O 40: Ultrafast electron dynamics at surface and interfaces – Poster (joint session O/TT)

Time: Tuesday 14:00–16:00 Location: P2

O 40.1 Tue 14:00 P2

Nonequilibrium phonon dynamics after laser-excitation — Tobias Held, Christopher Seibel, Markus Uehlein, •Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

Electron-phonon coupling is a fundamental process governing the energy relaxation dynamics of solids excited by ultrafast laser pulses. While this coupling is often described in terms of an effective electron temperature, recent works have highlighted the important roles of both nonequilibrium electronic distributions and detailed phononic properties.

In this study, we investigate how nonequilibrium electron occupations, phonon stiffness, and wavenumber-resolved coupling collectively shape the energy exchange between electrons and the lattice in metals. We find that deviations from thermal electronic distributions can substantially modify the coupling parameter, challenging the conventional assumption that electron temperature alone determines the coupling strength. We further identify a roughly quadratic scaling of the coupling parameter with phonon stiffness, with high-wavenumber phonon modes consistently dominating the interaction. Finally, we demonstrate that this preferential coupling leads to the emergence of hot phonons near the Brillouin-zone boundary, which in turn induces a collapse of the overall energy transfer rate and significantly delays electron-phonon equilibration.

O 40.2 Tue 14:00 P2

Comparing temperature change during light-matter interaction of thermal and athermal electron systems — •Fabio A. Müller, Tobias Held, Christopher Seibel, Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

When an ultrashort laser pulse irradiates a metal, the electronic system initially absorbs energy and is driven far from equilibrium. This transient nonequilibrium distribution modifies the light-matter interaction, in part through changes in Pauli blocking, while electron-electron scattering concurrently drives the system toward a hot Fermi-Dirac distribution. Consequently, ultrashort laser pulses of the same fluence but different duration lead to different absorption, even in the linear regime.

Here, we investigate how the capability of an electron ensemble to absorb photons depends on its instantaneous energy distribution. Specifically, we compare the absorption arising from nonequilibrium electron distributions with that of Fermi-Dirac distributions carrying the same energy density. Our results show that, for realistic materials, the relative absorption is highly sensitive to the photon energy, a behavior that can be traced back to distinct features in the electronic density of states.

O 40.3 Tue 14:00 P2

Role of non-thermal electrons on energy dissipation and phase transition in laser excited metals — •Lukas Jonda, Tobias Held, Markus Uehlein, Christopher Seibel, Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics andResearch Center OPTIMAS, RPTU Kaiserslautern-Landau

The influence of non-equilibrium electrons on energy dissipation and phase transitions is not well understood. It is known that during femtosecond laser irradiation of a surface, electrons are excited to a state of non-equilibrium in space and energy. These highly excited electrons then transport energy ballistically into the bulk. On a picosecond timescale, electrons transfer energy to the lattice via electron-phonon collisions. If the transferred energy is large enough to reach the melting point, the crystal lattice can undergo a phase transition.

We developed a hybrid model that combines a kinetic Monte Carlo simulation and a two-temperature model. The latter describes diffusive transport as well as electron-phonon equilibration, and the former describes primary electron excitation by the laser pulse, transport of non-equilibrium electrons, and secondary electron generation.

We present results for gold, where the influence of non-equilibrium electrons on energy transport is expected to be significant, due to the long mean free path of its electrons. Finally, we are interested in the influence of non-equilibrium electrons on the melting process.

O 40.4 Tue 14:00 P2

Capturing thermalization through electron-electron scattering with machine learning — •David L. Kaiser, Tobias Held, Christopher Seibel, Markus Uehlein, Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

Ultrafast excitation of metals by optical laser pulses induces nonequilibrium energy distributions in the electron system. This nonequilibrium gives rise to complex electron-electron scattering processes, which typically restore a Fermi-Dirac distribution on a femtosecond timescale. Accurately modelling the thermalization requires evaluating the full electron-electron collision integral, which is however computationally costly.

In this study, we explore the possibility to use machine learning to emulate the dynamics generated by the full collision integral. Our goal is to significantly accelerate these calculations, enabling efficient simulations of bulk and multilayer systems. This approach opens the door to uncovering new relaxation pathways and predicting the response of complex material systems to ultrafast excitation.

