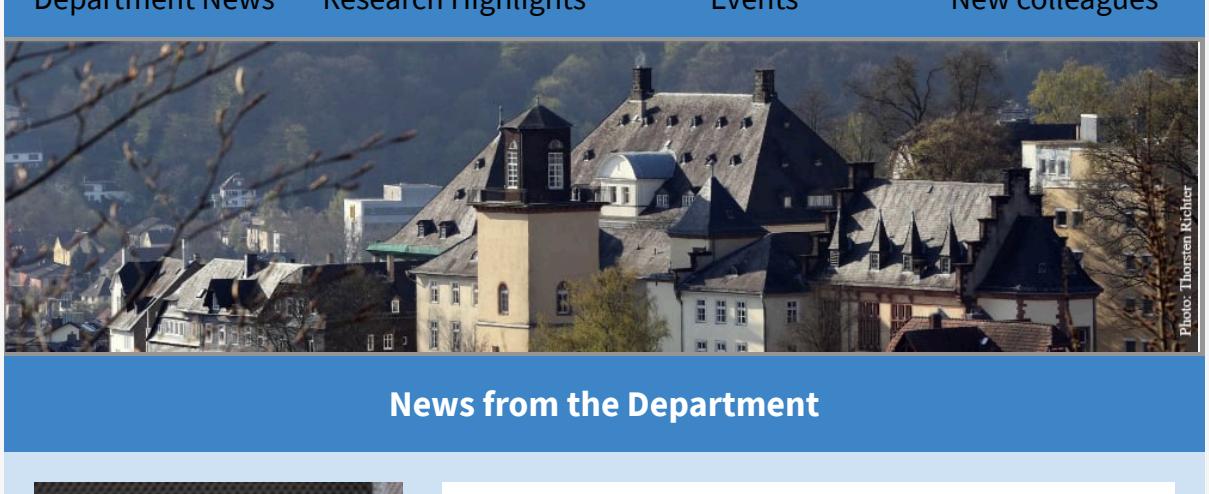
Philipps Universität Marburg

Newsletter Physics 07/25



News from the Department

Success in the excellence strategy

The Adaptive Mind – TAM: Adaptive Behavior is essential for everyday life; it's failure can lead to mental disorders. Importantly, its mechanisms remain largely unexplained and are absent even from the most advanced AI and robotic systems. Within the Excellence Cluster *The Adaptive Mind* (TAM), Justus Liebig University Giessen, Marburg University, and TU Darmstadt, together with partners in Frankfurt, bring together expertise from psychology, cognitive and neuroscience as well as artificial-intelligence and robotics research. The goal is to identify universal principles of human adaptability to promote mental health and to develop more robust AI and robotic systems. Researchers are investigating when the brain chooses which strategy, how it balances stability and transition, and what happens when the adaptation process fails. These questions concern not only human cognition but also learning robots or the training of neural networks. Frank Bremmer is the Marburg spokesperson of the consortium.

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Meet-the-prof interview with Marcel Reutzel

This time, Prof. Marcel Reutzel introduces himself in the new "Meet the Prof" video. His newly founded research group is called "Ultrafast and Coherent Phenomena". A small experiment with a Kapitza pendulum illustrates what his research group is working on. What drives the young professor? What motivated him to go into physics? What excites him about Marburg and what does he do in his free time? Find out the answers to all these questions in the video. The interview was conducted by Sarah Zajusch with Oliver Rehn behind the camera.

Im neuen „Meet the Prof"-Video stellt sich dieses Mal Prof. Marcel Reutzel vor. Seine frisch gegründete AG nennt sich „Ultraschnelle und kohärente Phänomene". Womit genau sich die AG beschäftigt, verdeutlicht er in einem kleinen Experiment mit einem Kapitza-Pendel. Was treibt den jungen Professor an? Welche Beweggründe haben ihn in die Physik geführt? Was begeistert ihn an Marburg und womit beschäftigt er sich in seiner Freizeit? All diese Fragen werden in dem Video beantwortet. Geführt wurde das Interview von Sarah Zajusch mit Oliver Rehn hinter der Kamera.

