O 58: Poster Session - Ultrafast Electron Dynamics at Surface and Interfaces

Time: Tuesday 18:15–20:00 Location: P2/2OG

O 58.1 Tue 18:15 P2/2OG

Photoinduced charge carrier dynamics and electron injection efficiencies in Au nanoparticle-sensitized TiO_2 determined with picosecond time-resolved X-ray photoelectron spectroscopy — Mario Borgwardt[1], Johannes Mahl[1], •Friedrich Roth[2], Lukas Wenthaus[3], Felix Brausse[1], Monika Blum[4], Klaus Schwarzburg[5], Guiji Liu[6], Francesca M. Toma[6], Wolfgang Eberhardt[3], and Oliver Gessner[1] — [1]Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA — [2]Institute of Experimental Physics, TU Bergakademie Freiberg, Leipziger Straße 23, D-09599 Freiberg, Germany — [3]Center for Free-Electron Laser Science / DESY, D-22607 Hamburg, Germany — [4]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States — [5]Institute for Solar Fuels, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, 14109, Berlin, Germany — [6]Joint Center for Artificial Photosynthesis, Lawrence Berkeley National Laboratory, California 94720, USA

We employ picosecond time-resolved x-ray photoemission spectroscopy to investigate photoinduced electron transfer in a plasmonic model system composed of 20 nm sized gold nanoparticles (NPs) attached to a nanoporous film of TiO_2. The measurement provides direct, quantitative access to transient local charge distributions selectively from the perspectives of the electron donor (AuNP) and electron acceptor (TiO_2). Back electron transfer from the perspective of AuNP is dominated by a fast recombination channel proceeding on a timescale of 60 ± 10 ps and a minor contribution that is completed after ≈ 1 ns.

O 58.2 Tue 18:15 P2/2OG

Time resolved ARPES using femtosecond extreme ultraviolet laser pulses at 1 MHz repetition rate — •Jan Philipp Bange, Germaine Arend, Marten Düvel, Christina Möller, Marco Merboldt, Marcel Reutzel, Matthijs Jansen, Sabine Steil, Daniel Steil, and Stefan Mathias — I. Physikalisches Institut, Georg-August-Universität Göttingen, Germany

Angle-resolved photoemission spectroscopy (ARPES) is a powerful tool to map the momentum and energy dependent electron distribution of solids. Moreover, a time resolved ARPES setup is predestinated to investigate the ultrafast behaviour of electrons and the versatile couplings between electron and structural degrees of freedom. We apply femtosecond high harmonic generated (HHG) extreme ultraviolet (EUV) pulses at 21.6 eV as a probe. By generating the EUV pulses in a tight focusing geometry in an argon gas jet and by using a combination of reflective and transmissive optics we achieve both a small spectral bandwidth and a high photon flux of the probe beam. This enables us to capture distinct features in the photoemission spectra while keeping the integration time short due to a repetition rate of 1 MHz. The fundamental of the laser at 1.2 eV acts as pump resulting in a pump-probe setup. With this stroboscopic technique we investigate and capture the ultrafast electron dynamics in various material systems such as metal-organic hybrid interfaces, complex transition metal oxides and dichalogenides.

O 58.3 Tue 18:15 P2/2OG

Femtosecond time-resolved momentum microscopy on Graphene — •David Schmitt[1], Marius Keunecke[1], Christina Möller[1], Hendrik Nolte[1], Wiebke Bennecke[1], Davood Momeni Pakdehi[2], Klaus Pierz[2], Hans Werner Schumacher[2], Matthijs Jansen[1], Marcel Reutzel[1], Daniel Steil[1], Sabine Steil[1], and Stefan Mathias[1] — [1]I. Physikalisches Institut, 37077 Göttingen, Germany — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany

Recent experiments have shown that the photoexcitation of electrons in graphene leads to an ultrafast polarization-dependent anisotropy in the unoccupied Dirac cones[1]. To observe and analyze such anisotropies it is advantageous to employ a photoemission experiment that enables simultaneous access to all k-points with femtosecond resolution. We have built such a setup in recent years, which is based on time-of-flight momentum microscopy in combination with a 1 MHz femtosecond high-harmonic generation light source. The capabilities of the setup are evidenced by following the excitation and relaxation of the electronic structure in the whole Brillouin zone. In our poster, we will discuss our time-resolved experimental results regarding the hot electron dynamics in graphene.

[1] S. Aeschlimann et al., Phys. Rev. B 96, 020301 (2017)

O 58.4 Tue 18:15 P2/2OG

Ultrafast electronic heating and interband dynamics in bulk $1T$-VSe_2 — •Paulina Majchrzak[1,2], Deepnarayan Biswas[1], Alfred Jones[1], Klara Volckaert[1], Charlotte Sanders[2], Igor Marković[3], Byoung Ki Choi[4], Federico Andreatta[1], Raman Sankar[5], Yu Zhang[2], Gabriel Karras[2], Richard Chapman[2], Adam Wyatt[2], Emma Springate[2], Jill Miwa[1], Philip Hofmann[1], Phil King[3], Young Jun Chang[4], and Søren Ulstrup[1] — [1]Department of Physics and Astronomy, Aarhus University, DK — [2]Central Laser Facility, Rutherford Appleton Laboratory, UK — [3]School of Physics and Astronomy, University of St Andrews, UK — [4]Department of Physics, University of Seoul, ROK — [5]Institute of Physics, Academia Sinica, TW

Layered TMDCs are intensely studied model systems for understanding strongly-correlated materials. One such compound of interest is $1T$-VSe_2. In the bulk, it is metallic, and exhibits out-of-plane charge density wave (CDW) ordering. Its monolayer form, on the other hand, shows enhanced CDW transition temperature and perfect Fermi surface nesting. Here, we use TR-ARPES to trace out the response of the bulk VSe_2 system to an optical excitation on femtosecond timescales. The (E,k,t)-dependent ARPES spectrum is simulated with a spectral function model incorporating bare bands obtained from DFT. As a result, the transient electronic heating and the interband dynamics in the Se- and V-derived states around the Fermi level are deconvolved. These findings lead to a more comprehensive understanding of the photoexcited behaviour in lesser-explored family of metallic TMDCs.

