HL 2: Ultrafast phenomena

Time: Monday 9:30–10:45 Location: H2

HL 2.1 Mon 9:30 H2

Ultrafast electron diffraction: Visualization of atomic motion in 4D — •Peter Baum — Max-Planck-Institute of Quantum Optics, and Ludwig-Maximilians-Universität München, Germany

The pathways of transitions in materials and molecules are determined by the motions of atoms and electron densities, on Angstrom scales and in femtosecond or attosecond times. We provide here an account of how ultrashort electron pulses can be used to obtain a four-dimensional visualization in space and time. At two examples, the insulator-metal phase transformation in VO_2 [1] and the interlayer dynamics of graphite [2], we demonstrate the resolution of coherent and incoherent atomic displacements with picometer and femtosecond resolution, indicating the sequential nature of atomic motion in condensed matter transitions. Electron densities can move in times as short as attoseconds. Single-electron pulses [3] afford some promise to reach into this novel regime [4]; we will discuss our approaches and what discoveries we may expect to see [5-6].

[1] Baum, Yang, Zewail, Science 318, 788 (2007)
[2] Carbone, Baum, Rudolf, Zewail, PRL 100, 035501 (2008)
[3] Aidelsburger, Kirchner, Krausz, Baum, PNAS 107, 19714 (2010)
[4] Baum and Zewail, PNAS 104, 18409 (2007)
[5] Baum and Zewail, Chem. Phys. 366, 2-8 (2009)
[6] Baum, Manz, Schild, Sci. China 53, 987 (2010)

HL 2.2 Mon 9:45 H2

Femtosecond point-projection imaging of nanostructures with coherent low-energy electron pulses — •Melanie Müller, Alexander Paarmann, and Ralph Ernstorfer — Fritz-Haber-Institut der MPG, Berlin, Germany

We report on the development of a novel approach for time-resolved imaging of nanostructures based on a metal nanotip used as laser-triggered low-energy electron point source (LEEPS) delivering highly coherent ultrashort electron pulses. Due to their high sensitivity to weak fields, low-energy electron pulses are particularly well-suited for mapping transient electric fields and charge distributions in photoexcited nanostructures. We present first experimental data on LEEPS projection imaging of semiconductor nanowires with femtosecond electron pulses, demonstrating spatial resolution of several 10 nm. For the upcoming implementation of pump-probe measurements we expect 100 femtosecond temporal resolution, supported by numerical simulations of the electron pulse propagation.

HL 2.3 Mon 10:00 H2

Towards Terahertz Pulse Shaping — •Jan-Martin Rämer[1,2] and Georg von Freymann[1,2] — [1]Fraunhofer-Institut für Physikalische Messtechnik IPM, 67663 Kaiserslautern, Germany — [2]Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We present a system capable of manipulation of phase and amplitude of pulsed terahertz radiation. A grating stretcher is used to spatially disperse the spectra of frequency doubled laser pulses generated by a $1.56\,\mu m$ femtosecond fiber laser. A spatial light modulator is placed within the fourier plane of the grating stretcher, allowing the application of phase changes on spectral components of the femtosecond pulse. Phase masks for shaping of the optical pulses are retrieved using the Gercherg-Saxton algorithm, allowing a fast retrieval time. Light temporally shaped by this setup is focussed onto a LTG-GaAs photoconductive antenna generating terahertz radiation which is measured using a second photoconductive antenna. We demonstrate temporal shifts of terahertz pulses as well as generation of terahertz pulse trains.

HL 2.4 Mon 10:15 H2

Longitudinal fields in focused terahertz beams — •Stephan Winnerl[1], Ralf Hubrich[1], Martin Mittendorff[1,2], Harald Schneider[1], and Manfred Helm[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Technische Universität Dresden, Dresden, Germany

In textbooks electromagnetic waves are often described as infinitely extended plane waves, which are of purely transverse character. For beams of finite size, however, also longitudinal fields are expected. In case of focused radially polarized beams, the longitudinal fields can actually be stronger as compared to the transverse components. This has been found in experiments recording the intensity of near-infrared beams. In our study we directly record the electric field of single cycle terahertz pulses of radial and linear polarization. This enables us to reveal the phase relation between longitudinal and transverse fields. The obtained value of $\pi/2$ is of universal nature as it does not depend on the type of mode, frequency or focusing condition. Additionally we demonstrate that the longitudinal components of radially polarized beams exhibit superior focusing properties.

HL 2.5 Mon 10:30 H2

Manipulating intraexcitonic transitions in quantum wells — •Sangam Chatterjee[1], William D. Rice[2,3], Junichiro Kono[2,3], Sabine Zybell[4,5], Stephan Winnerl[4], Jayeeta Bhattacharyya[4], Harald Schneider[4], Manfred Helm[4,5], Benjamin Ewers[1], Alexey Chernikov[1], Martin Koch[1], Hyatt M. Gibbs[6], Galina Khitrova[6], Lukas Schneebeli[1], Benjamin Breddermann[1], Mackillo Kira[1], and Stephan W. Koch[1] — [1]Faculty of Physics, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Department of Electrical and Computer Engineering, Rice University, Houston, Texas 77005, USA — [3]Department of Physics and Astronomy, Rice University, Houston, Texas 77005, USA — [4]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, D-01314 Dresden, Germany — [5]Technische Universität Dresden, 01062 Dresden, Germany — [6]College of Optical Science, University of Arizona, Tucson, Arizona 85721-0094, USA

We manipulate a $1s$ excitonic population in (GaIn)As quantum wells at cryogenic temperatures with free-electron laser (FEL) pulses tuned to the $1s$-$2p$ transition energy of the sample. The FEL induces strong emission at the $2s$ exciton seemingly invoking a transition which is forbidden in atomic systems due to selection rules. A microscopic many-body theory explains the experimental observations as a Coulomb-induced mixing of the $2s$ and $2p$ states, yielding an effective transition between the $1s$ and $2s$ populations making this observation a manifestation of the many-body nature of the excitonic system.