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Alfred Wegener PhD Award for Giuseppe Meneghini and Maximilian Dreher

For the fifth time, the Department of Physics is honouring the research achievements of young scientists with the Alfred Wegener Dissertation Prize. For the first time, the prize, which is sponsored by the Wilhelm and Else Heraeus Foundation and endowed with a total of 4,000 euros, has been split. The prize goes in equal parts to Dr Maximilian Dreher for his dissertation "Control and Refinement of Self-Organising Molecular Thin Film Structures" and Dr Giuseppe Meneghini for his dissertation "Hybrid Exciton Thermalization in Atomically-Thin Semiconductors". Both scientists completed their doctorates with distinction in 2024, Mr Dreher in Prof. Dr Gregor Witte's Molecular Solid State Physics group and Mr Meneghini in Prof. Dr Ermin Malic's Ultrafast Quantum Dynamics group.

Zum fünften Mal würdigt der Fachbereich Physik in diesem Jahr mit dem Alfred-Wegener-Dissertationspreis die Forschungsleistungen von Nachwuchs-wissenschaftlern. Zum ersten Mal wurde dabei der Preis geteilt, der durch die Wilhelm und Else Heraeus-Stiftung gefördert wird und mit insgesamt 4.000 Euro dotiert ist. Der Preis geht zu gleichen Teilen an Dr. Maximilian Dreher für seine Dissertation "Control and Refinement of Self-Organizing Molecular Thin Film Structures" und Dr. Giuseppe Meneghini für seine Dissertation "Hybrid Exciton Thermalization in Atomically-Thin Semiconductors". Beide Wissenschaftler haben 2024 ihre Promotion mit Auszeichnung abgeschlossen, Herr Dreher in der AG Molekulare Festkörperphysik von Prof. Dr. Gregor Witte und Herr Meneghini in der AG Ultraschnelle Quantendynamik von Prof. Dr. Ermin Malic.

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MINT-Summerschool for Girls

The Physics department has recently participated in the "MINT Summerschool for Girls". In this event, several female students from schools in Hessen have visited the science faculties in Marburg, hence also the Physics department. Guided by Gesa Helms, Lea Obermüller, Eike Pohlenz, and Tobias Breuer the students have performed experiments from the field of electronics and optics to introduce them into study experiences in physics courses. The event was very successful since all participants had fun throughout the day and stated that their impressions have increased their interest in physics and improved their expectations towards studying physics.

Der Fachbereich Physik hat sich kürzlich an der "MINT-Summerschool for Girls" beteiligt. Bei dieser Veranstaltung besuchen Schülerinnen von verschiedenen Schulen in Hessen und Nordrhein-Westfalen die naturwissen-schaftlichen Fachbereiche der Uni Marburg und somit auch die Physik. Angeleitet durch Gesa Helms, Lea Obermüller, Eike Pohlenz und Tobias Breuer haben die Schülerinnen Experimente aus den Gebieten Elektronik und Optik durchgeführt, um ihnen einen Einblick in das Experimentieren im Physik-Studium zu geben. Die Veranstaltung war sehr erfolgreichen, alle Beteiligten hatten Spaß und konnten sich ein positives Bild vom Studium der Physik machen.

Lara Heidrich: new doctor at the departement (AG Koch)

Lara Heidrich completed her PhD in May 2025 in the Semiconductor Photonics group under the supervision of Prof. Dr. Martin Koch. Her work focused on terahertz (THz) time-domain spectroscopy (TDS) as a powerful tool to analyze the crystallinity of pharmaceutical solids. In her work, Lara investigated amorphous drug systems using THz TDS and highlighted the advantages of the technique over more established methods. For example, she demonstrated that THz TDS is capable to detect subtle structural changes in amorphous drug formulations and in certain cases outperforms the gold standard of X-ray diffraction. Her research showcases the potential of THz TDS to offer new opportunities for solid state analysis in pharmaceutical development and beyond.