O 58.5 Tue 18:15 P2/2OG

Determining the orientation of transition dipoles of direct and indirect optical transitions in metals — •Tobias Eul, Michael Hartelt, Eva Prinz, Benjamin Frisch, Martin Aeschlimann, and Benjamin Stadtmüller — Department of Physics and Research Center Optimas, University of Kaiserslautern

Understanding the hot electron dynamics and their energy and momentum dissipation mechanisms paves the way to enhance the performance of next-generation electronic and spintronic devices. This understanding can be obtained by the combination of time-resolved photoemission spectroscopy and the recently developed momentum microscopy. However, to properly determine the electron dynamics with these techniques, it is crucial to clearly identify the orbital character of the initial, intermediate and final states that lead to the emission of a photoelectron.

Here, we propose a theoretical framework to predict the nature of the involved electronic states from the cross-correlation signal of a monochromatic 2PPE experiment. Our theory is based on the density matrix formalism, showing a dependence of the ratio between minimum and maximum of the cross-correlation trace and the orientation of the transition dipole with respect to the polarization of the incident light. Our calculations are then compared to momentum microscopy results for direct and indirect optical transitions in Ag(110), using both a phase-averaged and a phase-resolved pump-probe setup with a photon energy of 3.1eV. The comparison shows that the transition dipoles for direct transitions align along the ΓL-direction of the crystal.

O 58.6 Tue 18:15 P2/2OG

Towards realtime analysis of charge transport using a THz-pump photoemission-probe experiment — •Hamed Abbasi, Ping Zhou, Martin Mittendorff, and Uwe Bovensiepen — Faculty of Physics, University of Duisburg - Essen, Lotharstr. 1, 47057 Duisburg, Germany.

Investigation of electron transport is of fundamental interest in the field of charge carrier dynamics. Real-time experimental access can be obtained by exploiting the THz light pulse in a pump-probe experiment [1]. Here we report on generation and optimization of the THz field by using a photoconductive antenna [2], with which we obtained a field with 400 V/m amplitude with the near-IR laser of energy per pulse 1.4 nJ. As next steps, we plan to increase the field by an order of magnitude by exploiting a laser with higher energy per pulse (4 μJ), and synchronize it with an ultrashort UV pulse for time-resolved

angle-resolved photoemission spectroscopy.
We thank the German Research Foundation for funding through CRC 1242.
[1] J. Reimann et al. Nature **562**, 396 (2018).
[2] A. Dreyhaupt et al. Applied Physics Letters **86**, 121114 (2005).

O 58.7 Tue 18:15 P2/2OG

Electron-Phonon Coupling in Metals at Elevated Temperatures. — •Tobias Held[1], Sebastian T. Weber[1], Jan Vorberger[2], and Baerbel Rethfeld[1] — [1]Fachbereich Physik and Research Center OPTIMAS, TU Kaiserslautern — [2]Helmholtz-Zentrum Dresden-Rossendorf

In the case of a solid being irradiated by a short-pulsed visible light laser, the energy is almost entirely absorbed by the electrons while the lattice remains cold. The resulting energy flow between electrons and phonons is commonly described by the electron-phonon coupling parameter G_{ep} in most temperature-based models.
Recent density functional theory (DFT) calculations accompanied by experimental results [1] indicate that a phonon mode-resolved approach is necessary to fully capture the process as opposed to the common assumption that the coupling is dominated by the longitudinal mode.
The coupling parameter can be calculated using analytical methods like a plane-wave approximation [2] as well as via DFT. Here we contrast these approaches and identify each one's advantages.

[1] L. Waldecker, R. Bertoni, R. Ernstdorfer and J. Vorberger, PRX 6, 021003 (2016)
[2] B. Y. Mueller and B. Rethfeld, PRB 87, 035139 (2013)

O 58.8 Tue 18:15 P2/2OG

Simulation of spatially resolved CDW dynamics — •Kurt Lichtenberg[1], Mohamad Abdo[1,2], Shaoxiang Sheng[1], Luigi Malavolti[1,2], and Sebastian Loth[1,2] — [1]University of Stuttgart, Institute for Functional Matter and Quantum Technologies, Stuttgart, Germany — [2]Max Planck Institute for Solid State Research, Stuttgart, Germany

Charge-density waves (CDWs) feature collective excitations. They can, for example, be observed as an oscillatory collective response of the material's electron system to a fast optical stimulus [1]. On the other hand, scanning probe measurements reveal highly localized interaction with atomic defects [2]. Here we developed an empirical model for one-dimensional CDWs that treats the ultrafast dynamics of a CDW in real space and at the intrinsic time scale of the CDW motion. The model is based on time-dependent Ginzburg Landau Theory and motivated by former approaches [3,4]. Simulations based on this model enable the exploration of 1D CDW systems. We see a strong dependence of the collective mode behaviour on temperature, the impurity constellation and excitation intensity.

References [1] M.-A. Méasson et. al, PRB 89, 060503(R) (2014) [2] C. J. Arguello et. al, PRB 89, 235115 (2014) [3] W. L. McMillan, PRB 12, 1187-1196 (4) (1975). [4] G. Grüner, Density Waves in Solids. Perseus Publishing - Cambridge, Massachusetts, (2000).