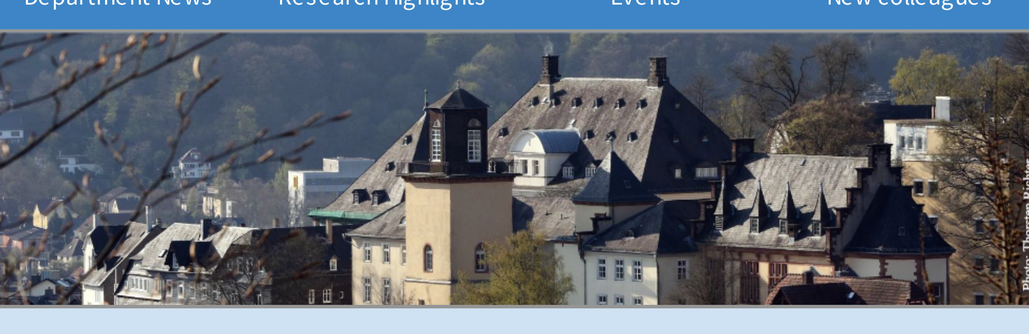
Newsletter Physics 10/22

Department News | Research Highlights | Events | New colleagues



Welcome back after the summer break!

If you have difficulties reading the newsletter, you can download it by clicking the "download pdf" button or on the department homepage (under events).

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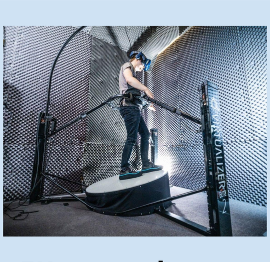
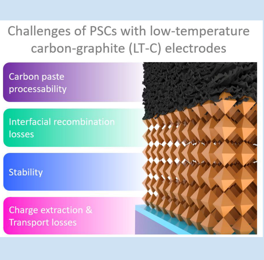
News from the Department



EU research grant (AG Bremmer)

A new European research grant has been awarded to the Neurophysics group. The project entitled PLACES (PLAsticity of perception in real and virtual spaCES) will commence in 2023 and run for 4 years. The research project aims to understand how sensorimotor interactions in virtual environments shape perceptual space and how this interacts with virtual (VS) and real (RS) space. The project is routed in the EU-RISE program, which supports enhanced research secondments of European partners to non-European countries. Like its predecessor project PLATYPUS (2017-2023), the consortium comprises groups in Germany (UnivMünster, UnivMarburg, and the Zeiss-Vision-Lab in Tübingen), the US (UnivRochester) and Australia (Monash Univ. in Melbourne, Western Sydney Univ). New partners come from Hamburg, London (UK), Vancouver (Canada) and Christchurch (New Zealand).



DFG project (AG Goldschmidt)

In the DFG Priority Programme "Perovskite Semiconductors: From Fundamental Properties to Devices" (SPP 2196) the AG "Solar Energy Conversion" successfully acquired funding for two projects. In the first project "Interfaces in all-perovskite tandem solar cells" the group will realize perovskite-perovskite tandem solar cells, which will then be subjected to rigorous characterization and modeling analysis. In Marburg, in-depth electrical and photoluminescence analysis will be performed. In the second project "Perovskite solar cells with graphite electrodes: advanced interfaces for highest performance and stability" the group will partner with the Dr. Uli Würfel from Freiburg University and Prof. Henry Snaith to unravel the full potential of perovskite solar cells with low-temperature processed graphite electrodes. Here the work in Marburg ranges from device processing to characterization analysis to photoluminescence characterization.

Ulrich Höfer Adjunct professor in Regensburg

As of September 1st, Prof. Ulrich Höfer has been appointed Adjunct Professor by the University of Regensburg. The appointment is for five years and will allow Prof. Höfer to conduct research projects in Regensburg and to supervise students there. The position of an Adjunct Professor has just recently been established by the University of Regensburg to attract external faculties to its newly established scientific centers, such as the Regensburg Center for Ultrafast Nanoscopy (RUN). The appointment of Prof. Höfer is the first of its kind. In collaboration with Rupert Huber, he will use a world-wide unique lightwave-ARPES experiment at RUN to extend the research of Marburg's SFB 1083 on ultrafast dynamics at interfaces to the coherent and high field regime.

