ALBA II - Workshop on Coherence and Time-resolved X-ray Science

Report of Contributions

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

Welcome

Monday, 31 May 2021 09:00 (15 minutes)

Presenter: ATTENKOFER, Klaus

Session Classification: Session I

Contribution ID: **2** Type: **not specified**

Coherent Correlation Imaging: An new tool for High-Resolution Imaging of Stochastic Dynamics

Monday, 31 May 2021 09:15 (30 minutes)

Coherent scattering of x-rays allows to obtain real space information via (iterative) phasing of the diffraction pattern or via direct phase detection by interference with a reference beam (holography). Regarding „movies"of dynamic processes, reproducibly triggered dynamics is accessible via pump-probe schemes, as they allow to collect sufficient statistics via repetition of the experiment. The observation of stochastic dynamics, including in particular a non-perturbative look at equilibrium dynamics, is more problematic: temporal resolution and spatial resolution are in direct competition (via the signal to noise in the scattering pattern achievable during a given exposure time of the order of the temporal resolution). The situation is identical to the making of a classical movie consisting of an untriggered image sequence: it is difficult to shoot a high speed movie at low light. Here, we present an approach mitigating this dilemma by going away form the blind, continuous averaging of subsequent coherent scattering patterns to a correlation-based classification of scattering patterns, allowing for high spatial resolution without compromising temporal resolution. As a proof-of-principle, the observation of thermal hopping of magnetic domain walls is presented.

About the speaker:
Stefan Eisebitt is a solid state physicist utilizing soft x-ray pulses from synchrotron sources, free electron lasers and high harmonic generation sources. His current research interests are ultrafast magnetization dynamics occurring in structures from the atomic range to the mesoscale, the development of interference based x-ray imaging, spectroscopy and scattering methods and their use to unravel spatio-temporal dynamics on short length and time scales. He is a Director at the Max Born Institute Berlin and Professor at the Technical University Berlin.
https://mbi-berlin.de/p/stefaneisebitt

Presenter: Prof. EISEBITT, Stefan (Max-Born Institute, Berlin, Germany)

Session Classification: Session I

Contribution ID: **3** Type: **not specified**

Condensed-phase chemical dynamics with ultrashort soft- and hard X-rays

Monday, 31 May 2021 09:45 (30 minutes)

In this talk I will try to give a brief overview of recent progress in time-resolved implementation of X-ray spectroscopic and scattering methods at X-ray free electron lasers and synchrotrons. I will focus the applications on condensed-phase chemical systems and timescales spanning from femtoseconds to nanoseconds.

About the speaker:
Wojciech Gawelda is a distinguished "Beatriz Galindo"Professor at the Department of Chemistry, Autónoma University Madrid and Associate Research Professor at IMDEA-Nanoscience, Spain.
He worked previously at the Femtosecond X-ray Experiments Group of the European XFEL (2010-2020), Instituto de Óptica-CSIC Madrid (2007-2010) and Ecole Polytechnique Federal de Lausanne, Switzerland (2002-2007)
Wojciech research focuses on the applications of advanced ultrafast X-ray techniques in combination with ultrafast optical spectroscopies to study photoinduced structural dynamics in molecular systems, mainly solvated transition metal complexes. He has pioneered several important implementations of time-resolved X-ray methodologies at synchrotrons and X-ray free electron lasers worldwide.

Presenter: Dr GAWELDA, Wojciech (Univ. Autonoma Madrid & IMDEA nanoscience)

Session Classification: Session I

Contribution ID: **4** Type: **not specified**

Ultrafast lattice, electron and spin dynamics

Monday, 31 May 2021 10:15 (30 minutes)

X-ray methods are powerful to study lattice, electron and spin properties of materials and get information on the dynamics by spectroscopic techniques in the steady state. In recent years, X-ray Free Electron Lasers extended the view on the dynamics to the ultrafast time scale, as these sources provide us with ultrashort fs x-ray pulses that extend spectroscopic techniques into time domain, allowing us to approach the intrinsic timescales of the lattice, the spins and certain electronic excitations in real time. Here, I will give examples how fs x-ray pulses can view ultrafast dynamics by pump-probe experiments to address new phenomena (questions) and how they complement (or can be complemented with) regular synchrotron based X-ray experiments.

About the speaker:
Urs Staub is the leader of the Microscopy and Magnetism group within the Photon Science division of the Swiss Light Source, which operates the X-Treme and SIM beamlines including the RESOXS endstation. His scientific research is currently focused on fundamental questions on the interplay of the crystal structure with the electronic and magnetic properties of advanced materials. His expertises include neutron, x-ray scattering and absorption spectroscopy, and ultra-fast studies at XFEL facilities, such as SwissFEL x-ray free-electron laser.