Lara Heidrich schloss ihre Promotion im Mai 2025 in der Arbeitsgruppe Halbleiterphotonik unter der Leitung von Prof. Dr. Martin Koch ab. Ihre Arbeit konzentrierte sich auf die Terahertz (THz) Zeitbereichsspektroskopie (TDS) als leistungsfähiges Werkzeug zur Kristallinitätsanalyse von pharmazeutischen Wirkstoffen. In ihrer Arbeit untersuchte Lara insbesondere verschiedene amorphe Arzneimittel-systeme mittels THz TDS und hob die Vorteile der Technik gegenüber etablierteren Methoden hervor. So zeigte sie beispielsweise, dass THz TDS in der Lage ist, subtile strukturelle Veränderungen in amorphen Arzneimittel-formulierungen zu erkennen und in bestimmten Fällen den Goldstandard der Röntgenbeugung zu übertreffen. Ihre Forschung verdeutlicht das Leistungsvermögen der THz TDS, neue Einblicke in der Kristallinitätsanalyse in der pharmazeutischen Entwicklung und darüber hinaus zu ermöglichen.

Yurii Radiev: new doctor at the departement (AG Witte)

Yurii Radiev completed his PhD with the Molecular Materials group led by Prof. Dr. Gregor Witte. His work focused on investigation of factors that contribute to the contact resistance in *p*- and *n*-channel organic field-effect transistors (OFETs), as well as methods of its reduction. As a part of his work, Yurii developed a full high-vacuum device preparation and characterization chain that allows variable-temperature transfer length method analysis without exposing prepared devices to ambient air. Using this technique, Yurii establishes key factors that affect the contact resistance in OFETs. His research reveals a direct connection between the injection barrier at the metal-organic interface and the activation energy of charge transport at the gate dielectric-organic interface. This result indicates the importance of an efficient charge transport for low contact resistance in OFETs, opening up possibilities for further advances in the field of organic electronics.

Yurii Radiev schloss seine Promotion in der Gruppe Molekulare Materialien unter der Leitung von Prof. Dr. Gregor Witte ab. Seine Arbeit konzentrierte sich auf die Untersuchung der Faktoren, die zum Kontaktwiderstand in organischen p- und n-Kanal-Feldeffekttransistoren (OFETs) beitragen, sowie auf Methoden zu dessen Verringerung. Im Rahmen seiner Arbeit entwickelte Yurii eine vollständige Hochvakuum-Bauteilpräparations- und -charakterisierungskette, die eine Analyse der Transferlängenmethode bei variablen Temperaturen ermöglicht, ohne dass die präparierten Bauteile der Umgebungsluft ausgesetzt werden müssen. Mit dieser Technik ermittelt Yurii die Schlüsselfaktoren, die den Kontaktwiderstand in OFETs beeinflussen. Seine Forschungen zeigen einen direkten Zusammenhang zwischen der Injektionsbarriere an der metallorganischen Schnittstelle und der Aktivierungsenergie des Ladungstransports an der dielektrisch-organischen Schnittstelle des Gates. Dieses Ergebnis weist auf die Bedeutung eines effizienten Ladungstransports für einen niedrigen Kontaktwiderstand in OFETs hin und eröffnet Möglichkeiten für weitere Fortschritte auf dem Gebiet der organischen Elektronik.

Summer Party at Physics department

On Tuesday, 24 June 2025, the annual summer party of the physics student council took place. In addition to a variety of cold drinks, there was a barbecue and delicious waffles. In addition, AG Koch kindly provided us with nitrogen ice cream again this year. We had the pleasure of welcoming two new additions to the department at this summer party: Prof. Marcel Reutzel and Prof. Mark Vogelsberger, who both took a moment to introduce themselves and their work. This year, the student council awarded the Patricia Pahamy Prize to Prof. Ermin Malic and Dr. Kevin Bauerbach to recognize their outstanding teaching. Furthermore, the commitment of the SOS tutors, especially Philipp and Bjarne, was recognized. Later in the evening, the pub quiz, table football, Viking chess and music provided entertainment so that we could enjoy a nice get-together until late. The student council would once again like to thank everyone who helped with the preparation and organization of this year's summer party. Every single helping hand contributes to making this party happen every summer and we can already start looking forward to next year.

