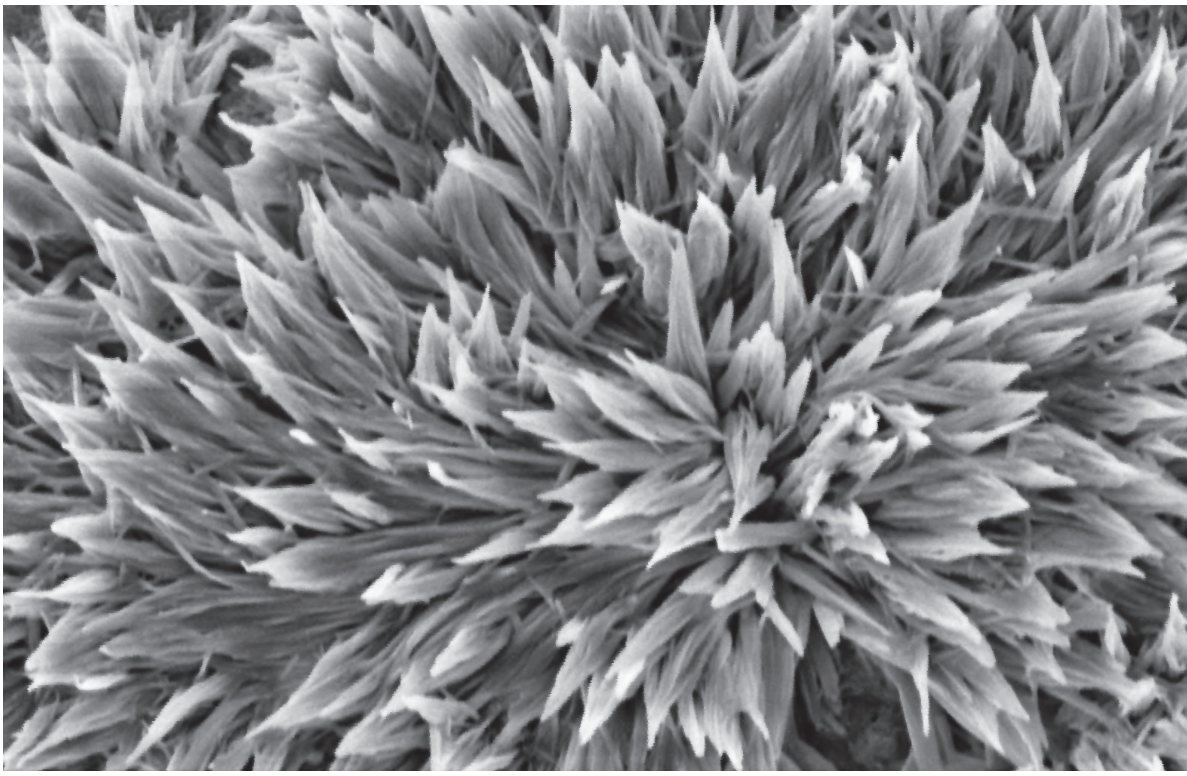
CINSaT Center for Interdisciplinary Nanostructure Science and Technology

Newsletter No. 6 (May 2019)



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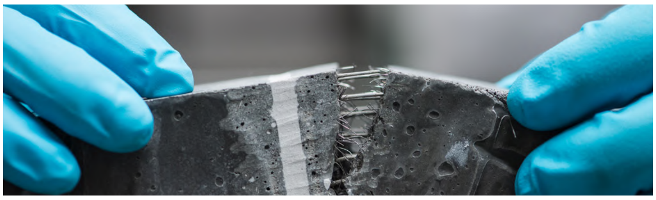


Cover image:
Benedikt Mohr (PhosMOrg)
Unsuccessful but beautiful attempt of silica precipitation by phosphate

Preface

Welcome to the first newsletter in 2019. After 6 issues, we thought is time to reconsider the layout to make it more modern style and attractive. This issue has now a new layout and we would like to get some feedback how you like it. Many thanks also to all of you who contributed to these newsletters with exciting reports.

This issue starts with some general summary report from the management as well as from different meetings that took place since the last newsletter.

In the educational section updated information about the nanoscience study program are given. Nanoscience is now part of the model study programme plusMINT and became elective subject in the BSc/MSc Mathematics programme. In addition, there is an overview of the pleasingly increasing number of students and possible exchange programs with a featured article about the ERASMUS program Sofia. This section also contains a contribution from the students reporting about their science slam held recently and the next one is already planned, just have a look at the announcements.

New exciting research highlight in physics and chemistry are reported: Prof. Christiane Koch as well as Prof. Dr. Philipp Demekhin together with Prof. Dr. Thomas Baumert report in two highlights about coherent control of photoelectron circular dichroism in chiral molecules and Prof. Dr. Ulrich Siemeling about the challenging activation of C-H bonds with divalent lead.

Embedded in the DFG Priority Program SPP1784 *Chemical Biology of Native Nucleic Acid Modifications* Prof. Dr. Schaffrath and his group aim to clarify different aspects of the regulatory tasks the cooperative tRNA modifications seem to fulfil.

Three members will introduce themselves and their groups in this issue: Dr. Arne Senftleben (Ultrafast structural dynamics - Faculty 10) who has just joined CINSaT in 2018, Prof. Dr. Rudolph Pietschnig (Chemical Hybrid Materials – Faculty 10) and apl. Prof Dr. Thomas Fuhrmann-Lieker (Macromolecular chemistry and Molecular materials – Faculty 10).

Finally, a report is given about the very successful spring meeting in Friedrichroda, which obtained again a record number in participants. You should also have a look on the announcements, in particular for the upcoming autumn colloquium. At the end you should not miss the nano arts.page.

Enjoy the reading of this issue.

J. P. Reithmaier

Johann Peter Reithmaier

General

Latest information from the CINSaT management

Here, we report briefly about major issues from the CINSaT committees any major discussion results in their meetings.

(a) Steering Committee

Since the last newsletter, we had three meetings (20th of December 2018, 20th of March and 23rd of April this year). The following points were addressed:

- Preparations for the renewal application for the next 5-year period of the CINSaT are in full swing.
- The meeting of the Scientific Advisory Board is scheduled to 18th December
- CINSaT has donated a prize for the competition “Schüler experimentieren” for the best interdisciplinary work.
- The center will be present at the Campus Fest and the Hessentag
- The management is now supported by a student assistant

(b) Research Coordination Committee

The steering committee had a joint meeting with the priority speakers at 23th April of this year. In this meeting, the priority speakers reported briefly about their experience with the focus sessions during the spring colloquium and gave feedback for further improvements. Also, first speakers for this year’s autumn colloquium on 16th October were proposed. The next meeting date of the research Coordination Committee is July 17th 2019 (location will be announced)

(c) Member Meeting

The last member meeting took place on 24th April. The major issues that were discussed, the info das was given and the decisions that were made are as follows:

- The financial report for 2018 was presented. The CINSaT executive manager and the CINSaT speaker were released
- The speaker as well as the deputy heads of the executive board were re-elected unanimously. The speaker and the members of the steering committee thanks the CINSaT member for their trust to guide the center through the next period.
- Prof. Dr. Georg Mayer and Prof. Dr. Angelika Brückner-Foit were elected as new full members after holding their introductory talks during the CINSaT spring colloquium
- Prof. Dr. Hans-Peter Heim will give his introductory talk on 27th June (16h c.t., HS100, Campus AVZ)
- The name of the priority topic “Biosensing” was changed to “Multiscale Bioimaging”

Education

News from the study programs

Nanoscience is part of Bachelor plusMINT

As a model study programme, supported by the Hessian ministry for higher education, research and the arts, the Bachelor of Science plusMINT is to be launched in the coming winter semester. MINT is the German acronym for STEM fields, i.e. science, technology, engineering and mathematics, including computer science. Within this programme, nine different study programmes of the University of Kassel, such as Mathematics, Computer science, Physics, Electrical Engineering, Mechatronics, Mechanical Engineering, Civil Engineering, Environmental Engineering, and Nanoscience, are joined under one heading. Before a student has to decide into which direction he or she wants to head, one initial year allows to get acquainted with these subjects for a better founded decision for a programme. In this additional year, students can attend lectures from the different programmes, join practical projects, and will get an overview about topics and job options in applied fields. In nanoscience, for example, they can participate in the basic module “Introduction to Nanoscience” and can do labwork in various projects on nanomaterials.

