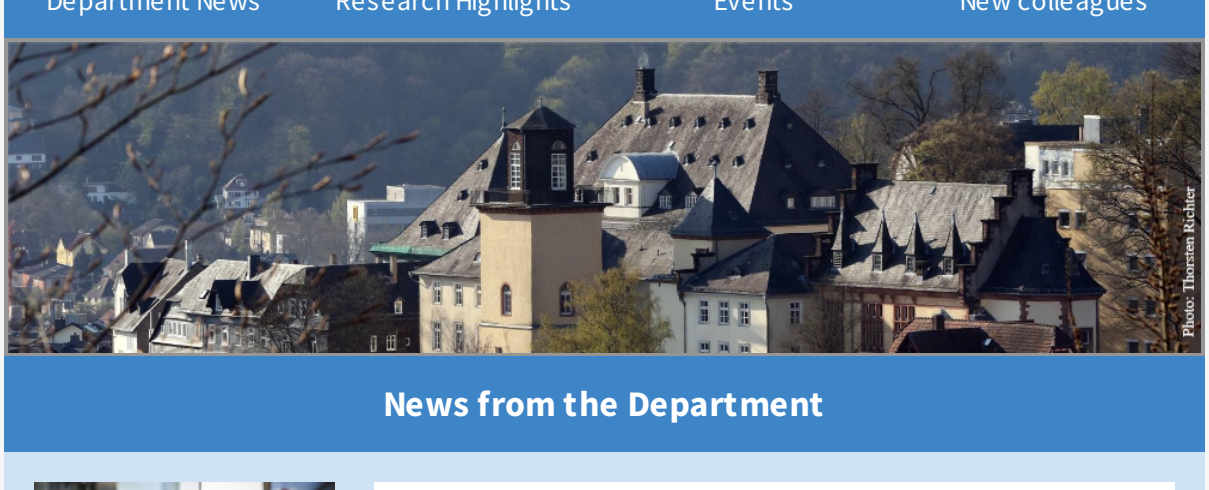
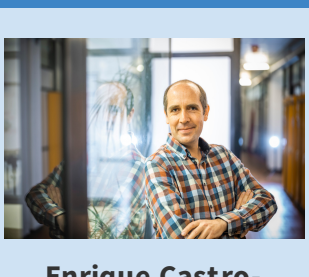
Philipps Universität Marburg

Newsletter Physics 12/22

Department News | Research Highlights | Events | New colleagues



News from the Department



Enrique Castro-Camus New professor at our Department

Enrique Castro-Camus is joining the Department as a W2 professor from 1st December. He will establish the research group "Terahertz systems" with the focus on the development and applications of terahertz systems. He will have activities both at the Renthof and the Lahnberge and will take over some lectures in our international master Functional Materials. We wish Prof. Castro-Camus a successful time in Marburg.

Video Interview with Martin Koch

The PR group has recently started a series of video interviews "meet-the-prof" with professors from our department. The idea is to offer new (and older) students the opportunities to get to know the professors from a different perspective. This time, Josefine Neuhaus interviewed Prof. Martin Koch, who has been at the department for a long time and heads the AG Semiconductor Photonics. The interview was cut by Oliver Rehn.

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DFG research unit (AG Volz / AG Gerhard)

The DFG research unit FOR 2824 was extended. It is a collaborative research project between groups from the universities of Marburg, Gießen and the Karlsruhe Institute of Technology, aiming to understand the fundamental mechanisms behind the extreme nonlinear properties of amorphous molecular materials. For the second funding period, two projects from the Department of Physics were granted: AG Volz will continue their studies based on electron microscopy and electron diffraction techniques and AG Gerhard joins the research unit with a new project investigating the static and dynamical structure-property-relationships by means of optical spectroscopy.

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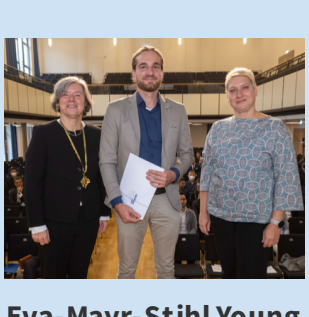
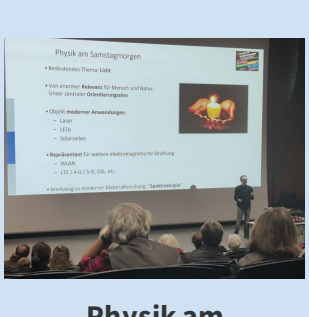