O 40.5 Tue 14:00 P2

Studies of laser ablation of band-gap materials — •Markus Bonifer[1,2], Sebastian T. Weber[1], Nils Cremer[2,3], Gabriel Schaumann[2,3], and Baerbel Rethfeld[1] — [1]Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, Germany — [2]Focused Energy GmbH, Im Tiefen See 45, 64293, Darmstadt, Hessen, Germany — [3]Institute of nuclear physics (IKP), Technische Universität Darmstadt, Darmstadt, Germany

We aim to explore laser ablation as a possible approach for creating clean, well-defined microholes in polymers used for laser fusion targets where symmetry and control of surface roughness are important. Because polymers differ widely in their properties, general insights into laser material interaction are sought through modeling of density-dependent excitation in band-gap materials.

The theoretical models used are based on the density-dependent two-temperature model (nTTM) and extended multiple rate equations (EMRE). These calculations are intended to guide experimental studies carried out in collaboration with Focused Energy to identify suitable processing conditions and improve overall feature quality.

O 40.6 Tue 14:00 P2

Thermalization of optically excited electrons in metals: electron-electron scattering dynamics — •Stephanie Roden, Christopher Seibel, Tobias Held, Markus Uehlein, Sebastian T. Weber, and Baerbel Rethfeld — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

When a metal is irradiated with a short-pulsed optical laser, the electron distribution is disturbed into a state far from equilibrium. On a femtosecond timescale, the non-thermal electrons thermalize by collisions with each other, which drives the electrons towards a hot Fermi distribution.

In this work, we present a derivation of the full electron-electron Boltzmann collision integral within the random-$\boldsymbol{k}$ approximation. Building on this approach, we trace the temporal evolution of the electron energy distribution in metals after ultrafast excitation. Furthermore, we examine to which extent the resulting dynamics can be captured by the numerically simpler relaxation time approach, applying a constant and an energy-dependent relaxation time derived from Fermi-liquid theory.

We find a better agreement with the latter, while specific features caused by the balance of scattering and reoccupation can only be captured with a full collision integral.

O 40.7 Tue 14:00 P2

Time-resolved PEEM and μARPES using a 100 kHz ToF momentum microscope — •Isabella Alexandra Hofmeister[1,2], Michael Herb[1,2], Maria Federl[1], Franz Seitz[1], and Isabella Gierz[1,2] — [1]University of Regensburg, Regensburg, Germany — [2]Regensburg Center for Ultrafast Nanoscopy - RUN, Regensburg, Germany

Momentum microscopy provides energy-resolved imaging in real and reciprocal space with $< 100\,\mathrm{meV}$ resolution, combining PEEM

($\Delta x < 40\,\mathrm{nm}$ lateral resolution) and μARPES ($\Delta k < 0.02\,\mathrm{Å}^{-1}$) capabilities. We implemented an ultrafast setup with a time-of-flight momentum microscope and a 100 kHz laser system delivering 6 eV probe pulses and pump pulses tunable from the mid-infrared to visible range. Procedures for converting time-of-flight to kinetic energy and for establishing spatial and temporal pump-probe overlap are discussed. Proof-of-principle time-resolved PEEM and μARPES experiments on the topological insulator Bi_2Se_3 demonstrate femtosecond-resolved carrier dynamics with high spatial and momentum precision.

O 40.8 Tue 14:00 P2

First steps with a qPlus-based MIR AFM — •Furkan Özyigit, Lukas Böhm, Leonie Weiss, Jay Weymouth, Rupert Huber, and Franz Giessibl — University of Regensburg, 93053 Regensburg