Nanoscience becomes elective subject in the BSc/MSc Mathematics programme

Following the wishes of students in the last Studiengangsgespräch in Mathematics, selected courses of the nanoscience modules are opened now for students in mathematics. The newly formed modules are called “Molecules, Ions, Interfaces”, “Genes and Databases” and “Fundamentals of Biochemical Networks” and prepare the background in chemistry and biology for later work in fields such as molecular modelling and bioinformatics.

MSc Nanoscience with increasing number of students from abroad

Since the language in the Master programme in Nanoscience was switched to English in 2016, the number of incoming students from all over the world increased continuously. With this summer semester the targeted number of 30 new students per year is reached, thanks to the additional entries in the summer semester as the following table shows.

	German nationality	**Other nationality**	**German entry degree**	**Other entry degree**	**Total**
Winter semester 16/17	11	0	11	0	11
Summer semester 17	2	0	2	0	0
Winter semester 17/18	8	7	9	6	15
Summer semester 18	2	6	2	6	8
Winter semester 18/19	7	10	7	10	17
Summer semester 19	1	19	1	19	20

Further exchange collaborations established

In addition to the successful student, staff and lecturer exchange with the University of Jyväskylä), several new partnerships under the Erasmus+ programme were established and already used by students for extending their skills abroad. The Heriot-Watt University in Edinburgh, Scotland, named after the goldsmith and philanthropist George Heriot and the famous engineer and inventor of the steam engine James Watt, can be regarded as one of the first technical universities. The Erasmus contract covers exchange with the school of Engineering and Physical Sciences in the fields of nanoscience for up to 3 students per year. The University of Crete, located on the Greek island of the same name in Rethymnon and Heraklion, offers exchange in biology and nanoscience. Students and lecturers going to Crete will probably meet Ioannis Pavlidis, former lecturer for biotechnology in the nanoscience curriculum. The University of València, has a nanoscience programm that is shared with other Spanish universities and co-hosts the annual European School on Molecular Nanoscience at different locations in Spain. The first student from Kassel will visit the València programme in 2019.

	Subject	Students	Staff	Coordinator
University of Jyväskylä	Nanoscience	6/year	8/year	Fuhrmann-Lieker
Heriot Watt University	Physical Sciences (Nanoscience)	3/year	2/year	Fuhrmann-Lieker
University of Crete	Biology/Nanoscience	1/year	6/year	Herberg
Universitat di València	Chemistry (Nanoscience)	1/year	-	DiFuccia

Exchange programmes in which Nanoscience is explicitly mentioned. The complete database including further exchange programmes in physics, biology, engineering etc. can be found at https://unikassel.moveon4.de/publisher/2/deu

CINSaT supports young scientists

This year for the first time ever the "Landeswettbewerb Hessen" for the competition "Schüler experimentieren" took place at the Faculty of Electrical Engineering and Computer Science (12.-13.4.2019). In this event, CINSaT participated as sponsor for a special prize for an interdisciplinary project. The prize was awarded to Teresa Dinges, Neyla Fritz and Sophia Rogosch for their work on antimicrobial agents. We congratulate the team for its excellent work.

Text:
Thomas Fuhrmann-Lieker
Member of CINSaT steering committee
Coordinator of nanoscience programmes

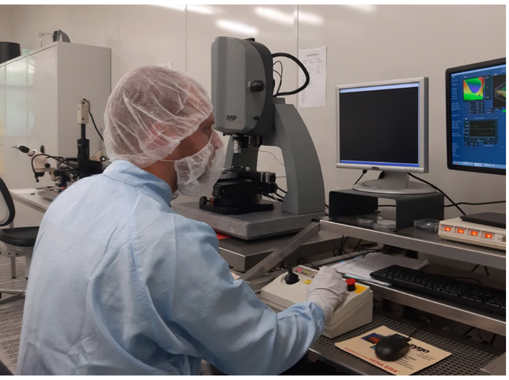
ERASMUS program Sofia

The Erasmus bilateral agreement with the University of Chemical Technology and Metallurgy (UCTM), Sofia, Bulgaria has almost the same age as CINSaT. It was initially signed in 2001 and the first student arrived to Kassel in the summer semester of that year. Since then 22 students from different departments of UCTM related to Materials Science and Engineering came to Kassel for one semester supported by the Erasmus program, most of them for preparation of their master theses, few to prepare parts of their dissertations. During all these years there were also regular exchange visits of lecturers, their participations in exam commissions in Kassel and Sofia, meetings and seminars with students. The Erasmus students who stayed in Kassel have a good networking: they share information with the current students interested to come to Kassel and organize alumni meetings.

Currently Martin Pernikov from the UCTM is preparing his MSc thesis at the group of Technological Physics, Institute of Nanostructure Technologies and Analytics supervised by Prof. Dr. Cyril Popov. Part of the measurements will be performed in collaboration with the groups of Prof. Dr. Thomas Fuhrmann-Lieker (Macromolecular Chemistry and Molecular Materials) and Prof. Dr. Hartmut Hillmer (Technological Electronics), also members of CINSaT. Martin arrived at the beginning of April 2019, but for a short period of time he gained a lot of impressions from the University and from Kassel.

Alumni meeting in Sofia before Christmas 2012

“I am so glad to be in Kassel, it is a nice, calm and green city full of interesting places to visit. The central campus of the University, where I live, and the campus here where I work, carry a typical academic atmosphere. Everyday I am learning something new, regarding my study or the daily life in Germany. Being able to practice my English and German I am getting more and more confident with my language skills. With respect to my work, in the first weeks of my stay I was introduced to new analytical techniques, which are very important for my thesis, but not available at my home university. To all students from my university who are interested to come for a semester in Kassel I will say – it is definitely worth, there you can gain valuable and unforgettable experience”.



Martin operating the white light interferometer in the clean room facilities of the INA

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Science Slam at Faculty 10

In November 2018 the junge Deutsche Physikalische Gesellschaft (jDPG) and the JungChemikerForum (JCF) Kassel organized a Science Slam for the first time. Three lecturers presented topics like "Why physicists calculate with cats" or "Zombies in Science". The evening ended with mulled wine and cookies and was completed with PowerPointKaraoke. What is that? Volunteers spontaneously present slides – which they havn't seen before. Entertainment guaranteed, aside dull lecture contents.

On Tuesday 22.10.2019 (at the start of the winter semester) the jDPG and JCF are organizing a second Science Slam. You can vividly present your thesis? Or you are an expert in a very bizarre topic, which you always wanted to present to public? The stage is yours.

The language can be English or German. A Science Slam trophy can be won.

Also: slides that are suitable for a PowerPointKaraoke are welcome.

