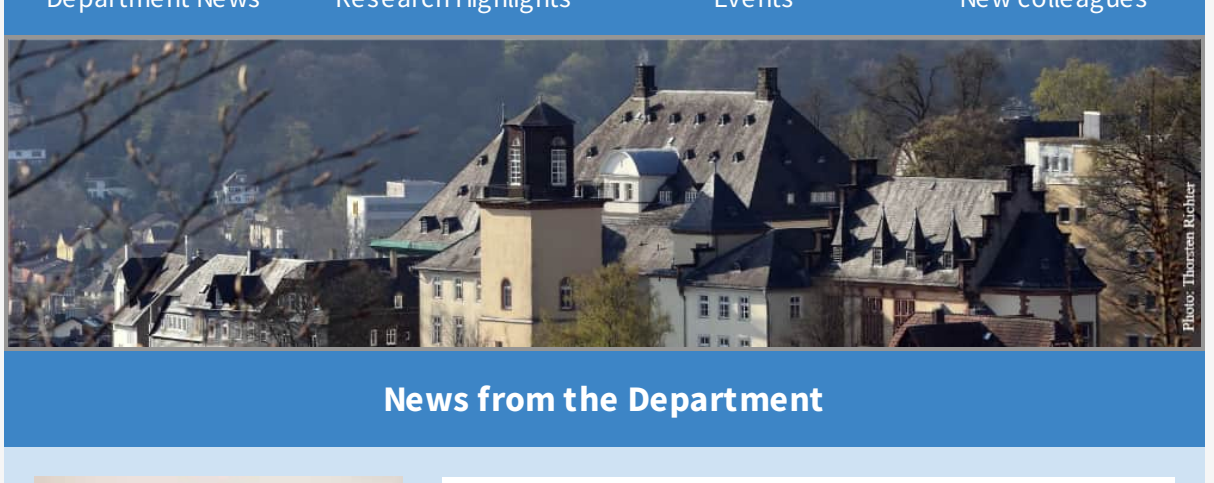
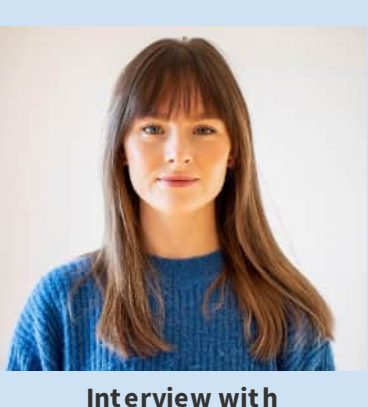
Philipps Universität Marburg

Newsletter Physics 12/23

Department News | Research Highlights | Events | New colleagues



News from the Department

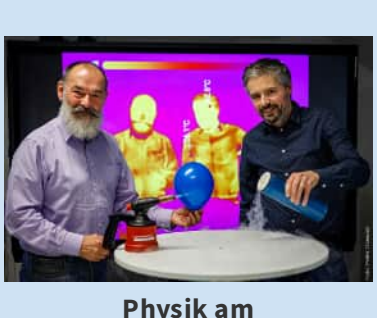


Interview with Laura Nießen

We continue the series of interviews with key people in our department. Laura Nießen is a name you have probably heard in recent months. She is relatively new in the economic administration of our department and tells us in this interview about her former dream of becoming a Lufthansa pilot and her special relationship to coffee and cake. Read below the full interview (in German) that has been conducted by Sarah Zajusch.

Wir setzen unsere Interviewreihe mit Schlüsselpersonen in unserem Fachbereich fort, diesmal mit Laura Nießen. Diesen Namen haben wir sicher alle in den letzten Monaten schon einmal gehört. Sie ist realtiv neu in der Wirtschaftsverwaltung unseres Fachbereichs und erzählt uns von ihrem einstigen Traum Lufthansa-Pilotin zu werden sowie von ihrer besonderen Vorliebe für Kaffee und Kuchen. Das ganze Interview, geführt von Sarah Zajusch, können Sie unter dem Button Interview lesen.

