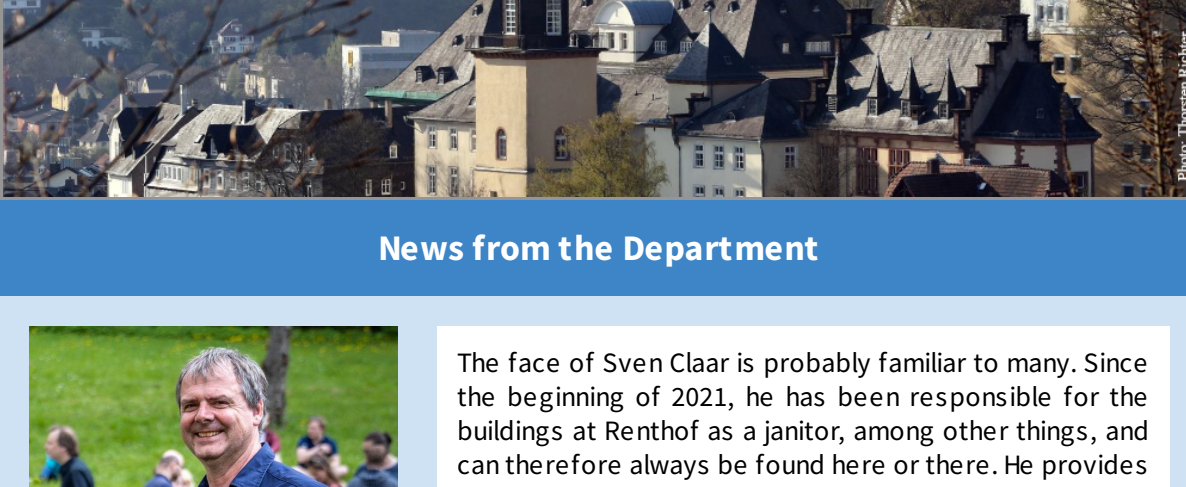
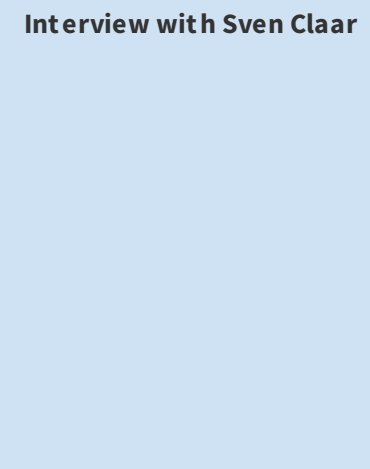


# Newsletter Physics 07/23

Department News    Research Highlights    Events    New colleagues



## News from the Department

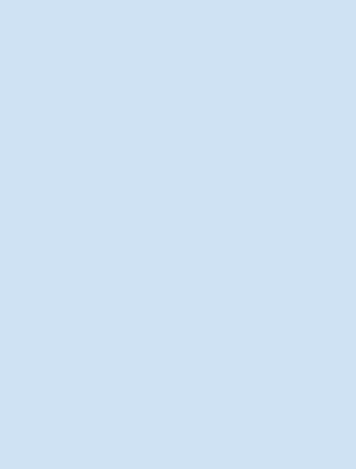


Interview with Sven Claar

The face of Sven Claar is probably familiar to many. Since the beginning of 2021, he has been responsible for the buildings at Renthof as a janitor, among other things, and can therefore always be found here or there. He provides support – even beyond the "normal" workload – when it comes to organizing a summer party or a physics day. He is also active in his spare time, in the fire department, in politics or at village festivals. Read more about Sven Claar in the detailed portrait.

Das Gesicht von Sven Claar ist vermutlich vielen bekannt. Seit Anfang 2021 ist er als Hausmeister-Vorarbeiter unter anderem für die Gebäude am Renthof zuständig und daher immer mal hier oder dort anzutreffen. Tatkräftig unterstützt er - auch über das "normale" Arbeitspensum hinaus -, wenn es beispielsweise um die Organisation eines Sommerfest oder einen Tag der offenen Tür geht. Tatkräftig und mit viel Engagement ist er auch in seiner Freizeit aktiv, bei der Feuerwehr, in der Politik oder bei Dorf-fest-en. Lesen Sie mehr über Sven Claar im ausführlichen Porträt.