Presenter: Prof. STAUB, Urs (Swiss Light Source, Paul Scherrer Institute)

Session Classification: Session I

Contribution ID: **5** Type: **not specified**

Energy Conversion Pathways in Graphite from Attosecond Soft X-ray Spectroscopy

Monday, 31 May 2021 11:00 (30 minutes)

The conversion of light to fundamental excitations of matter is governed by the build-up of electronic coherences and their dephasing to excited quasiparticles due to scattering processes, which occur on atto- and femtosecond timescales. Disentangling the interplay of these mechanisms, and how they lead to a specific flow of energy inside a material, is extremely challenging since many of these effects occur on overlapping temporal scales. I will discuss the semimetal graphite, which was investigated with attosecond K-shell X-ray absorption near edge structure (XANES) spectroscopy and show how the combination of our new measurement methodology with theoretical modelling allows to assign the spectroscopic signatures to microscopic processes relating to the dynamic evolution of electrons, holes and phonon modes of the material.

About the speaker:
Jens Biegert received his PhD in 2001 with distinction from the Technical University Munich and his work was awarded the Allen Prize of the Optical Society (OSA). He went on to head a research group on ultrafast pulse generation and strong field physics during his Habilitation at ETH Zurich from 2001 until 2006. Since 2007 as tenured Professor at ICFO and ICREA Professor, his research focus lies on the investigation of the real-time quantum dynamics of electrons and nuclei in atoms, molecules and solids.
Author of the Whitebook leading to the pan-European Extreme Light Infrastructure (ELI), CHair of the General Assembly of Laserlab-Europe-AISBL, Board of Vice Chairs of the Analytical Research Infrastructures of Europe (ARIE), elected member of the Management Board of Laserlab-Europe and Laserlab-Europe AISBL, Chair of the Board of Meetings of The Optical Society (OSA) and on the Meetings Council of OSA, Panel Member of the ERC and at the Volkswagen Foundation, and traveling lecturer of The Optical Society (OSA).
He holds an appointment as Adjunct Professor at the University of New Mexico in the USA, as Guest Professor at the Fritz Haber Institute of the Max Planck Society at Berlin. He is Associate Editor of APL Photonics, Associate Editor of Ultrafast Science, received the Thousand Talents Program Award from the Government of China, is Fellow of the German Academic Scholarship Foundation, Fellow of Optical Society of America, and Fellow of the American Physical Society. He currently holds an ERC Advanced Grant, coordinates a FET Consortium and was awarded the Bessel Prize of the Alexander von Humboldt Foundation.

Presenter: Prof. BIEGERT, Jens (ICFO, Spain)

Session Classification: Session II

Contribution ID: **6** Type: **not specified**

Tracking charge and spin dynamics using attosecond XUV pulses

Monday, 31 May 2021 11:30 (30 minutes)

Few cycle optical fields at allow manipulating electronic and spin degrees of freedom in solid state systems at optical clock rates faster than de-coherence. As an example I will discuss ultrafast bidirectional energy transfer between a light-field and the band-structure of silica and optically induced spin transfer in ferromagnetic heterostructures.

About the speaker:
Martin Schultze has helped developing attosecond spectroscopy to track electron dynamics and transfer the methods to the study of condensed phase systems. His chair for experimental physics at the Technical University Graz investigates ultrafast spin- and charge dynamics driven by optical fields using time-, energy- and momentum resolved electron spectroscopy

Presenter: Prof. SCHULTZE, Martin (Technical University Graz)

Session Classification: Session II

Contribution ID: **7** Type: **not specified**

Structured EUV/soft x-ray attosecond pulses

Monday, 31 May 2021 12:00 (30 minutes)

The quest of achieving complete control over the generation of coherent x-ray sources has driven the efforts over the scientific community during the last years due to their unique ability to capture the fastest electronic and spin dynamics in a wide variety of materials. Among other x-ray sources, high-harmonic generation (HHG) stands as a robust mechanism to generate highly spatially and temporally coherent radiation from the extreme-ultraviolet (EUV) to the soft x-ray regimes, with exquisite temporal accuracy in the attosecond regime. Remarkably, such control is acquired through a highly nonlinear up-conversion process, where the properties of an infrared driving field are mapped into high-frequency harmonics. However, such mapping process is far from trivial.
In this contribution we will review the recent advances in the generation of structured coherent EUV/soft x-ray pulses through HHG. In particular, the use of structured driving beams with controlled spin and/or orbital angular momentum has opened exciting opportunities to harness the properties of the high-order harmonics and attosecond pulses [1], such as their polarization state [2-5], their self-torque [6], or their spectral and focusing properties [7].