We report initial progress in an ultrafast non-contact atomic force microscope/scanning tunneling microscope (NC-AFM/STM) platform based on qPlus sensors, integrated with a CEP-stabilized mid-infrared (MIR) pump-probe system and tunable optical parametric amplifier (OPA) for versatile excitation. In first experiments, we successfully induced transient tunneling currents on Cu(111) using MIR pulses, demonstrating precise control of ultrafast electronic excitation at the atomic scale via laser-coupled tunneling. While the tunneling cur- rent reflects the ultrafast electronic excitation dynamics, the qPlus sensor permits complementary force detection to monitor subsequent structural or electrostatic interaction changes, such as those resulting from induced charge redistribution or lattice relaxation. This enables simultaneous probing of electronic and mechanical dynamics with femtosecond time and sub-nanometer spatial resolution. Beyond investigations of transient electrostatic forces, this versatile system facilitates a broad class of ultrafast nanoscale experiments, including scattering-type scanning near-field optical microscopy (s-SNOM) for imaging carrier and phase dynamics, time-resolved tip-enhanced spectroscopy for molecular states, and pump-probe tunneling spectroscopy.

O 40.9 Tue 14:00 P2

Image potential states of oxide quasicrytals — •Barbara Drobinski[1], Friederike Wührl[1], Richard Kraska[1], Konrad Gillmeister[1], Stefan Förster[1], Cheng-Tien Chiang[2], and Wolf Widdra[1] — [1]Institute of Physics, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]Institute of Atomic and Molecular Sciences , Academia Sinica, Taipeh, Taiwan

Quasicrystals are aperiodically ordered materials that lack translational symmetry. Their aperiodic potentials give rise to an infinitely dense set of Fourier components, which can induce gaps and mini-gaps in the electronic band structure. Here, we investigate this phenomenon for nearly free-electron-like image-potential surface states, where electrons propagate in front of the surface while experiencing the aperiodic potential. Using momentum-resolved two-photon photoemission, we determine both the electronic dispersion and relaxation dynamics of oxide quasicrystals (OQCs) based on Ba-Ti-O/Pt(111) [1] and Eu-Ti-O/Pt(111). The latter is obtained via Eu decoration of a Ti_2O_3 honeycomb precursor [2]. In both systems, we observe n=1 and n=2 image potential states, located 340 meV (360 meV) and 150 meV (190 meV) below the vacuum level for Ba-Ti-O (Eu-Ti-O), respectively. The states exhibit parabolic dispersions without apparent gap openings. We discuss the momentum-dependent electron lifetimes in the context of possible mini-gaps in the underlying aperiodic potential.
[1] S. Förster *et al.*, Nature **502**, 215 (2013)
[2] M. Haller *et al.*, http://arxiv.org/abs/2510.11426

O 40.10 Tue 14:00 P2

Ultrafast Electron Diffraction Study of Lattice Dynamics in Elemental Chromium — •Justus Richter[1,2], Victoria Taylor[1], Hyein Jung[1,2], Ralph Ernstofer[1,2], and Yoav William Windsor[1,2] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Institut für Physik und Astronomie, Technische Universität Berlin

Femtosecond electron diffraction (FED) allows to quantitively study ultrafast atomic motion. Here we use FED to study photoinduced atomic motion in Cr. We saw that measurements taken above- and below T_N exhibit qualitatively different responses from the lattice, hinting to the effect of the spin-induced periodic lattice distortion within the antiferromagnetic Cr phase, though further investigation is required. A two temperature model (TTM) was used to model the energy flow between the electronic and lattice subsystems by which we extract an estimate for the electron-phonon coupling constant $G_{ep} = (4.8 \pm 0.6) \times 10^{17}\ \mathrm{Jm^{-3}K^{-1}}$, which fits into the wide range of values reported in literature. Finally, we measured Cr side-by-side with Pt and demonstrate qualitative differences in their temporal responses, including a significantly faster thermalization of the Cr lattice and differences in the shape of their temporal response.