Doctoral scholarship Lara Heidrich (AG Koch)

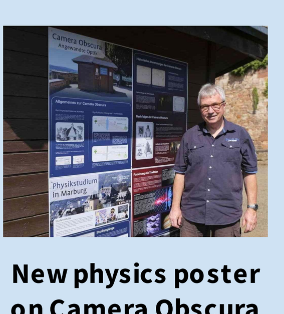
Terahertz spectroscopy enables the non-destructive crystallinity analysis of many active pharmaceutical ingredients in different formulations, e.g. tablets for oral administration. Lara Heidrich, a PhD student in the semiconductor photonics group of Prof. Martin Koch, recently received a doctoral scholarship from the Friedrich-Ebert-Stiftung, to continue her research on this topic. The funding runs for an initial period of two years and, in addition to financial support, also includes many other networking and training opportunities. "I am very pleased that I received the scholarship and look forward to the various offers and the foundation's support for my research project and beyond".

School students are back

This summer semester, numerous groups of students visited us at the physics department to see how physics works at the university and to deepen their knowledge above the school level. Elementary school students were guests at a children's lecture on the subject of "Air", designed by Dr. Catrin Ellenberger (didactics) and Georg Otto (lecture hall department). The MINT summer school for girls (11th grade), headed by Sruthika Konde (AG Gerhard) and Laura Hentschke (AG Didaktik), was busy testing the newly developed separators for the physics of microplastics from Stefan Brackmann (AG Koch). In addition, several 10th graders were able to carry out experiments on radioactivity in the school laboratory of the Didactics group (Dr. Ellenberger). We hope that the interest in physics will remain strong at school and we are looking forward to welcoming more students after the summer break.

Open Monument Day

On September 11, the German Heritage Day, many interested people again took the chance to visit the historic Gerling Observatory and get an insight into how astronomers worked in the 19th century. There are only two occasions each year when the observatory opens its doors to the public. The number of visitors was very large, the event was a complete success.



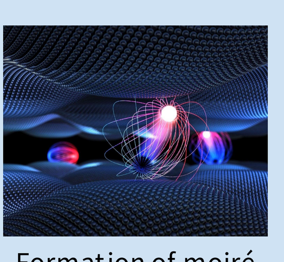
New physics poster on Camera Obscura

After we have already placed the poster of the Department Physics on the Camera Obscura, now the PR team, with a great support of Andreas Schrimpf, has prepared a second poster explaining the working principle of the camera and giving an overview of research and teaching at our Department. Please stop by and have a look at our posters on the Camera Obscura.

Picture gallery in Renthof 5

Since last week the stairway to the big lecture hall in Renthof 5 is decorated with a picture gallery of all professors and lecturers of the physics department. Stop by and read the different teaching and research mottos.

Research Highlights



Formation of moiré interlayer excitons in space and time **(AG Malic)**

Moiré superlattices in atomically thin van der Waals heterostructures hold great promise for extended control of electronic and valleytronic lifetimes, the confinement of excitons in artificial moiré lattices and the formation of exotic quantum phases. To exploit the full potential of correlated moiré and exciton physics, a thorough understanding of the ultrafast interlayer exciton formation process and the real-space wavefunction confinement is indispensable. In a joint experiment-theory study with the group of Stefan Matthias in Göttingen, AG Malic developed a microscopic model to describe ultrafst charge transfer dynamics in van der Waals heterostrutures. We demonstrate that the transfer is driven by a phonon-assisted two-step process via scattering into strongly hybridized dark exciton states. Our work provides direct access to interlayer exciton formation dynamics in space and time and reveals opportunities to study correlated moiré and exciton physics for the future realization of exotic quantum phases of matter. The work was published in Nature.

