Workshop to explore the Science Potential of high power CW VUV FELs

Report of Contributions

https://indico.desy.de/e/22649

Contribution ID: **0** Type: **not specified**

Radiation Source ELBE Upgrade Considerations

Thursday, 2 May 2019 09:30 (30 minutes)

The Radiation Source ELBE at Helmholtz-Zentrum Dresden-Rossendorf (HZDR) is a user facility based on a 1 mA - 40 MeV CW SRF LINAC. Presently HZDR is considering upgrade options for the ELBE or its replacement with a new CW, SRF LINAC-based user facility. A part of the user requirements is the capability to generate IR and THz pulse in the frequency range from 0.1 through 30 THz, with pulse energies in the range from 100 uJ through a few mJ, at the repetition rate between 100 kHz and 1 MHz.
In addition to the high pulse energy IR-THz capability, an addition of short wavelength probes is considered. It is envisioned that the IR-THz beams and short wavelength probe beams could operate simultaneously.
The two flavors of short wavelength probes are under consideration. One of them is the ultrafast electron diffraction (UED) made with an electron beam of a few MeV beam energy, and bunch length as short as 10 fs. Another kind of short wavelength probe can be a photon beam in UV and VUV wavelength range generated by FELs.
The CW SRF accelerator technology presently used at ELBE would allow construction of a CW FEL system(s) with statistical and spectral properties superior to a SASE FEL. We present a preliminary consideration on the possible performance of a UV oscillator operating in the wavelength range from 150 nm through 450 nm. Such an oscillator could be used as a continuously tunable, high repetition rate seed for an HGHG FEL system operating in the wavelength range from 50 nm through 150 nm. The UV oscillator and the VUV HGHG FEL could operate with pulse energies of at least 30 uJ, and with pulse length on the order of 100 fs. In this contribution, we outline the key accelerator and FEL aspects of the concept, which will allow achieving such photon beam parameters.

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Co-authors: Dr ARNOLD, André (HZDR); Dr SCHNEIDER, Christof (HZDR); Dr TEICHERT, Jochen (HZDR); Dr KLOPF, John Michael (HZDR); Dr KUNTZSCH, Michael (HZDR); Prof. MICHEL, Peter (ELBE); Mrs XIANG, Rong (HZDR); Prof. COWAN, Tom (HZDR); Dr LEHNERT, Ulf (Helmholtz-Zentrum DResden-Rossendorf)

Presenter: Dr EVTUSHENKO, Pavel (HZDR / ELBE)

Track Classification: FELs / Accelerators

Contribution ID: **1** Type: **not specified**

Welcome / HZDR Introduction

Thursday, 2 May 2019 09:00 (10 minutes)

Presenter: Prof. SAUERBREY, Roland (HZDR)

Contribution ID: **5** Type: **Invited Oral**

Ultrafast Processes in Free Nanoparticles

Thursday, 2 May 2019 11:30 (30 minutes)

Free nanoparticles are of primary interest for investigating in intense radiation fields the surface and bulk properties of well-defined nanoscopic matter including size effects without experiencing electrical charging and radiation damage. Photon-induced dynamics of free nanoparticles is briefly reviewed. The dynamics of photoemission, ion emission, and light scattering is reported, which involves radiation emitted from short pulse lasers as well as free electron lasers. Photon-induced processes occurring on different time scales are observed, which may range from picoseconds into the attosecond time regime. These reveal the dynamics of excited states, electron motion, electron emission, as well as molecular fragmentation. The experimental results are assigned by model calculations providing deep insights into the ultrafast dynamics of photon-induced processes.

The possible use of future CW-VUV-FEL radiation is subsequently discussed. Here, spectroscopic studies that are complementary to time-resolved experiments are of primary interest, providing novel insights into the structure and dynamics of processes occurring on the surface and bulk of free nanoparticles.