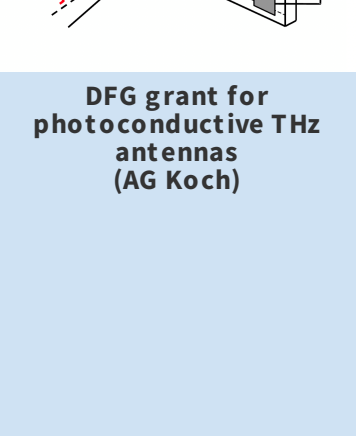
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DFG research grant on attention orienting in 3D visual space (AG Bremmer)

Dr. Baptiste Caziot and Prof. Frank Bremmer received a DFG research grant to investigate the orienting of attention in 3D visual space. Today visual attention is often described as a spotlight, which disregards depth information. We have recently found that visual attention is in fact intrinsically a 3-dimensional process, that can be oriented in depth as well as to "2D" locations in the visual scene. This is the starting point of the newly funded research program which aims at answering related questions, such as what are spatial and temporal extents of this effect, how it interacts with eye-movements, how it contributes to produce a sense of visual stability in the visual scene, and finally to reveal how these effects are implemented in the brain by recording from behaving non-human primates. This project will be an international collaboration with Drs. Guillaume Masson and Martin Szinte from Marseille University in France. This work is important not only to better understand visual science, but is also highly relevant for the developing VR and AR technologies.

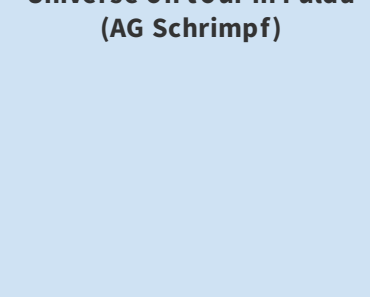
Dr. Baptiste Caziot und Prof. Frank Bremmer haben ein neues DFG-Forschungsprojekt erhalten, um die Orientierung der Aufmerksamkeit im visuellen 3D-Raum zu untersuchen. Heutzutage wird die visuelle Aufmerksamkeit oft als ein Spotlight beschrieben, das Tiefeninformationen außer Acht lässt. Wir haben kürzlich herausgefunden, dass die visuelle Aufmerksamkeit tatsächlich ein dreidimensionaler Prozess ist, der sich sowohl in der Tiefe als auch an "2D"-Stellen im visuellen Szenario orientieren kann. Dies ist der Ausgangspunkt des neu geförderten Forschungsprojekts, bei dem verwandete Fragen beantwortet werden, wie z. B. welche räumlichen und zeitlichen Ausmaße dieser Effekt hat, wie er mit Augenbewegungen interagiert, wie er dazu beiträgt, ein Gefühl der visuellen Stabilität in der visuellen Szene zu erzeugen, und schließlich aufzuzeigen, wie diese Effekte im Gehirn umgesetzt werden, indem Aufnahmen von nicht-menschlichen Primaten gemacht werden. Dieses Projekt ist eine internationale Zusammenarbeit mit Dr. Guillaume Masson und Martin Szinte von der Universität Marseille in Frankreich. Diese Arbeit ist nicht nur wichtig, um die visuelle Wissenschaft besser zu verstehen, sondern auch für die Entwicklung von VR- und AR-Technologien von großer Bedeutung.



DFG grant for photoconductive THz antennas (AG Koch)

The most widespread method to perform measurements in the far-infrared is terahertz time-domain spectroscopy, a technique which relies on photoconductive antennas which are gated by ultrashort laser pulses. In the past a consortium from HU Berlin, the Heinrich-Hertz-Institute in Berlin and the AG Koch has explored the potential of Fe, Rh, and Ru-doped InGaAs structures as base material for THz antennas. In the new DFG funded project, which will run for 12 months, the team will study dual-transition metal doped InGaAs structures hoping for an improved performance. The funding for AG Koch is 60.000 Euros.

