MA 31: Ultrafast Electron and Spin Dynamics

Time: Tuesday 18:30–20:30 Location: P2-EG

MA 31.1 Tue 18:30 P2-EG

Excited Electron Dynamics in Thiophene-based Polymers — •Carsten Winter, Deb Kumar Bhowmick, Nils Fabian Kleimeier, and Helmut Zacharias — Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Optically active thiophene-based polymers are promising candidates for solar cell, OLED or transistor applications. Several variants of thiophene polymers coupled with pyrrole or fluorene chains exist, and form an internal donor-acceptor system.

In this presentation we show the results of a time-dependent photoemission study on the three thiophene polymers PFTT (with a fluorene extension), PDPP4T and DTT (with a pyrrole extension) on a Si(100) substrate. The fundamental, second and third harmonics of a 6 kHz, 35 fs Ti:Sapphire laser system with a time-of-flight spectrometer are utilized for static 3PPE to determine the energetic positions of high lying occupied and intermediate unoccupied electronic levels. Dynamic 3PPE is then used to study the electron dynamics of the intermediate states directly in the time domain.

One-color 3PPE with 3 eV on PFTT shows intermediate lifetimes of 65 to 195 fs depending on the electron kinetic energy and the order of p- and s-pulse. On PDPP4T and DTT a two-color experiment (1.5 eV and 4.5 eV) can determine two distinct, longer electronic lifetimes between 1 and 10 ps for the faster channel and 20 to 100 ps for the slower channel.

MA 31.2 Tue 18:30 P2-EG

Ultrafast Doublon Dynamics in 1*T*-TaS_2 — •Manuel Ligges[1], Isabella Avigo[1], Denis Golež[2], Matthias Kalläne[3], Kai Rossnagel[3], Martin Eckstein[4], Phillip Werner[2], and Uwe Bovensiepen[1] — [1]Faculty of Physics, Universität Duisburg-Essen — [2]Department of Physics, University of Fribourg, 1700 Fribourg, Switzerland — [3]Institute of Experimental and Applied Physics, Universität Kiel, 24098 Kiel — [4]Max Planck Research Department for Structural Dynamics, University of Hamburg-CFEL, 22761 Hamburg

Using time- and angle-resolved photoemission we study photo-induced electron dynamics in the (quasi-)2D Mott insulator 1*T*-TaS_2. In the low excitation limit, we observe population and subsequent decay dynamics of the upper Hubbard band that are significantly faster than expected, indicating a characteristic time scale of $\hbar/J$ for the underlying scattering processes. Theoretical calculations based on dynamic mean field theory indicate that such dynamics only occur when the system is effectively hole-doped. We furthermore stress that on these time scales the electronic and phononic subsystems are decoupled.

MA 31.3 Tue 18:30 P2-EG

Ultrafast electron dynamics in single crystals studied by time-resolved two-photon momentum microscopy — •Tobias Eul[1], Florian Haag[1], Benjamin Frisch[1], Philip Thielen[1], Martin Piecuch[1], Mirko Cinchetti[2], Martin Aeschlimann[1], and Benjamin Stadtmüller[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany — [2]Experimentelle Physik VI, Technische Universität Dortmund, 44221 Dortmund, Germany

Electron dynamics in solid state systems and at interfaces play a crucial role for the performance of nanoscale spintronic devices. Therefore, it is essential to investigate the electron dynamics in the materials used for such devices.

The inelastic lifetimes of electronic states can be directly obtained with time resolved two-photon photoemission, using a cross-polarized pump-probe setup. Combining this technique with momentum spectroscopy in a ToF-PEEM operated in K-space mode, we are able to observe the energy dependent electron dynamics for each point in the accessible momentum space. This allows us to analyze cross-correlation traces for different intermediate state energies and different positions in the k_x/k_y-plane. As first model systems, we focused on bulk states of simple noble metal surfaces using different angles of incide of laser light. Based on the observed behavior, we aim to tune the electron lifetime of the metal surface by adsorption of organic molecules

MA 31.4 Tue 18:30 P2-EG

Ab initio approach to the ion stopping power at the plasma-solid interface — Karsten Balzer, •Niclas Schlünzen, Jan-Philip Joost, Lasse Wulff, and Michael Bonitz — CAU Kiel, Germany

The energy loss of ions in solids is of key relevance for many applications of plasmas, ranging from plasma technology to fusion. Standard approaches are based on density functional theory or SRIM simulations, however, the applicability range and accuracy of these results are difficult to assess, in particular, for low energies. Here, we present an independent approach that is based on ab initio nonequilibrium Green functions theory, e.g. [1,2] that allows to incorporate electronic correlations effects of the solid. As first application of this method to low-temperature plasmas, we concentrate on proton and alpha-particle stopping in a graphene layer and similar finite honeycomb lattice systems. In addition to the stopping power we present time-dependent results for the local electron density, the spectral function and the photoemission spectrum [3] that is accessible in optical, UV or x-ray diagnostics [4].