Just send a short mail to kassel@jdpg.de

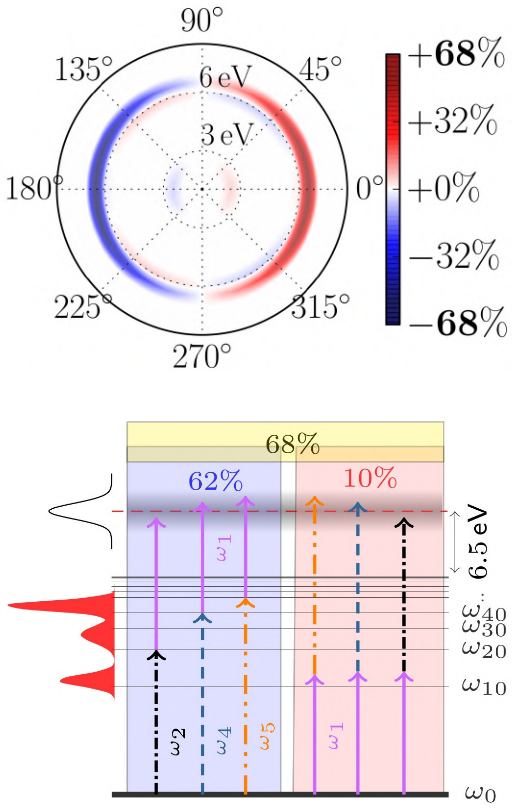
Research Highlights

Quantum Control of Photoelectron Circular Dichroism

Chiral molecules are nonsuperimposable mirror images of each other, referred to as enantiomers. Recent advances in measuring enantiomer-sensitive observables in gas phase table top experiments have brought chiral molecules into the spotlight of current atomic, molecular and optical research. One of these observables is photoelectron circular dichroism (PECD), i.e., the differential photoelectron angular distribution obtained by ionizing randomly oriented molecules with left-circularly and right-circularly polarized light.

We demonstrate coherent control over the PECD in randomly oriented chiral molecules, based on quantum interference between multiple photoionization pathways. To significantly enhance the chiral signature, we use a finite manifold of indistinguishable (1+1′) resonantly enhanced multiphoton ionization pathways interfering at a common photoelectron energy but probing different intermediate states. We show that this coherent control mechanism maximizes the number of molecular states that constructively contribute to the dichroism at an optimal photoelectron energy. It outperforms other schemes, including interference between opposite-parity pathways driven by bichromatic (ω, 2ω) fields as well as sequential pump-probe ionization.

Further Information
R E. Goetz, C.P. Koch and L. Greenman
Phys. Rev. Lett. **122**, 013204 (2019).
DOI:10.1103/PhysRevLett.122.013204



Angular resolved photoelectron distribution corresponding to photoelectron circular dichroism of almost 70% (top), thanks to interference between various two-photon ionization pathways (bottom)

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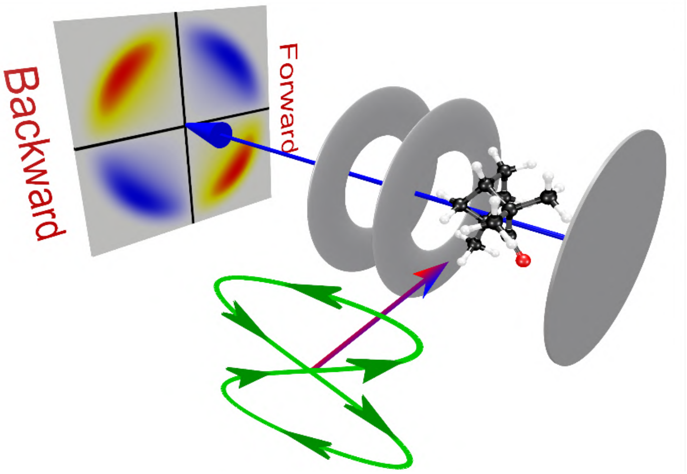
Photoelectron circular dichroism with two overlapping laser pulses of carrier frequencies ω and 2ω linearly polarized in two mutually-orthogonal directions

Photoionization of randomly oriented chiral molecules using a Lissajous type electric field configuration has been studied, and a sizable forward/backward asymmetry in the photoelectron angular distribution is observed being sensitive to the rotational direction of the tailored field.

Until now, circularly polarized light was essential to detect chiro-optical effects. Prominent examples are the traditional circular dichroism in absorption and photoelectron circular dichroism resulting from ionization of chiral molecules. Here, we show that chiro-optical effects can also be triggered by a laser field consisting of carrier frequencies ω and 2ω linearly polarized in two mutually-orthogonal directions. These fields can be tailored in such a way, that the resulting electric field vector mimics rotational motion in different directions perpendicular to the propagation of the laser. Our simulations show a sizable forward/backward asymmetry in the photoelectron angular emission distribution, which depends on the handedness of a chiral molecule and the rotational direction of the field. We propose that the effect of such rotationally-tailored fields does not rely on the photon-electron angular momentum transfer, as is the case in conventional chiro-optical effects. Nowadays, such bichromatic fields can be generated in many experimental laboratories in the optical and even XUV regimes and experimental verifications of this new scheme are expected in the near future.

Further Information
P. Demekhin et al.
Phys. Rev. Lett. **121**, 253201 (2018);
DOI: 10.1103/PhysRevLett.121.253201



Scheme of the experiment with bichromatic laser pulses.

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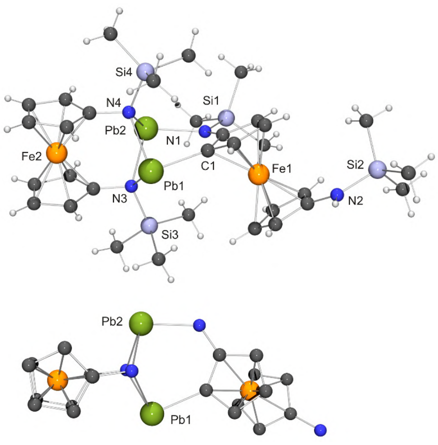
C – H Activation under Ambient Conditions with Divalent Lead

Lead is a metal that has been known since ancient times. It is abundant and inexpensive. On top of that metalwork is particularly easy with lead. Since Roman times, and until just a generation ago, it was used for water pipes. Today, lead is still present in everyday life in our cars, where the lead accumulator is predominantly used for electrical energy storage. The lead accumulator contains elemental lead as well as a divalent and a tetravalent lead compound, namely lead sulfate ($PbSO_4$) and lead dioxide (PbO_2).

Lead is one of the longest known and most familiar elements. Consequently, it comes as a big surprise when fundamentally new aspects are discovered, as was recently the case in the Organometallic Chemistry Group headed by Prof. Siemeling at the University of Kassel. The discovery was made in the area of molecular synthetic chemistry.

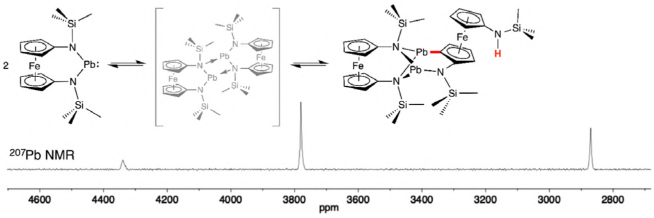


Top: Molecular structure of the plumbylene dimer in the solid state (single-crystal X-ray diffraction result).

Bottom: View of the molecule (H atoms and Si(CH$_3$)$_3$ units omitted for clarity) showing that it contains an approximately C_{2v}-symmetric unit (left) and a planar-chiral moiety (right).

Chemical synthesis is based on bond breaking and bond making. Organic chemistry is an area of paramount importance in this context, because it forms the basis of a large variety of popular consumer products, ranging from polymers to drugs. Bonds between carbon and hydrogen atoms are of particular relevance for organic chemistry. C – H bonds are very strong, stronger than, for example, C – C bonds. Consequently, the specific activation of C – H bonds is a challenge, which is of great current interest. In the past, concepts have been followed which rely on the use of precious-metal compounds for C – H activation. Indeed, such metals are unrivalled for this task. However, precious metals are highly expensive and particularly rare, which is in contrast to good old lead. Experiments performed in Prof. Siemeling's lab demonstrate that C – H activation may be achieved with divalent lead compounds. The new concept of C – H activation with divalent lead was developed during the course of a project dealing with the activation of fundamentally important small molecules with divalent compounds of the elements belonging to Group 14 of the Periodic Table of the Elements (carbon, silicon, germanium, tin and lead).

More specifically, an N-heterocyclic plumbylene with ferrocene-based backbone forms an aggregation dimer, which undergoes an intramolecular electrophilic substitution by an endo attack of a divalent Pb atom, causing the cleavage of a C – H bond and the formation of a Pb – C and an N – H bond. The reaction is the first example of a C – H activation with divalent lead. It affords a nano-sized planar-chiral heavy-metal cluster.