Die am weitesten verbreitete Methode für Messungen im Fern-Infrarot-Bereich ist die Terahertz-Zeitbereichs-spektroskopie, eine Technik, die sich auf photoelektrische Antennen stützt, die durch ultrakurze Laserpulse geschaltet werden. In der Vergangenheit hat ein Konsortium der HU Berlin, des Heinrich-Hertz-Instituts in Berlin und der AG Koch das Potenzial von Fe-, Rh- und Ru-dotierten InGaAs-Strukturen als Basismaterial für THz-Antennen untersucht. In dem neuen, von der DFG geförderten Projekt, welches eine Laufzeit von 12 Monaten hat, wird das Team InGaAs-Strukturen untersuchen, die mit zwei Übergangsmetallen gleichzeitig dotiert sind. Die Finanzierung der AG Koch beträgt 60.000 Euro.

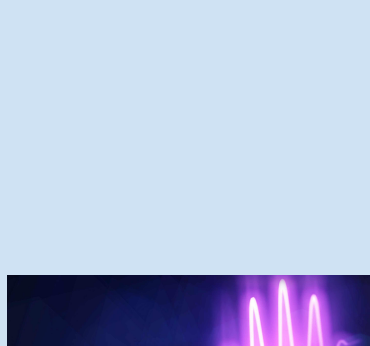


Materials Research day

Materials research in Central Hesse was the focus of a conference organized in Marburg on 15 June. Around 200 researchers presented and discussed their work and results at the Central Hessian Materials Research Day, which was held by the Scientific Center for Materials Science at Philipps University Marburg and the Center for Materials Research at Justus Liebig University Gießen as well as the Technical University of Central Hesse at the Marburg University Library.

Die mittelhessische Materialforschung stand im Fokus einer Tagung, die am 15. Juni in Marburg organisiert wurde. Rund 200 Forschende präsentierten und diskutierten ihre Arbeiten und Ergebnisse auf dem mittelhessischen Materialforschungstag, den das Wissenschaftliche Zentrum für Materialwissenschaften der Philipps-Universität Marburg und das Zentrum für Materialforschung der Justus-Liebig-Universität Gießen sowie die Technische Hochschule Mittelhessen in der Universitätsbibliothek Marburg durchführten.

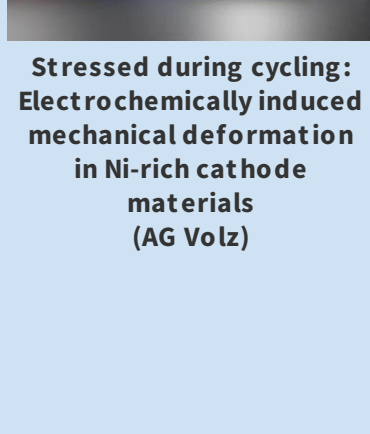
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Universe on tour in Fulda (AG Schrimpf)

The astronomy group of the department joined the "Universe On Tour" roadshow in Fulda on 16-17 June. This roadshow offers a mobile planetarium show and a tent with information about the universe and different ways to discover its secrets as well as solar telescopes from local partners. The roadshow is funded by the German ministry for education and research, is embedded in this years motto "Our Universe" and tours across the country. The astronomy group presented itself to the public with a poster and answered questions about the group, physics and the universe. Prof. Schrimpf also gave a talk about the measurement of star positions on Friday evening.

Die Astronomiegruppe des Fachbereichs nahm am 16. und 17. Juni an der Roadshow "Universe On Tour" in Fulda teil. Diese Roadshow bietet eine mobile Planetariumsshow und ein Zelt mit Informationen über das Universum und verschiedene Möglichkeiten, seine Geheimnisse zu entdecken, sowie Sonnenteleskope von lokalen Partnern. Die Roadshow wird vom Bundesministerium für Bildung und Forschung gefördert, ist eingebettet in das diesjährige Motto "Unser Universum" und tourt quer durch das Land. Die Astronomiegruppe stellte sich mit einem Plakat der Öffentlichkeit vor und beantwortete Fragen zur Gruppe, zur Physik und zum Universum. Prof. Schrimpf hielt am Freitagabend außerdem einen Vortrag über die Messung von Sternpositionen.

