O 54: Poster Session IV: Poster to Mini-Symposium: Ultrafast surface dynamics at the space-time limit II

Time: Tuesday 13:30–15:30 Location: P

O 54.1 Tue 13:30 P

Ultrafast nano-imaging of the order parameter in a structural phase transition — •Till Domröse[1], Thomas Danz[1], and Claus Ropers[1,2] — [1]4th Physical Institute - Solids and Nanostructures, University of Göttingen, Germany — [2]Max Planck Institute for Biophysical Chemistry, Göttingen, Germany

Ultrafast transmission electron microscopy has proven a versatile tool to investigate out-of-equilibrium dynamics in heterogeneous nanostructures on their intrinsic time and length scales [1]. Here, we report on ultrafast dark-field domain mapping in our Göttingen UTEM [2] as a means to image a structural phase transition between two charge density wave (CDW) phases in the correlated material 1T-TaS_2 [3]. Selective contrast enhancement enabled by a tailored dark-field aperture array provides real-space sensitivity to the local CDW amplitude with unprecedented simultaneous femtosecond temporal and nanometer spatial resolution. After optical excitation, we observe a global quench of the CDW amplitude, followed by formation, condensation and subsequent spatiotemporal relaxation of domain patterns, ranging from the femtosecond into the nanosecond regime. Accompanying Ginzburg-Landau simulations reproduce key experimental observations, elucidating the order parameter dynamics specifically near domain walls.

[1] A. H. Zewail, Science 328, 187 (2010).
[2] A. Feist et al., Ultramicroscopy 176, 63 (2017).
[3] T. Danz et al., accepted for publication in Science, arXiv:2007.07574

O 54.2 Tue 13:30 P

Determining the orientation of transition dipoles of direct and indirect optical transitions in metals — •Tobias Eul, Michael Hartelt, Eva Prinz, Benjamin Frisch, Benjamin Stadtmüller, and Martin Aeschlimann — 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 54.3 Tue 13:30 P

Ultrafast hot electron relaxation in a metallic THz-STM junction — •Natalia Martín Sabanés[1,2], Faruk Krecinic[1], Fabian Schulz[1], Chenfang Lin[1,3], Takashi Kumagai[1,4], Martin Wolf[1], and Melanie Müller[1] — [1]Fritz Haber Institute, Berlin, Germany — [2]IMDEA nanoscience, Madrid, Spain — [3]College of Materials Science and Engineering, Hunan University, Hunan, China — [4]Center for Mesoscopic Sciences, Institute for Molecular Science, Okazaki, Japan

We investigate the ultrafast dynamics of photoexcited hot electrons in a metallic STM junction through modulation of the junction barrier with an ultrabroadband THz field. The ability for phase-resolved quantitative sampling of the THz bias induced in the junction allows to probe the relaxation of hot carriers in the STM on THz sub-cycle time scales. Exact knowledge of the THz voltage is obtained via THz-field-induced modulation of instantaneous photocurrents excited with 8 fs near-infrared (NIR) laser pulses [1-3]. In the presence of a non-instantaneous response, distortions of the original THz waveform occur, from which the ultrafast photocurrent decay can be extracted. Applying a 1D-model for the transmission of thermalized hot electrons to reproduce the distorted THz waveforms, we obtain quantitative information about the electronic temperature in the tip and its ultrafast decay. Our approach provides a new route for non-resonant probing of charge carrier dynamics in photoexcited STM on time scales much shorter than a single THz cycle. [1] L. Wimmer et al., Nat. Phys., 10, 432-436, 2014. [2] M. Müller et al., ACS Photonics, 7(8), 2046-2055, 2020. [3] S. Yoshida et al., ACS Photonics 6, 1356-1364, 2019.

O 54.4 Tue 13:30 P

3-in-1 time-resolved ToF momentum microscopy using FEL and HHG radiation — •N. Wind[1,2], D. Kutnyakhov[2], M. Heber[2], F. Pressacco[2], L. Wenthaus[2], G. Mercurio[3], H. Meyer[1], S. Gieschen[1], K. Bühlmann[4], D. Curcio[5], K. Volckaert[5], S. Däster[4], R. Gort[3], M. Bianchi[5], C. Sanders[5], J. Miwa[5], S. Ulstrup[5], A. Oelsner[6], C. Tusche[7,8], Y.J. Chen[7,8], S.Y. Agustsson[9], D. Vasilyev[9], K. Medjanik[9], G. Brenner[2], S. Dziarzhytski[2], H. Redlin[2], J. Hauer[10], P. Xian[10], M. Dendzik[10], S. Dong[10], L. Rettig[10], F. Diekmann[11], H.J. Elmers[9], J. Demsar[9], P. Hofmann[5], R. Ernstorfer[10], Y. Acremann[4], M. Martins[1], G. Schönhense[9], W. Wurth[1,2], and K. Rossnagel[2,11] — [1]IEXP, Univ. Hamburg — [2]DESY Hamburg — [3]EuXFEL Schenefeld — [4]ETH Zürich — [5]Univ. Aarhus — [6]Surface Concept GmbH — [7]FZ Jülich GmbH — [8]Univ. Duisburg-Essen — [9]Univ. Mainz — [10]FHI Berlin — [11]CAU Kiel

Time-resolved PES with ultrafast pump and probe pulses is an emerging technique with wide application potential. Combining valence-band and core-level spectroscopy with photoelectron diffraction in a single, ultra-efficient photoelectron detection scheme for electronic, chemical and structural analysis requires soft X-ray pulses of few 10 fs duration at some 10 meV spectral resolution. This is feasible at high-repetition-rate FELs. We present an optimized, versatile setup for the use at FLASH as well as a laboratory HHG source that combines short-pulsed XUV/soft X-ray capabilities with a multidimensional recording scheme for ultrafast photoemission studies of quantum materials.