MO 12: Experimental Techniques 2

Time: Wednesday 14:00–15:30 Location: BEBEL SR144

Invited Talk MO 12.1 Wed 14:00 BEBEL SR144

Ultrafast X-ray Auger Probing of photoexcited molecular dynamics — B. K. McFarland[1], J. Farrell[1,2], S. Miyabe[1], F. Tarantelli[3], A. Aguilar[4], N. Berrah[5], C. Bostedt[6], J. D. Bozek[6], P. H. Bucksbaum[1,2], J. C. Castagna[6], R. N. Coffee[6], J. P. Cryan[1,2], L. Fang[5], R. Feifel[7], K. J. Gaffney[1], J. M. Glownia[1,2], T. J. Martinez[1,8], M. Mucke[7], B. Murphy[5], A. Natan[1], T. Osipov[5], V. S. Petrovic[1,2], S. Schorb[6], Th. Schultz[9], L. S. Spector[1,2], M. Swiggers[6], I. Tenney[1,2], S. Wang[1,2], J. L. White[1,2], W. White[6], and •M. Guehr[1,2] — [1]PULSE, SLAC, Menlo Park, USA — [2]Physics/Applied Physics, Stanford Univ., Stanford, USA — [3]Chemistry, Univ. Perugia, and ISTM-CNR, Perugia, Italy — [4]ALS, LBNL, Berkeley, USA — [5]Physics, WMU., Kalamazoo, USA — [6]LCLS, SLAC Menlo Park, USA — [7]Physics/Astronomy, Uppsala Univ., Uppsala, Sweden — [8]Chemistry, Stanford Univ., Stanford, USA — [9]Max-Born-Institut, Berlin, Germany

Molecules efficiently and selectively convert light energy into other energy forms through ultrafast nuclear and electronic rearrangements. Efforts to distinguish the role of nuclear and electronic dynamics remain challenging. We performed femtosecond ultraviolet pump - x-ray Auger probe spectroscopy at the linac coherent light source (LCLS). This method can be used to separate electronic and nuclear relaxation in photoexcited molecular dynamics and we address the UV photoprotection mechanism of isolated nucleobases. We find a very fast electronic relaxation within 200 fs after excitation, which cannot be described within the Born-Oppenheimer approximation.

MO 12.2 Wed 14:30 BEBEL SR144

X-ray diffraction from aligned gas-phase molecules with a free-electron laser — •Stephan Stern[1,2], Jochen Küpper[1,2], Henry N. Chapman[1,2], and Daniel Rolles[1] — [1]Center for Free-Electron Laser Science (CFEL), DESY, Hamburg, Germany — [2]University of Hamburg, Hamburg, Germany

We report experimental results on x-ray diffraction of state-selected and aligned ensembles of the prototypical molecule 2,5-diiodobenzonitrile using the Linac Coherent Light Source. The results confirm necessary steps toward x-ray diffractive imaging of such weakly-scattering molecular samples: the ability to provide quantum-state selected ensembles of molecules, to strongly laser-align these, and to perform single-photon detection with the photon detector, even above severe background levels. The approach is suitable for studying ultrafast dynamics of small isolated molecules utilizing the femtosecond x-ray pulses from XFELs together with femtosecond pulses from optical lasers in future pump-probe experiments.

This work was carried within a collaboration, for which J. Küpper, H. Chapman and D. Rolles are spokespersons. The collaboration consists of CFEL (DESY, MPG, University Hamburg), Fritz-Haber-Institute Berlin, MPI Nuclear Physics Heidelberg, MPG Seminconductor Lab, Aarhus University, FOM AMOLF Amsterdam, Lund University, MPI Medical Research Heidelberg, TU Berlin, Max Born Institute Berlin, and SLAC Menlo Park, USA. The experiments were carried out using CAMP (designed and built by the MPG-ASG at CFEL) at the LCLS (operated by Stanford University on behalf of the US DOE.)