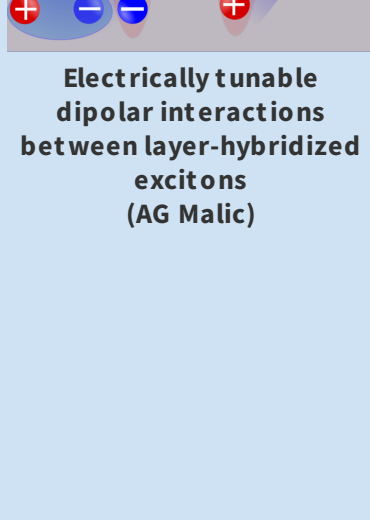


Experiments in physics practical course

In the physics practical courses, various experiments are offered to give students a clear understanding of physics topics and also to train experimental and evaluation skills such as the plotting of data, the comparison with reference data sets and the graphical evaluation of correlations. In the coming newsletters, we would like to present some examples of such experiments to give interested readers an insight into our experimental portfolio. As a first example we present the experiment "Ultrasound".

In den Physik-Praktika werden diverse Versuche angeboten, um den Studierenden physikalische Themen anschaulich näherzubringen und zudem Experimentier- und Auswertungskompetenzen auszubilden wie beispielsweise das Auftragen von Daten, den Vergleich mit Referenzdatensätzen und die graphische Auswertung von Zusammenhängen. In den kommenden Newslettern werden wir wir beispielhafte Impressionen solcher Versuche anbringen, um den interessierten Leser:innen einen Einblick in unser Versuchsportfolio zu geben. Als erstes Beispiel möchten wir den Versuch „Ultraschall“ vorstellen.

[read more](#)

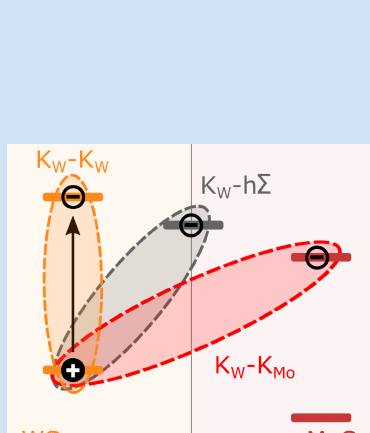


Physics colloquium

The physics colloquium has been so far a success, in particular we have reached the goal of attracting more students. The new concept with more general talks addressing topics of high interest (and of course the delicious cake after the talk) has been the key. What is still missing to have a great physics colloquium is that more group leaders and their group members attend the colloquium. Here, we have a lot of room for improvement. Dear research group leaders, please encourage your team members to go to the colloquium, expand their horizons and use the opportunity to meet the colleagues.

Das Physik-Kolloquium war bis hier ein Erfolg, insbesondere haben wir das Ziel erreicht, mehr Studenten zu gewinnen. Das neue Konzept mit allgemeineren Vorträgen zu Themen, die von großem Interesse sind (und natürlich der leckere Kuchen nach dem Vortrag), war der Schlüssel dazu. Was noch fehlt, um ein großartiges Physik-Kolloquium zu haben, ist, dass mehr Gruppenleiter und ihre Gruppenmitglieder das Kolloquium besuchen. Hier haben wir noch viel Raum für Verbesserungen. Liebe Forschungsgruppenleiter, bitte ermutigen Sie Ihre Teammitglieder, das Kolloquium zu besuchen, um ihren Horizont zu erweitern und die Gelegenheit zu nutzen, Kollegen zu treffen.