Am Dienstag, den 24. Juni 2025 fand das alljährliche Sommerfest des Fachschaft Physik statt. Neben einer Vielzahl an kalten Getränken gab es Grillgut im Brötchen und leckere Waffeln. Außerdem hat uns die AG Koch freundlicherweise auch in diesem Jahr mit Stickstoff-Eis versorgt. Wir durften bei diesem Sommerfest gleich zwei Neuzugänge am Fachbereich begrüßen: Prof. Marcel Reutzel und Prof. Mark Vogelsberger, die sich beide einen Moment Zeit genommen haben, um sich und ihre Arbeit vorzustellen. Auch in diesem Jahr hat die Fachschaft wieder den Patricia-Pahamy-Preis verliehen, um herausragende Lehre am Fachbereich auszuzeichnen. Dieses Jahr ging der Preis an Prof. Ermin Malic und Dr. Kevin Bauerbach. Des Weiteren wurde der Einsatz der SOS-Tutoren, insbesondere Philipp und Bjarne, gewürdigt. Im späteren Verlauf des Abends haben dann das Pub-Quiz, der Kicker, Wikingerschach und Musik für Unterhaltung gesorgt, sodass wir noch bis spät ein schönes Beisammensein genießen konnten. Die Fachschaft möchte sich noch einmal ganz herzlich bei allen bedanken, die bei der Vorbereitung und Durchführung des diesjährigen Sommerfestes mitgewirkt haben. Jede einzelne helfende Hand trägt dazu bei, dieses Fest jeden Sommer auf die Beine zu stellen und ab jetzt können wir schon mal anfangen, uns auf nächstes Jahr zu freuen.

Patricia-Pahamy Award 2025

The Patricia-Pahamy Award 2025 is awarded annually at the Physics Department's summer festival. Professor Malic has been nominated multiple times and is popular among students for his clear, structured teaching style and innovative lecture concept. He uses quizzes, well-planned breaks, and understandable explanations of mathematical content, which helps many students overcome their fear of theoretical physics. His well-prepared lecture notes and exercises, along with fair exams, are highly appreciated. Kevin Bauerbach has also been nominated several times and impresses with his dedication and ability to explain complex topics clearly. Especially in "Computational Methods 2," he manages to make abstract content accessible. The tutors Philipp, Bjarne, and the entire SoS tutoring team do exceptional work: they invest a lot of time, explain patiently and with humor, and help students get started in physics studies. Their efforts are recognized as deserving of the award.

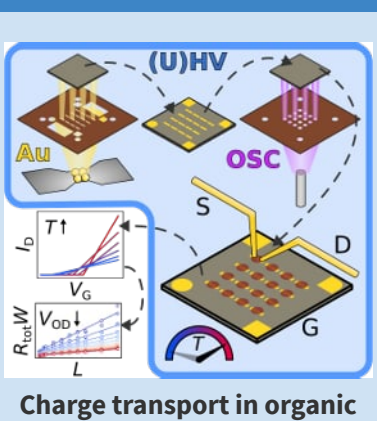
Der Patricia-Pahamy-Preis 2025 wird jährlich auf dem Sommerfest des Fachbereichs Physik verliehen. Professor Malic wurde mehrfach nominiert und ist bei Studierenden für seine klare, strukturierte Didaktik und sein innovatives Vorlesungskonzept beliebt. Er nutzt Wissensquizze, gut geplante Pausen und verständliche Vermittlung mathematischer Inhalte, was vielen Studierenden die Angst vor theoretischer Physik nimmt. Seine gut ausgearbeiteten Skripte und Übungen sowie die fairen Klausuren werden hoch geschätzt. Kevin Bauerbach wurde ebenfalls mehrfach nominiert und beeindruckt durch sein großes Engagement und seine Fähigkeit, komplexe Themen verständlich zu erklären. Besonders in „Rechenmethoden 2" schafft er es, abstrakte Inhalte anschaulich zu vermitteln. Die Tutoren Philipp, Bjarne und das gesamte SoS-Tutorium leisten außergewöhnliche Arbeit: Sie investieren viel Zeit, erklären geduldig und humorvoll, um den Studierenden den Einstieg ins Physikstudium zu erleichtern. Ihr Einsatz wird als preiswürdig anerkannt.

Excursion to the Isabellenhütte Heusler

As part of the "More (for) female physics students*" project, a visit to Isabellenhütte Heusler took place on 6 June. Women from various areas of the Department of Physics came together: from Bachelor's students and doctoral students to employees from the secretariat and the precision engineering workshop. Together, they gained exciting insights into the work processes on site, learnt about the company and made contacts with each other.

