Philipps Universität Marburg

Newsletter Physics 02/22

Department News | Research Highlights | Events | New colleagues

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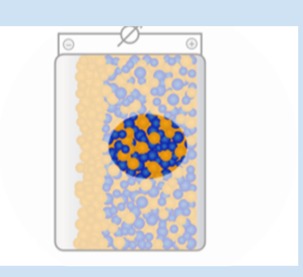
News from the Department



BMBF grant on batteries within the FestBatt cluster (AG Volz)

Solid state batteries are a promising concept to further develop our current battery technology. Instead of a liquid electrolyte, they use a solid electrolyte, which has distinct advantages, but is much less investigated. Solid state batteries can achieve higher storage capacities, shorter charging times and increased safety compared to batteries, which use a liquid electrolyte. In the cluster of competence „FestBatt", which is financed by the BMBF, more than 20 groups from all over Germany work on experimental and theoretical concepts regarding solid state batteries. In the "FestBatt" cluster, the work of the group of Kerstin Volz on understanding the structure and the interfaces in battery materials is supported with 650.000€ over the next three years.

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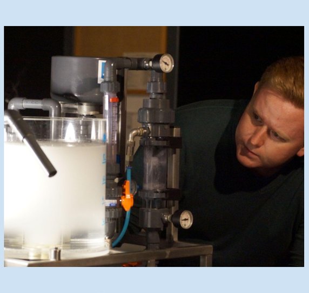
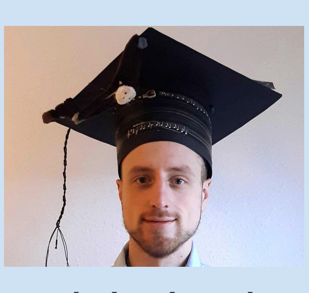


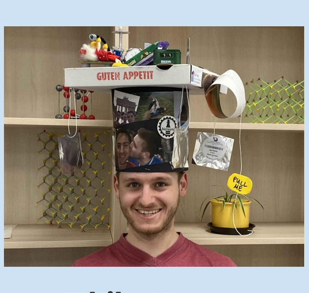
Grant on microplastics (AG Koch)

Dissolved air flotation is a standard process for cleaning waste water. It should also be suitable for removing microplastics from water bodies. In the process tiny air bubbles are created in the water to which small particles attach, which are then carried to the surface. The semiconductor photonics group has been awarded a new project worth just under 200,000 Euros to determine the size and density of the air bubbles using various measurement methods. The funding is provided by the new Federal Agency for Leap Innovations - SprinD.



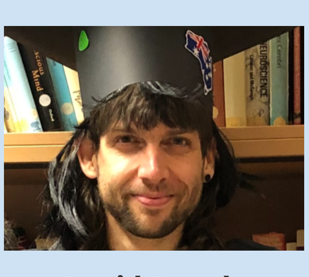
Jakob Schwenk: new doctor at our department! (AG Bremmer)

Jakob Schwenk completed his PhD on „Neural processing of continuous temporal information: visual and visuomotor systems" in the group of Prof. Frank Bremmer (Neurophysics). In his work, he investigated how the brain processes the temporal dimension of incoming information at different stages of the visual hierarchy. Among other findings he demonstrated that, when the incoming information is broadband, the visual system performs an active selection of the input by temporal frequency already at the earliest cortical stages of visual processing, and that this selectivity is maintained across behavioral variability. His findings show that frequency-dependent response biases should be explored as a key functional property of neural populations in the future.



Thilo Hepp: new doctor at our department! (AG Volz)

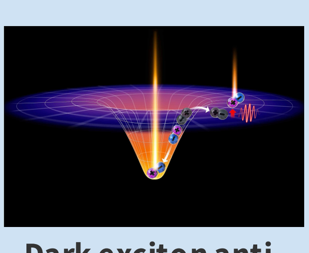
Highly mismatched alloys such as dilute bismuth containing materials are special class of semiconductors that may end the long pursuit of laser devices at 1.55 µm and beyond based on the GaAs platform. The epitaxial growth of the quaternary (Ga,In)(As,Bi) on GaAs is demonstrated for the first time using metalorganic vapor phase epitaxy. However, due to a strong interaction of In and Bi on the growth surface, the desired compositions for low band gap material cannot be achieved. In a second approach, two different materials are stacked on top of each other to a so-called type-II structure. Heavy adaptions to the growth conditions at the interfaces are required to allow the growth with sufficient quality. Finally, it was possible to show room temperature laser operation for the first time employing a Ga(As,Bi) based type-II structure.