Primary author: Prof. RÜHL, Eckart (Physikalische Chemie, Freie Universität Berlin)

Presenter: Prof. RÜHL, Eckart (Physikalische Chemie, Freie Universität Berlin)

Contribution ID: **6** Type: **Invited Oral**

Surface-specific spectroscopy of water and ice

Friday, 3 May 2019 09:30 (30 minutes)

Water and ice surfaces and interfaces are ubiquitous, not just in nature (e.g. for various naturally occurring forms of snow and ice) but also in many technological applications (such as food science and artificial snow machines). Water is a rather unique liquid, owing to its strong intermolecular interactions: strong hydrogen bonds hold water molecules together. At the surface of ice, the water hydrogen-bonded network is abruptly interrupted, conferring distinct properties on the interface compared to bulk.
We elucidate the structure of interfacial water molecules at the surface of solid ice, and of water in contact with different materials, using surface-specific vibrational spectroscopy of interfacial water molecules. For ice, we find an excess of hydrogen bonds at the ice-vapor interface around 200 K, due to a competition between entropic and enthalpic contributions to the free energy. Around 250 K temperatures, surface melting of ice is found to occur in a bilayer-by-bilayer fashion. Finally, we relate the temperature-dependent molecular structure of the ice surface to the macroscopic friction coefficient, and explain why ice is most slippery around 264 K.

Primary authors: Dr GRECHKO, Maksim (Max Planck Institute for Polymer Research); Prof. BONN, Micha (Max Planck Institute for Polymer Research)

Presenter: Dr GRECHKO, Maksim (Max Planck Institute for Polymer Research)

Contribution ID: **8** Type: **Invited Oral**

Photofragmentation studies of cold trapped molecular ions

Thursday, 2 May 2019 14:00 (30 minutes)

In this presentation, I will discuss photodetachment and photodissociation experiments of cold trapped ions. Results in the form of photodestruction cross sections are particularly relevant for modeling ion abundances in interstellar molecular clouds.

Presenter: Prof. WESTER, Roland (Universität Innsbruck)

Contribution ID: **9** Type: **not specified**

Spin- and angle-resolved photoemission with a high average power source

Thursday, 2 May 2019 14:30 (30 minutes)

Presenter: Prof. SEDDON, Elaine (Daresbury Lab, University of Manchester, UK)

Contribution ID: **10** Type: **Invited Oral**

Spin-dependent dynamics of topological matter

Thursday, 2 May 2019 15:00 (30 minutes)

The electron spin plays an important role in topological matter because the lifting of the spin degeneracy by the spin-orbit interaction is crucial. Moreover, the interaction of topological insulators with ferromagnets enables novel effects such as the quantum anomalous Hall effect. Spin- and angle-resolved photoemission is an efficient probe of the spin-dependent occupied electronic structure.

Performing the spin- and angle-resolved photoemission experiment in an ultrafast way by a 1.5 eV pump and a 6 eV probe pulse on the 100 fs time scale, we gain valuable insight into the carrier dynamics of topological insulators such as Bi2Te3 and Sb2Te3. We witness the occupation of the upper half of the Dirac cone surface state and find that its decay is slowed down by a bottleneck effect.

The creation of a spin-polarized surface current by circularly polarized 1.5 eV light has been claimed in transport experiments. By our pump-probe experiment, we can directly prove this interpretation through the time-dependence of the circular dichroism signal. Adding spin resolution reveals another interesting result: While the ground state spin texture is predominantly in the surface plane, the circularly polarized pump pulse rotates the spin out of the surface plane along the propagation direction of the light. Furthermore, the orientation of the spin is controlled by the light helicity. Analysis of the dynamics reveals that the excited spin decays twice as fast as the excited charge.

These carrier dynamics depend very much on the bulk insulating property of the topological insulator. We found that the typical decay times of about 2 ps for metallic samples increase dramatically when the material composition of the topological insulator is such that the chemical potential is in the bulk band gap. We observe a persistent photovoltage and interpret it as being due to a band bending effect.

Going beyond the currently used 6 eV lasers will enlarge the available range of electron wave vectors k. This holds for 2D as well as 3D momentum space.