Im Rahmen des Projekts „Mehr (für) Physikstudentinnen*" fand am 6. Juni ein Besuch bei der Isabellenhütte Heusler statt. Dabei kamen Frauen aus unterschiedlichen Bereichen des Fachbereichs Physik zusammen: von Bachelorstudentinnen über Doktorandinnen bis hin zu Mitarbeiterinnen aus dem Sekretariat und der feinmechanischen Werkstatt. Gemeinsam erhielten sie spannende Einblicke in die Arbeitsabläufe vor Ort, informierten sich über das Unternehmen und knüpften Kontakte untereinander.

Research Highlights



Charge transport in organic field-effect transistors (AG Witte)

Charge transport in organic field-effect transistors (OFETs) is significantly affected by the properties of the metal-organic injection interface and the gate dielectric-OSC interface. In a recent collaboration between the research groups of Prof. Witte (Marburg) and Dr. Klauk (MPI for Solid State Research, Stuttgart), a custom full-vacuum device preparation and characterization chain is used to perform variable-temperature transfer length method analysis of *p*- and *n*-channel OFETs. Comparison of the devices with a bare and a tetradecylphosphonic acid (TDPA)-functionalized Al_2O_3 gate dielectric demonstrates that trap states induced by the surface hydroxyl groups affect both hole and electron conductivity. Furthermore, an increase in performance of OFETs with a TDPA-functionalized dielectric is attributed to a reduced activation energy of charge transport. Finally, a strong correlation between the activation energy and the injection barrier is observed, indicating a direct effect of the space charge region on the latter. This study highlights key limitations in OFET performance, helping to further advance the field of organic electronics. The work is published in **Advanced Materials**.

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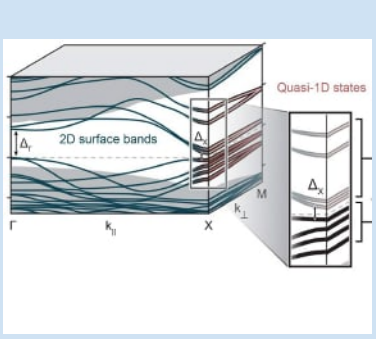

Valley-controlled photoswitching of metal–insulator nanotextures (AG Wippermann)

The ability to manipulate materials at the nanoscale is key to future technologies, from ultrafast electronics to quantum computing. A longstanding challenge has been to control electronic properties with high spatial precision. In a recent study, the groups of Prof. Wippermann (Marburg), Prof. Manmana (Göttingen) and Prof Ropers (MPI-NAT, Göttingen), demonstrate a novel approach to switch nanoscale insulating and metallic regions in a material using laser pulses. This phenomenon, termed "valley-controlled photoswitching", leverages the interplay between light polarization and specific electronic states - so-called "valleys" in the band structure - to dynamically reconfigure a material's conductive properties. By selectively inducing specific optical transitions, this work opens new possibilities for designing reconfigurable electronic devices and optoelectronic applications. The study marks a major advance in light-induced phase transitions, demonstrating how valley-specific optical excitation can drive materials into new, non-equilibrium states beyond the limits of conventional thermodynamic. The work is published in **Nature Physics.**

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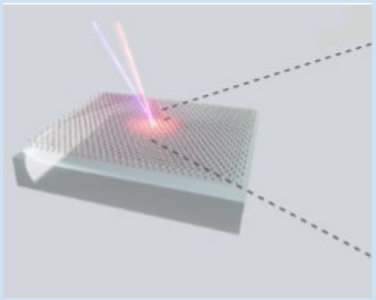

Ultrafast and negative diffusion in MoSe2 (AG Malic)

Understanding the ultrafast transport properties of charge carriers in transition metal dichalcogenides is essential for advancing technologies based on these materials. In this joint experiment theory study including Klaas-Jan Tielrooij (University of Eindhoven) and AG Malic, we study MoSe2 crystals with thicknesses down to the monolayer, combining ultrafast spatiotemporal microscopy and quantitative microscopic modelling. Crucially, we obtain the intrinsic ultrafast transport dynamics by studying suspended crystals that do not suffer from detrimental substrate effects. In mono- and bilayer crystals, we identify four sequential transport regimes. The first two regimes involve high-energy non-thermalized and quasi-thermalized carriers that propagate rapidly with diffusivities up to 1000 cm2/s. After ~1.5 ps, a remarkable third regime occurs with apparent negative diffusion, finally followed by exciton propagation limited by trapping into defect states. Interestingly, for trilayer and thicker crystals, only the first and last regimes occur. This work underscores the role of traps and dielectric environment in electron transport, offering valuable insights for the development of (flexible) (opto)electronic applications. This work was published in **Nature Communications.**