^{207}Pb NMR spectrum of the monomer/dimer equilibrium mixture at room temperature in C_6D_6 solution showing a low-field signal due to the monomeric plumbylene (left) and two signals at higher field due to the dimer (right). The aggregation dimer shown in grey was not observed. Its role as an intermediate is strongly supported by computational results.

Further Information

R. Guthardt, J. Oetzel, J. I. Schweizer,*et al.*
Angew. Chem. 2019, **131**, 1401; *Angew. Chem.* Int. Ed. 2019, **58**, 1387.
DOI: 10.1002/anie.201811559

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New Projects

DFG Priority Program 1784/2 Chemical Biology of Native Nucleic Acid Modifications - Functions of tRNA modifications in mRNA decoding, translational fidelity and proteostasis

The 70 to 90 nucleotides long transfer RNAs (tRNA) canonically function as adapter molecules to transport appropriate amino acids to translating ribosomes according to mRNA codons, which are decoded by the tRNA anticodons. Moreover, it has been known for decades that tRNA is subject to chemical alterations of the standard RNA nucleosides including methylations, thiolations, base isomerizations and complex side chain additions, collectively known as tRNA modifications. Such modified nucleosides are found all over the tRNA sequence, however, the individual impact of these on tRNA function has only begun to be elucidated in recent years. Since different tRNAs contain varying combinations of modifications, it is not well established how these cooperatively support a specific function of the adapter molecule. To find evidence for the physiological relevance of functionally collaborating tRNA modifications, the Division of Microbiology led by Professor Dr. Schaffrath investigates combined modification defects in the budding yeast Saccharomyces cerevisiae.

Protein biosynthesis in all living organisms relies on different critical molecules, among which transfer RNA (tRNA) represents a key component for the translation process. Its task is the delivery of one of the 20 canonical amino acids (AA) to the translating ribosome. The ribosome samples different tRNAs and accepts those that contain an anticodon cognate to the mRNA codon. Since AAs are selectively attached to the tRNA with the matching anticodon, this ensures that only correct AAs are incorporated in the peptide chain during translation. A tRNA is a single stranded RNA molecule of 70-90 nucleotides (nt) length which adopts via intramolecular base pairing a clover-leaf-structure and is further folded into an L-shaped structure via tertiary base pairing. Interestingly, each of the four standard RNA nucleosides in tRNA can be chemically modified with various chemical groups, ranging from e.g. the transfer of a simple methyl group on a base or ribose, isomerization of uridines (pseudouridine) up to the addition of whole amino acids like threonine or lysine. As a result, different tRNAs harbor unique combinations of modifications at different sites. The assumed function of these can roughly be categorized into (i) tertiary structure stabilization, (ii) identity for AA-charging and (iii) supporting/fine-tuning of the translational capacity. For *Saccharomyces cerevisiae*, 25 different modifications are known and different tRNAs are modified on average 9 to 13 times at different positions

Despite the categorization mentioned above, the exact purpose of many tRNA modifications and how these impact the translational competence of the adaptor molecules remain elusive. For example, the complex anticodon modification 5 methoxy-carbonyl-methyl-2-thio modification (mcm^{5}s^2) is installed at the wobble uridines (U$_{34}$) of tRNA$^{Lys}_{UUU}$, tRNA$^{Gln}_{UUG}$ and tRNA$^{Glu}_{UUC}$ by the protein complex Elongator and the Urm1 pathway (**Fig.1A**).These represent two partially independent modification cascades installing the mcm^{5}U and s^{2}U parts, respectively. In depth analysis of the in vivo function has indicated that loss of either modification led to various defects including +1 frameshifting, ribosomal tRNA rejection, translational slow down, protein aggregation as well as proteome-, transcriptome- and metabolome changes, which are assumed to be responsible for stress sensitivity phenotypes of the corresponding mutants (**Fig.1B**). Furthermore, the combined loss of mcm^{5}U and s^{2}U generally aggravates the negative effects, suggesting that different modifications installed by distinct pathways can cooperate to support a specific function of tRNA (**Fig.1B**).

To test this hypothesis with more combinations, our group created different double tRNA modification mutants, which lack critical genes of the mcm^{5}s^2-pathways (*elp3* or *urm1*) together with the *deg1* or *tcd1* knock-out (*elp3/urm1 tcd1* and *elp3/urm1 deg1*, **Fig.1A**). Deg1 is an isomerase which converts uridines at position 38/39 of specific tRNAs into pseudouridines while Tcd1 cooperates with Tcd2 to convert the N^6-threonylcarbamoyl adenosine (t^{6}A) into cyclic N^6-threonylcarbamoyl adenosine (ct^{6}A) at position 37 (**Fig.1A**). Intriguingly, the search for adaptor molecules decorated with this set of different modifications revealed that tRNA$^{Lys}_{UUU}$ and tRNA$^{Gln}_{UUG}$ are the only ones which natively harbor mcm^{5}s^{2}U$_{34}$ together with ct^{6}A$_{37}$ (tRN$^{Lys}_{UUU}$) or Ψ_{38} (tRNA$^{Gln}_{UUG}$). Since overexpression of undermodified tRNAs in modification mutants can suppress negative in vivo effects in some cases, we analyzed whether this also applies for the above mentioned tRNAs. Indeed, phenotypic profiling of the newly created double mutants revealed that the aggravated stress sensitivities were rescued by higher than normal dosage of tRNA$^{Lys}_{UUU}$ (*tcd1* combinations) or tRNA$^{Gln}_{UUG}$ (*deg1* combinations) (**Fig.1C**, left). For testing translational defects in the different modification mutants, we chose genes encoding proteins with exceptionally high percentage of either glutamine (*RNQ1*) or lysine (*SRP21*) and examined their expression efficiency. Indeed, both proteins were weakly expressed in the different mutants (**Fig.1C.1** and **1C.2**, right) and this defect again can be rescued by tRNA overexpression. Quantification of the corresponding mRNA levels indicated these expression defects to result from inefficient translation rather than inappropriate transcription.This identified the *RNQ1* and *SRP21* mRNAs as modification tunable transcripts (MoTTs), depending

on the above described combinations of modifications in tRNA$^{Lys}_{UUU}$ and tRNA$^{Gln}_{UUG}$.
Based on these initial findings and embedded in the SPP1784 *Chemical Biology of Native Nucleic Acid Modifications* (SCHA750/20-1 & -2 and KL2937/1-1 &-2), we aim to clarify different aspects of the regulatory tasks cooperative tRNA modifications seem to fulfill. In this respect, it is critical to investigate global proteome/transcriptome changes upon combined loss of tRNA modifications, which likely mediates the observed physiological changes.

Such global approaches are essential to understand which pathways are activated or suppressed in tRNA modification mutants.