O 40.11 Tue 14:00 P2

Ultrafast electron dynamics in the valence-fluctuating intermetallic $EuIr_2Si_2$ — •Abeer Arora[1], Túlio de Castro[1], Amine Wahada[1], Lawson Lloyd[1], Tommaso Pincelli[2], Kristin Kliemt[3], Cornelius Krellner[3], Denis V. Vyalikh[4,5], Yoav Will Windsor[2], Martin Wolf[1], Ralph Ernstorfer[1,2], and Laurenz Rettig[1] — [1]Fritz Haber Institute of the Max Planck Society, Berlin, Germany — [2]Institut für Physik und Astronomie, TU Berlin, Germany — [3]Physikalisches Institut, Göthe-Universität Frankfurt, Germany — [4]Donostia International Physics Center, San Sebastián, Spain — [5]Ikerbasque, Basque Foundation for Science, Bilbao, Spain

$EuIr_2Si_2$ is a valence-fluctuating intermetallic compound that, despite its non-magnetic bulk, develops 2D ferromagnetic order below 48 K in the topmost Eu layer due to a stable Eu^{2+} configuration. Its heavy Ir ions generate strong Rashba spin-orbit coupling, which interacts with magnetic exchange and influences the surface electronic states. Probing the non-equilibrium dynamics of the 2D electrons in the Si-Ir-Si surface layer offers a direct way to study the coupling of the spin-orbit and surface magnetic interaction. Using femtosecond XUV time- and angle-resolved photoemission spectroscopy, we investigate how the surface states evolve following photoexcitation with a 1.55 eV pulsed laser. Our preliminary results show an ultrafast quenching of the surface-state splitting, which we discuss in terms of demagnetization of the Eu 4f moments and modified spin-orbit coupling.

O 40.12 Tue 14:00 P2

Ultrafast STEM locked to GHz sample excitation — •Andreas Wendeln[1], Alexander Schröder[1], Sakal Singla[1], and Sascha Schäfer[1,2] — [1]Department of Physics, University of Regensburg, Regensburg, Germany — [2]Regensburg Center for Ultrafast Nanoscopy (RUN), Regensburg, Germany

Ultrafast transmission electron microscopy (UTEM) has been an established method for investigating nanoscale dynamics for several years, combining the nanometer spatial resolution of TEM with the femtosecond temporal resolution of a pump-probe approach. In recent years, there have been numerous advances in the development of new femtosecond electron sources, such as laser-driven Schottky [1] or cold-field emitters [2]. A combination of these sources with advanced electron optical elements, such as a probe aberration corrector, is expected to deliver even smaller electron spot sizes and to increase the available pulsed current but was not yet demonstrated. Here, we present a measurement scheme for ultrafast STEM with a focus on magnetic imaging, utilizing an aberration corrector and a laser-driven cold-field emitter. In initial measurements using a continuous photoelectron beam, the measurement method is characterized regarding experimental parameters, such as probe currents, focal spot sizes, and stability. Subsequently, we report the locking of femtosecond electron pulse train at repetition rates between 100 kHz up to 80 MHz to GHz radiofrequency currents which we aim to employ for DPC and ptychography imaging schemes of current-driven magnetic dynamics. [1] Feist et al., Ultramicroscopy, 2017. [2] Schröder et al., Ultramicroscopy, 2025.

O 40.13 Tue 14:00 P2

Probing Ultrafast Structural Dynamics in Multilayer Graphene Using ULEEM — •Simon Briesenick[1,2,4], Johannes Otto[1,2,4], Leon Brauns[1,2], Philip Schädlich[3], and Claus Ropers[1,2] — [1]Department of Ultrafast Dynamics, Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Göttingen, Germany — [3]Institute of Physics, TU Chemnitz, Chemnitz, Germany — [4]authors contributed equally

Multilayers of graphene (MLG) exhibit electronic and structural properties that vary strongly with, e.g., layer number and stacking order, making MLG a suitable model platform for studying ultrafast phenomena in two-dimensional materials [1]. We investigate the behavior of MLG after excitation with ultrashort light pulses using our newly developed ultrafast low-energy electron microscope (ULEEM) [2]. The instrument allows for the investigation of surface structural dynamics with sub-picosecond and nanometer spatial resolution, utilizing low-energy ($\leq$ 100 eV) ultrashort probe electron pulses. We present first data on the light-induced Debye-Waller effect in MLG, demonstrating the potential of ULEEM studies for resolving ultrafast structural behavior in MLG.

