O 92: Poster Session - Ultrafast Electron Dynamics at Surface and Interfaces II

Time: Wednesday 18:15–20:00 Location: P2/1OG

O 92.1 Wed 18:15 P2/1OG

Electronic energy transfer during scattering of H^+/Al(111) studied with TDDFT-MD and adiabatic GGA — •Lukas Deuchler and Eckhard Pehlke — Institut für Theoretische Physik und Astrophysik, CAU Kiel, 24098 Kiel, Germany

In order to quantify the electronic energy transfer that occurs during the scattering of hyperthermal H^+ ions incident on the on-top position of an Al(111) surface, Ehrenfest molecular dynamics simulations based on time-dependent density functional theory have been performed. The Al-surface is represented by a cluster geometry. We have used the Octopus code [1] by A. Rubio *et al.* Scattering and charge transfer of H^+ at Al surfaces has been studied experimentally and theoretically since long [2-4]. Here we extend our previous TDDFT-MD simulations of the charge transfer [4] and demonstrate how the electronic energy transfer (and thus the kinetic energy of the scattered hydrogen) is linked to the distance where the charge transfer occurs.

[1] X. Andrade *et al.*, Phys. Chem. Chem. Phys. **17**, 31371 (2015).
[2] H. Winter, J. Phys.: Condens Matter **8**, 10149 (1996).
[3] J. Merino *et al.*, Phys. Rev. B **54**, 10959 (1996).
[4] J. Merino *et al.*, Phys. Rev. B **57**, 1947 (1998).
[5] N. Schlünzen *et al.*, Contrib. Plasma Phys. e201800184 (2019).

O 92.2 Wed 18:15 P2/1OG

Describing the electronic nonequilibrium after ultrashort laser excitation — •Markus Uehlein, Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany

Laser-matter interaction is an important topic in fundamental research for industrial applications. The energy of ultrashort laser pulses in the visible range is only absorbed by the electrons of the solid and then transferred to the phonons. For this dynamics multiple descriptions exist, ranging from phenomenological models to kinetic simulations. Here, we want to compare an extension of the TTM [1] by a non-thermal electron distribution and its interactions [2], with a complete kinetic description applying complete Boltzmann Collision Integrals [3]. Both descriptions are applied for various metals. Results as well as the range of applicability of the models will be compared.

[1] S. I. Anisimov *et al.*, JETP **39**, 375 (1974)
[2] E. Carpene, PRB **74**, 024301 (2006)
[3] B. Y. Mueller and B. Rethfeld, PRB **87**, 035139 (2013)

O 92.3 Wed 18:15 P2/1OG

Dual-channel laser system with gap-less tuning from 250 - 1300 nm at megahertz repetition rates for time-resolved photoelectron-emission microscopy and spectroscopy — •Michael Schulz[1], Gregor Indorf[1], Ivanka Grguras[1], Jan-Heye Buss[1], Torsten Golz[1], Mark Prandolini[1,2], and Robert Riedel[1] — [1]Class 5 Photonics GmbH, Notkestrasse 85, 22607 Hamburg, Germany — [2]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

A dual-channel, high-power laser system with gap-less tuning from 250 - 1300 nm at 30 - 50 femtoseconds pulse duration is presented as the ideal tool for time-resolved photo-emission microscopy and spectroscopy experiments in order to study ultrafast condensed phase and interface dynamics. The system integrates an industrial Yb-doped femtosecond laser, two independently tunable optical-parametric amplifiers, second-harmonic generation and third-harmonic generation, and features repetition rates from 0.1 - 4 MHz with maximum average power of 3 W per channel.

O 92.4 Wed 18:15 P2/1OG

Implementation of a bichromatic beamline for time-resolved two-photon momentum microscopy — •Martin Mitkov, Ralf Hemm, Florian Haag, Sebastian Emmerich, Sebastian Hedwig, Martin Aeschlimann, and Benjamin Stadtmüller — University of Kaiserslautern and Research Center OPTIMAS, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern

Mapping excited state dynamics in momentum space on a femtosecond time scale by time-resolved two-photon photoemission is an important prerequisite for understanding the optical and transport properties of new functional and materials. This is typically challenging for molecular materials due to their large ionization potential.

Here, we present a novel beamline for our momentum microscope [1] that is optimized for molecular spectroscopy with femtosecond time-resolution. It consists of a bichromatic UV beamline for 3 eV pump, 6 eV probe spectroscopy. The femtosecond time resolution will be demonstrated by cross-correlation measurements using a C_{60} multilayer film evaporated on Cu(111) as model system. For comparison, we will show autocorrelation traces recorded for the 3 eV probe pulse on a clean Cu(111). Finally, the capability of our approach of time-resolved momentum microscopy for molecular materials will be discussed for the prototypical molecular system C_{60} on Cu(111).