To achieve these aims, we are currently pursuing these major tasks:

- Quantification of up/down regulated genes at the proteometranscriptome level,
- Clarification of the nature of tRNA$^{Lys}_{UUU}$ and tRNA$^{Gln}_{UUG}$ malfunction (stability/amino acylation)
- Identifying pathways that are activated/suppressed in composite tRNA modification mutants

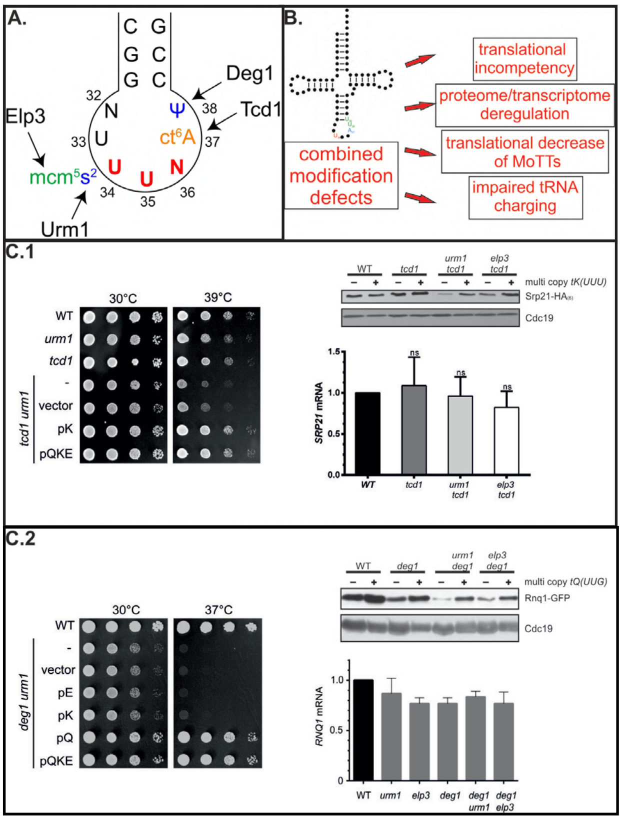

Fig.1. Functional relevance of combined tRNA modifications in the anticodon stem loop.
(A) The schematic overview of an anticodon stem loop depicts different nucleotides modified by the Elongator complex (Elp3, mcm^5), Urm1 pathway (s^2), Deg1 (Ψ) and Tcd1 (ct^6).
(B) Combined deletion of these key modifiers can lead to severe defects, which are exemplified in the boxes. Investigating the growth phenotypes of composite tRNA modification mutants (**C.1** and **C.2**, left panels) as well as translational competency of *RNQ1* (Q-rich) and *SRP21* (K-rich) mRNAs (**C.1** and **C.2**, right panels) reveal strong defects, which can be suppressed by overexpression of tRNA$^{Lys}_{UUU}$ (*tK: tcd1* combinations) or tRNA$^{Gln}_{UUG}$ (*tQ: deg1* combinations). mRNA quantification indicates that the protein (Rnq1, Srp21) expression defects occur at the translational rather than transcriptional levels in the composite tRNA modification mutants (**C.1** and **C.2**, bar diagrams).

Further Information

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New Members

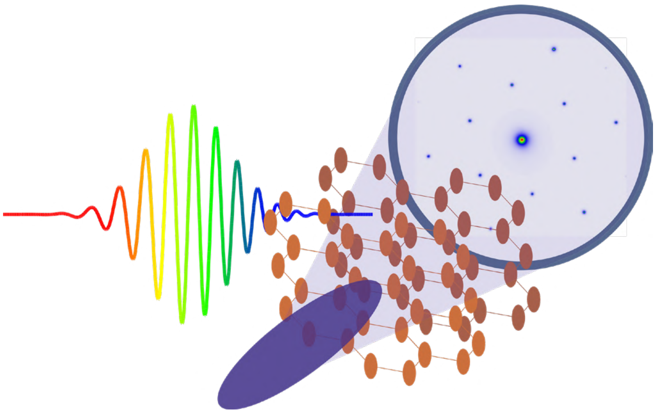
Ultrafast structural dynamics - Faculty 10

How do atoms in molecules or solid states systems evolve in time on the onset of a chemical reaction or change in physical conditions? This question is addressed by Dr. Arne Senftleben who leads the scientific efforts on ultrafast structural dynamics within the Femtosecond spectroscopy and ultrafast laser control (experimental physics 3) of Prof. Dr. Thomas Baumert. Dr. Senftleben joined CINSaT as an associate member in 2018. In the group, ultrafast structural dynamics after interaction of a system with an intense femtosecond laser pulse are probed by electron diffraction in two different approaches:

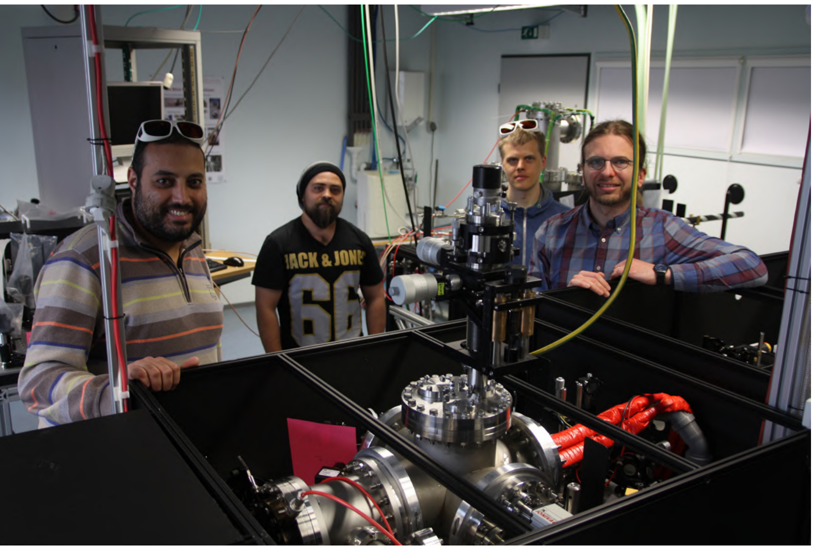
In ultrafast electron diffraction, a thin solid film is excited by an optical pump pulse. The excitation changes the electronic temperature and subsequently induces changes in the atomic structure. A snapshot of the evolving dynamics is taken by an electron pulse that can be as short as one hundred femtoseconds. Changing the delay between the two pulses allows to obtain a movie of the structural evolution. The solid films investigated have typical thicknesses of a few nanometers or sometimes even a single atomic layer.

In another electron diffraction approach, Dr. Senftleben investigates the structural dynamics of molecules. In this case the diffraction on the molecular structure is performed by an electron that is emitted from the molecule itself by a femtosecond mid-infrared laser field. This laser field subsequently accelerates the electron and drives it back to the molecule to scatter from it. These experiments are performed in the lab of Prof. Dr. Jens Biegert at the ICFO in Barcelona.

Arne Senftleben is also interested in the control of structural dynamics. Within the collaborative research center ELCH, he is investigating a route to transform a chiral molecule from one enantiomer to the other.



An electron bunch (blue ellipse) diffracts on a laser-excited crystal (brown) to create the ultrafast electron diffraction pattern in the background.



The ultrafast electron diffraction group with the set-up

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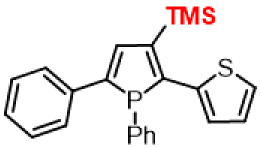
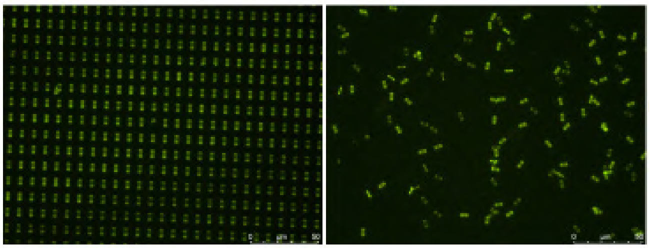
Research Groups

Chemical Hybrid Materials - Faculty 10

Prof. Dr. Rudolf Pietschnig was appointed in 2011 and started the research area of Chemical Hybrid Materials at the University of Kassel. In spring 2012 he joined CINSaT. The research of his group is specialized in the chemistry of organoelement compounds which are molecular hybrid structures consisting of organic and inorganic building units with a particular focus on p-Block elements such as phosphorus and silicon. In this context he was actively involved in the European Networks "PhoSciNet" devoted to molecular phosphorus chemistry and "SIPs" focusing on smart inorganic polymers. Moreover, he is founding member of the "Fachgruppe Phosphorchemie" of the German Chemical Society (GDCh). His research interests range from applied topics (luminescent materials, inorganic surfactants, novel pharmacophors) over sustainable chemistry (energy storage materials, catalytic C-H activation) to fundamental research (structure and bonding, chirality). In turn the unique bonding situation and electronic properties of heavier elements endow organic materials with advantageous features related to the interaction with light or electromagnetic fields in general.