[1] K. V. Emtsev, et al. Phys Rev B. 77, 155303 (2008) [2] J. Otto et al. (in preparation)

O 40.14 Tue 14:00 P2

Hot-electron dynamics in moiré structures studied with resonant scanning tunneling spectroscopy — •Martin Lülff, Marta Przychodnia, Maciej Bazarnik, and Anika Schlenhoff — Institute of Physics, University of Münster, Germany

To study hot-electron dynamics in Gr-metal heterostructures, image-potential states (IPSs) serve as ideal model system. While their energies are known to be highly sensitive to the respective Gr-metal distance variation within the moiré unit cell [1, 2], recent two-photon photoemission experiments suggest moiré-site dependent lifetimes [3].

Here, utilizing the high spatial resolution of resonant scanning tunneling microscopy (STM) and spectroscopy (STS) we study the moiré-site dependent IPSs' lifetimes for highly corrugated Gr/Fe/Ir(111) and Gr/Ir(111), respectively. Comparing these resonant STS data with those recorded on bare Fe/Ir(111) and Ir(111), respectively, enables the influence of the varying Gr-metal distance on the lifetimes to be distinguished from that of the underlying metal substrate. We analyse the IPSs' lifetimes for a Stark shift in their energies by applying various electric field strengths in current-dependent STS series, and discuss the results in terms of their resulting energetic positions with respect to the underlying unoccupied electronic band structure. Our work contributes to an in-depth understanding of electron transfer processes at Gr-metal interfaces.

[1] M. Bazarnik and A. Schlenhoff, ACS Nano **19**, 25812 (2025)
[2] N. Armbrust *et al.*, New J. Phys. **17**, 103043 (2015)
[3] N. Armbrust *et al.*, Phys. Rev. Lett. **108**, 056801 (2012)

O 40.15 Tue 14:00 P2

Photo-induced electron pressure drives THz phonon in Platinum-Copper superlattice — •Jan-Etienne Pudell[1], Maximilian Mattern[2,3], Marc Herzog[2], Alexander von Reppert[2], Daniel Schick[3], Chandan Singh[4], Peter M. Oppeneer[4], Michel Hehn[5], Ulrike Boesenberg[1], Angel Rodriguez-Fernandez[1], Roman Shayduk[1], Wonhyuk Jo[1], Johannes Möller[1], Jörg Hallmann[1], James Wrigley[1], Matias Bargheer[2,6], and Anders Madsen[1] — [1]European XFEL — [2]University Potsdam — [3]MBI, Berlin — [4]Uppsala University — [5]IJL, Université Lorraine — [6]HZB Berlin

Using ultrafast X-ray diffraction (UXRD) at the MID end-station at the European XFEL, we investigate the ultrafast lattice dynamics of metal-metal superlattice (SL) with few atomic layers of Pt and Cu upon femtosecond photoexcitation. Our results reveal that the absorbed optical energy is rapidly localizes within the Pt layers, driving the excitation of a coherent artificial THz phonon mode defined by the superlattice period. The signal's amplitude and phase modulation of the SL Bragg peaks induced by the lattice excitation i.e. the artificial THz phonon, are predominantly driven by electron pressure within the first picosecond. This response is faster than the Debye-Waller effect, which is limited by the electron-phonon coupling time.

O 40.16 Tue 14:00 P2

Experimental realization of an interferometric XUV-trARPES experiment with phase-stabilized IR pulses — •Antonius Naujok[1], Gregor Zinke[1,2], Franz Spartz[1], Sebastian Hedwig[1], Tobias Eul[2], Martin Aeschlimann[1], and Benjamin Stadtmüller[2] — [1]Department of Physics and Re search Center OPTIMAS, RPTU University Kaiserslautern- Landau, 67663 Kaiserslautern, Germany — [2]Experimental Physics II, Institute for Physics, University of Augsburg, 86159 Augsburg