David Engel: new doctor at our department! (AG Bremmer)

In my thesis, I investigated how the visual percept of (self-)motion influences balance and postural control in humans, and how this is affected by neurodegenerative diseases like Parkinson's. I developed a mobile and cost-effective setup consisting of a virtual reality headset, a force platform, and a video-based motion tracking system, which I used to simulate oscillatory visual perturbations while simultaneously tracking participants' postural responses. Conducting studies in collaboration with the neurology department of the UKGM, I found patients at early stages of Parkinson's to have an impaired motor control but intact visuomotor processing, expressed in their phase locking responses, through which I contributed to a better understanding of the sensorimotor aspects of the disease. My findings along with the newly introduced setup hold the potential to facilitate discovery of biomarkers that are indicative of neurological disease, which could provide the means for an early diagnosis and improve the quality of life of those affected.

Research Highlights



Dark exciton anti-funneling (AG Malic)

In conventional materials, electronic transport can be controlled by applying electric fields. Atomically thin semiconductors, however, are governed by excitons, which are neutral electron-hole pairs and as such cannot be controlled by electrical fields. Recently, strain engineering has been introduced to manipulate exciton propagation. AG Malic togehter with the experimental group of Rudi Bratschitsch (University of Münster) has combined spatiotemporal photoluminescence measure-ments with microscopic theory to track the way of excitons in time, space and energy. We find that excitons surprisingly move away from high-strain regions. This anti-funneling behavior can be ascribed to dark excitons which possess an opposite strain-induced energy variation compared to bright excitons. The work was published in Nature Communications.

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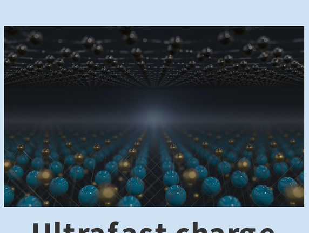

Ultrafast charge transfer in TMD-graphene heterostructures (AG Malic)

Van-der-Waals heterostructures show many intriguing phenomena including ultra-fast charge separation following strong excitonic absorption in the visible spectral range. Despite the enormous potential for future applications in the field of optoelectronics, the underlying microscopic mechanism remains controversial. AG Malic together with the experimental group of Isabella Gierz (University of Regensburg) has combined tr-ARPES measurements with many-particle theory to reveal the relevant microscopic charge transfer channels in WS2/graphene heterostructures. We find that the timescale for the charge separation is determined by direct tunneling at those points where WS2 and graphene bands cross. We observe both in theory and experiment a faster tunnerling of holes. The gained insighs can be exploited for the design of highly efficient light harvesting and detecting devices. The work was published in Physical Review Letters.

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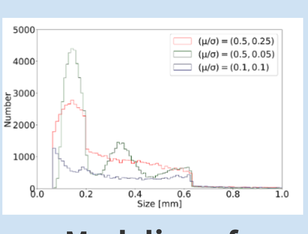

Modeling of microplastic decay rates (AG Lenz, AG Koch)

How should microplastic data be obtained in the future?
In a work carried out by the Complex Systems Group under the direction of Prof. Dr. Peter Lenz, it was shown that the data available so far on environmental microplastic pollution are not sufficient to describe the decay of plastic particles and their transport in nature. To this end, Timo Metz used a rate equation model and a stochastic simulation algorithm to generate complex artificial data that can serve as models for future measurements. The work was published in Scientific Reports.

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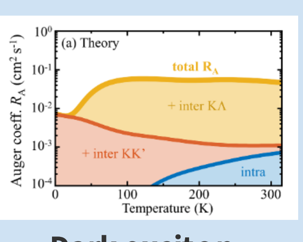

Dark exciton-exciton annihilation in atomically thin semiconductors (AG Malic)

At elevated densities, excitons can interact through exciton-exciton annihilation, an Auger-like recombination process limiting the efficiency of optoelectronic applications. Although this is a well-known and particularly important process in atomically thin semiconductors determining exciton lifetimes and affecting transport at elevated densities, its microscopic origin has remained elusive. AG Malic together with the experimental group of Alexey Chernikov (University of Dresden) has combined microscopic and material-specific theory with time- and temperature-resolved photoluminescence measurements to demonstrate the key role of dark intervalley exciton states. The work was published in Physical Review B (Editors' Suggestion).