The combination of molecular frameworks with ferrocene, a redox switchable organometallic unit, is explored in order to access reactive species and intermediates such as radicals and heterocarbenes with the intention of taming such transient species to allow their characterization and to study their reactivity and properties. In this respect controlling the stereochemistry of stereogenic group 15 centers is part of ongoing investigations, be it for fundamental questions of chirality or the stereochemical alignment of multiple stereogenic centers. Prof. Pietschnig's group is involved in cooperations with various national and international partners mainly from France, Austria, Sweden, Hungary, Japan and Canada. At the University of Kassel he participates in the joint interdisciplinary projects ELCH (CRC 1319) devoted to bespoke chiral molecules in the gas phase, SMolBits (LOEWE) aiming at surface immobilized molecular entities for optical switching and information storage and "MASH" exploring embedment of functional molecules in nano- and micro-imprinted polymer matrices and structures.





Unsymmetrically substituted phospholes (TMS = $Si(CH_3)_3$; Ph = C_6H_6) show a low tendency to undergo phase separation from polymer blends, which allowed the preparation of luminescent imprinted structures and particles taking advantage of this unique chiral dye (F. Roesler, B. Kaban, D. Klintuch, U.-M. Ha, C. Bruhn, H. Hillmer, R. Pietschnig, manuscript to be submitted).

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Photo of the Chemical Hybrid Materials group members.

Macromolecular Chemistry and Molecular Materials - Faculty 10

Being de facto without head of the Fachgebiet since 2010, the group has continued to be active in nanoscience research and teaching under **apl. Prof. Dr. Thomas Fuhrmann-Lieker** as CINSaT member and since 2016 member of the executive board. Our research is focused on self-organization and photonics of soft matter. We want to reveal the physicochemical principals (yes, our basic expertise is physical chemistry) of pattern formation on a mesoscopic scale that provides an optical function to a soft material. Examples of projects that address this issue in a variety of ways are given in the following overview. At the moment we are concentrating on two distinct material classes: organic optoelectronic materials and hybrid biological materials.

Effective organic solar cells are formed if a photoactive interface layer of high area is placed between two interpenetrating networks of charge transporting materials. We aim at the generation of thermodynamically stable nanophases of molecular glasses suited for a reliable realization of these structures. In a recent work represented by **Michael Grimann**, who obtained his PhD in 2018, we succeeded in generating phase separation in molecular glasses in the solid state and were able to stabilize the interface with a third compound.

In the field of lasers, random lasers in which resonating modes form spontaneously are an important topic of interest at the moment. We generate random structures from mechanically stressed films that relax to surface corrugations with a dominant spatial wavelength, so-called wrinkles (Fig. 1). Doing this with organic lasing materials that have been developed for a long time in Kassel, also in collaboration with other CINSaT members [1], we were able to show that within the spectral range of amplified spontaneous emission (3 nm width) numerous laser modes can be excited. As a side activity of this project, represented by **Nicolai Hoinka**, we also achieved stimulated emission in daily-life materials such as copy paper as scattering medium. The latter results were released recently in the online-journal Scientific Reports of the Nature publishing group [2].

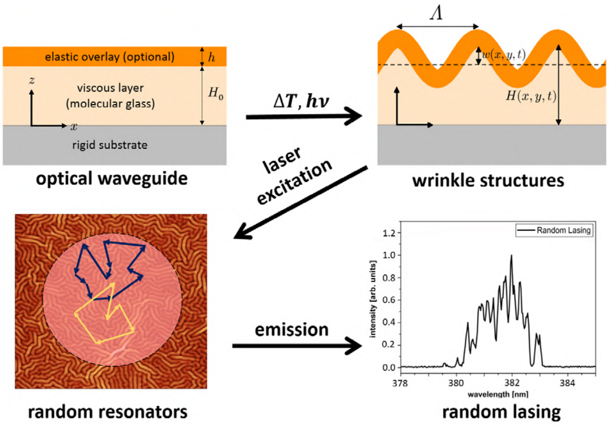

Fig.1 Self-organization in organic thin films. Molecular glasses with functions such as efficient emission, charge transport and/or photoresponse are used. Stressed multilayer films of these materials form wrinkles by heating or in the case of azo materials by irradiation with light. The evolving random structures are photonic resonators that are identified by narrow-band emission. (© Hoinka, Ostwald)

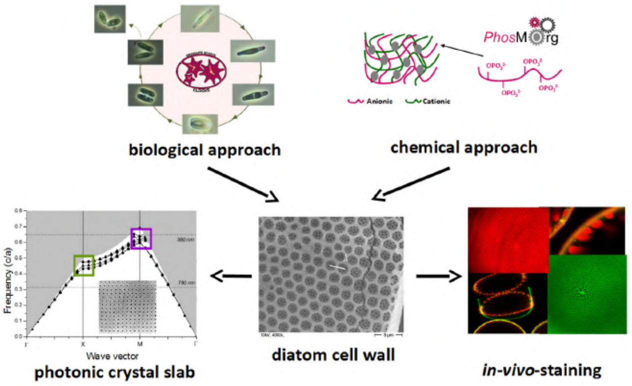

Fig.2 Self-organization of biological materials. The cell walls of diatoms are self-replicated by a unique biological clock (biological view) and self-assembled using highly phosphorylated biopolymers (chemical view). They can be regarded as photonic crystal slab waveguides and are stained with laser dyes for elucidating the photonic properties. The diatoms displayed are *Phaeodactylum tricornutum* and *Coscinodiscus wailesii*. (© Mohr, Khonsari, Horn, Fuhrmann-Lieker, Kucki)

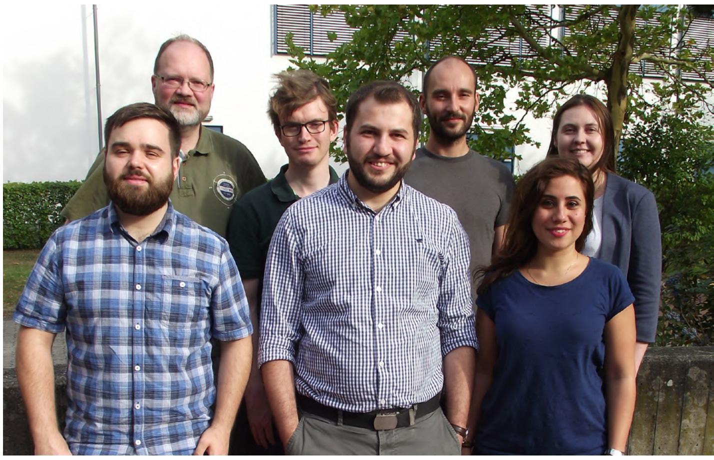

Fig. 3 Group photo of the group members featured in this article.

3D-nanofabrication with azo materials is a project represented by **Sekvan Bagatur** that explores the possibility of producing three-dimensional structures from flat layer systems with the help of light. Key materials are molecular glasses and high-performance polymers that bear the photosensitive azo group allowing optical and mechanical deformation in response to polarized light [3]. Self-organized surface patterns [4], birefringent helices in the bulk, holographic patterns and micro-origami structures belong to the realizable structures with these materials.

In diatoms, single-celled algae that bear an ornamental silica cell wall (Fig. 2), all these photonic structures that nanoscientists dream of are built by biological morphogenesis [5]. In order to reveal the formation process, we investigate as member of the PhosMOrg consortium the role of highly phosphorylated proteins in interaction with polycations and silica. In a biomimetic approach, represented by **Benedikt Mohr**, we address fundamental questions of self-organization in polyelectrolyte solutions with model polymers. The ornamental structures are inherited from generation to the next, involving a large degree of self-organization. The influence of the unique reproduction mechanism of diatoms on the pattern formation is addressed within the graduate programme "Biological clocks". PhD student **Bahar Khonsari** is the link to microbiology and ageing mechanisms in diatoms and yeast as prototypes of unicellular eukaryotes.