References
[1] C. Hernández-García, "A twist in coherent X-rays", Nature Physics 13, 327-329 (2017).
[2] P.-C. Huang, et al., "Polarization Control of Isolated High-Harmonic Pulses", Nature Photonics 12, 349-354 (2018).
[3] K.-Y. Chang, et al. "High-Order Nonlinear Dipole Response Characterized by Extreme-Ultraviolet Ellipsometry", Optica 8, 484 (2021).
[4] K. M. Dorney, et al. "Controlling the polarization and vortex charge of attosecond high-harmonic beams via simultaneous spin-orbit momentum conservation". Nat. Photon. 13, 123-130 (2019).
[5] L. Rego, J. San Román, L. Plaja, C. Hernández-García, "Trains of attosecond pulses structured with time-ordered polarization states", Opt. Lett. 45, 5636-5639 (2020).
[6] L. Rego, et al., "Generation of extreme-ultraviolet beams with time-varying orbital angular momentum". Science 364, eaaw9486 (2019).
[7] L. Rego et al. "Necklace-structured high harmonic generation for low-divergence, soft X-ray harmonic combs with tunable line spacing", under review.

About the speaker:
Dr. Carlos Hernández-García (36) is a Senior Researcher (Ramón y Cajal Fellow), at Universidad de Salamanca (Spain). PI of the ERC Starting Grant project ATTOSTRUCTURA. More than 50 peer-review articles indexed in JCR (including 3 Science, 3 Nature Photonics, 2 PNAS, 5 PRL, 3 Optica, among others). Recipient of the 2019 Fresnel Prize, awarded by the European Physical Society (EPS) and the RSEF-BBVA Physics Prize 2019 for Young Researchers, awarded by the Royal Spanish Society and the BBVA Foundation.

Presenter: Dr HERNANDEZ GARCÍA, Carlos (Universidad de Salamanca)

Session Classification: Session II

Contribution ID: **8** Type: **not specified**

From femtoseconds to hours –measuring dynamics over 18 orders of magnitude with coherent X-rays

Monday, 31 May 2021 12:30 (30 minutes)

X-ray photon correlation spectroscopy (XPCS) enables the study of sample dynamics between micrometer and atomic length scales. As a coherent scattering technique, it significantly benefits from the increased brilliance of the next-generation synchrotron radiation and Free-Electron Laser (FEL) sources.

In my presentation I will introduce the XPCS concepts and show some recent examples of dynamics studies of soft matter and liquids at storage rings [1,2,3] and FEL [4] sources. Furthermore, I will discuss future opportunities of XPCS and the related technique X-ray speckle visibility spectroscopy (XSVS) at new X-ray sources. Thanks to its particular signal-to-noise ratio, the time scales accessible by XPCS scale with the square of the coherent flux, allowing to dramatically extend its applications. This will soon enable studies over more than 18 orders of magnitude in time by XPCS and XSVS.

[1] L. Frenzel et al., J. Phys. Chem. Lett. 10, 5231 (2019); Soft Matter 16, 466 (2020).
[2] A. Jain et al., Soft Matter 16, 2864 (2020).
[3] F. Lehmkühler et al., Sci. Adv. 6, eabc5916 (2020).
[4] F. Lehmkühler et al., PNAS 117, 24110 (2020).

About the speaker:
Felix Lehmkühler obtained his Ph.D. in physics at TU Dortmund (Germany) in 2010. Afterwards, he worked as postdoc in the Coherent X-ray scattering group at DESY and became a senior scientist in 2014 at DESY. Felix' research interests cover X-ray studies on the structure and dynamics of soft matter, nanomaterials and water-based systems, with special attention on developing and using coherent X-ray scattering methods at modern free-electron laser and synchrotron radiation sources.

Presenter: Dr LEHMKÜHLER, Felix (Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany)

Session Classification: Session II

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

pending

Monday, 31 May 2021 14:00 (30 minutes)

pending

Session Classification: Session IIIa

Contribution ID: **10** Type: **not specified**

Spin-lattice coupling from ns to fs time-scales

Monday, 31 May 2021 14:30 (30 minutes)

Although often neglected the coupling of spin and lattice motion plays a role on many length and timescales. Novel spintronic applications aim at controlling magnetization precession and spin currents via lattice strain waves while also angular momentum transfer via the Einstein-de Haas effect can play a role. In this presentation I will give an overview how synchrotrons and x-ray free electron lasers can be used to follow magneto-elastic coupling in non-linear nanoscale magnetic textures. I will also give an outlook how time-resolved electron diffraction promises an interesting alternative to using large-scale facilities.