Eva-Mayr-Stihl Young Scientist Award for Lukas Wagner (AG Goldschmidt)

Lukas Wagner was awarded this year's Eva-Mayr-Stihl Young Scientist Award of the Albert Ludwig University of Freiburg. The prize is awarded for outstanding dissertations in the field of sustainability research. He received the price for his doctoral dissertation entitled "Perovskite photovoltaic modules with a very low CO2-eq footprint: the in-situ technology", which was carried out at Freiburg's Institute for Sustainable Technology Systems (INATECH) and the Fraunhofer Institute for Solar Energy Systems ISE. The prize is endowed with 5000€ and was awarded at the opening ceremony of the academic year 2022/23 in Freiburg.



Physik am Samstagmorgen

The first presentation in our series "Physik am Samstagmorgen" was given on Nov 12th. Tobias Breuer talked about "the three magical properties of light". The presentation took place in the Audimax and has appealed a large audience of people (about 250 visitors of all ages). Supported by a total of 16 experiments - some of which were performed in complete darkness - effects like metamerism, polarization and light perception were shown and explained. Motivated by the success of the first round of our series, we are looking forward to the upcoming presentations of Jan-Christoph Goldschmidt, Ermin Malic and Marina Gerhard.

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EU Project DIAMOND (AG Goldschmidt)

The AG Physics of Solar Energy Conversion participated in a successful EU project proposal. In the DIAMOND project 6 European leading universities (UGroningen, UUppsala, EPFL, URome-TV, UPorto, UMarburg), 2 research institutes (Fraunhofer ISE, CEA) and 4 industry partners (Dyenamo, BeDimensional, Solaronix, PixelVoltaic) from 7 different countries will develop ultra-stable, highly-efficient and low-cost perovskite PV with minimised environmental impact. The solar cells will rely on graphite-based electrodes and new encapsulation technologies. The focus of the work in Marburg will be mostly on characterizing and understanding the stability of the solar cells.

Science slam workshop

Take your thoughts in new directions and bring your science to a wider audience. In science slams, the aim is to present research to a non-expert audience in an entertaining way. In the semester break, the PR team plans to organize a science slam workshop with an external expert leading the workshop. Are you interested and would like to participate? **Write us an email.** We need 10 participants for this workshop to take place.

Next year, the PR team is also planning a day of physics including a science slam session. Here, you will have a chance to show (of course only if you like) what you have learned in the workshop.

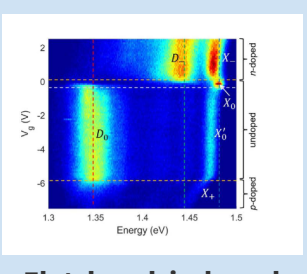
email

Posters in lecture hall Renthof 7

To make our lecture hall in Renthof 7 look nicer and above all to improve the acoustics in this large room, the PR team has put up the Department poster and further AG posters showing the broad spectrum of the research performed at out Department. We would like to thank Sven Claar for his help!

Research Highlights

Note that the newsletter team does not judge on the importance of papers and lists them just in the order of the impact factors of the journals they are published in.



Flat-band-induced interactions in layered materials (AG Malic)

Interactions among a collection of particles generate many-body effects in solids resulting in striking modifications of material properties. The heavy carrier mass that yields strong interactions and gate control of carrier density over a wide range, make two-dimensional semiconductors an exciting playground to explore many-body physics. In a joint experiment-theory work with the group of Andras Kis (ETH Zürich), AG Malic studied charge-tunable excitons in few-layer InSe. From the optical spectra, we establish that free excitons in InSe are more likely to be captured by ionized donors due to the large exciton Bohr radius, leading to the formation of bound exciton complexes. Surprisingly, a pronounced redshift of the exciton energy accompanied by a decrease of the exciton binding energy upon hole-doping reveals a significant band gap renormalization and dynamical screening induced by the presence of the Fermi reservoir. Our findings establish InSe as a reproducible and potentially manufacturable platform to explore electron correlation phenomena without the need for twist-angle engineering. This work was publishedin Nano Letters.