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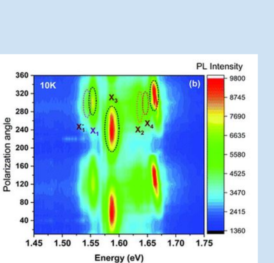

Excitons in an anisotropic ReS2-based heterostructure **(AG Koch/AG Malic)**

Two-dimensional semiconductors have opened new horizons for future optoelectronic applications through efficient light–matter and many-body interactions at quantum level. Anisotropic 2D materials, such as rhenium disulphide (ReS2) present a new class of materials with polarized excitonic resonances. In a joint experiment theory study, AG Koch and AG Malic investigated a WSe2/ReS2 heterostructure which exhibits a significant photoluminescence quenching. This indicates an efficient charge transfer due to the electron–hole exchange interaction. The band alignment of two materials suggests that electrons optically injected into WSe2 are transferred to ReS2. Furthermore, polarization resolved luminescence measurements reveal two additional polarization-sensitive exciton peaks in ReS2 in addition to the two conventional exciton resonances. Overall, our findings provide a better understanding of optical signatures in 2D anisotropic materials. The work was published in Nanoscale.

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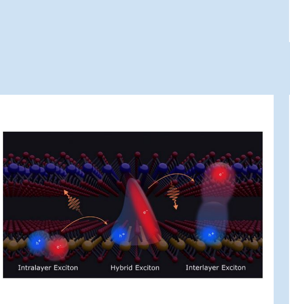

Ultrafast charge transfer in TMD-based heterostructures **(AG Malic)**

Van der Waals heterostructures built by vertically stacked transition metal dichalcogenides (TMDs) exhibit a rich energy landscape, including interlayer and intervalley excitons. Recent experiments demonstrated an ultrafast charge transfer in TMD heterostructures. However, the nature of the charge transfer process has remained elusive. Based on a microscopic and material-realistic exciton theory, AG Malic revealed that phonon-mediated scattering via strongly hybridized intervalley excitons governs the charge transfer process that occurs on a sub-100fs timescale. We track the time-, momentum-, and energy-resolved relaxation dynamics of optically excited excitons and determine the temperature- and stacking-dependent charge transfer time for different TMD bilayers. The provided insights present a major step in microscopic understanding of the technologically important charge transfer process in van der Waals heterostructures. The work was published in Natural Sciences.

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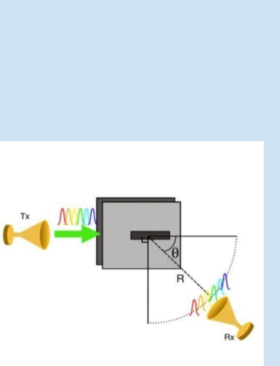

Angular dispersion of THz data transmission **(AG Koch/Camus)**

High speed telecommunications is probably the one most clear applications currently driving terahertz technological development. One of the key distinctions between current wireless systems opperationg at few GHz carrier frequency and future THz wireless transmissions is that THz links will require high directionality, to overcome the large free-space path loss. Because of this directionality, optical phenomena become increasingly important as design considerations. A key example lies in the strong dependence of angular radiation patterns on the transmission frequency. In this work, A collaborative team including Prof. Daniel Mittleman, who will soon be doing a Humboldt-funded visit to our department and Prof. Enrique Castro-Camus, curently guest profesor at AG Koch, explored the implications of this type of effect by incorporating either a diffraction grating or a leaky wave antenna into a communication link. These general considerations will have significant implications for the robustness of data transmissions at high frequencies. The work was published in Scientific Reports.

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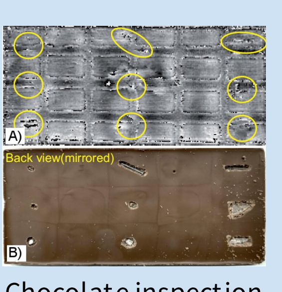

