O 92: Poster Session VII: Ultrafast electron dynamics at surface and interfaces III

Time: Thursday 10:30–12:30 Location: P

O 92.1 Thu 10:30 P

FEL based tr-ARPES of ultrafast electron dynamics in quantum materials — •M. Heber[1], K. Kühlmann[2], D. Kutnyakhov[1], F. Pressacco[1], N. Wind[3], D. Curcio[4], K. Volckaert[4], V. Shokeen[5], A. Yaroslavsev[5], H. Noei[1], M. Wagstaffe[1], Ch. Sanders[6], S. Y. Agustsson[7], H. Redlin[1], S. Dziarzhytski[1], G. Brenner[1], L. Wenthaus[1], K. Medjanik[7], H.J. Elmers[7], G. Schönhense[7], Y. Acremann[2], Ph. Hofmann[4], H. Dürr[5], W. Wurth[1,3], and K. Rosnagel[1,8] — [1]DESY, Hamburg, D — [2]Department of Physics, ETH Zürich, CH — [3]Physics Department, University of Hamburg, D — [4]Aarhus University, DK — [5]Uppsala University, S — [6]Rutherford Appleton Laboratory, Harwell, GB — [7]University of Mainz, D — [8]IEAP, CAU Kiel, D

We investigated the ultrafast electronic structure dynamics of various quantum materials by time- and angle-resolved photoelectron spectroscopy. To this end, a time-of-flight momentum microscope enabling the parallel detection of the photoelectrons two surface-parallel momentum components plus their kinetic energy was combined with the short-pulsed monochromatized XUV radiation from the PG2 beamline of FLASH at DESY. The use of XUV pulses specifically provides the possibility to study the combined temporal response of valence and core electrons. Here, the results of three different experiments will be presented, focusing on the Dirac cone of graphene on Ir(111), the surface and bulk valence bands and core levels of Bi_2Se_3, as well as the hot electrons in a thin ferromagnetic nickel film on W(110). Pump fluence- and momentum-dependent dynamical effects will be discussed.

O 92.2 Thu 10:30 P

Dynamics of charge transfer processes at nanoparticle/oxide interface studied by free electron laser — •Eleonora Spurio[1,2], Jacopo Stefano Pelli Cresi[3], Emiliano Principi[3], Daniele Catone[4], Patrick O'Keeffe[4], Stefano Turchini[4], Stefania Benedetti[2], Avinash Vikatakavi[1,2], Sergio D'Addato[1,2], Claudio Masciovecchio[3], Jagadesh Kopula Kesavan[5], Federico Boscherini[5], and Paola Luches[2] — [1]Università degli Studi di Modena e Reggio Emilia — [2]CNR-NANO, Modena — [3]Elettra-Sincrotrone Trieste — [4]ISM-CNR, Rome — [5]Università di Bologna, Italy

In order to make wide band gap semiconductors suitable for a widespread use as green solar photocatalysts, it is fundamental to expand their photoactivity in the visible range. This is possible for example combining these materials with plasmonic nanoparticles(NP). In our work, we have studied a system based on Ag NP embedded in a film of CeO2. Here, we have exploited the chemical sensitivity of free electron laser time-resolved soft X-ray absorption spectroscopy to obtain information on the ultrafast energy transfer process at the NP/film interface, following photoexcitation of the plasmon resonance of Ag NP. We have observed ultrafast changes ($<$ 200 fs) of the Ce N4,5 absorption edge, revealing a highly efficient charge transfer from Ag NP to the Ce atoms of the CeO2 film[1]. These results also demonstrate the power of this technique for the characterization of energy transfer in these novel hybrid plasmonic/semiconductor materials. [1] J. S. Pelli Cresi et al., submitted for publication (2021).

O 92.3 Thu 10:30 P

Density-dependent electron-phonon coupling in multiband systems. — •Tobias Held, Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany

When a solid is irradiated with a short-pulsed visible light laser, the energy is almost entirely absorbed by the electrons while the lattice remains cold. The subsequent energy flow between electrons and phonons is commonly described by the electron-phonon coupling parameter, a central parameter in the Two-Temperature Model and most other temperature-based models.