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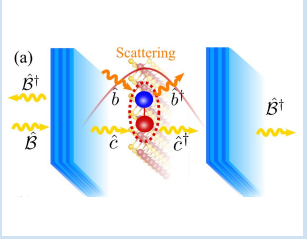

Signatures of dark excitons in polariton optics in 2D materials (AG Malic)

Integrating 2D materials into high-quality optical microcavities opens the door to fascinating many-particle phenomena including the formation of exciton-polaritons. These are hybrid quasi-particles inheriting properties of both the constituent photons and excitons. In this work, AG Malic investigates the so-far overlooked impact of dark excitons on the momentum-resolved absorption spectra of hBN-encapsulated WSe2 and MoSe2 monolayers in the strong-coupling regime. In particular, thanks to the efficient phonon-mediated scattering of polaritons into energetically lower dark exciton states, the absorption of the lower polariton branch in WSe2 is much higher than in MoSe2. It shows unique step-like increases in the momentum-resolved profile indicating opening of specific scattering channels. Our study contributes to an improved microscopic understanding of exciton-polaritons and their interaction with phonons, potentially suggesting experiments that could determine the energy of dark exciton states via momentum-resolved polariton absorption. This work was publishedin 2D Materials.

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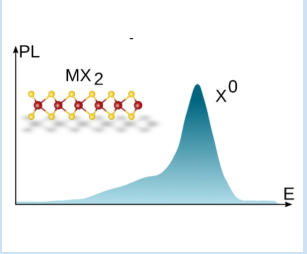

Exciton optics, dynamics & transport in 2D materials (AG Malic)

Atomically thin semiconductors exhibit a very strong Coulomb interaction, giving rise to a rich exciton landscape. This makes these materials highly attractive for efficient and tunable optoelectronic devices. In this article, AG Malic reviews the recent progress in the understanding of exciton optics, dynamics and transport, which crucially govern the operation of TMD-based devices. We highlight the impact of hBN-encapsulation, which reveals a plethora of many-particle states in optical spectra, and we outline the most novel breakthroughs in the field of exciton-polaritonics. Moreover, we underline the direct observation of exciton formation and thermalization in TMD monolayers and heterostructures in recent time-resolved ARPES studies. We also show the impact of exciton density, strain and dielectric environment on exciton diffusion and funneling. Finally, we put forward relevant research directions in the field of atomically thin semiconductors for the near future. The work was published in Applied Physics Materials.

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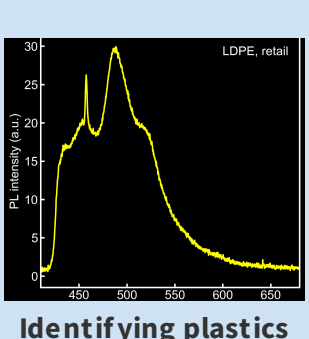

Identifying plastics with PL spectroscopy and machine learning (AG Lenz / AG Koch)

The research groups of Peter Lenz and Martin Koch have published a joint paper. It deals with the classification of microplastic particles via their luminescence and the use of machine learning algorithms. The approach could provide the first step for analyses performed on large scales. As the best preforming algorithm is based on an unsupervised learning technique, one can expect the approach to be robust against alternation of the input data, i.e. that it will perform similarly well for new data that significantly differs from the currently available spectroscopic data. The work was published in Scientific Reports.

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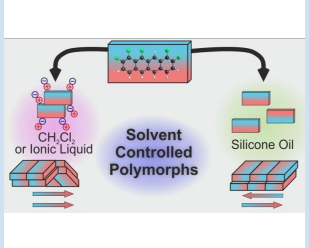

Solvent Polarity Influenced Polymorph Selection of Polar Aromatic Molecules (AG Witte)

Molecular materials are ubiquitous in today's life and their properties are largely determined by the molecular arrangement and packing motif in the solid phase. In this study, the influence of solvent polarity on crystallization has been investigated for an extended π-conjugated molecule with large in-plane dipole moment by AG Witte. Liquid assisted crystallization from polar solvents results in a dipole-parallel molecular arrangement, while nonpolar solvents lead to a more stable polymorph, which exhibits a dipole-antiparallel arrangement with a slip-stacked packing. The different growth modes are attributed to a screening of the electrostatic forces by the solvent during nucleation. Overall, this study opens up new ways to crystallize organic semiconductors and demonstrates that solvent polarity needs to be considered when exploring the polymorphic landscape of molecular materials. This work was published in Crystal Growth & Design.