Recently, our team has been reinfoced by postdoctoral researcher **Dr. Marilia Horn** from Brazil establishing new activities in the field of biopolymers and nanopharmacy. With new Bachelor, Master and PhD students we hope to contribute further to the nanoscience activities within CINSaT.

Key publications

[1] T. Fuhrmann-Lieker, et al. “Optical amplification and stability of spiroquaterphenyl compounds and blends”, *J. Europ. Opt. Soc. Rap. Public.* **10**, 15007 (2015)

[2] N. Hoinka, T. Fuhrmann-Lieker, "Amplified Spontaneous Emission in Paper", *Scientific Reports* **9**, 1862 (2019)

[3] A. Perschke, T. Fuhrmann, "Molecular Azo Glasses as Grating Couplers and Resonators for Optical Devices", *Adv. Mater.* **14**, 841 (2002)

[4] P. Gruner, M. Arlt, T. Fuhrmann-Lieker, “Surface wrinkling induced by photofluidization of low molecular glasses”, *ChemPhysChem* **14**, 259 (2013)

[5] T. Fuhrmann, S. Landwehr, M. El Rharbi-Kucki, M. Sumper, "Diatoms as living photonic crystals", *Appl. Phys. B.* **78**, 257 (2004)

Website

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Fig. 4 We are still chemists, anyway.

Awards

Brilliant Poster Award for Julia Heupel

Julia Heupel won the Brilliant Poster Award at the Hasselt Diamond Workshop 2019 (SBDD XXIV, 13-15 March 2019, Hasselt, Belgium) for the poster “Fabrication of planarized nanocrystalline diamond films” with co-authors Nina Felgen, Alexander Schmidt, Johann Peter Reithmaier and Cyril Popov (Institute of Nanostructure Technologies and Analytics (INA), CINSaT, University of Kassel). The poster was selected by the international jury (Prof. Paul May (University of Bristol), Dr. Julien Barjon (CNRS & University of Versailles), Dr. Shannon Nicley (University of Oxford)) from 116 posters presented by participants from 28 countries.

Latest Reports

CINSaT Spring Colloquium 2019

CINSaT uses internal conference for thematic sharpening of scientific priorities

As in previous years, the CINSaT invited its members to participate to the internal science colloquium taking place at the Ahorn Berghotel in Friedrichroda from 7.-8. March 2019. The annual colloquium is an important communication platform not only for current research within the focus topics, it also serves to discuss the further development of the focus topics and to plan coordinated joint projects. An important contribution to this is made by the PhD students in the individual departments who, through their contributions, fill the meeting with life and thus contribute to the creation of a broad discussion platform. The fact that this concept has a positive effect on the development of the scientific center was confirmed by the nearly 90 participants. In addition to the warm welcome and opening by the head of CINSaT, Prof. Dr. Johann Peter Reithmaier, and the regular series of talks within the context of CINSaT's research interests there was once again, after the introduction last year, an individual focus topic session under the guidance of the respective speaker. In smaller groups, ideas could be exchanged within these topics and plans for further cooperation could be forged. This was further strengthened by the possibility to switch between the individual sessions in order to gather suggestions for potential new collaborations and projects. The hike following the session in brilliant sunshine and relatively mild temperatures was used for further exchange and getting to know each other in a relaxed atmosphere. The series of lectures, which were each initiated by a brief overview talk by the focus topic speakers and subsequently moderated, once again demonstrated the high quality of the contributions by the scientific staff of the participating disciplines and impressively demonstrated the success of the interdisciplinary cooperation within the center. In addition, the lecture sessions were complemented by the two introductory talks given by Prof. Dr. Angelika Brückner-Foit (Faculty 15, Institute of Materials Technology / Department of Quality and Reliability) and Prof. Dr. Georg Mayer (Faculty 10, Faculty of Zoology) enriched and rounded off the CINSaT membership applications submitted in advance. The evening poster session was a successful completion of the first day. The numerous research activities of the CINSaT were presented in an impressive and creative way on a total of 57 posters and provided an excellent basis for further discussions. As in the previous year, the end was deliberately left open so that there was plenty of time to exchange ideas and plan future collaborations.

The audience listeing to the interesting intruductory talk of Prof. Dr. Georg Mayer

Impressions from the hiking tour

Exciting discussions during the poster session

More impressions from the poster session

Group photo of the participants

Announcements

Autumn Colloquium 2019

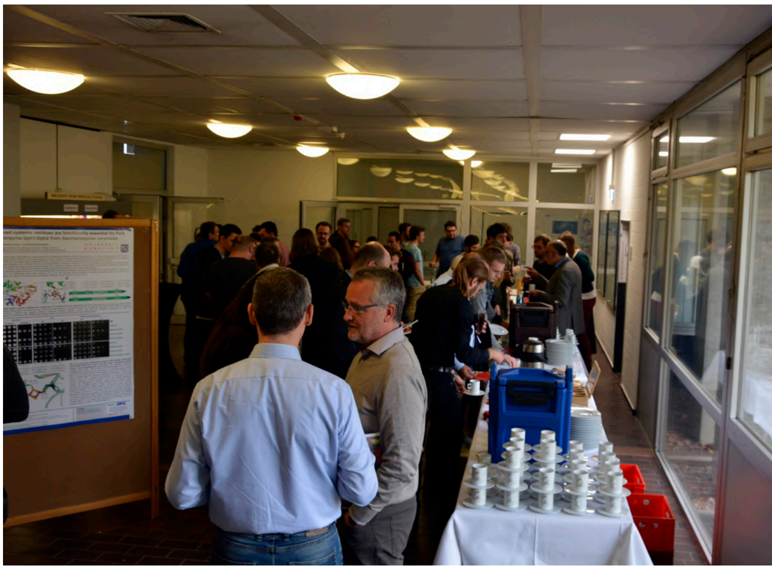
CINSaT cordially invites you to join the annual autumn colloquium which takes place on **Wednesday, the 16th of October 2019**, between 13:00 and 18:00, at the lecture hall 282, Campus Heinrich-Plett-Straße. The spirit of the colloquium is to provide current research issues within the interdisciplinary framework of nanostructure science to a broad audience in order to find a common language for research.

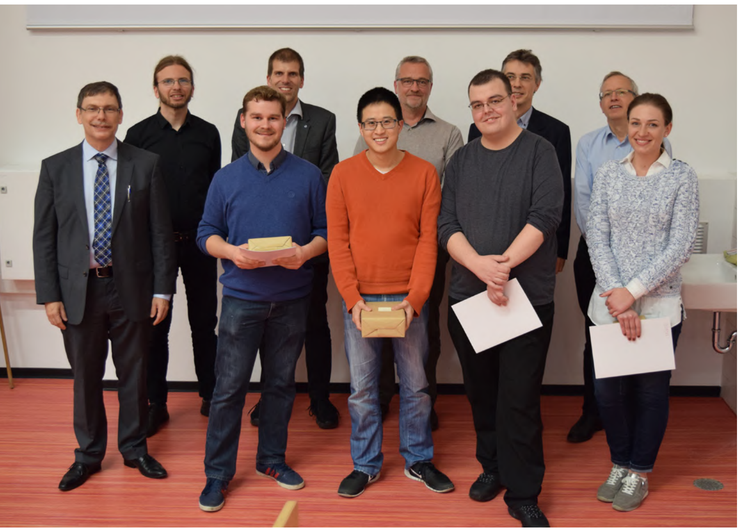
The program is organized in a way that invited external speakers were chosen to represent current and future activities within the scope of CINSaT's scientific key topics. The event is completed by a poster session in which the participants have the opportunity to hold scientific discussions and informal exchanges about current activities winthin the CINSaT. Note that the physical well-being of the participants is ensured.

We are pleased to welcome you to the colloquium and look forward of your participation!