## Research Highlights



Stressed during cycling: Electrochemically induced mechanical deformation in Ni-rich cathode materials (AG Volz)

Shamail Ahmed and Kerstin Volz comment on defects Cathode Active Materials for Lithium Ion Batteries in an invited pre-view by the Cell Press journal Matter. Nowadays, nickel-rich layered cathode materials are being considered as the near-term future for lithium-ion batteries. They have a two-fold advantage over traditionally used layered cathode materials. They contain little-to-no cobalt and have high, also practically achievable specific capacities in contrast to traditionally used LiCoO<sub>2</sub> and low Ni-fraction NCM (Ni, Co, and Mn-containing) cathode materials. However, although nickel-rich cathode materials have high energy densities, they suffer from premature degradation. A cathode active material constitutes the biggest fraction of the cost of a typical lithium-ion battery cell, let it can be one of the significant capacity-limiting factors in a lithium-ion battery cell under standard cycling conditions. This, without any doubt, builds a strong case to make a significant effort to improve the performance of layered cathode active materials, especially Ni-rich layered cathode active materials. This work is published in **Matter**.

[read more](#)



Spatially-Resolved Potential Drops at Hetero-Interfaces Using 4D-STEM (AG Volz)

Characterizing long-range electric fields and built-in potentials in functional materials at nano to micrometer scales is of supreme importance for optimizing devices, e.g., the functionality of semiconductor heterostructures or battery materials is determined by the electric fields established at interfaces which can also vary spatially. In this study, we propose momentum-resolved four-dimensional scanning transmission electron microscopy (4D-STEM) for the quantification of these potentials. Researchers in the group of Kerstin Volz show the optimization steps required to reach a quantitative agreement with simulations for the GaAs/AIAs hetero-junction model system. This work is published in **Small Methods**.

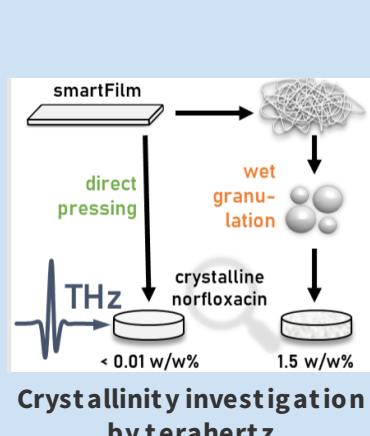
[read more](#)



Electrically tunable dipolar interactions between layer-hybridized excitons (AG Malic)

Transition-metal dichalcogenide bilayers exhibit a rich excitonic landscape including layer- and inter-layer excitons, i.e. excitons which are of partly intra- and inter-layer nature. In this work, AG Malic in collaboration with Andras Kis (ETH) investigated hybrid exciton-exciton interactions in naturally stacked WSe<sub>2</sub> homobilayers. In these materials, the exciton landscape is electrically tunable such that the low-energy states can be strengthened more or less inter-layer-like depending on the strength of the external electric field. Based on a microscopic and material-specific many-particle theory, we reveal two intriguing interaction regimes: a low-dipole regime at small electric fields and a high-dipole regime at larger fields, involving interactions between hybrid excitons with a substantially different intra- and inter-layer composition in the two regimes. While the low-dipole regime is characterized by weak inter-excitonic interactions between intralayer-like excitons, the high-dipole regime involves mostly interlayer-like excitons which display a strong dipole-dipole repulsion and give rise to large spectral blue shifts and a highly anomalous diffusion. Overall, our microscopic study sheds light on the remarkable electrical tunability of hybrid exciton-exciton interactions in atomically thin semiconductors and can guide future experimental studies in this growing field of research. This work is published in **Nanoscale**.

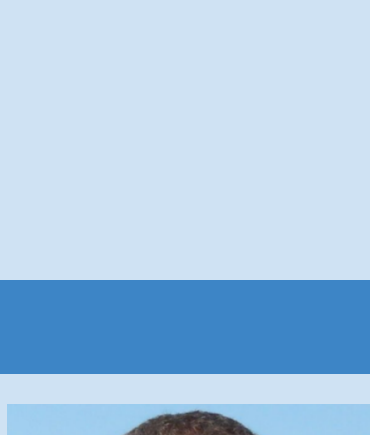
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Twist-angle dependent dehybridization of excitons in TMD heterostructures (AG Malic)