Presenter: Prof. RADER, Oliver (Helmholtz-Zentrum Berlin)

Contribution ID: **13** Type: **Invited Oral**

VUV-based trARPES at MHz repetition rates: momentum-resolved visualization of excited states

Friday, 3 May 2019 10:00 (30 minutes)

Time-resolved photoemission, combined with angle-resolved acquisition, can extend band-structure mapping to excited states which are only occupied out-of-equilibrium and evolve on a femtosecond timescale [1]. The full potential of time- and angle-resolved photoemission spectroscopy (trARPES) is reached by performing the experiment with time-bandwidth-limited pulses at high repetition rates - towards the MHz level - limiting space charge effects and data acquisition time [2]. Vacuum-ultraviolet (VUV) photon energies grant access to the whole Brillouin zone of solids, however, femtosecond sources at this wavelength rely on inefficient nonlinear processes (high-harmonic generation, HHG) or on FEL facilities (FLASH, FERMI) operating at low repetition rates, non-ideal for photoelectron spectroscopies. The proposed upgrade of the ELBE FEL to the VUV spectral range will be discussed in the context of trARPES, highlighting the requirements and unique opportunities for a user-access ARPES end-station.

[1] C. Nicholson et al., Science,362,6416,821-825,2018
[2] M. Puppin et al., Review of Scientific Instruments,90,2,023104,2019

Primary author: Dr PUPPIN, Michele (École Polytechnique Fédérale de Lausanne)

Presenter: Dr PUPPIN, Michele (École Polytechnique Fédérale de Lausanne)

Contribution ID: **16** Type: **Invited Oral**

Spectro-temporal photon pulse shaping at FERMI FEL

Friday, 3 May 2019 12:00 (30 minutes)

The talk describes electron and photon beam manipulation techniques for control of the bandwidth and temporal duration of FERMI VUV FEL pulses. An overview of the FEL performance in relation to specific user needs is given.

Presenter: Dr DI MITRI, Simone (FERMI@Eletta)

Track Classification: FELs / Accelerators

Contribution ID: **18** Type: **Invited Oral**

Opportunities of THz-ARPES for studies of solids and interfaces

Friday, 3 May 2019 14:45 (30 minutes)

There is an increasing interest to control and manipulate the properties of solids with intense light fields. Prominent examples are photo-induced insulator-to-metal transitions, light-induced superconductivity, the observation of Floquet-Bloch states and light-wave driven electrical currents. Experiments along these lines benefit tremendously when the capability of angle-resolved photoelectron spectroscopy (ARPES) is exploited to probe the electronic structure of the material. Here, new opportunities arise in combination with THz excitation and moving beyond pump-probe schemes for time-resolution as demonstrated recently by our observation of THz-driven Dirac currents [1]
In the first subcycle time-resolved ARPES experiment, it has been revealed how the carrier wave of a THz pulse accelerates Dirac fermions in the topological surface state of Bi2Te3. While terahertz streaking of photo-emitted electrons traces the electromagnetic field at the surface, the acceleration of Dirac states leads to a strong redistribution of electrons in momentum space (Fig.1) The electrons carrying the current react inertia-less on the accelerating field and travel ballistically with the Fermi velocity of 410 nm/ps over distances of several hundreds of nanometres. This scenario opens up a realistic parameter space for dissipation-free lightwave-driven electronic devices at optical clock rates.

[1] J. Reimann, J., S. Schlauderer, C.P. Schmid, F. Langer, S. Baierl, K.A. Kokh, O.E. Tereshchenko, A. Kimura, C. Lange, J. Güdde, U. Höfer and R. Huber, Nature 562, 396 (2018).

Presenter: Prof. HÖFER, Ulrich (Philipps-University of Marburg, Marburg, Germany)

Contribution ID: **19** Type: **Invited Oral**

Atomistic modeling of effects of irradiation on 2D materials

Friday, 3 May 2019 12:30 (30 minutes)

Ion irradiation has successfully been used for introducing impurities and creating defects in two-dimensional (2D) materials in a controllable manner. Moreover, focused ion beams, especially when combined with in-situ or post-irradiation chemical treatments, can be employed for patterning and even cutting 2D systems with a high spatial resolution. The optimization of this process requires the complete microscopic understanding of the interaction of energetic ions with the low-dimensional targets. At the same time, lots of attention has recently been paid to the mechanisms of defect creation in 2D systems under electron irradiation in a transmission electron microscope, further motivating the research in this area.

In my presentation, I will dwell upon the multi-scale atomistic computer simulations of the impacts of electrons and ions onto free-standing (e.g., suspended on a TEM grid) and supported (deposited on various substrate) 2D materials, including graphene and transition metal dichalcogenides (TMDs), such as MoS2 and WS2. The theoretical results will be augmented by the experimental data obtained by the coworkers.