Autumn
Colloquium
Location: HPS, HS 282

October
16th 2019
13^{00}-18^{00}





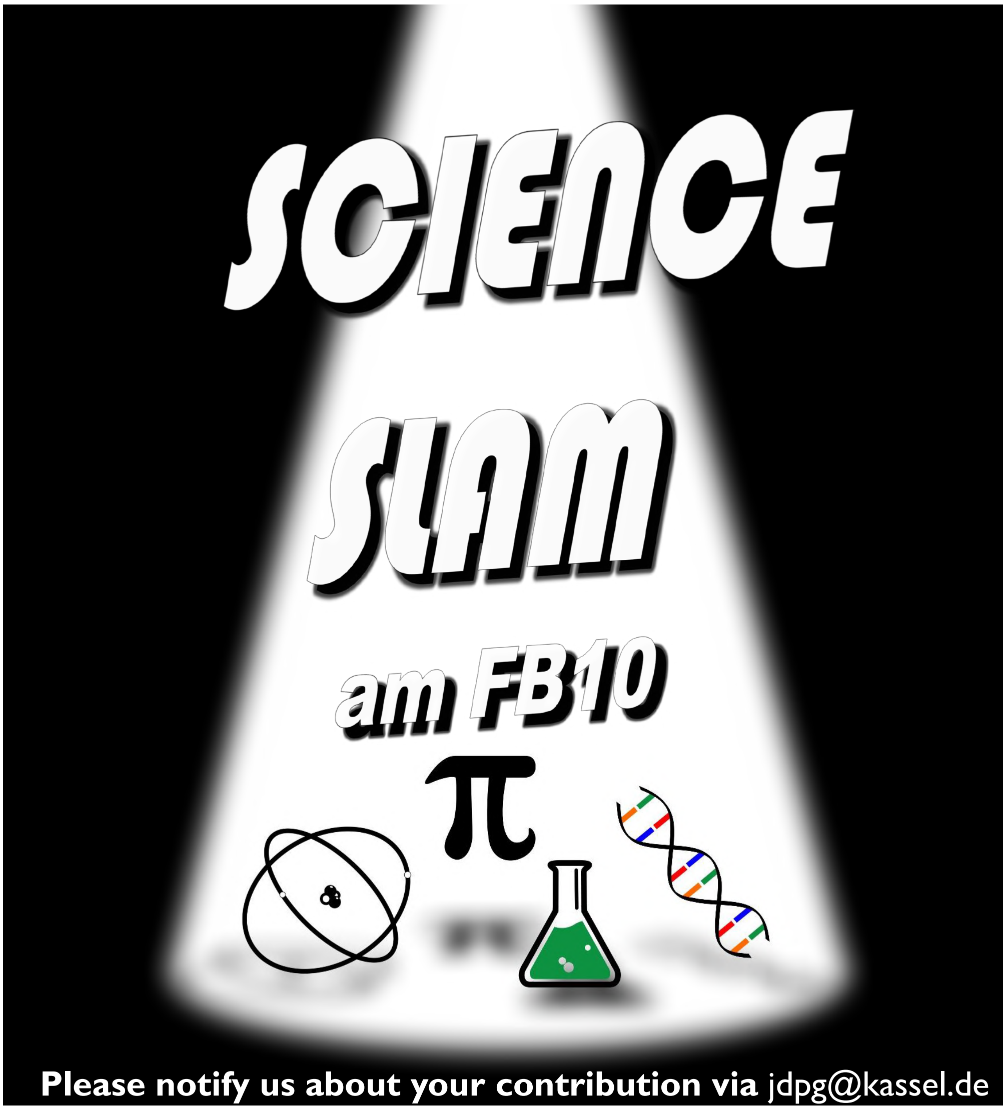
Impressions of the autumn colloquium 2018

Science Slam Faculty 10

Tuesday,

22.10.2019

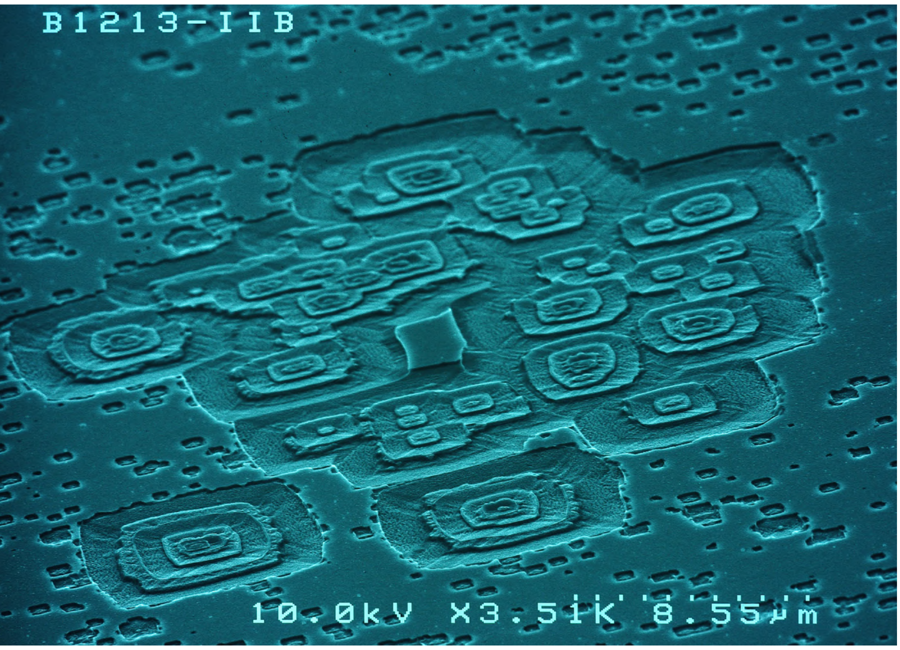
Room: TBA



Please notify us about your contribution via jdpg@kassel.de

Nano arts

In this section, artistically appealing images from the CINSaT groups will be presented. If you obtained any kind of visually appealing and fascinating data during your experiments with focus on micro- and nanometer length scales, you are cordially invited to submit your contribution to the editors.



Etch defects in indiium phosphide
(Dr. Annette Becker, Technische Physik)

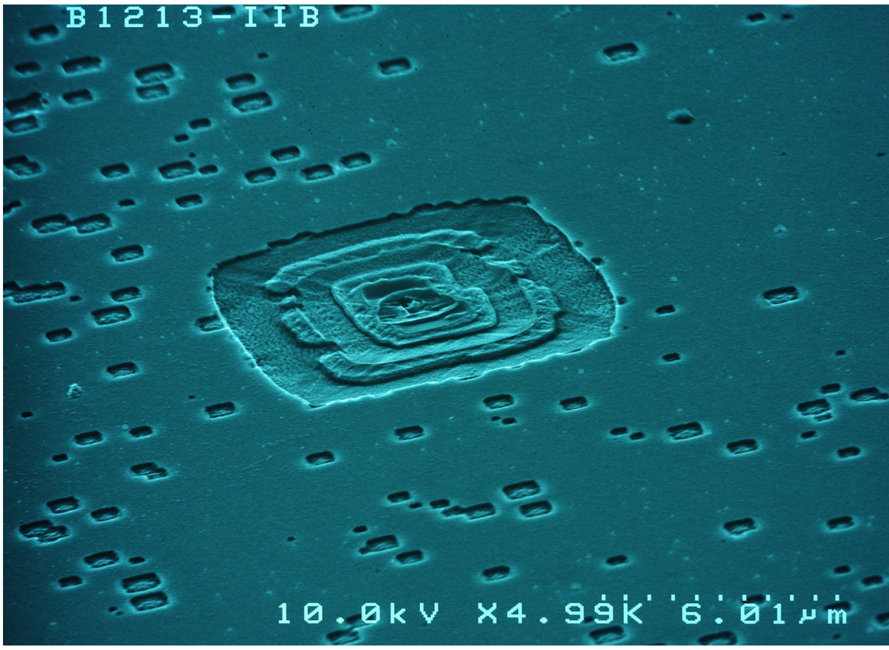


photo: Campus Heinrich-Plett-Straße, Press and Public Relations Office University of Kassel, Studio Blåfield

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