the minutes of the jury, which should allow the contributions to be further processed in a targeted manner.

After the 3rd and 4th prizewinners announced that they would not take part in the negotiation process, talks will be held with the first two prizewinners at the beginning of September. After the final decision to commission the concrete planning phase will begin with the aim of creating a decision document.

The progress of the planning will be reported in a later newsletter.
JP Reithmaier

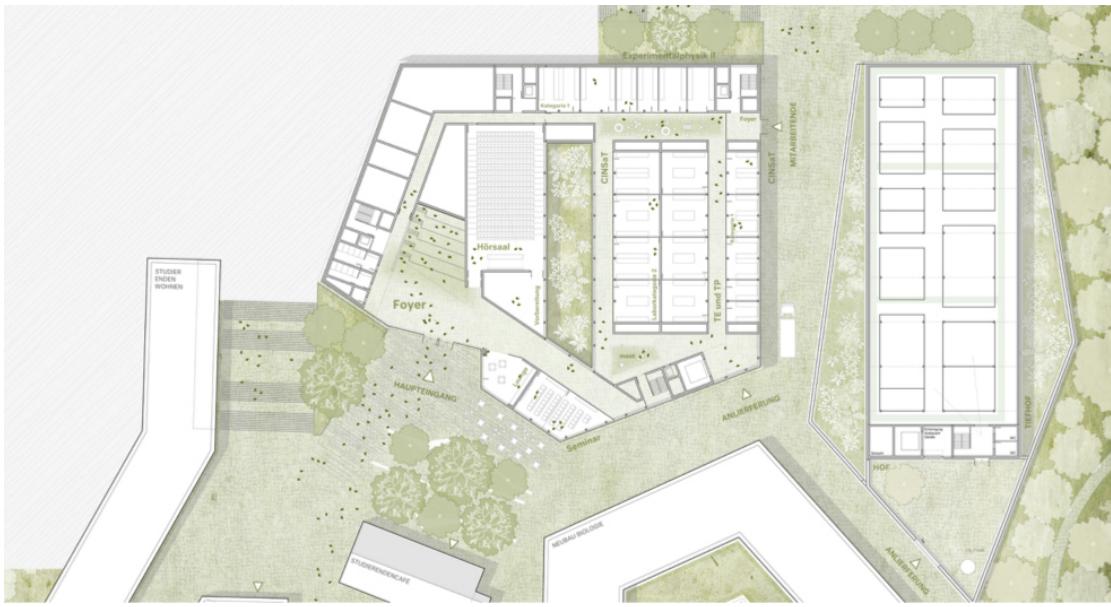
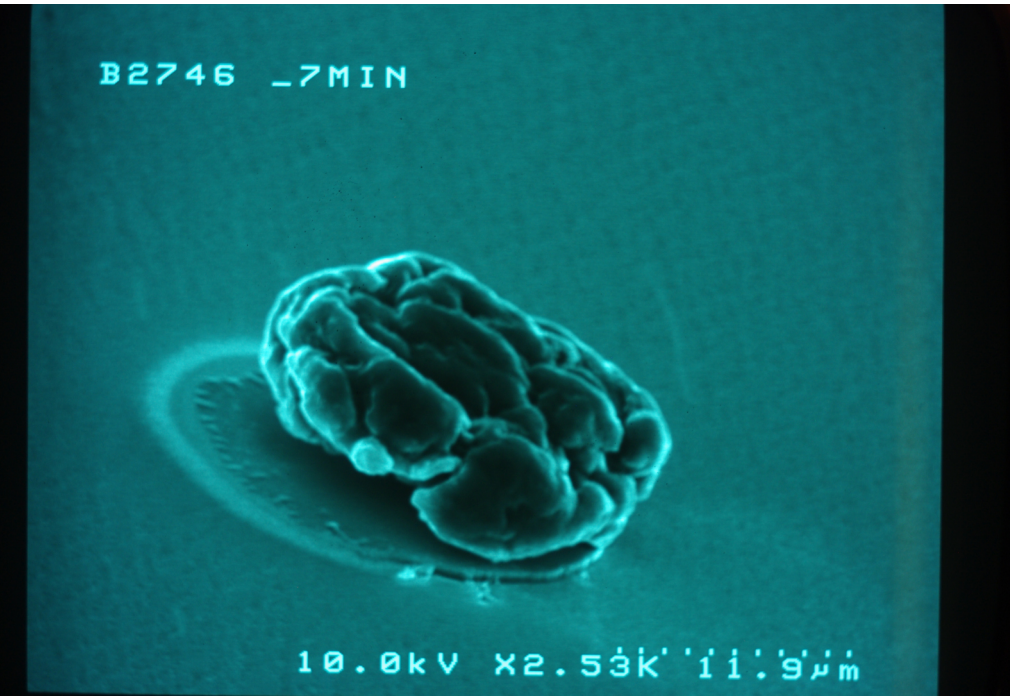