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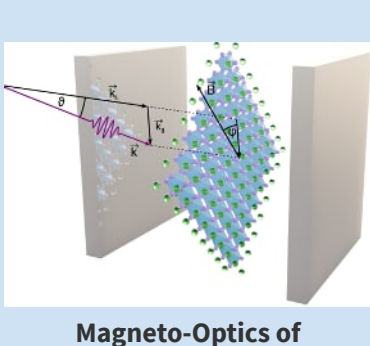

Magneto-Optics of Anisotropic Exciton Polaritons in 2D Perovskites (AG Malic)

Layered two-dimensional (2D) organic–inorganic perovskite semiconductors support strongly confined excitons that offer significant potential for ultrathin polaritonic devices due to their tunability and huge oscillator strength. The application of a magnetic field has proven to be an invaluable tool for investigating the exciton fine structure observed in these materials, yet the combination of an in-plane magnetic field and the strong coupling regime has remained largely unexplored. In this work, AG Malic combined microscopic theory with a rigorous solution of Maxwell's equations to model the magneto-optics of exciton polaritons in 2D perovskites. We predict that the brightened dark exciton state can enter the strong coupling regime. Furthermore, the magnetic-field-induced mixing of polarization selection rules and the breaking of in-plane symmetry lead to highly anisotropic polariton branches. This study contributes to a better understanding of the exciton fine structure in 2D perovskites and demonstrates the cavity control of anisotropic and polarization-sensitive exciton polaritons. The work was published in **Nano Letters.**

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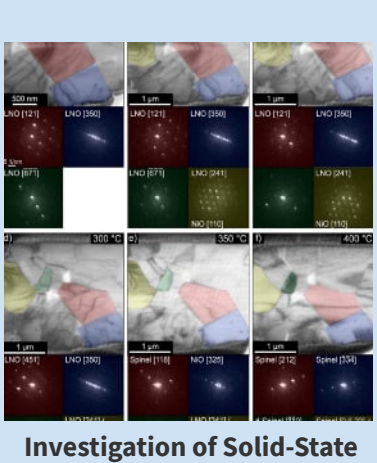

Investigation of Solid-State Batteries Under Realistic Processing Conditions (AG Volz)

To meet the ever-increasing demand for high-energy and high-power-density batteries, extensive research is ongoing to gain a fundamental understanding of the structure of battery materials. With its unmatched resolution and spectroscopic capabilities, the (scanning) transmission electron microscope ((S)TEM) is often the technique of choice. However, most (S)TEM studies are performed ex situ, which does not provide a complete view of the involved processes. Therefore, the research group of Prof. Volz (Marburg) developed an in situ experimental setup that allows heating battery components in a gaseous atmosphere of up to 1 bar inside the TEM, thereby replicating real-world sintering conditions. The functionality of this setup was demonstrated using $LiNiO_2$ (LNO) particles as a model system, which were heated in oxygen. By employing a scanning nanobeam diffraction mode (SNBD), videos of the heating process could be recorded, with the possibility of rapidly switching to diffraction data acquisition. While the videos reveal morphological changes at the sample surface during heating, the SNBD data provides insight into structural transformations. In this case, a phase transition from LNO's layered phase to a NiO rock-salt structure was observed to begin at 350 °C. This onset temperature is significantly higher than that observed for LNO heated in vacuum, highlighting the importance of replicating realistic conditions. This study was published in **Small Methods**.