This coupling parameter depends on a multitude of variables as reinforced by recent results. The most commonly considered dependence is the one on the electron temperature.

In this work we aim to see how the density distribution between different electronic subsystems affects the coupling parameter in combination with the electronic temperature. For the different electron subsystems we distinguish between orbital types in gold and spins in magnetic nickel. The results show that the total coupling strongly depends on the density distribution for gold, while for nickel the influence is compensated within both bands.

O 92.4 Thu 10:30 P

Electron-phonon coupling for different stages of relaxation dynamics after ultra-short laser-excitation — •Sebastian T. Weber and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany

For the excitation of metals with ultra-short laser pulses of visible light, the energy is absorbed by the electrons. Later, the energy is transferred to the phonons.

The strength of this energy transfer is determined by the electron-phonon coupling parameter. It in turn depends on a multitude of parameters, like the electronic temperature, the different stages of electronic nonequilibrium [1] and phononic properties [2].

We study the electron-phonon coupling in dependence on different states of ultra-fast dynamics after laser-excitation. First, the coupling strength is mostly determined by the electron temperature. It is also influenced by the laser-induced nonequilibrium electron distribution. With the heating of the phonons, the lattice temperature comes into play. The decreasing Debye Temperature [2] leads to a strong drop of the electron-phonon coupling strength. Moreover, the cooling of electrons by phonons induces a long-lasting nonequilibrium of the electronic system, which influences the coupling strength as well [1].

[1] S. T. Weber and B. Rethfeld, PRB **99**, 174313 (2019)
[2] M. Z. Mo *et al.*, Science **360**, 1451 (2018)

O 92.5 Thu 10:30 P

Electron Thermalization in laser-excited Graphite — •Katharina Hilgert, Sebastian T Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Erwin-Schroedinger- Strasse 46, 67663 Kaiserslautern, Germany

In this contribution we present a theoretical calculation of electron thermalization in a laser-excited graphite sample. Our calculations are motivated by an experimental paper applying trARPES, which concludes that the electron gas has reached a Fermi-Dirac distributed state only 50 fs after the excitation [1]. We have recreated these observations using a simulation based on full Boltzmann collision integrals [2] and were able to achieve comparable results. We then extended our examination by using two alternative analyzation methods utilizing the energy density of non-equilibrium electrons and the temporal evolution of the entropy, respectively. We have found that the method proposed in the experimental paper slightly underestimates the relaxation time but overall predicts results in an accurate order of magnitude.

[1] G. Rohde *et al.*, PRL **121**, 256401 (2018)
[2] B.Y. Mueller and B. Rethfeld, PRB **87**, 035139 (2013)

O 92.6 Thu 10:30 P

Ultrafast dynamics of direct and indirect excitation pathways of the topologically protected surface state on Sb2Te3 — •Jan Böhnke[1], Haydar Altug Yildirim[1], Cornelius Gahl[1], Jaime Sánchez-Barriga[2], Oliver Rader[2], and Martin Weinelt[1] — [1]Fachbereich Physik, Freie Universität Berlin, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany

Dirac cone like topologically protected surface states (TSS) have attracted high interest for spintronic applications due to their specific spin texture in momentum space and the long electron mean free path because of reduced scattering phase space. Optical control of electric currents at the surface of topological insulators has been discussed controversially. We investigated the role of direct and indirect population channels for the TSS on Sb_2Te_3 in 2D momentum space by time- and angle-resolved two-photon photoemission spectroscopy. Excitation with 1.55 eV photons leads to an initially anisotropic population of the Dirac cone depending on the helicity of the excitation pulse.

This circular dichroism however predominantly exhibits a 3-fold symmetry, which reflects the symmetry group of the bulk material but does not correspond to a macroscopic current in the TSS. Since the photon energy exceeds the bulk band gap, the optical excitation creates also a significant electron population in the conduction band, which relaxes towards the band minimum on the timescale of few 100 fs. On the same timescale electrons scattered from the conduction band dominate the population in the TSS so that the anisotropy decays rapidly.