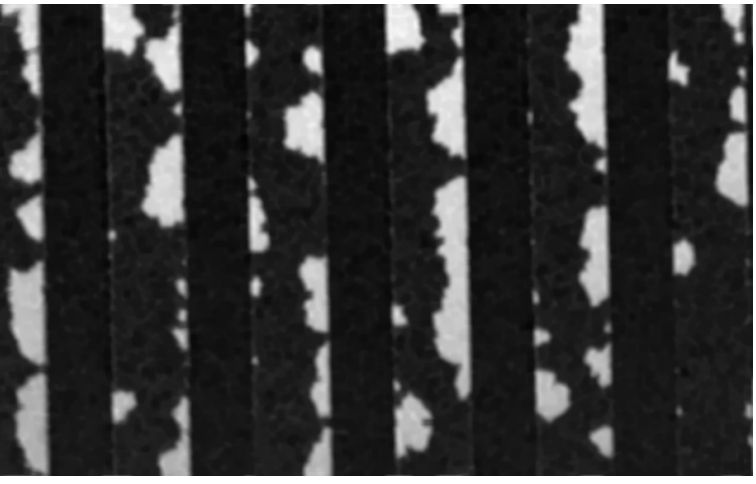
Fig. 2: Ground floor of the physics (left) and NTC clean room building (right) of the award winner Birk Heilmeyer & Frenzel Gesellschaft von Architekten mbH from Stuttgart.

Fig. 3: Cross section of the Physics (left) and NTC clean room building (right) of the award winner Birk Heilmeyer & Frenzel Gesellschaft von Architekten mbH from Stuttgart.

Nano Arts



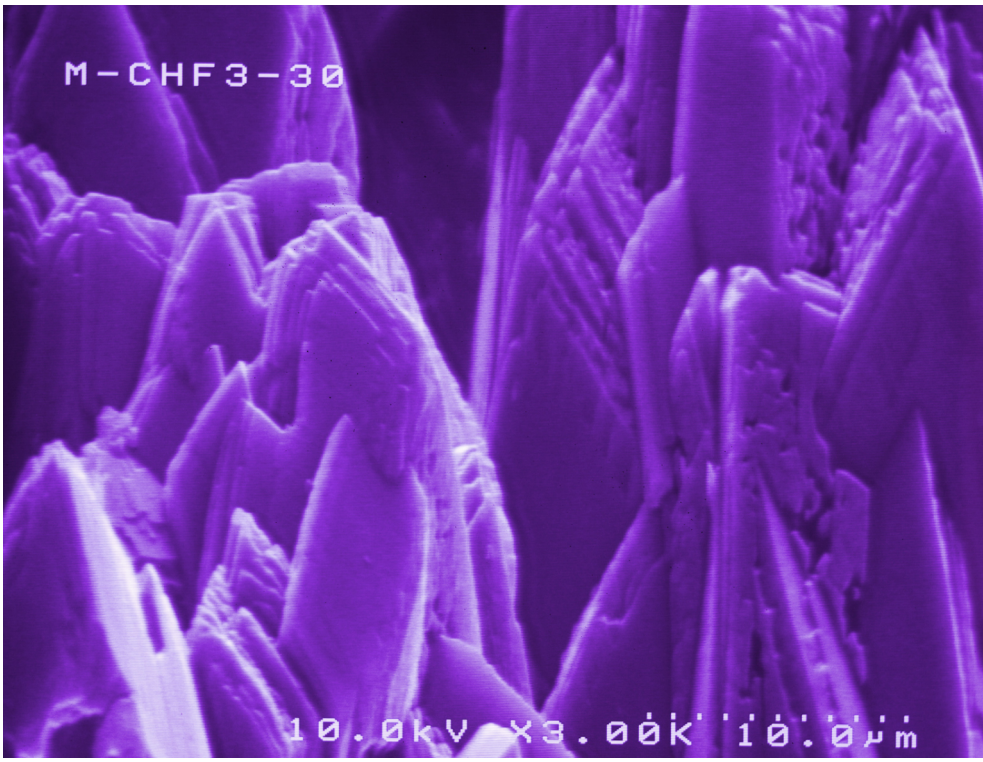
Diffraction pattern of a graphite–tantalum disulfide heterostructure obtained with ultrafast electron diffractometer at the Baumert/Senftleben group.