Layered 2D van der Waals materials, such as TMDCs, have been extensively studied for their optical properties and coherent responses. However, exploring coherent excitations and dephasing processes in such materials using time-resolved ARPES is challenging because the key points of the materials' band structure cannot be accessed using phase-stabilized pulses in the visible regime, as has been done in most experiments thus far [1]. To overcome this limitation, we introduce a modified version of coherent multidimensional spectroscopy. This new method is based on time-resolved ARPES and utilizes a pair of phase-stabilized femtosecond infrared (fs-IR) pulses in combination with femtosecond XUV pulses for photoionization. We demonstrate the feasibility of our approach by focusing on the A-exciton excitation and the subsequent carrier dynamics in WSe_2. Through temporal Fourier-analysis of the entire ARPES spectrum, we're able to resolve distinct frequency components within characteristic features of the WSe_2 electronic band structure. [1] M. Aeschlimann et al., Phys. Rev. B. 105, 205415 (2022)

O 40.17 Tue 14:00 P2

Implementation of white light continuum probing for pump-probe spectroscopy — •Joris Wicker, Tim Titze, Maximilian Staabs, Jacob Kutzner, Stefan Mathias, and Daniel Steil — University of Göttingen, 1. Institute of Physics, Göttingen, Germany

We integrated a white-light continuum (WLC) probe together with a prism spectrometer in a conventional two-color femtosecond pump-probe setup. Further, we developed a custom measurement program using Microsoft's .NET Framework and Python, enabling instrument control, automated measurement sequences, and preliminary data analysis. To test the modified setup and software, we investigated the transient evolution of the reflectivity in metallic thin film systems and perovskite oxides using 1030 nm pumping. Spectrally and temporally resolved reflectivity variations were observed, confirming the proper functionality of the system. Furthermore, the stability of the WLC source was characterized. Possible future improvements include integrating a Wollaston prism to enable spectrally and time-resolved magneto-optical Kerr effect (MOKE) measurements.

O 40.18 Tue 14:00 P2

Investigation of the light-dressed bandstructure of graphene — •Lina Segerer[1], Marco Merboldt[1], Mattis Langendorf[1], Paul Werner[1], Jan Philipp Bange[1], Junde Liu[1], Wiebke Bennecke[1], Marcel Reutzel[2], and Stefan Mathias[1] — [1]Georg-August-Universität Göttingen, I. Physikalisches Institut, Germany — [2]Philipps-Universität Marburg, Germany

Time-periodic driving of solids with strong laser fields enables optical control of material properties. Photon-driven systems not only exhibit replicas of their equilibrium band structure, known as Floquet-Bloch states, but can undergo non-trivial topological phase transitions when excited with circularly polarized light. Recent advances in angle-resolved photoemission spectroscopy (ARPES) have shown that Floquet-Bloch states can be generated in graphene using linear polarized laser pulses [1,2]. However, the oblique incidence angle of the pump pulse so far has limited the realization of a purely circularly polarized light field. In this study, we overcome this challenge by integrating an extra beam path in our ultrafast momentum microscopy (MM) setup enabling backside normal-incidence excitation with linearly and strictly circularly polarized IR pump pulses. We observe light-induced Floquet-Bloch states and investigate the polarization dependence of Floquet-Volkov interference as well as modifications in the light-dressed band structure of epitaxial graphene.

[1] M. Merboldt *et al.*, Nat. Phys. **21**, 1093 (2025).
[2] D. Choi *et al.*, Nat. Phys. **21**, 1100 (2025).

O 40.19 Tue 14:00 P2

Table-top 3D ultrafast momentum microscopy with a time-preserving EUV-monochromator — •Lennart Weinhagen[1], Wiebke Bennecke[1], Jan Philipp Bange[1], David Schmitt[1], Marco Merboldt[1], Bent van Wingerden[1], Thi Lan Dinh[2], Fabio Frasetto[3], Luca Poletto[3], Marcel Reutzel[1], Daniel Steil[1], D. Russel Luke[2], Stefan Mathias[1], and G.S. Matthijs Jansen[1] — [1]1st Institute of Physics, University of Göttingen, Göttingen, Germany — [2]Institute for Numerical and Applied Mathematics, University of Göttingen, Göttingen, Germany — [3]Institute for Photonics and Nanotechnologies CNR-IFN, Padova, Italy