The moire superlattice has emerged as a powerful way to tune excitonic properties in two-dimensional van der Waals structures. However, the current understanding of the influence of the twist angle for interlayer excitons in heterostructures is mainly limited to momentum-direct  $\Gamma$ -K transitions. In this work, AG Malic in collaboration with P. Plochocka (NRS Toulouse) exploited a combination of spectroscopy and many-particle theory to investigate the influence of the twist angle on momentum-indirect interlayer excitons of a MoSe<sub>2</sub>/MoS<sub>2</sub> heterostructure. Here, the energetically lowest state is a dark and strongly hybridized  $\Gamma$ -K exciton. We show that increasing the twist angle from an aligned structure gives rise to a large blue shift of the interlayer exciton, which is a manifestation of the strong dehybridization of this state. Our finding contributes to a better fundamental understanding of the influence of the moire pattern on the hybridization of momentum-dark interlayer exciton states, which may be important for applications in moire-tronics including novel quantum technologies. This work is published in **2D Materials** within the focus issue on Optics of Moire Materials.

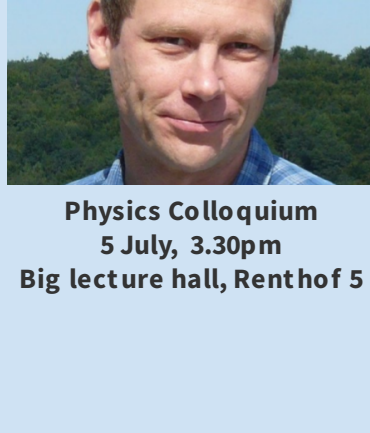
[read more](#)



Ultrafast dynamics of bright and dark excitons TMD heterostructures (AG Malic)

The energy landscape of optically excited excitons in mono- and few-layer transition metal dichalcogenides is dominated by optically bright and dark excitons. In addition, there are so-called hybrid excitons whose electron- and/or hole-component are delocalized over two or more TMD layers, and therefore provide a promising pathway to mediate charge-transfer processes across the momentum interface. In this work, using femtosecond time-resolved microscopy combined with many-particle modeling, AG Malic and AG Mathias (Göttingen) quantitatively compare the dynamics of momentum-indirect intralayer excitons in monolayer WSe<sub>2</sub> with the dynamics of momentum-indirect hybrid excitons in heterobilayer WSe<sub>2</sub>/MoS<sub>2</sub>, and draw three key conclusions: First, we find that the energy of hybrid excitons is reduced when compared to excitons with pure intralayer character. Second, we show that the momentum-indirect intralayer and hybrid excitons are formed via exciton-phonon scattering from optically excited bright excitons. And third, we demonstrate that the efficiency for phonon absorption and emission processes in the mono- and the heterobilayer is strongly dependent on the energy alignment of the intralayer and hybrid excitons with respect to the optically excited bright exciton. Overall, our work provides microscopic insights into exciton dynamics in TMD mono- and bilayers. This work is published in **2D Materials** within the focus issue on Optics of Moire Material.

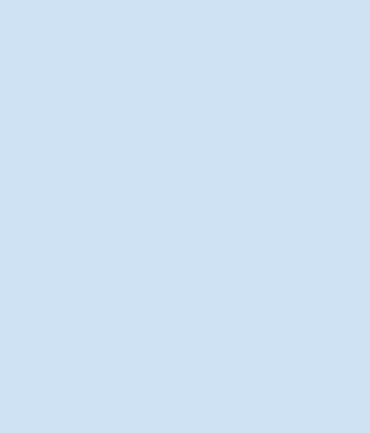
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Interlayer hybridization and charge transfer in WS<sub>2</sub>-graphene heterostructures (AG Malic)

Ultrafast charge separation after photoexcitation is a common phenomenon in various van-der-Waals heterostructures with great relevance for future applications in light harvesting and detection. Theoretical understanding of this phenomenon converges towards a coherent mechanism through charge transfer states accompanied by energy dissipation into strongly coupled phonons. The detailed microscopic pathways are material specific as they sensitively depend on the band structures of the individual layers, the relative band alignment in the heterostructure, the twist angle between the layers, and interlayer interactions resulting in hybridization. In a collaboration between AG Malic and AG Gierz (Regensburg), we used time- and angle-resolved photoemission spectroscopy combined with tight binding and density functional theory electronic structure calculations to investigate ultrafast charge separation and recombination in WS<sub>2</sub>-graphene heterostructures. We identify several avoided crossings in the band structure and discuss their relevance for ultrafast charge transfer. We relate our own observations to existing theoretical models and propose a unified picture for ultrafast charge transfer, where band alignment and twist angle emerge as the most important control parameters. This work is published in **2D Materials** within the focus issue on Optics of Moire Material.