Asymmetric magnetic domain motion in exchange-biased perpendicular magnetized nano stripes

Zeolite Flowers

SEM images taken by Ramizraza Saiyed (Technical Electronics) for Nano Diamond Group and nicely colored by Julia Heupel



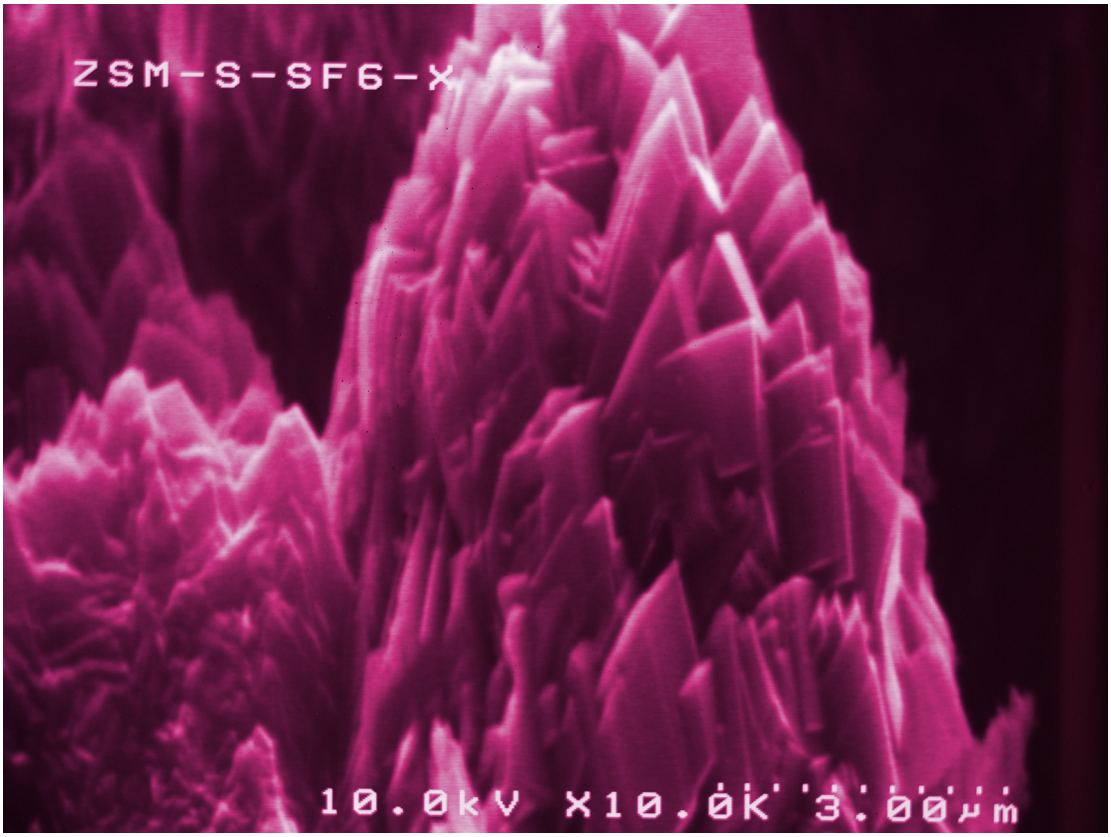


Photo: Campus Heinrich-Plett-Straße, Press and Public Relations Office University of Kassel, Studio Blåfield

Imprint

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print:
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Martin-Luther-King-Weg 30a
48155 Münster

Responsible according to press law (german: ViSdPR):
CINSaT executive board,
University of Kassel