About the speaker:
Hermann Dürr is a professor at the Department of Physics and Astronomy, FREIA Laboratory in Uppsala University. Before he was a group leader researcher at the Stanford Institute for Materials and Energy Sciences, in SLAC National Accelerator Laboratory.
Prof. Dürr research research encompasses the use of ultrashort (10^-15sec) nonlinear laser, x-ray and electron spectroscopies to probe various aspects of condensed matter systems.
https://katalog.uu.se/profile/?id=N17-2307

Presenter: Prof. DÜRR, Hermann (Department of Physics and Astronomy - Uppsala University)

Session Classification: Session IIIa

Contribution ID: **16** Type: **not specified**

Open Roundtable

Contribution ID: **19** Type: **not specified**

Advanced Methods for Soft X-ray Scanning Transmission Microscopy

Monday, 31 May 2021 15:00 (30 minutes)

Scanning Transmission X-ray Microscopy (STXM) is
an established method for high resolution (down to <20nm) microscopy with chemical and magnetic imaging using NEXAFS / XMCD as contrast mechanism. Due to its scanning probe nature, this method can utilize specialized detectors for advanced imaging possibilites. Examples shown will include the use of fast single photon detectors for time resolvedpump-and-probe microscopy as well as using CCD Cameras to collect cohernet scattering at each point to improve spatial resolution using Ptychography.

About the speaker:
Markus Weidgand, did a Diploma in Physics in 2006 at
Würzburg University on the topic of RIXS on liquids and a PhD at MPI Stuttgart on time-resolved STXM on magnetic vortex cores. Since 2009 he was on working at MAXYMUS STXM instrument at BESSY II, Berlin. In 2019 he joined the HZB to be manager for MAXYMUS and the new MYSTIIC STXM instruments at BESSY II:

Presenter: Dr WEIGAND, Markus (Helmholtz-Zentrum Berlin für Materialien und Energie)

Session Classification: Session IIIb

Contribution ID: **20** Type: **not specified**

Time-resolved imaging spectroscopy of nanoscale phase dynamics in quantum materials

Monday, 31 May 2021 15:30 (30 minutes)

Quantum materials host exotic properties that make them highly desirable for applications, but the complex internal interactions that lead to these properties also make them difficult to understand. Ultrafast spectroscopy is a promising route to disentangle the important degrees of freedom in such materials, but spontaneous phase separation and other nanoscale dynamics mean both temporally and spatially resolved measurements are key to understand these systems. Here I present recent results using coherent X-ray imaging at free electron lasers to build up complete temporal, spatial, and spectral maps of nanoscale phase separation in the prototypical light-induced phase transition of vanadium dioxide.

About the speaker:
Allan Johnson is a PROBIST postdoctoral fellow in the Ultrafast Dynamics of Quantum Materials group at ICFO in Barcelona. Previously he was a Marie Skłodowska Curie PhD fellow and NSERC PGSD grant holder at Imperial College London, where he obtained his PhD for the development of new attosecond X-ray laser sources and spectroscopies. Most recently he has been awarded a "La Caixa" junior leader fellowship to begin a research group studying the coherent control of quantum materials.

Presenter: Dr JOHNSON, Allan (ICFO, Spain)

Session Classification: Session IIIb

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

Harnessing Attosecond Quantum Technologies

Monday, 31 May 2021 16:00 (30 minutes)

pending

About the speaker:

Presenter: Prof. MURNANE, Margaret (University of Colorado)

Session Classification: Session IIIb

Contribution ID: **22** Type: **not specified**

Coherent X-ray Scattering on Magnetic and Electronic Materials

Monday, 31 May 2021 16:30 (30 minutes)

With the advent of diffraction limited light sources, coherent X-rays will play an important role in understanding and characterizing nanoscale magnetic surfaces and interfaces with unique and novel spin textures. Coherent X-ray scattering give rise to speckle pattern that contain unique finger-print about the sample heterogeneity. In this talk I will show various examples to demonstrate how speckle pattern enable us to undertake studies that provide insight into spatial and temporal correlation of magnetic and electronic features in a quantum material. I will show Photon Correlation Spectroscopy (XPCS) studies performed on a 2D square magnetic lattice performed at a synchrotron, where we observed two distinct regimes of domain wall motion—a low temperature ballistic, and a high temperature diffusive type. I will also show a pulse-pair method employed at the LCLS to perform sub-nanosecond fluctuation studies on a magnetic thin film. Finally, I will also show our recent studies on generating soft X-ray orbital angular momentum beams using magnetic nanostructures that has the potential to unravel new information about quantum properties in materials.

Work is funded by U.S. DOE.

Dr. Sujoy Roy is a beamline scientist at the Cosmic Beamline at the Advance Light Source of the Berkeley National Laboratory, and also serving as manager for the x-ray scattering program.

Presenter: Dr ROY, Sujoy (Advanced Light Source, Berkeley National Laboratory)

Session Classification: Session IIIb