[1] M. Bonitz, *Quantum Kinetic Theory, 2nd edition* (Springer, 2016)
[2] K. Balzer and M. Bonitz, Lect. Notes Phys. **867** (2013)
[3] M. Eckstein and M. Kollar, Phys. Rev. B **78**, 245113 (2008)
[4] K. Balzer, N. Schlünzen, and M. Bonitz, Phys. Rev. B, accepted for publication, arXiv:1602.06928 (2016)

MA 31.5 Tue 18:30 P2-EG

Ultrafast transition to a hidden state in 1*T*-$TaS_{2-x}Se_x$ single crystals — •Ljupka Stojchevska[1,2], Ebru Ekici[3], Kira Kolpatzeck[3], Christian A. Bobisch[3], Dragan Mihailovic[1], and Uwe Bovensiepen[2] — [1]Complex Matter Department, Jozef Stefan Institute, Ljubljana, Slovenia — [2]Faculty of Physics, University of Duisburg-Essen, Duisburg, Germany — [3]Faculty of Physics, Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Duisburg, German

We report on femtosecond pump-probe spectroscopy study on the relaxation dynamics in 1*T*-$TaS_{2-x}Se_x$ single crystals with 6%, 7.5%, 17% and 19% selenium doping. We observe a transition to a new hidden state [1] (H-state) which is inaccessible under normal equilibrium conditions and can only be reached after a quench with a single femtosecond laser pulse at 1.6-4.8 mJ/cm^2 fluence. Similarly as in [1], a notable change in the coherent phonon spectra plays the role of the fingerprint of the successful switching to a new state via optical path. The major output is observation of the significantly higher temperature stability of the H-state ($\sim$ 104 K) in comparison with the parent 1*T*-TaS_2 material ($\sim$ 70 K). In addition, intense experimental efforts are currently undergoing in order to microscopically characterize H-state by means of scanning tunneling microscopy (STM) and to investigate the electronic structure with femtosecond time- and angle-resolved photoemission spectroscopy (trARPES). [1] Stojchevska, L. et al., Science, 344, 177 (2014).

MA 31.6 Tue 18:30 P2-EG

Characterization of an ultrafast MHz electron point source — •Jannik Malter, Melanie Müller, Faruk Krecinic, and Ralph Ernstorfer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Ultrafast electron point sources allow for electron microscopy and diffraction [1] as well as scanning probe techniques [2] with very high spatial and temporal resolution. The laser repetition rate is a crucial parameter as it directly influences statistics of the measurement, and taking the required laser pulse energy into account determines the thermal stress on the tip. We discuss photoemission from a metal tip using an optical parametric amplified laser in the low-MHz regime. Photoemission is either triggered by direct illumination of the apex, or by excitation and nanofocusing of surface plasmon polaritons [3]. Due to the better thermal response of the tip, the latter approach could possibly lead to femtosecond electron holography and contribute to laser-triggered ultrafast STMs.

[1] Müller et al. Femtosecond electrons probing currents and atomic structure in nanomaterials. Nature Comm. 5, 2014
[2] Cocker et al. Tracking the ultrafast motion of a single molecule by femtosecond orbital imaging. Nature 539, 2016
[3] Müller et al. Nanofocused Plasmon-Driven Sub-10 fs Electron Point Source. ACS Photonics 3 (4), 2016

MA 31.7 Tue 18:30 P2-EG

Mahan cone formation and time-resolved two-photon photoemission of the adsorbate system Tin-Phthalocyanine on Ag(111) — •Stephan Jauernik, Petra Hein, Max Gurgel, Julian Falke, and Michael Bauer — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany

Recently, the adsorption of tin-phthalocyanine (SnPc) on Ag(111) has attracted considerable interest due to peculiarities in the adsorbate-substrate interaction and switching capabilities reported for the adsorbed SnPc [1]. Using Low Energy Electron Diffraction (LEED) and Photoemission/Two-Photon Photoemission (PES/2PPE) we address in this work the correlation of structural and electronic properties of this model-type system in the incommensurate adsorption phase which forms in the coverage regime between 0.90 ML and 1.0 ML. 1PPE data of 1ML SnPc on Ag(111) reveal the formation of Mahan cones [2,3] which we associate with a direct optical transition within the Ag sp-band modified by diffraction in the presence of the 2D adsorbate superstructure. Using time-resolved bichromatic 2PPE we focus on the electronic structure of the adsorbate layer and the characteristic relaxation dynamics of molecular resonances.

[1] C. Stadler et al., Nature Physics 5, 153 (2009)
[2] G. D. Mahan, Phys. Rev. B 2, 4334 (1970)
[3] Winkelmann et al., New Journal of Physics, Volume 14 (2012)