Presenter: Dr KRASHENINNIKOV, Arkady (Helmholtz-Zentrum Dresden-Rossendorf)

Contribution ID: **21** Type: **not specified**

Velocity resolved kinetics for surface chemistry

Thursday, 2 May 2019 10:00 (30 minutes)

Knowledge of the rates of elementary gas phase reactions has contributed decisively to our understanding of important chemistry with great human impact. For example rate-constant data bases for atmospheric chemistry provide the essential input for computer models of urban air pollution, stratospheric ozone depletion and global climate change. Developing databases for elementary chemical reactions at surfaces could similarly have a powerful impact on our understanding of heterogeneous catalysis. Examples of possible impacts include: catalysts and electrocatalysts for producing cleaner fuels from fossil fuels or renewables (electricity or biomass), synthesis of ammonia and other commodity chemicals, cleaning automobile exhaust, converting carbon dioxide into fuels or chemicals, to name just a few. While there are databases already with numerous accurate experimental energies of adsorbed catalytic reaction intermediates on metal surfaces, there are relatively few known activation energies of elementary surface reactions, or the energies and entropies of their transition states. This is mainly due to limitations on our methods for measuring rate constant of elementary surface reactions. In this talk, I will present recent experimental advances in our ability to measure the rates of elementary reactions at surfaces, which rely on a stroboscopic pump-probe concept designed for neutral matter. In at least two examples, these measurements reveal data of sufficient quality to also reveal surface-site-specific kinetic information. This provides important benchmarks for testing first principles methods for calculating reaction rates, another potentially powerful tool with which to investigate heterogeneous catalysis. The time is ripe to expand efforts to understand the fundamentals of reaction rates in heterogeneous catalysis. New concepts for advanced experimental methods employing free electron lasers can enable this field.

Primary author: Prof. WODTKE, Alec (Max Planck Institute for biophysical chemistry)

Presenter: Prof. WODTKE, Alec (Max Planck Institute for biophysical chemistry)

Contribution ID: **22** Type: **Invited Oral**

Photolytic production of atoms and radicals for studying chemistry of unstable species

Thursday, 2 May 2019 10:30 (30 minutes)

Electron transfer at surfaces is central to catalysis and electrochemistry. Such processes often involve nonadiabatic dynamics, which present extreme challenges for ab initio theory. Experiments have demonstrated the importance of electronically nonadiabatic dynamics in the trapping of H-atoms at metal surfaces, where the mechanism is dominated by nonadiabatic loss of translational energy to electron hole pair excitation. Experimental results are well described by phenomenological electronic friction based theories, which treat nonadiabatic interactions using a friction force that is proportional to the local electronic density. However, it is unclear if the lessons learned from H atoms are applicable to polyelectronic atoms, where friction would likely be less important due to lower velocities, but electron transfer could be an important factor. In our work, state-to-state inelastic scattering experiments will be performed at metal and semi-metal surfaces using beams of polyelectronic atoms (C, N, O) prepared by a VUV photolysis source in well-defined electronic states and with well-defined incidence translational energy and angle. The most likely mechanism for spin violation (e.g. O(1D)⟶O(3P) is the exchange of two electrons of opposite spin, since spin transitions are unlikely on the timescale of the scattering event. Effects of fine structure, surface electronic structure, incidence translational energy and atomic orbital orientation on the electronically inelastic branching ratios and final angular and speed distributions will provide the most fundamental benchmarks for theories of nonadiabatic electron transfer processes at surfaces. VUV photolysis will also be explored as a novel source of well-defined high-energy source of diatomic and polyatomic radicals to probe state-specific reactivity.