Chocolate inspection by means of phase-contrast imaging **(AG Koch/Camus)**

The enormous potential of terahertz radiation for non-destructive inspection has been one of the main dirvers of research in the subject. We have developed a method that allows fast imaging that opens new oprtunities for using teraherz waves. The team of AG Koch and their guest Enrique Castro-Camus demonstrated the method by imaging defects in chocolate bars, yet it can be extended to many other materials. Their method requires only a continuous wave (CW) monochromatic source and detector at relatively low frequencies (280 GHz) corresponding to a relatively long wavelength of 1.1 mm. These components are used to construct a common-path configuration enabling the capturing of several images of THz radiation diffracted by the test object at different axial depths. The captured diffraction-rich images are used to constrain the associated phase retrieval problem enabling full access to the wave field, i.e., real amplitude and phase distributions. This allows full-field diffraction-limited phase-contrast imaging. Thus, they experimentally demonstrate the possibility of identifying contaminant particles with dimensions comparable to the wavelength without using any intermediate focusing optics. The work was published in Optics Letters.

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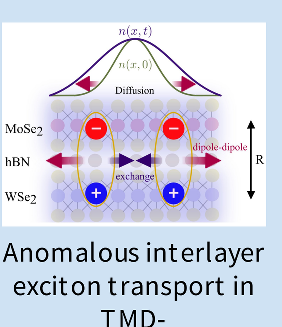

Anomalous interlayer exciton transport in TMD-heterostructures **(AG Malic)**

Van der Waals heterostructures constitute a platform for investigating intriguing many-body quantum phenomena. In particular, transition-metal dichalcogenide hetero-bilayers host long-lived interlayer excitons which exhibit permanent out-of-plane dipole moments. AG Malic developed a microscopic theory for interlayer exciton-exciton interactions including both the dipolar nature of interlayer excitons as well as their fermionic substructure, which gives rise to an attractive fermionic exchange. We find that these interactions contribute to a drift force resulting in highly non-linear exciton propagation at elevated densities in the MoSe2-WSe2 heterostructure. We show that the propagation can be tuned by changing the number of hBN spacers between the TMD layers or by adjusting the dielectric environment. Overall, our work contributes to a better microscopic understanding of the interlayer exciton transport in technologically promising atomically thin semiconductors. The work was published in Phys. Rev. Materials.

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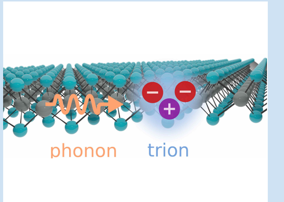

Trion-phonon interaction 2D materials **(AG Malic)**

Optical and transport properties of doped monolayer semiconductors are dominated by trions, which are three-particle compounds formed by two electrons and one hole or vice versa. In this work, AG Malic investigated the trion-phonon interaction in MoSe2 monolayeron a microscopic footing. We determine the trion series of states and their internal quantum structure by solving the trion Schrödinger equation. Furthermore, we investigated the trion propagation and computed the diffusion coefficient and mobility. In the low density limit, we find that trions propagate less efficiently than excitons and electrons due to their stronger coupling with phonons and their larger mass. For increasing densities, we predict a drastic enhancement of diffusion caused by the build-up of a large pressure by the degenerate trion gas, which is a direct consequence of the fermionic character of trions. Our work provides microscopic insights into the trion-phonon interaction and its impact on the diffusion behaviour in atomically thin semiconductors. The work was published in Phys. Rev. B.

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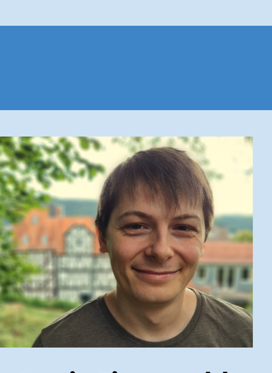
New Colleagues



Jamie Fitzgerald
(Postdoc AG Malic)

I am a postdoc in the Ultrafast Quantum Dynamics group of Prof. Ermin Malic. I received my PhD at Imperial College London working on plasmonics. Afterwards, I moved to Chalmers University of Technology in Sweden and designed photonic crystal-based devices for cavity optomechanics. I then joined Prof. Malic's group and currently work on modeling exciton polaritons in two-dimensional semiconductors. In my free time I enjoy reading, traveling and hiking. I am very happy to be here in Marburg!

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

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