SYSD 1: SKM Dissertation Prize

Time: Monday 9:30–12:00 Location: HSZ 02

Invited Talk SYSD 1.1 Mon 9:30 HSZ 02

Disentangling transport in topological insulator thin films down to the nanoscale — •Felix Lüpke — Peter Grünberg Institut (PGI-3) and JARA-FIT, Forschungszentrum Jülich, 52425 Jülich, Germany — Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37831-6487, USA — Department of Materials Science and Engineering, University of Tennessee, Knoxville, Tennessee 37996, USA

Three-dimensional topological insulators (TIs) are prime candidate materials for applications in future electronic devices, such as quantum computers, due to the unique electronic properties of their two-dimensional topological surface states (TSS). In epitaxial TI thin films there are several parallel conduction channels which can contribute to the charge transport and which are difficult to disentangle in transport experiments. In my talk, I demonstrate the use of multi-tip scanning tunneling microscopy to systematically analyze the charge transport properties of pristine epitaxial $BiSbTe_3$ thin films under ultra-high vacuum conditions and down to the nanoscale.

Invited Talk SYSD 1.2 Mon 9:55 HSZ 02

Spintronics with Terahertz Radiation: Probing and driving spins at highest frequencies — •Tom Sebastian Seifert[1] and Tobias Kampfrath[2] — [1]ETH Zurich, Switzerland — [2]Free University Berlin, Germany

In spintronics, the spin of the electron is envisioned to enable novel functionalities for data processing [1]. As state-of-the-art information technology is approaching the terahertz (THz) frequency range [2], a central question is if important spintronic effects remain operative at THz rates. Important examples include the spin Seebeck effect [4] and the spin (dependent) Hall effects [3], which allow for the generation and interconversion of spin and charge currents, respectively. Here, we will address the high-frequency realization of these key spintronic transport effects and demonstrate their functionality on sub-picosecond time scales [5,6]. We use these insights to design efficient spintronic emitters of terahertz electromagnetic pulses [5] and to operate an antiferromagnetic memory cell employing strong terahertz writing pulses [7]. The presented work involved close collaborations with the research groups of M. Kläui, Y. Mokrousov, D. Turchinovich, M. Münzenberg, G. Woltersdorf, S. Gönnenwein, P. Oppeneer, C. Ciccarelli, P. Brouwer, and T. Jungwirth.

[1] V. Baltz et al., Rev. Mod. Phys. **90** (2018). [2] J. Walowski et al., J. Appl. Phys. **120** (2016). [3] J. Sinova et al., Rev. Mod. Phys. **87** (2015). [4] K. Uchida et al., Nature **455** (2008) [5] T. S. Seifert et al., Nat. Phot. **10** (2016). [6] T. S. Seifert et al., Nat. Commun. **9** (2018). [7] K. Olejnik, T. S. Seifert et al., Science Adv. **4** (2018).

Invited Talk SYSD 1.3 Mon 10:20 HSZ 02

Non-radiative voltage losses in organic solar cells — •Johannes Benduhn — Institut für Angewandte Physik, Technische Universität Dresden, Dresden, Germany

Global warming is one of the biggest challenges of this century and therefore new, green and cost-efficient technologies are needed to supply the electricity of tomorrow. In this regard, organic solar cells (OSCs) offer several unique advantages as they can be semi-transparent, lightweight, flexible, and cost-efficiently produced and therefore allow for an easy integration into surfaces of already existing buildings and mobile applications. A widespread use of this technology however requires an increase in the power conversion efficiency, which is currently still lower than that of established inorganic photovoltaic technologies. The main reason is that the voltage produced under illumination is low as compared to the optical gap of the absorber molecules, indicating high energy losses per absorbed photon.

In this work, I trace the origin of these losses back to large, non-radiative recombination losses mediated by molecular vibrations and electron-phonon coupling. With this understanding, reductions in non-radiative decay rates by a factor of 1.000 as compared to the current state-of-the-art OSCs are achieved, through a rational choice of molecules with appropriate energy levels and optical gaps. The resulting device does not only exhibit good photovoltaic properties, but also acts as a rather efficient light emitting device; resolving a long-believed paradigm that good emission and charge-carrier generation are mutually exclusive properties in organic optoelectronic devices.

Invited Talk SYSD 1.4 Mon 10:45 HSZ 02

Multivalent ions for tuning the phase behaviour of protein solutions — •Olga Matsarskaia — University of Tübingen, Germany — present address: Institut Laue-Langevin, Grenoble, France

Protein interactions can be mediated by a variety of factors such as charges introduced *via* ions. These interactions, in turn, determine protein phase behaviour including aggregation, phase separation and crystallisation with implications for several pathologies, biotechnology and structural biology. A detailed understanding of ion-mediated protein phase behaviour is thus crucial. Here, this subject was investigated using aqueous solutions of a globular protein in the presence of multivalent ions. The ion-induced phase behaviour was studied by a multi-method approach including calorimetry, UV-Vis absorption and small-angle scattering. In a first step, the unusual temperature dependence of the experimental system was analysed and determined to be due to hydration entropy effects. Subsequently, this entropy-driven mechanism was visualised on a molecular level by monitoring the ion-protein interactions. Finally, ion-specific effects were investigated. Intriguingly, the type of ion used was found to have a profound impact on both equilibrium phase behaviour and phase separation kinetics, in spite of all ions used featuring the same net charge. These results imply that subtle differences in ion properties are important factors capable of tuning protein interactions. The findings presented thus help advance an in-depth understanding of charge-mediated protein thermodynamics.

Invited Talk SYSD 1.5 Mon 11:10 HSZ 02

Network Dynamics under Constraints — •Malte Schröder — Chair for Network Dynamics, Institute for Theoretical Physics and Center for Advancing Electronics Dresden (cfaed), TU Dresden

The concept of networks provides a framework for the description of large complex systems with heterogeneous interactions between the individual parts. The structure and dynamics of these systems are often the result of complex optimization problems under constraints, either of the network as a whole or of the individual parts. Examples range from biological and technical systems achieving desired dynamics with minimal energy expenditure to optimal routing in transport and mobility systems. Understanding the fundamental mechanisms that shape the structure and dynamics across systems enables the identification of necessary and sufficient mechanisms for the emergence of collective phenomena. Here I discuss this concept of analyzing network dynamics as constrained optimization problems with applications to synchronization of coupled oscillators, network formation and percolation, and the dynamics of human mobility.

Invited Talk SYSD 1.6 Mon 11:35 HSZ 02

Exciton spectroscopy of van der Waals heterostructures — •Philipp Nagler — University of Regensburg, 93040 Regensburg, Germany

Heterostructures represent one of the most important concepts of solid-state physics. The observation of various fundamental physical phenomena along with several technological breakthroughs in the last decades can be traced back to this principle.

Recently, the notion of the heterostructure was significantly expanded by the discovery of atomically thin van der Waals crystals with different functionalities such as graphene or MoS_2. Those materials can be used as building blocks for the deterministic fabrication of heterostructures in the ultimate thickness limit, so-called van der Waals heterostructures.

Here, we employ optical spectroscopy to shed light on the rich physics of excitons in van der Waals heterostructures. Using a tailor-made $WSe_2/MoSe_2$ heterostructure, we demonstrate the emergence of spatially indirect interlayer excitons with ultra-long lifetimes. We further show that the twist angle, as a new degree of freedom, can be harnessed to engineer hitherto inaccessible optical transitions in momentum space. Finally, we unravel the complex hybrid composition of biexcitons in an $hBN/WS_2/hBN$ system, opening up new avenues for the study of many-body systems in the two-dimensional limit.