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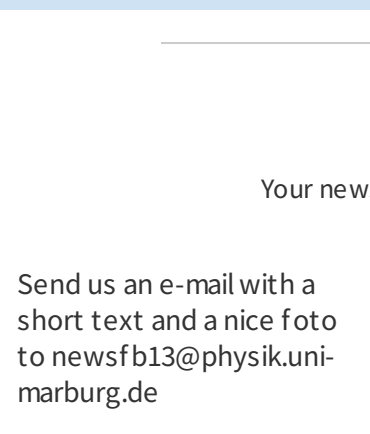


Crystallinity investigation by terahertz spectroscopy (AG Koch/Camus)

The industrial large-scale production of pharmaceutical tablets requires a proper flowability of the solid ingredients. For this purpose, wet granulation is an established and widely used intermediate production step. However, during the procedure, the excipients are exposed to water and high temperature, which can influence the crystallinity and consequently bioavailability of the active pharmaceutical ingredient. In this work, AG Koch/Camus studied the possible impact of wet granulation on the crystallinity of norfloxacin dispersed in so called smartFilms using terahertz (THz) time-domain spectroscopy (TDS) and x-ray powder diffraction (XRD). THz TDS enables a more straightforward analysis than XRD. Moreover, using THz TDS, it is possible to detect partial recrystallization of norfloxacin after the granulation, whereas this is not possible by XRD. The work was published in **Pharmaceutics**.

[read more](#)

## Events



Physics Colloquium 5 July, 3.30pm Big lecture hall, Renthof 5

Dr. Hagen Klauk, Max-Planck-Institut Stuttgart

Flexible Nanoscale Organic Thin-Film Transistors  
Organic thin-film transistors (TFTs) are field-effect transistors in which the semiconductor is a thin layer of conjugated organic molecules. Unlike transistors based on inorganic semiconductors (such as silicon or zinc oxide), organic TFTs can often be fabricated at process temperatures no higher than about 100 degrees Celsius and thus on a wide range of unconventional substrates, including plastics, textiles and paper. This makes organic TFTs potentially useful for flexible electronics applications, such as foldable or rollable displays or conformable sensor arrays. An important performance parameter of transistors in general (and of organic TFTs in particular) is the transit frequency, which is the highest frequency at which the transistors are able to switch or amplify electrical signals. A field-effect transistor's transit frequency depends critically on the channel length and the parasitic gate-to-contact overlaps. Since organic TFTs often have channel lengths and overlaps of several microns or even tens of microns, their transit frequencies are usually no higher than a few megahertz. To explore the performance of organic TFTs with aggressively scaled dimensions, we have used electron-beam lithography and fabricated organic TFTs with channel lengths and overlaps as small as 100 nm on flexible plastic substrates.



Physics Colloquium 12 July, 3.30pm Big lecture hall, Renthof 5

Dr. Günter Erfurt, Meyer Burger

Solarindustrie 2.0 in Europa - Zurück zu den Wurzeln einer Einsteinschen Schlüsseltechnologie  
Meyer Burger wird 2023 70 Jahre alt und hat die weltweite Solarindustrie maßgeblich mitgestaltet und wesentliche Produktionsstandards für z.B. PERC Zellen und Solar-Wafer gesetzt. Innerhalb von nur 3 Jahren haben wir uns zum Gigawatt-Solarmodul-Produzenten mit unabhängiger Lieferkette sowie F&E und Produktion in der Schweiz und Deutschland gewandelt und sprechen über Herausforderungen und unsere Ambitionen.

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## Share your good news

Your newsletter team: Carina Hlawaty and Ermin Malic

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