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Co-authors: Prof. WODTKE, Alec (Max Planck Institute for biophysical chemistry); Dr KRÜGER, Bastian (1Max Planck Institute for Biophysical Chemistry, Göttingen, Germany)

Presenter: Dr PARK, Barratt (Max Planck Institute for Biophysical Chemistry)

Track Classification: VUV FEL applications

Contribution ID: **23** Type: **Invited Oral**

Band structure engineering with tailored light fields

Friday, 3 May 2019 11:30 (30 minutes)

The structure and electronic properties of a solid are determined by the deepest minimum on its potential energy surface. To date there are different well established means to shape the potential energy surfaces and thereby control the electronic properties such as varying the chemical composition of a material, changing the temperature, or applying strong magnetic fields. The development of strong-field laser pulses with tunable photon energy has opened up an alternative pathway for electronic structure control. Depending on their photon energy these light pulses can couple to different degrees of freedom of the solid and, e.g., resonantly excite electronic transitions or lattice vibrations. If the scattering time of the Bloch electrons in the solid is long compared to the inverse driving frequency, laser pulses can also be used to coherently modulate the momentum of the Bloch electrons.

I will show that all of these excitation schemes can be exploited for electronic structure control of different low-dimensional solids. For this purpose we combine tunable wavelength excitation with a time- and angle-resolved photoemission (tr-ARPES) probe at extreme ultraviolet (XUV) wavelengths to gain access to the band structure of different photo-excited solids across the whole first Brillouin zone and beyond. I will show how photo-doping across the charge density wave (CDW) band gap in one-dimensional indium wires results in an ultrafast insulator-to-metal phase transition [1,2], how resonant excitation of the in-plane bond stretching phonon in bilayer graphene enhances the electron-phonon coupling in the material [3,4], and how coherent modulation of the Bloch electrons'momenta can result in light-induced topological phase transitions.

[1] M. Chávez-Cervantes, R. Krause, S. Aeschlimann, and I. Gierz, Phys. Rev. B 97, 201401(R) (2018)

[2] M. Chávez-Cervantes, G. E. Topp, S. Aeschlimann, R. Krause, S. A. Sato, M. A. Sentef, and I. Gierz, arXiv:1810.09731

[3] I. Gierz et al., Phys. Rev. Lett. 114, 125503 (2015)

[4] E. Pomarico et al., Phys. Rev. B 95, 024304 (2017)

Primary author: Dr GIERZ, Isabella (MPI-SD Hamburg and University of Regensburg)

Presenter: Dr GIERZ, Isabella (MPI-SD Hamburg and University of Regensburg)

Track Classification: VUV FEL applications

Contribution ID: **24** Type: **Invited Oral**

Dynamical processes in interstellar molecular ices studied by correlated FEL pulses

Friday, 3 May 2019 09:00 (30 minutes)

The interaction XUV and VUV radiation with doped molecular ices on grains is important for light-assisted association or dissociation reactions in or on these ices, particularly in accretion disks and the photon dominated regions of interstellar clouds [1]. Important insights into the non-thermal desorption kinetics of CO from pure CO [2] and CO:N2 ice mixtures [3] have been obtained through electronically resonant excitation using quasi-cw synchrotron radiation. For probing the underlying molecular dynamics of bond formation or breaking, as well as the de-sorption process itself, femtosecond duration pulses are required. For studying such processes the VUV/XUV spectral region is of particular importance, because such radiation is abundant in the photon dominated region of interstellar clouds.
Using XUV pulses from the free-electron laser FLASH in Hamburg various molecular ices and ice mixtures were irradiated. Neutral products were state selectively detected by REMPI while ionic desorption products were directly detected by a linear time-of-flight mass spectrometer. Examples to be discussed are the desorption of neutral CO, and the formation of clusters in me-thane/water ice mixtures. Highly nonlinear yields were observed for the latter process which allowed a measurement of the initial dynamics by two-pulse time-correlated desorption. A pre-liminary analysis shows a width of the desorption yield of about 1.5 ps (FWHM), with the peak delayed by less than 500 fs. This points to an electronic process for the primary step, as ex-pected at these photon energies.