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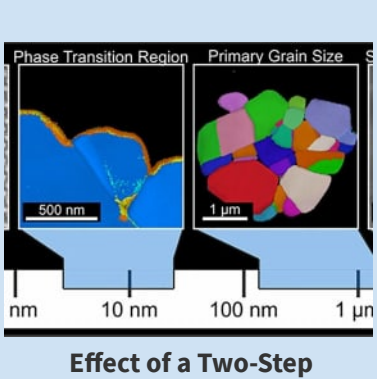

Effect of a Two-Step Temperature-Swing Synthesis (AG Volz)

Batteries play a vital role in modern-day life, and the demand for high energy and power density continues to grow. To enhance battery capacity, current research focuses on optimizing the cathode active material (CAM). Together with BASF, the research group of Prof. Volz (Marburg) investigated how a special two-step temperature-swing synthesis of the CAM $LiNiO_2$ affects the material's properties on various length scales. While initial testing revealed improved cycling capabilities of the sample that was heat-treated after calcination, scanning precession electron diffraction (SPED) and electron energy loss spectroscopy (EELS) studies detected a phase transition layer on the surface, which is widely seen as detrimental to battery performance. This finding challenges that assumption, indicating that it may be more beneficial to deliberately form this layer outside the battery cell, rather than allowing uncontrolled phase transitions to occur in contact with the electrolyte during battery operation. This study was published in **Chemistry of Materials**.

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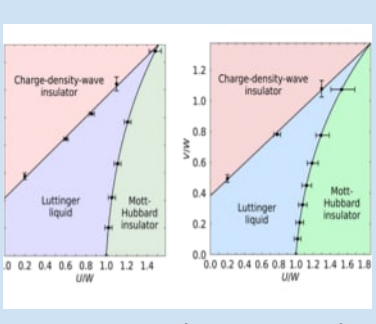

On the screening problem in interacting electron systems (AG Gebhard)

We show that the screening problem is indeed insignificant: The quantum phase diagrams of a generic Hubbard model with nearest-neighbor interactions (top) and with 1/*r*-long-range interactions (bottom) agree qualitatively. Using constant renormalization factors, the agreement of the phase transition lines can even be made quantitative. Thus, at low energies, Hubbard-type models are seen to provide a significant and viable approach to the interacting electron problem. The work was published in **Physical Review B (Editors' suggestion)**.

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Events

Alfred Wegener Award Ceremony
4 July 2025 at 4pm

Academic ceremony on the occasion of the awarding of the Alfred Wegener Dissertation Prize on July 4 at 4pm in the big lecture hall in Renthof 5. Dr Maximilian Dreher and Dr Giuseppe Meneghini will be honoured equally with the prize. The keynote speech entitled "Simulated Universes" will be given by Prof Dr Mark Vogelsberger.

program

Excursion to the climbing forest in Marburg
4 July 2025 at 3pm

The project "More (for) female physics students" invites all female physics students* (f/d) to an excursion to the climbing forest in Marburg. Meeting at the department of phisics on the parking place (Renthof). Further information will follow with the confirmation of participation.

registration

Lecture by Lukas Wagner
9 July 2025 at 3.30pm

Lecture by Dr Lukas Wagner with the title: "Sustainable Perovskite Solar Cells" will take place in the big lecture hall in Renthof 5.

Noeks conference
8-12 September

The 17th Noeks conference will take place in Marburg from 8th to 12th September 2025 in the big lecture hall in Renthof 5.

New Colleagues

Lea Obermüller (AG Goldschmidt)

I am a doctoral student in Prof. Goldschmidt's Solar Energy Conversion Group. Following the completion of my master's thesis in the same group, where I investigated charge extraction and recombination dynamics in perovskite solar cells using time-resolved photoluminescence spectroscopy, I am now shifting my research focus toward the sustainability aspects of perovskite photovoltaics. My current work aims to contribute to the development of terawatt-scale perovskite solar cells by integrating environmental, social, and economic sustainability considerations into the design and fabrication processes.

Konstantin Wenzel (AG Koch)

I am an external PhD student in Prof. Martin Koch's Semiconductor Photonics Group. Having completed my Master's degree in Theoretical Physics at the Technical University of Berlin, I began the experimental research for my PhD in the Terahertz Sensors and Systems Group at the Fraunhofer Heinrich-Hertz-Institute (HHI) in Berlin. I am interested in developing ultrafast, compact optoelectronic terahertz (THz) spectrometers and applying them to non-contact material analysis to extract key electrical and physical properties of microscopically thin conductive films and multilayer stacks.

Share your good news

Your newsletter team: Carina Hlawaty, Oliver Rehn and Ermin Malic

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