Interview



Physik am Samstagmorgen

We are happy to announce the next start of our popular lecture series "Physik am Samstagmorgen" this winter. In four lectures (given by Tobias Breuer, Heinz Jänsch, Lukas Stock, and Hans-Jürgen Stöckmann) exciting effects related to everyday phenomena will be presented. The lectures are suitable to everyone interested in physics. Pre-knowledge or even a graduation in physics is not required, as the presentations will be easy to understand for everyone and will be supported by vivid experiments. In this term, the lectures will be about temperature and heat effects, the GAIA space mission and effects related to wave phenomena. In this term, all lectures will take place in the great lecture hall of Renthof 5. All presentations are given in German. We are looking forward to welcoming all of you as well as your family, friends and neighbours!

Wir freuen uns, den nächsten Start unserer beliebten Vortragsreihe "Physik am Samstagmorgen" in diesem Winter ankündigen zu können. In vier Vorträgen (gehalten von Tobias Breuer, Heinz Jänsch, Lukas Stock und Hans-Jürgen Stöckmann) werden spannende Effekte im Zusammenhang mit Alltagsphänomenen vorgestellt. Die Vorlesungen richten sich an alle, die sich für Physik interessieren. Vorkenntnisse oder gar ein abgeschlossenes Physikstudium sind nicht erforderlich, da die Vorträge für jeden leicht verständlich sind und durch anschauliche Experimente unterstützt werden. In diesem Semester geht es um Temperatur- und Wärmeeffekte, die Weltraummission GAIA und Effekte im Zusammenhang mit Wellenphänomenen. In diesem Semester finden alle Vorträge im großen Hörsaal des Renthof 5 statt. Alle Vorträge werden in deutscher Sprache gehalten. Wir freuen uns auf jeden von Ihnen sowie auf Ihre Familie, Freunde und Nachbarn!

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DFG grant on Janus 2D materials (AG Malic)

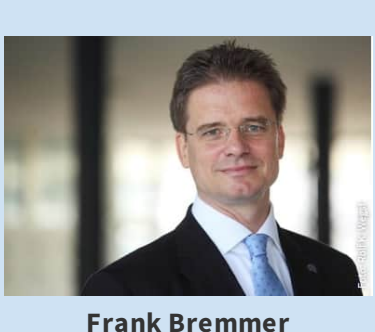
The vertical stacking of 2D materials into heterostructures allows the realization of a plethora of physical phenomena and technological applications. The interface between these two materials dictates the emergent properties, which can be tuned through choice of material, twisting and electric fields. A radical approach to alter the behaviour of these interfaces is to chemically modify the constituent layers. TMDs monolayers consist of a transition metal layer between two chalcogen layers. Therefore, by substituting one of these chalcogen layers with a different one, it is possible to grow a "Janus" TMD. The inherent dipole in Janus TMDs is expected to drastically alter their interfacial behaviour in Janus TMD heterostructures. The proposal "Dipolar excitons and interlayer coupling: optics, dynamics and transport in Janus TMD heterostructures" by AG Malic in collaboration with Bernhard Urbaszek (TU Darmstadt) and Andrey Turchanin (University Jena) has been approved by the DFG within the priority programm SPP 2244 "Physics of Van der Waals heterostructures". The grant runs over 3 years and will be carried out by three PhD students.

Die vertikale Stapelung von 2D-Materialien zu Heterostrukturen ermöglicht die Realisierung einer Vielzahl physikalischer Phänomene und technologischer Anwendungen. Die Grenzfläche zwischen diesen beiden Materialien bestimmt die entstehenden Eigenschaften, die durch die Wahl des Materials, den Verdrehungswinkel sowie elektrische Felder eingestellt werden können. Ein radikaler Ansatz zur Veränderung des Verhaltens dieser Grenzflächen ist die chemische Veränderung der konstituierenden Schichten. TMD-Monoschichten bestehen aus einer Übergangsmetallschicht zwischen zwei Chalkogenschichten. Durch Ersetzen einer dieser Chalkogenschichten durch eine andere ist es daher möglich, eine "Janus"-TMD herzustellen. Es wird erwartet, dass der inhärente Dipol in Janus-TMDs ihr Grenzflächenverhalten in Janus-TMD-Heterostrukturen drastisch verändert. Der Antrag "Dipolar excitons and interlayer coupling: optics, dynamics and transport in Janus TMD heterostructures" der AG Malic in Zusammenarbeit mit Bernhard Urbaszek (TU Darmstadt) und Andrey Turchanin (Universität Jena) wurde von der DFG im Rahmen des Schwerpunktprogramms SPP 2244 "Physics of Van der Waals heterostructures" bewilligt. Die Förderung läuft über 3 Jahre und wird von drei Doktoranden durchgeführt.