[1] K.I. Öberg, Chem. Rev. 116, 9631 (2016)

[2] M. Bertin et al., Phys. Chem. Chem. Phys. 14, 9929 (2012)

[3] M. Bertin et al., Ap. J. 779, 120 (2013)

Primary author: Prof. ZACHARIAS, Helmut (University of Münster)

Presenter: Prof. ZACHARIAS, Helmut (University of Münster)

Track Classification: VUV FEL applications

Contribution ID: **25** Type: **Invited Oral**

Vacuum Ultraviolet Photons for the Study of Photodissociation and Bimolecular Reactions

Friday, 3 May 2019 11:00 (30 minutes)

We have developed a technique called Multiplexed Photoionization Mass Spectrometry for the study of unimolecular and bimolecular chemical reactions. We utilize a low repetition rate pulsed UV laser to initiate a chemical reaction in a collisional environment by breaking a bond in a precursor molecule. The resulting free radicals (resulting from unimolecular dissociation), and the ensuing bimolecular reactions as these radicals react, are probed by extracting a molecular beam sample from the thermal, collisional reaction environment, followed by valence photoionization using quasi-cw, tunable VUV synchrotron radiation. The result is a highly multiplexed experiment (detecting all masses simultaneously), that has high sensitivity (due to single ion counting), is universal (every atom and molecule can be ionized, no exceptions), time-resolved, and sensitive to molecular structure through the photoionization spectra that are obtained. I will give a brief overview of this technique, and compare it to time-resolved Photoelectron Photoion Coincidence Spectroscopy (PEPICO), which we are developing as an even more powerful method to study chemical reactions. Finally, I will discuss the advantages and disadvantages of three regimes of VUV ionization sources: low repetition rates (< 200 Hz), medium repetition rates (0.1 −1 MHz), and quasi-cw repetition rates (> 100 MHz). VUV free electron lasers that achieve moderate spectral resolution, with rapid and wide tunability, at medium repetition rates are the least available source today, but have distinct promise in the study of gas phase chemical physics.

Primary author: Dr OSBORN, David (Sandia National Laboratories)

Presenter: Dr OSBORN, David (Sandia National Laboratories)

Track Classification: VUV FEL applications

Contribution ID: **26** Type: **not specified**

Radiation Source ELBE as User Facility

Thursday, 2 May 2019 09:20 (10 minutes)

Presenter: Prof. MICHEL, Peter (ELBE)

Contribution ID: **27** Type: **Invited Oral**

VUV Sources for Time-Resolved Gas and Solution Phase Photoelectron Spectroscopy

Thursday, 2 May 2019 12:00 (30 minutes)

Time-resolved photoelectron spectroscopy (TR-PES) is a powerful tool for examining the photoinduced dynamics of molecules in the gas or solution phase.[1] However, to fully exploit the power of TR-PES for unravelling complex photochemical reactions, it is necessary to have probe photons of sufficiently high energy, capable of ionising the system of interest over the full range of the potential energy surface sampled after photoexcitation. Given that many small molecules have ionisation energies in excess of 10 eV, VUV sources provide the ideal energy range for TR-PES studies of such systems.

While recent advances in filamentation four-wave mixing[2] and high-harmonic generation (HHG) have made it possible to realise such experiments in a tabletop format, they are often hampered by issues including poor flux. The greater brilliance of advanced light sources addresses some of these issues but there are few facilities capable of producing ultrafast pulses in this energy range. I will present the results of two studies in the gas and solution phase in the context of how the proposed ELBE parameters could have facilitated or improved such experiments. The first study concerns the investigation of gas-phase ring-opening reactions with TR-PES at the FERMI FERMI free-electron laser and the second utilises a liquid microjet to use TR-PES to investigate solution-phase energy transfer processes, performed at our in-house HHG facility, HARMONIUM.[3]

1. T. Suzuki, Int. Rev. Phys. Chem., 2012, 31, 265–318.
2. T. Horio et al., Opt. Express, 2013, 21, 22423–22428.
3. C. Arrell et al., Chim. Int. J. Chem., 2017, 71, 268–272.