[1] F. Haag et al., Rev. Sci. Instr. 90, 103104 (2019)

O 92.5 Wed 18:15 P2/1OG

Energy and momentum streaking in subcycle THz-ARPES — •Jens Güdde[1], Johannes Reimann[1], Suguru Ito[1], Stefan Schlauderer[2], Christoph Schmid[2], Christoph Lange[2], Rupert Huber[2], and Ulrich Höfer[1] — [1]Fachbereich Physik, Philipps-Universität Marburg, Germany — [2]Fakultät für Physik, Universität Regensburg, Germany

Recently, we have demonstrated a novel concept of subcycle THz-ARPES, which permits a direct access to carrier transport in non-trivial band structures with high time resolution [1]. This concept employs time- and Angle-Resolved Photoelectron Spectroscopy (ARPES) to observe how the carrier wave of a THz pulse accelerates Dirac fermions in the topological surface state of Bi_2Te_3.

Here, we will show that in addition to this acceleration within the sample, the THz electric field also leads to an energy and momentum streaking of the photoemitted electrons, the size of which depends on its polarization direction. For UV photoemission pulses that are much shorter than the period of the THz driving field, this streaking can be used for an in-situ sampling of the electric field at the sample surface, but also needs to be taken into account for a correct interpretation of the photoelectron spectra. We will discuss how the acceleration within the sample and the streaking in front of the surface both affect energy and momentum of the detected photoelectrons in a different manner, and how these contributions can be disentangled.

[1] J. Reimann *et al.* Nature **562**, 396 (2018).

O 92.6 Wed 18:15 P2/1OG

Localized linear photoemission from a cold field emitter — •Alexander Schröder, Jelto Jordan, Nora Bach, Christopher Rathje, and Sascha Schäfer — Institute of Physics, University of Oldenburg, Germany

Ultrafast transmission electron microscopy (UTEM) combines the femtosecond temporal resolution of a pump-probe approach with the nanometer spatial resolution of a TEM. Further improving the spatio-temporal resolution in UTEM requires the development of novel high-coherence photoelectron sources with stable laser-driven emission currents over long time periods.

Here, we report on the current status of our development of a laser-driven cold field emitter. Using a field ion microscope, we prepared atomically clean (311)-oriented sharp tungsten tips. Above a certain threshold potential localized photoemission from these tips is observed using a continuous-wave 355-nm laser beam focused onto the tip apex. Photocurrent characterization yields a stable, linear photoemission regime in the fA-range, ideally suited for application in UTEM.

O 92.7 Wed 18:15 P2/1OG

Momentum Microscope vs. Hemispherical analyzer - a quantitative comparison of electron analyzer performance for time-resolved ARPES experiments — Julian Maklar, Tommaso Pincelli, Samuel Beaulieu, Shuo Dong, Maciej Dendzik, Martin Wolf, Ralph Ernstorfer, and •Laurenz Rettig — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany

For angle-resolved photoelectron spectroscopy (ARPES), an important element is the employed electron analyzer. While hemispherical analyzers with angle-dispersing electron lenses have been the working horse for decades, recently time-of-flight based momentum microscopes have shown a huge improvement in parallel detection efficiency, allowing for simultaneous detection of multiple Brillouin zones without the

need to rearrange the sample geometry. However, one drawback of such instruments, in particular in time-resolved studies, arises from the large energy and momentum range covered simultaneously, which in combination with detection limitations of delay-line detectors can severely reduce the effective detection rate for selected energy-momentum regions compared to conventional hemispherical analyzers. Additionally, the high electron energies employed in the more complex electron lens system designs impose new constraints in terms of space charge. Using our XUV time-resolved ARPES system hosting both a hemispherical analyzer (SPECS Phoibos 150) and a momentum microscope (SPECS Metis 1000) in one experimental setup, we quantitatively compare the advantages and disadvantages of both types of analyzers for various kinds of trARPES experiments.

O 92.8 Wed 18:15 P2/1OG

Observation of electron excitation dynamics by time-resolved two-photon momentum microscopy based lifetime analysis — •Lars Pidde, Florian Haag, Tobias Eul, Eva Walther, Benjamin Stadtmüller, and Martin Aeschlimann — Department of Physics and research center OPTIMAS, TU Kaiserslautern

The investigation of the dynamics of hot electrons are fundamental to understand many chemical and physical phenomena at surfaces, interfaces or in bulk materials. The evolution of such electrons on ultrafast timescales are dominated by inelastic and elastic scattering processes which simultaneously affect both the electron energy and their momentum. To capture these complex dynamics, we present a data analysis scheme based on time-resolved two-photon momentum microscopy [Rev. Sci: Instrum. 90, 103104 (2019)]. It incorporates the well established *tr-2PPE* experiments, momentum resolved *photoemission electron microscopy* and either *double hemispherical* or *time-of-flight* energy analyzers. To determine lifetimes of electrons in predefined energy and momentum regions we present a data analysis scheme to create so called lifetime maps at constant energies.

The capability of this approach is exemplary illustrated by the study of a metallic surface.