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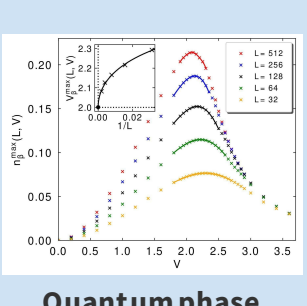

Quantum phase transitions (AG Gebhard)

How can we accurately determine the critical interaction strength for quantum phase transitions? This task is particularly difficult for spinless fermions in one dimension when the single-particle gap opens exponentially in a Kosterlitz-Thouless-type transition from a Luttin-ger-liquid metal to a charge-density-wave insulator at finite interaction strength. Since the Bethe Ansatz provides exact results, this model constitutes a perfect testing ground for approximate numerical and analytical approaches. The collaboration between the *Many-particle theory group* (Kevin Bauerbach, Florian Gebhard) and Örs Legeza from the Wigner Institute of the HAS in Budapest employs the Density Matrix Renormalization Group (DMRG) method on rings with up to 512 sites for an accurate localization of the transition. The maximum of the quasiparticle density in the upper Hartree-Fock band develops a peak close to the critical interaction whose position extrapolates to the exact result V=2 in the thermodynamic limit with an accuracy of better than one percent. Monitoring the Luttinger parameter permits to locate the transition with an accuracy of three percent. This work was published in Physical Review B.

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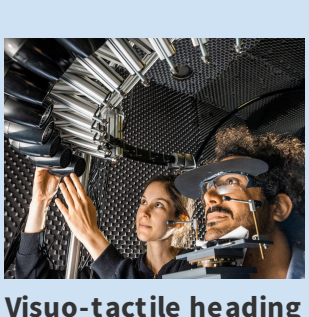

Visuo-tactile heading perception (AG Bremmer)

Self-motion through an environment induces various sensory signals, i.e., visual, vestibular, auditory, or tactile. Numerous studies have investigated the role of visual and vestibular stimulation for the perception of self-motion direction (heading). Here, AG Bremmer investigated the rarely considered interaction of visual and tactile stimuli in heading perception. Participants were presented optic flow simulating forward self-motion across a horizontal ground plane (visual), airflow toward the participants' forehead (tactile), or both. In separate blocks of trials, participants indicated perceived heading from unimodal visual or tactile or bimodal sensory signals. Visual and tactile stimuli were designed to achieve comparable precision of heading reports between modalities. Nevertheless, in bimodal trials heading perception was dominated by the visual stimulus. A change of head orientation had no significant effect on perceived heading, whereas, surprisingly, a change in eye orientation affected tactile heading perception. Overall, we conclude that tactile flow is more important to heading perception than previously thought. The work was published in the Journal of Neurophysiology.

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Events

SFB - Colloquium Gerd Bacher
7 Dec., 4:15 pm, small lecture room, Renthof 5

Prof. Dr. Gerd Bacher
(Werkstoffe der Elektrotechnik & CENIDE, University Duisburg-Essen, Duisburg)

Scalable optoelectronic devices based on 2D materials

Two-dimensional (2D) materials represent a fascinating, ultrathin material class with an exciting application potential in optoelectronics. A wide variety of proof-of-concept devices with outstanding performance has been reported in literature. However, they mostly rely on micrometer-scale, mechanically exfoliated 2D materials, and are thus of limited practical use. Overcoming the bottleneck to real-world applications requires both scalable materials and scalable device architectures. In this contribution we report on wafer-scale 2D materials grown by (MO-) CVD and their implementation in scalable optoelectronic devices. As a proof-of-concept, we demonstrate integration of directly grown graphene as a transparent electrode in Ga(In)N/Ga(Al)N light emitting devices. The optoelectronic application potential of ultrathin, scalable TMDC semiconductors is demonstrated by embedding MOCVD grown WS2 monolayers in a vertical light emitting device design. Direct MOCVD growth of 2D material heterostructures on a sapphire substrate enables the fabrication of heterostructure photodetectors without involving any transfer process. We demonstrate an enhancement of the responsivity by more than 5 orders of magnitude in a WS2-MoS2 heterostructure device as compared to a single layer reference.

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Physik am Samstagmorgen
10 Dec., 11 am, Audimax

As part of the popular lecture series "Physik am Samstagmorgen", Prof. Jan Christoph Goldschmidt will talk on how novel tandem solar cells will help to mitigate climate change. In particular, he will discuss the relevance of photovoltaics for a global energy transition, and how efficiency can be increased by the combination of different solar cells materials.