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Presenter: Dr INGLE, Rebecca (École Polytechnique Fédérale de Lausanne)

Track Classification: VUV FEL applications

Contribution ID: **29** Type: **Invited Oral**

How Photoelectron Spectroscopy can reveal THz-Driven Dynamics

Friday, 3 May 2019 14:00 (15 minutes)

Low-energy Terahertz (THz) excitation at surfaces offers resonant access to a multitude of fundamental modes, e.g., lattice vibrations, molecular rotations, spin precession and the motion of free electrons [1]. The TELBE THz facility at HZDR aims at controlling and manipulating these degrees of freedom in the nonlinear regime and thereby resolving the resulting dynamics on a femtosecond timescale [2]. A highly promising method for probing THz-driven dynamics is THz pump –time-resolved ARPES probe, which is currently implemented at TELBE. Once established, this technique may offer a direct view on THz-induced changes of the electronic structure in highly relevant processes from metal-insulator-transitions [1] to superconductivity [3] and catalytic activity [4, 5]. The TELBE facility with its unparalleled high repetition rate of 100 kHz quasi-CW repetition rate offers ideal prerequisites for the duty-cycle-hungry ARPES probe. Along the path towards a THz-ARPES facility, a number of experimental challenges have to be mastered, such as residual THz streaking of the nascent photoelectrons.

[1] T. Kampfrath et al. Nat. Photonics 7, 680–690 (2013)

[2] B. Green et al., Sci. Rep. 6, 22256 (2016)

[3] D. Nicoletti, and A. Cavalleri, Adv. Opt. Photon. 8, 401 (2016)

[4] L. A. Pellouchoud and E. J. Reed, Phys. Rev. A 91, 052706 (2015)

[5] J. LaRue et al., Phys. Rev. Lett. 115, 036103 (2015)

Primary author: Dr DEINERT, Jan-Christoph (Helmholtz-Zentrum Dresden-Rossendorf)

Presenter: Dr DEINERT, Jan-Christoph (Helmholtz-Zentrum Dresden-Rossendorf)

Track Classification: VUV FEL applications

Contribution ID: **30** Type: **not specified**

Multidimensional photoelectron spectroscopy of solids in non-equilibrium states

Friday, 3 May 2019 14:15 (30 minutes)

in collaboration with:
S. Dong, P. Xian, S. Beaulieu, M. Dendzik, T. Pincelli, M. Puppin, C. Nicholson, Y. Windsor, M. Wolf, L. Rettig

Recent developments of photoelectron spectrometers based on time-of-flight techniques using multi-dimensional delay-line detectors such as k-TOFs and momentum microscopes are fueling the emerging field of multidimensional photoemission spectroscopy (MPES) [1]. It enables a rapid volumetric mapping of the electronic band structure of materials and naturally incorporates the extension to further dimensions such as ⌧⌧ dispersion, spin or pump-probe time. I discuss four-dimensional time- and angle-resolved photoelectron spectroscopy (trARPES) employing a momentum microscope detector combined with a 500 kHz extreme-ultraviolet (XUV) light source operating at 21.7 eV probe photon energy [2], which allows us to measure the out-of-equilibrium electronic band structure of solids (including excited states) in the entire Brillouin zone [3,4]. On the basis of exemplary data on inorganic and organic semiconductors, I will discuss technical aspects of this approach as well as the prospect of establishing an open experimental electronic structure database as generic benchmark for electronic structure calculations.

References:
[1] K. Medjanik et al., Nature Materials 16, 615 (2017).
[2] M. Puppin et al., Rev. Sci. Inst. 90, 023104 (2019).
[3] C.W. Nicholson et al., Science 362, 821 (2018);C.W. Nicholson et al., Phys. Rev. B 99, 155107 (2019).

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Presenter: Dr ERNSTORFER, Ralph (Fritz-Haber-Institut)

Contribution ID: **32** Type: **not specified**

Openning :: Participants Introduction

Thursday, 2 May 2019 09:10 (10 minutes)

Presenter: Dr EVTUSHENKO, Pavel (HZDR / ELBE)

Contribution ID: **33** Type: **not specified**

Wave packet interferometry on extreme timescales with coherent VUV and XUV FEL pulses

Thursday, 2 May 2019 12:30 (30 minutes)

Electron wave packet interferometry provides the full motion picture of non-stationary states, their relative amplitudes and phases and dominant relaxation pathways. The demonstrated sensitivity to phase changes on the few-attosecond time scale makes this method a powerful tool to probe even weak electronic perturbations and couplings, respectively. In this contribution I will present first results obtained for small quantum systems studied at FLASH.

Primary author: Dr LAARMANN, Tim (HASYLAB/DESY)

Presenter: Dr LAARMANN, Tim (HASYLAB/DESY)

Track Classification: VUV FEL applications