O 65: Time-resolved spectroscopies III

Time: Friday 11:15–13:00 Location: SCH A315

O 65.1 Fri 11:15 SCH A315

Transient electronic structure and melting of a charge density wave in $TbTe_3$ — F. Schmitt[1], P. S. Kirchmann[2], •U. Bovensiepen[2], R. G. Moore[1,3], L. Rettig[2], M. Krenz[2], J.-H. Chu[1], N. Ru[1], L. Perfetti[2], D. H. Lu[3], M. Wolf[2], and Z.-X. Shen[1,3] — [1]Stanford University, Department of Applied Physics, USA — [2]Freie Universität Berlin, Fachbereich Physik, Germany — [3]Stanford Synchrotron Radiation Laboratory, USA

Obtaining insight into cooperative effects is fascinating because, through self-coordination and collectivity, they can lead to instabilities with macroscopic impacts like phase transitions. The responsible interactions are of particular interest to understand these phenomena. We used femtosecond time- and angle-resolved photoelectron spectroscopy to analyze the electronic structure of the quasi-1D charge density wave (CDW) material $TbTe_3$ which exhibits an energy gap at the Fermi surface along the nesting direction. A Te derived mode at 3.6 THz can be monitored by binding energy variations at all electron momenta, incident fluence F, and temperatures (T=100, 300K). A second mode at 2.3 THz is found only at low T and F, and exclusively at the Fermi surface. For higher F=2 mJ/cm^2 we find after 100 fs a closing of the energy gap and a recurrence of quasi-free electron like dispersion crossing the Fermi surface. This indicates unambiguously an ultrafast melting of the CDW state and identifies the 2.3 THz mode as the CDW amplitude mode. We expect that the information which is accessible with trARPES will greatly enhance the understanding of materials exhibiting cooperative phenomena.

O 65.2 Fri 11:30 SCH A315

Ultrafast dynamics in Silicon studied at FLASH — •Martin Beye[1], Alexander Föhlisch[1], Florian Sorgenfrei[1], Bill Schlotter[1], Torben Beeck[1], Annette Pietzsch[2], Franz Hennies[2], and Wilfried Wurth[1] — [1]Department Physik, Universität Hamburg, Deutschland — [2]MAX-lab, Lund, Sweden

Soft X-ray spectroscopies at new light sources like the free electron LASER at Hamburg (FLASH), which provide pulses of some tens of fs length with unrivaled brilliances, provide new tools for the element specific analysis of ultrafast processes resolving local and long range symmetries. We present measurements on crystalline Silicon unraveling timescales of electronic and nuclear processes after specific excitations.

We either use an optical pump laser or the XUV pulses from FLASH to excite phonons, valence or core electrons, respectively. Their temporal evolution is tracked via X-ray emission spectroscopy of Silicon induced by variably delayed FLASH pulses. This shows the dynamics of the electronic system, resolves temporal changes in the bandstructure, in the electron distribution and of the orbital and crystal momentum.

Using the optical laser as a probe instead, we are sensitive to changes in the electronic structure around the bandgap and the long range structure of the crystal itself. We track those changes after X-ray excitation and their decay via different cascading electronic and phononic processes by analyzing transient reflectivity changes.

We acknowledge financial support from the BMBF priority program FSP301: "FLASH"and the GrK 1355 "Physics with new coherent light sources"

O 65.3 Fri 11:45 SCH A315

Femtosecond melting of orbital order in magnetite — •Niko Pontius[1], Torsten Kachel[1], Hermann A. Dürr[1], Christian Schüssler-Langeheine[2], Bill Schlotter[3], Martin Beye[3], Alexander Föhlisch[3], and Wilfried Wurth[3] — [1]Helmholtz-Zentrum Berlin, BESSY II, Albert-Einstein-Str. 15, 12489 Berlin — [2]Physikalisches Institut, Universität zu Köln, Zülpicher Straße 77, 50937 Köln — [3]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The Verwey transition in magnetite (Fe_3O_4), discovered by Verwey in 1939 [1], takes place at $T_V \approx$120K and becomes manifest in a metal-to-insulator transition as well as a structural phase transition, leading to the appearance of superstructure x-ray diffraction peaks. Recent soft x-ray diffration (RSXD) experiments confirm charge and orbital order in the low temperature phase [2]. However, the microscopic origin of the transition,is still controversial.

By using time-resolved RSXD we investigate the "melting"of charge and orbital order to get a more detailed insight into the driving forces of the transition, in partitular the interplay of structural and electronic degrees of freedom. The Verwey transition is induced from below T_V by absorbing an infrared fs-laser pulse. The subsequent temporal evolution of the orbital order is probed by RSXD using fs x-ray pulses the free electron laser FLASH in Hamburg.