Seminar AG Malic / SFB Colloquium Alexey Chernikov
13 Dec., 1 pm, lecture hall, Renthof 7

Prof. Alexey Chernikov
(Institute of Applied Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden)

Mobile excitons in inorganic and hybrid 2D materials

Transport of optical excitations in semiconducting solids plays a central role from both fundamental and technological perspectives. In systems with strong Coulomb interaction the propagation of optically injected carriers is dominated by excitons instead of free electrons or holes. These correlations can affect both the overall energy landscape and the interactions with vibrational modes, with a strong impact on the mobility of the excitations.

In this talk I will present recent studies focused on propagation of mobile exciton quasiparticles in semiconducting van der Waals monolayers and hybrid perovskite materials. In these systems, the electron-hole correlations present a particularly interesting case combining the properties of Wannier-Mott excitations in inorganic quantum well systems with high exciton binding energies that are more characteristic for Frenkel-like states in molecular crystals. I will discuss non-linear and anomalous diffusion, impact of exciton-carrier interactions, including demonstration of tightly bound trions in electrically-tunable 2D perovskites, as well as high-density propagation phenomena in van der Waals heterostructures at the Mott transition.

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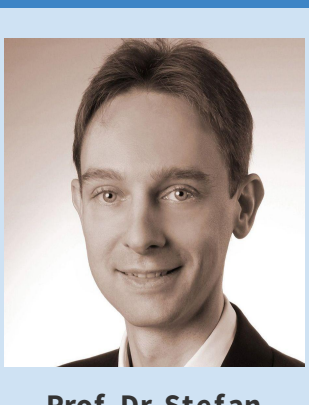
New Colleagues



Prof. Dr. Stefan Wippermann

I started the new research group Computational Energy Materials in August 2022. After studying at Paderborn University and subsequent research stays at North Carolina State University, Raleigh, Tsinghua University, Beijing, and University of California, Davis, I became Max-Planck group leader at the Max-Planck-Institut für Eisenforschung, Düsseldorf in 2013. I develop and apply next generation /ab initio/ methods to explore and predict a wide range of materials properties in nanomaterials and at electrified interfaces with electrolytes. The goal is to explain experimental findings, design novel materials and suggest new technological concepts for sustainable energy conversion and storage, optoelectronics and information processing.

Dr. Ahmad Al-Latif (Physik Praktikum)

I just started in my new position at the FB Physik as supervisor for the internship courses (Physik Praktikum) as well as Safety Administrator. Furthermore I will be active in the field of Science Management. Prior to this role I was working at the Leibniz Universität Hannover in the department of 'Building and Energy Technology' (teaching and research). In the past I have worked as a lecturer at many universities both in Germany and abroad. My activity as a lecturer includes: physical mathematical fundamentals, renewable energies and energy technology, medical physics and physics for engineers, to name a few. I also worked as a supervisor for physics lab courses. Beyond the academic environment I was for a few years active in the fields of Quality Management and ISO standards. I studied at the Universities of Heidelberg and Tübingen, where I also earned my PhD. The subject fields of my Diplomarbeit and my PhD thesis were laser spectroscopy and atomic physics respectively. Beside work I like spending time with friends and keeping up with my social network. I like playing football, hiking, walking and other outdoor activities. I also like playing chess.

Dr. Bahareh Taghizadeh (AG Bremmer)

I am a new postdoc in the Neurophysik Group of Prof. Frank Bremmer. I received my PhD from the University of Göttingen, where I worked on sensorimotor processings in humans and non-human primates at the German Primate Center. Afterwards, I was a postdoc at School of Cognitive Sciences of Institute for Research in fundamental Sciences in Tehran, Iran, where I worked on more cognitive aspects of sensory processing. I then did a short postdoc at the University of Montreal in Canada and recently moved to Marburg. Here, I work on visuospatial processes in human and non-human primates. I love traveling, learning about new cultures and meeting new people. It is great to be here at the University of Marburg.

Sebastian Anhäuser (AG Witte)

I recently finished my master thesis in the group of Prof. Witte, where I studied structural and optoelectronic properties of organic molecular single crystals and crystalline films. Now starting as a PhD student, I will continue my work with a special focus on excitonic states in donor-/acceptor-systems. By combining stuctural characterization via XRD with polarisation-resolved spectroscopy, I aim at shedding some light on the interplay between molecular packing and optical, as well as charge transfer properties. My interests apart from work are music and sports: I am a jazz guitarist playing in my band „Duophonic", and I like to go running and kayaking.

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Christmas Break

We are back in February 2023 and wish everybody Merry Christmas and a Happy New Year 2023!

Share your good news

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

write e-mail