DFG grant for high-performance computing (AG Noack, Gebhard, Lenz, Malic, Volz, Wippermann)

The DFG has approved an application for partial funding of a High-Performance Computing (HPC) cluster prepared by members of the Departments of Physics and Chemistry. The DFG Major Research Instrumentation Grant will cover up to 407,000 Euros out of a planned total financing of 1.08 million Euros. The new HPC cluster, to be named "MaRCQuant", will be used by research groups in physics and theoretical chemistry to perform modeling and analysis of quantum systems ranging from molecules to low-dimensional materials to solid-state devices. The application as well as the forthcoming acquisition is being coordinated by Prof. Robert Berger (Dept. of Chemistry) and Prof. Reinhard Noack (Dept. of Physics), supported in particular by Dr. Thomas Gebhardt (HRZ). Participating research groups are AG Berger (Chemistry), AG Gebhard, AG Lenz, AG Malic, AG Noack, AG Volz, and AG Wippermann (Physics); a portion of the computing resources will be available for other groups.

Die DFG hat einen Großgeräteantrag zur Teilfinanzierung eines HPC-Clusters, den Arbeitsgruppen aus den Fachbereichen Physik und Chemie vorbereitet haben, bewilligt. Der DFG-Anteil im Rahmen des Forschungsgroßgeräteprogramms beträgt bis zu 407.000 Euro, die geplanten Anschaffungskosten liegen bei 1.08 Millionen Euro. Der neue HPC-Cluster mit dem Namen "MaRCQuant" wird von mehreren Arbeitsgruppen in der Physik und in der Theoretischen Chemie verwendet werden, um Quantensysteme verschiedener Art zu untersuchen, die sich von Molekülen über niedrigdimensionale Materialien bis zu Festkörperbauteilen erstrecken. Die Beantragung und eine spätere Beschaffung werden von Prof. Dr. Robert Berger (Chemie) und Prof. Dr. Reinhard Noack (Physik) koordiniert, unterstützt insbesondere von Dr. Thomas Gebhardt (HRZ). Beteiligte Arbeitsgruppen sind die AG Berger (Chemie) sowie die AGs Gebhard, Lenz, Malic, Noack, Volz und Wippermann (Physik). Ein Anteil der Rechenkapazität wird weiteren Arbeitsgruppen zur Verfügung gestellt.



Frank Bremmer appointed to DFG Statutory Body

Frank Bremmer has been elected by the Senate of the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG), and appointed by its president, Prof. Katja Becker, as member of the 'Senate Committee and the Grants Committee on Research Training Groups' from January 2024 on for a three-year term of office. The Senate Committee is responsible for advising the DFG's decision-making bodies on issues relating to Research Training Groups and for preparing the final decisions by the relevant Grants Committee. This Grants Committee is responsible for the establishment and funding of Research Training Groups. The committee is made up of 39 scientists and academics from all research areas, and two representatives of the federal government (Bund) and one representative from each of the 16 federal states (Länder).

Frank Bremmer wurde vom Senat der Deutschen Forschungsgemeinschaft (DFG) gewählt und von deren Präsidentin, Prof. Dr. Katja Becker, ab Januar 2024 für eine Amtszeit von drei Jahren zum Mitglied des "Senatsausschusses und des Bewilligungsausschusses für Graduiertenkollegs" bestellt. Der Senatsausschuss hat die Aufgabe, die Entscheidungsgremien der DFG in Fragen der Graduiertenkollegs zu beraten und die abschließenden Entscheidungen des zuständigen Bewilligungsausschusses vorzubereiten. Dieser Bewilligungsausschuss ist für die Einrichtung und Förderung von Graduiertenkollegs zuständig. Dem Ausschuss gehören 39 Wissenschaftlerinnen und Wissenschaftler aus allen Fachgebieten sowie je zwei Vertreterinnen und Vertreter des Bundes und der 16 Bundesländer an.

Mehr (für) Physikstudentinnen

The "More (for) female physics students" project organized a breakfast for female physicists at the OE. A complete success! 24 female students from different year groups filled the room. A rarity, as male students are usually in the majority and dominate the event. Female Bachelor's, Master's, teacher training and doctoral students exchanged ideas about studying physics with its joys but also its pitfalls, informed themselves about the project "More (for) female physics students" and the offers of Mentoring Hessen for female MINT students. Finally, there were experiments on granular physics with coffee and muesli!