Photoemission momentum microscopy with tunable probe-photon energy gives unique access to electronic and molecular structures, enabling Fermi-surface imaging, photoemission electron diffraction (PED) and 3D orbital tomography (3D-POT). However, such measurements have largely relied on synchrotron radiation, thus limiting their use in femtosecond-resolved experiments. Here, we present a table-top EUV source with a time-preserving monochromator driven by a 1030 nm femtosecond laser, using an off-plane grating at grazing incidence to reduce spatial chirp. Integrated into our time-resolved momentum microscope [1], it delivers femtosecond, photon-energy-tunable EUV probe pulses. Demonstrated on PTCDA/Ag(110), the setup enabled full 3D reconstruction of the frontier orbitals highlighting the potential of laboratory-scale, energy-selective momentum microscopy [2].

[1] Schmitt *et al.*, Nature 608, 499-503 (2022).
[2] Bennecke *et al.*, arXiv:2502.18269 (2025).

O 40.20 Tue 14:00 P2

Multimode momentum microscopy of cleaved 1T-TaS_2 crys-

tals — •Bent van Wingerden[1], Olena Tkach[2], Hashima Marukara[1], Jan Philipp Bange[1], Wiebke Bennecke[1], Marcel Reutzel[3], Junde Liu[1], Gerd Schönhense[2], and Stefan Mathias[1] — [1]Georg-August-Universität Göttingen, Germany — [2]Johannes Gutenberg-Universität Mainz, Germany — [3]Philipps-Universität Marburg, Germany

Ultrafast momentum microscopy has evolved as one of the most powerful tools to study non-equilibrium electronic structure dynamics of 2D quantum materials [1]. However, the large electric field strength generated by the immersion lens limits its versatility in terms of sample systems. One critical issue is related to vacuum-cleaved van-der-Waals-crystals that often show microscopic protrusions, which are prone to field-induced electron emission and flashovers, both of which can destroy the sample itself as well as the microscope's electronics. In our work, we test the momentum imaging capabilities of a newly designed multimode momentum microscope [2,3] in combination with an EUV table-top HHG source. Using vacuum-cleaved bulk crystals of *1T*-TaS_2, we show that operating in modes of reduced electric field strength at the sample position suppresses field emission, while still preserving the field-of-view and imaging quality. We carry out detailed comparisons of different operating modes with the new lens system.

[1] Reutzel, Jansen, Mathias, *Adv. in Phys. X* 9, 2378722 (2024).
[2] Tkach & Schönhense, *Ultramicroscopy* 276, 114167 (2025).
[3] Tkach et al., arXiv:2401.10084 (2024).

O 40.21 Tue 14:00 P2

Towards time-resolved momentum microscopy of plasmon excited quantum materials — •Mattis Langendorf[1], Lina Segerer[1], Paul Werner[1], Marco Merboldt[1], Jonas Pöhls[1], Tobias Meyer[1], Daniel Steil[1], Junde Liu[1], Jan Philipp Bange[1], Wiebke Bennecke[1], G. S. Matthijs Jansen[1], R. Thomas Weitz[1], Marcel Reutzel[2], and Stefan Mathias[1] — [1]Georg-August-Universität Göttingen, Germany — [2]Philipps-Universität Marburg, Germany

For the realization of Floquet*Bloch engineering as well as for the study of formation and propagation of excitons in two-dimensional quantum materials using time- and angle-resolved photoemission spectroscopy (ARPES), a highly localized excitation on a micron scale seems ideal [1]. However, achieving such spatial confinement poses a significant experimental challenge. Surface plasmon polaritons (SPPs) offer a promising solution, as these collective charge-carrier oscillations enable strong electromagnetic field localization and can therefore provide the required tightly focused excitation conditions [2]. In combination with femtosecond momentum microscopy that enables spatiotemporal access to electron and exciton dynamics [3], we investigate the concept of exploiting SPPs as a driving field to excite quantum materials.

[1] Merboldt *et al.*, Nat. Phys. **21**, 1093*1099 (2025).
[2] Dreher *et al.*, Nanophotonics **11**, 3687-3694 (2022).
[3] Reutzel, Jansen, Mathias, Adv. in Phys. X **9**, 2378722 (2024).