MO 12.3 Wed 14:45 BEBEL SR144

Nuclear magnetic resonance spectroscopy on a (5nm)^3 sample volume — Tobias Staudacher[1], Carlos Meriles[2], •Friedemann Reinhard[1], and Jörg Wrachtrup[1] — [1]Universität Stuttgart and Research Center SCoPE, Stuttgart, Germany — [2]The City College of New York, CUNY New York, USA

We have recently demonstrated nuclear magnetic resonance spectroscopy (NMR) on a nanoscale volume ((5nm)^3) of various liquid and solid samples, a size comparable to a single macromolecule [1,2]. Access to such small length scales is enabled by an atomically small magnetic field sensor, the nitrogen-vacancy center in diamond. This color defect can be employed as a magnetic sensor by performing precision spectroscopy on its spin sublevels.

I will discuss the details of this experiment as well as one future prospect, hyperpolarization of the sample. It seems feasible to increase magnetization of the sample volume to a level close to unity by coherently transfering magnetization from the optically polarized NV center to the sample.

[1] T. Staudacher et al., Science **339**, 561 (2013)
[2] H.J. Mamin et al., Science **339**, 557 (2013)

MO 12.4 Wed 15:00 BEBEL SR144

Femtosecond time-resolved photoelectron spectroscopy with XUV pulses in aqueous solution utilizing the liquid microjet technique — •Jan Metje[1,2], Mario Borgwardt[1,2], Alexandre Moguilevski[1,2], Alexander Kothe[1,2], Nicholas Engel[1,2], Martin Wilke[1,2], Ruba Al-Obaidi[1,2], Daniel Tolksdorf[1,2], Alexander Firsov[3], Maria Brzhezinskaya[3], Alexei Erko[3], Igor Kiyan[1,2], and Emad Flear Aziz[1,2] — [1]Joint Ultrafast Dynamics Lab in Solutions and at Interfaces (JULiq), Helmholtz-Zentrum Berlin, Albert-Einstein-Str. 15, 12489 Berlin — [2]Freie Universität Berlin, FB Physik, Arnimallee 14, 14195 Berlin — [3]Institute for Nanometer Optics and Technology, Helmholtz-Zentrum Berlin, Albert-Einstein-Str. 15, 12489 Berlin

We present a newly built laser-based tabletop setup for time resolved photoelectron spectroscopy of liquids and dissolved molecules. The system provides femtosecond extreme ultraviolet (XUV) light generated as high harmonic (HHG) from a titanium sapphire laser as the probe. The spatial, spectral, and temporal characteristics of the XUV beam are presented. Monochromatization of the XUV light with minimum temporal pulse distortion is the central issue of this work. Off-center reflection zone plates are shown to be superior to gratings when selection of a desired harmonic is carried out with the use of a single optical element. A cross-correlation technique was applied to characterize the performance of the zone plates in the time domain. By using laser pulses of 25 fs length to pump the HHG process, a pulse duration of 45 fs for monochromatized harmonics was achieved.

MO 12.5 Wed 15:15 BEBEL SR144

Nuclear spin control with a transient electron spin ancilla — •Helmut Fedder[1], Sang-Yun Lee[1], Matthias Widmann[1], Torsten Rendler[1], Marcus Doherty[2], Neil Manson[2], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut and Research Center SCoPE, University Stuttgart, Germany — [2]Laser Physics Center, Research School of Physics and Engineering, Australian National University, Canberra, Australia

Electron spins associated with point defects in crystals are promising systems for solid state quantum technology [1-3]. In particular, defects with a spin-less ground state and an excited triplet state have been proposed as universal ancillae for addressing nuclear spins [2]. In here we demonstrate the control of an individual ^{13}C lattice nuclear spin in diamond by exploiting a novel electron spin defect that features an excited triplet state. Using optical and microwave control, we demonstrate coherent manipulation of the triplet electron spin and characterize its photo-physics. We then show coherent manipulation of the nuclear spin in the spin-less electronic ground state.

[1] J.J.L. Morton et al. Solid-state quantum memory using the 31P nuclear spin. Nature 455, 1085 (2008).
[2] V. Filidou et al. Ultrafast entangling gates between nuclear spins using photoexcited triplet states. Nature Phys. 8, 596 (2012).
[3] P.C. Maurer et al. Room-Temperature Quantum Bit Memory Exceeding One Second. Science 336, 1283 (2012).