Das „Mehr (für) Physikstudentinnen" Projekt veranstaltete in der OE ein Physikerinnen-Frühstück. Ein voller Erfolg! 24 Studentinnen aus verschiedenen Jahrgängen füllten den Raum. Eine Seltenheit, sind doch sonst männliche Studierende in der Überzahl und dominieren das Geschehen. Bachelor-, Master-, Lehramts- und Promotionsstudentinnen tauschten sich über das Physik-Studium mit seinen Freuden aber auch Tücken aus, informierten sich über das Projekt „Mehr (für) Physik-Studentinnen" und die Angebote von Mentoring Hessen für MINT-Studentinnen. Abschließend gab es Experimente zur Granularphysik mit Kaffee und Müsli!

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Carbon Club Team (AG Goldschmidt)

On October 11-12, the AG Goldschmidt organized the Carbon Club Conference. The First International Conference on Carbon Electrode-based Perovskite Solar Cells was a great success with >440 registrations and >1150 clicks on the youtube stream. During the online-conference, 37 internationally leading scientists and industry experts presented their lates achievements on printable perovskite solar cells in scientific talks and during an industy panel discussion. We thank all the people who joined us in Großer Hörsaal where the talks where streamed and moderated.

Am 11. und 12. Oktober organisierte die AG Goldschmidt die Carbon Club Conference. Die erste internationale Konferenz über Perowskit-Solarzellen auf Basis von Kohlenstoffelektroden war mit >440 Anmeldungen und >1150 Klicks auf den Youtube-Stream ein großer Erfolg. Während der Online-Konferenz präsentierten 37 international führende Wissenschaftler und Industrieexperten ihre neuesten Errungenschaften auf dem Gebiet der druckbaren Perowskit-Solarzellen in wissenschaftlichen Vorträgen und während einer Podiumsdiskussion mit der Industrie. Wir danken allen, die im Großen Hörsaal dabei waren, wo die Vorträge gestreamt und moderiert wurden.

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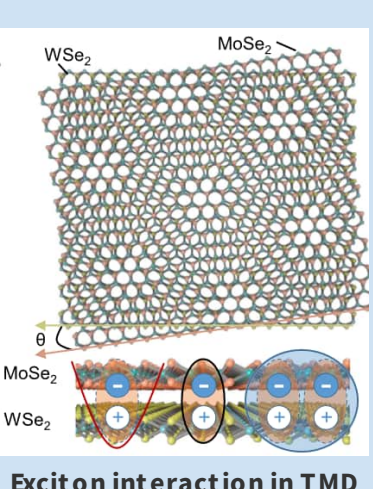
Research Highlights



Exciton interaction in TMD heterobilayers (AG Malic)

Transition metal dichalcogenide (TMD) heterobilayers provide a versatile platform to explore unique excitonic physics via the properties of the constituent TMDs and external stimuli. Interlayer excitons (IX) can form in TMD heterobilayers as delocalized or localized states. However, the localization of IX in different types of potential traps, the emergence of biexcitons in the high-excitation regime, and the impact of potential traps on biexciton formation have remained elusive. In this joint experiment theory work, W. Wieczorek (Chalmers) in collaboration with AG Malic finds two types of potential traps in a MoSe2/WSe2 heterobilayer, which result in significantly different emission behavior of IX at different temperatures. We identify the origin of these traps as localized defect states and the moiré potential of the TMD heterobilayer. Our work elucidates the different excitation and temperature regimes required for the formation of both localized and delocalized IX and biexcitons and, thus, contributes to a better understanding and application of the rich exciton physics in TMD heterostructures. This work is published in **Nature Communications.**

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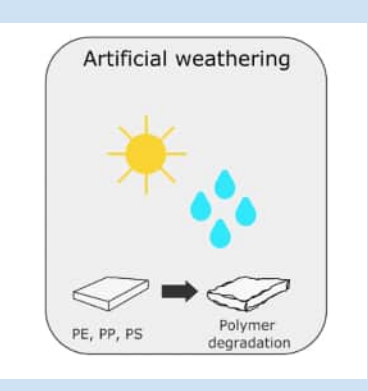

Plastics degradation (AG Koch)