[1] E.J.W. Verwey, Nature 144, 327-328 (1939)
[2] J. Schlappa et al. , Phys. Rev. Lett. 100, 026406 (2008)

O 65.4 Fri 12:00 SCH A315

Direct measurement of core-level relaxation dynamics on a surface-adsorbate system — •Stefan Mathias[1], Luis Miaja-Avila[2], Guido Saathoff[3], Jing Yin[2], Chan La-o-vorakiat[2], Michael Bauer[4], Martin Aeschlimann[1], Margaret Murnane[2], and Henry Kapteyn[2] — [1]University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]JILA and University of Colorado, Boulder, Colorado, 80309, USA — [3]Max-Planck-Institute of Quantum Optics, 85748 Garching, Germany — [4]Universität Kiel, 24908 Kiel, Germany

Electronic coupling in surface/adsorbate systems, which occurs on ultrafast time scales in the low femto- to attosecond regime, is fundamental to the understanding of surface chemistry. However, the dynamics of highly-excited adsorbate states have only been studied indirectly to-date. In this work, we present the first direct time-resolved observation of the lifetime of a core-excited state of an atom adsorbed onto a surface using high-harmonic generation (HHG) EUV light pulses. By combining the laser-assisted photoelectric effect (LAPE) on surfaces [1,2] with laser-assisted Auger decay on an adsorbate/surface system, we directly measure the lifetime of the $4d^{-1}$ core level of Xenon on Pt(111) to be 7 ± 1 fs [3]. This result opens up time domain measurements of highly-excited state dynamics in materials systems where, because of complex interactions, energy-resolved measurements provide incomplete information.

[1] L. Miaja-Avila et al., Phys. Rev. Lett. 97, 113604 (2006)
[2] G. Saathoff et al., Phys. Rev. A 77, 022903 (2008)
[3] L. Miaja-Avila et al., Phys. Rev. Lett. 101, 046101 (2008)

O 65.5 Fri 12:15 SCH A315

Ultrafast dynamics in the 1T-$TiSe_2$ transition-metal dichalcogenide in the vicinity of the CDW phase transition — •Martin Wiesenmayer[1], Stephan Hilgenfeldt[1], Stefan Mathias[2], Timm Rohwer[1], and Michael Bauer[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Kiel, 24098 Kiel, Germany — [2]Department of Physics, TU Kaiserslautern, 67663 Kaiserslautern, Germany

The layered transition metal dichalcogenides (TMDC) have attracted considerable attention in the past due to a wide range of phenomena associated with their reduced dimensionality, such as charge density wave (CDW) instabilities and enhanced correlation effects. In this paper we report on a two-photon photoemission study of the TMDC compound 1T-$TiSe_2$. Static 2PPE measurements reveal a strong quenching of the signal of the *occupied* Se 4p bands as the incident laser intensity increases. We find that the characteristic timescales associated with this quenching lie in the femtosecond to picosecond range, indicating the involvement and relevance of electronic excitations. Furthermore, the experiments show clear differences in the quenching behavior between the normal and the CDW state of 1T-$TiSe_2$. Our results will be discussed under consideration of the highly disputed mechanism for the CDW transition of this compound.

O 65.6 Fri 12:30 SCH A315

Kinetic Approach for Laser-excited Solids — •Banaz Omar and Baerbel Rethfeld — Technical University of Kaiserslautern, Department of Physics, Erwin Schroedinger Str. 46, D-67663 Kaiserslautern, Germany.

The microscopic dynamical processes for ultrashort laser-excited solids have been investigated theoretically. The transient non-equilibrium evolution of electron distribution function due to excitation and the subsequent thermalization of the free electrons, as well as the dynamics of phonons are studied in metals. The microscopic collision processes, such as inverse bremsstrahlung absorption, electron-electron collision and electron-phonon interaction are considered in the collision terms of Boltzmann equation [1]. We apply our kinetic approach to the case

of gold by taking the total electron density of states into account. A free-electron like conduction band is considered in the d-band, which lies within the conduction band at about 2.5 eV below the Fermi surface. In the case of dielectrics, impact ionization and multi-photon ionization generate free electrons in the conduction band and holes in the valance band. Intense short laser-pulse change a cold solid to a hot dense plasma. With increasing free electron density a dynamical collision frequency is required for quasi-particle collisions.

[1] B. Rethfeld, A. Kaiser, M. Vicanek, and G. Simon, Phys. Rev. B 65, 214303 (2002)

O 65.7 Fri 12:45 SCH A315

Spectroscopy and dynamics of a surface-switchable phthalocyanine — •Nils Heinemann, Oleksiy Andreyev, Till Leissner, Timm Rohwer, and Michael Bauer — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel

Molecular switching is a highly topical research field driven for instance by potential applications in molecular electronics.

The non-planar (shuttlecock-shaped) tin-phthalocyanine (SnPc) can adsorb in two different orientations on a surface due to its geometry. Wang et al. have demonstrated, that it is possible to induce a switching between these geometries with the tip of a scanning tunnelling microscope [1].

We present a two photon photoemission (2PPE) study of SnPc on Ag(111) suggesting the possibility of light-induced switching. The electronic structure of the adsorbate has been investigated and laser-induced, intensity dependent changes in the characteristic 2PPE spectra have been observed. We interpret this observation as a transient modification of the adsorbed molecules. Time-resolved 2PPE measurements show, that the characteristic relaxation dynamics take place on a femto- to picosecond time scale.

[1] Y. Wang, J. Kröger, R. Berndt, W. Hofer, *Probing structural and electronic properties of ultrathin SnPc films on Ag(111) at the single molecule level*, Angewandte Chemie (2008) (accepted)