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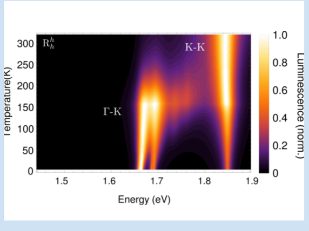

Exciton landscape in van der Waals heterostructures (AG Malic)

TMD heterostructures exhibit a rich landscape of bright and dark intra- and interlayer excitons. In spite of a growing literature in this field of research, the type of excitons dominating optical spectra in different heterostructures has not yet been well established. Combining exciton density matrix formalism and density functional theory, AG Malic in collaboration with the DFT group of Paul Erhart (University of Chalmers) could shed light on the exciton landscape in TMD homo- and heterobilayers at different stackings. This allows us to identify on a microscopic footing the energetically lowest lying exciton state for each material and stacking. The work was published in Physical Review Research.

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Events

Due to the pandemic, our colloquium presentations are digitial events. The planned inauguration lectures of Marina Gerhard, Jan-Christoph Goldschmidt and Ermin Malic have been moved to the summer semester.

BBB link

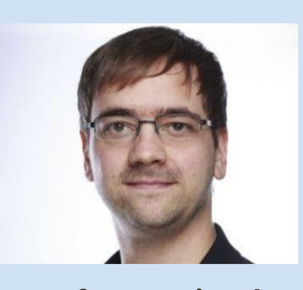
Colloquium Caterina Cocchi 10 Feb, 5.15 pm

Prof. Dr. Caterina Cocchi (Institute of Physics, University of Oldenburg)

Insight into Excitons in Organic and Hybrid Materials from First-Principles Many-Body Theory

The diversified nature of quasiparticles that are generated in materials upon their interaction with light calls for an in-depth understanding that can be efficiently and reliably provided by ab initio methods. Density-functional theory and many-body perturbation theory are the state-of-the-art approaches to tackle these challenges. In this colloquium, I will briefly review these methods and, with the aid of a few significant examples, I will demonstrate their ability to disclose the nature of excitons in a variety of materials, ranging from organic semiconductors even in their crystalline arrangement, to hybrid organic/inorganic interfaces. I will also discuss how the gained insight can be straightforwardly connected with experimental observations, in order to achieve a comprehensive knowledge of such complex systems.

New Colleagues



Stefan Dowiasch (postdoc, AG Bremmer)

I am a PostDoc in the Neurophysics department of Professor Bremmer since 01.01.2022 (again) in order to habilitate. For this purpose, I am conducting neurophysiological and psychophysical studies on eye movements and spatial perception, and research on biomarkers and their use in clinical practice as well as artificial neural networks. From 2017 till the end of 2021, I was Head of Research & Development at Thomas RECORDING GmbH in Giessen for almost 5 years, where, among other things, I researched and established two systems for early detection of Parkinson's disease by means of non-invasive eye movement measurement as head of a BMBF-funded collaborative project with the University of Marburg (see also: https://youtu.be/j1tQKTB_PUc). In my spare time, I farm our garden with my wife and two children or program an AI that now plays Starcraft 2 much better than I do.

Thilo Hepp (postdoc, AG Volz)

During my PhD in the research group of Volz/Stolz I conducted epitaxial growth of III/V semiconductors using the metalorganic vapor phase epitaxy technique. I am eager to continue my work on this topic and contribute to the progress of the rather novel dilute bismides as part of the collaborative research center. Additionally, I am happy to dive into new fields and advance my knowledge about crystal growth with atomic layer deposition. Fabrication of today's microelectronics would be barely possible without this technique. My interest is to develop low temperature deposition of III/V semiconductors and coatings for various applications. Besides baking crystals, I love baking cakes, cookies, and more. In my free time I play drums and do some sport activities.

Lara Heidrich (PhD, AG Koch)

I recently finished my state examination and started working as a PhD student for the semiconductor photonics group of Prof. Martin Koch. I am interested in physical chemistry and will study the crystallinity of pharmaceutical substances using terahertz spectroscopy.
Besides work I love spending time with friends, hiking and cycling in nature.

Jonas Scheunert (PhD, AG Volz)

Over the last year I did my master thesis is the research group of Prof. Volz. For that I studied the applicability of convolutional neural networks as a method for extracting information from 4D-STEM images. I am looking forward to continue my work as PhD student in this field and to expand the usage of machine learning techniques in material science. Outside work I am interested in board games and do climbing in my spare time.

Share your good news

Your newsletter team: Carina Hlawaty, Maya Strobel, and Ermin Malic

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