Environmental influences lead to a slow degradation of plastics in nature. As a result, plastics gradually fragment into microplastics. The degradation process is generally spatially heterogeneous. AG Koch was able to show on a series of controlled aged polymer samples that so-called laser-induced breakdown spectroscopy (LIBS) is suitable for obtaining a depth profile of the oxidation of plastics. This work is published in **Chemosphere.**

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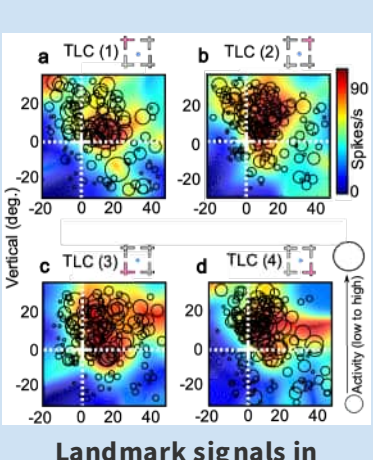

Landmark signals in macaque frontal cortex visual responses (AG Bremmer)

To look or reach toward an object, the visual system can either specify its direction relative to the eye (an egocentric reference frame) or it can detect its location relative to some other object or landmark (an allocentric reference frame). One can consciously choose to use one or the other frame, but behavioral experiments show that usually the brain automatically weighs between these two in an 'optimal' fashion, depending on their relative reliability. Ultimately, this information is converted into egocentric muscle contractions, e.g., to move the eye relative to the head or the arm relative to the body. This poses a fundamental question for neuroscience: how does the brain integrate egocentric and allocentric cues to generate accurate action plans? Here, AG Bremmer tested landmark influence on the visual response to saccade targets recorded from neurons in two cortical regions of trained non-human primates. Visual response fields were tested in the presence of four target-landmark configurations. Overall, eye-centered target codes predominated, but 30% of FEF neurons preferred landmark location. Finally, neurons that coded both landmarks and targets showed the most landmark influence on target coding. Overall, these data show that landmark information is retained and influences target coding in the prefrontal visual responses, likely to stabilize movement goals in the presence of noisy egocentric signals. This work is published in **Communications Biology.**

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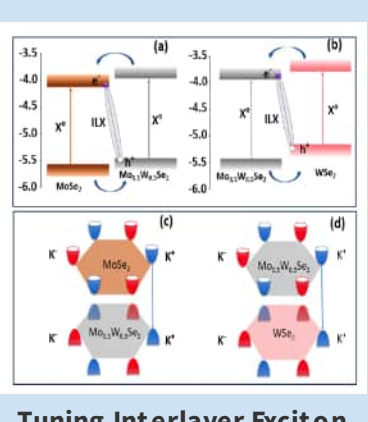

Tuning Interlayer Exciton Emission with TMD Alloys (AG Koch)

Two-dimensional transition metal dichalcogenides have attracted considerable attention in recent years, particularly because a new class of devices could become possible on their basis. Of particular interest are heterostructures in which two or more monolayers lie on top of each other. AG Koch has shown that the use of ternary monolayers provides further degrees of freedom to spectrally tune the emission wavelength of charge-transfer excitons in these structures. Temperature-dependent photoluminescence measurements show a rich excitonic spectrum in the corresponding heterostructures. This work is published in **Nanomaterials**.

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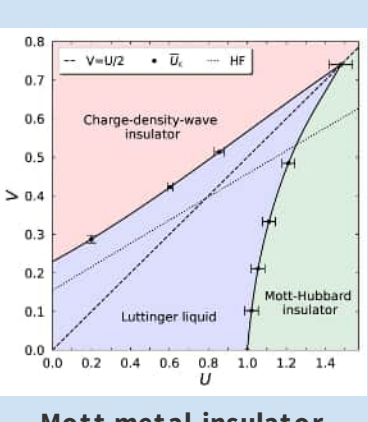

Mott metal-insulator transitions and generic phase diagram (AG Gebhard)

In an electronic single-band model and at half band-filling, the Coulomb interaction can induce quantum phase transitions between a metal and a Mott-Hubbard insulator (Mott transitions). When the nearest-neighbor interaction V is strong enough in comparison with the local (Hubbard) interaction U and the bandwidth W, the system crosses over from a metallic phase or from the Mott-Hubbard insulating phase to a charge-density-wave insulator. The collaboration of Kevin Bauerbach and Florian Gebhard (Many-particle theory group, Marburg) with Örs Legeza (Wigner Institute, Budapest) presents the first calculated generic phase diagram for a one-dimensional extended Hubbard model. All phases (Luttinger liquid metal, Mott-Hubbard insulator, charge-density-wave insulator) occupy a finite region in the ground-state phase diagram. The calculations were performed using the density-matrix renormalization group (DMRG) method that permits the treatment of sufficiently large systems so that reliable extrapolations to the thermodynamic limit can be performed. Simple approximate theories such as Hartree-Fock (HF) are insufficient to treat this strongly-correlated electron problem. This work is published in **Physical review B.**

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Events

Physics Colloquium
13 December, 3.30pm
Big lecture hall, Renthof 5

Prof. Dr. Stefan Mathias, Universität Göttingen

Excitonics at Space-Time Limit

In 2D semiconducting quantum materials, organic semiconductors and their heterostructures, the energy of absorbed light is stored in Coulomb-bound electron-hole pairs, which are called excitons. For future technological applications of these classes of materials, for instance in optoelectronics and for energy harvesting, it is crucial to study the initial exciton formation and also the subsequent relaxation and dissipation processes at the fundamental level and on the relevant length and time scales. In our research, we have built a new photoemission-based experiment that is capable of studying excitonics at the space-time limit corresponding to nanometers and femtoseconds. In a series of experiments, we identified characteristic signatures in the exciton formation process and the pathways of subsequent energy conversion and thermalization. In addition, the new experiment gives us access to the so-called "dark exciton landscape", where we can follow exciton dynamics with unprecedented temporal and spatial resolution. In my talk, I will present the ultrafast formation dynamics of dark interlayer excitons in twisted WSe2/MoS2 heterostructures. In particular, I will report on the identification of a key signature of the moiré superlattice that is imprinted on the momentum-resolved interlayer exciton photoemission signal. Furthermore, I will present photoemission exciton tomography that allows us to disentangle multiorbital contributions in the exciton formation of the organic semiconductor buckminster fullerene.

Physics Colloquium
17 January, 3.30pm
Big lecture hall, Renthof 5

Prof. Dr. Paul Erhart, Chalmers University of Technology

Dynamical materials: From atomic scale modeling via machine learning to experiments

The dynamical behavior of materials at the atomic scale, i.e., the motion of individual atoms, is crucial not only for their thermodynamic stability but directly impacts their electronic, optical, and transport properties. Detailed insight into these dynamics is therefore fundamental for understanding and designing materials. By the very nature of the problem the length and time scales involved are extremely short. As a result, atomic scale modeling plays an important role in guiding and interpreting experimental studies, and discovering novel phenomena and mechanisms. Traditional approaches of condensed matter physics are built on perturbation theory and typically assume a regular reference lattice. As the complexity of materials increases, for example, through dimensional engineering as in the case of layered materials or by integrating organic and inorganic components such as in hybrid perovskites, these approaches reach their applicability limit, both due to the explosion of the degrees of freedom and a failure of the underlying assumptions. Here, the combination of atomic scale simulations, correlation function based analysis, and machine learned potentials is emerging as a tool set that can lead to a paradigm shift in how we approach these questions. In this presentation, I will show some recent work from my group that showcases the approach and illustrates its potential. I will focus on atomic dynamics in perovskites, a very large class of materials with wide-ranging applications in, for example, actuators, sensors, energy harvesting, and optical devices.

Physics Colloquium
31 January, 3.30pm
Big lecture hall, Renthof 5

Prof. Dr. Alexander Föhlisch, Universität Potsdam und Helmholtz Zentrum Potsdam

Synchrotron Radiation as a Modern Tool in Materials Science

What governs the efficiency of functional materials or the rate and selectivity of energy conversion and chemical processes remains experimentally challenging. Soft x-ray spectroscopy from Synchrotron Radiation Sources and Free-Electron Lasers allows to break down complex electronic structure problems into the atomic constituents and molecular moieties. This element specific and chemical state selective projection of soft X-rays - down to the atomic level - I will utilize and illustrate in this talk. The example I focus on deals with the mechanisms that allow MoS_2 to act as an efficient material for photo-electrochemical water splitting. In this effort, we have investigated for one the electronic structure properties of the layered dichalcogenide MoS_2 interacting with the relevant molecular units, its photo excitation and charge transfer dynamics.

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Your newsletter team: Carina Hlawaty and Ermin Malic

Send us an e-mail with a short text and a nice foto to newsfb13@physik.uni-marburg.de

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