HL 16: Ultrafast Phenoma II

Time: Monday 14:45–17:30 Location: POT 51

Invited Talk HL 16.1 Mon 14:45 POT 51

The role of phonons for the optical control of semiconductor quantum dots — •Doris Reiter — Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Semiconductor quantum dots are a versatile source of single or entangled photons, hence a high fidelity control of the quantum dot states is required. For semiconductor quantum dots, which are embedded in a crystal matrix, the optical control is greatly influenced by the electron-phonon interaction. Here, I will discuss the phonon influence for different types of excitation mechanisms. For an excitation with pulses having a constant frequency, Rabi oscillations of the electronic system occur, which are damped due to the electron-phonon interaction. Fascinatingly, the phonon influence depends non-trivially on the excitation power. At sufficiently high pulse intensity, phonons become less influential and a reappearance of Rabi rotations has been predicted. Experimentally this reappearance has not been observed, yet. Using an excitation with chirped laser pulses, the electron-phonon interaction can also deteriorate the state preparation. Again, for sufficiently high pulse intensity a decoupling of the phonons takes place, but in contrast to Rabi rotations at lower excitation power. Therefore it has been recently possible to experimentally enter the reappearance regime in excellent agreement with theoretical predictions. In my talk, I will present the latest results on phonon effects on optical control of quantum dots comparing the two excitation scenarios.

HL 16.2 Mon 15:15 POT 51

Impact of the electronic band structure in high-harmonic generation spectra of solids — •Nicolas Tancogne-Dejean[1], Oliver D. Mucke[2,3], Franz X. Kartner[2,3,4,5], and Angel Rubio[1,2,4] — [1]Max Planck Institute for the Structure and Dynamics of Matter and ETSF, Luruper Chaussee 149, 22761 Hambourg, Germany — [2]Center of Free-Electron Laser Science, DESY, Notkestrasse 85, 22607 Hamburg, Germany — [3]The Hamburg Center of Ultrafast Imaging, Luruper Chaussee 149, 22761 Hambourg, Germany — [4]Physics Department, University of Hamburg, Luruper Chaussee 149, 22761 Hambourg, Germany — [5]Research Laboratory of Electronics, Massachusetts Institute of Thechnology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA

An accurate analytic model describing high-harmonic generation (HHG) in solids is derived. Extensive first-principles simulations within a time-dependent density-functional framework corroborate the conclusions of the model. Our results reveal that: (i) the emitted HHG spectra are highly anisotropic and laser-polarization dependent even for cubic crystals, (ii) the harmonic emission is enhanced by the inhomogeneity of the electron-nuclei potential, the yield is increased for heavier atoms, and (iii) the cutoff photon energy is driver-wavelength independent. Moreover, we show that it is possible to predict the laser polarization for optimal HHG in bulk crystals solely from the knowledge of their electronic band structure. Our results pave the way to better control and optimize HHG in solids by engineering their band structure.

HL 16.3 Mon 15:30 POT 51

Electron transport in small CdSe Quantum Dots coupled with Methyl Viologen — •Mona Rafipoor[1,2], Jan-Philip Merkl[1], Zhi Wang[1], Gabriel Bester[1,2], and Holger Lange[1,2] — [1]Physikalische chemie, Uni Hamburg, Germany — [2]center of ultrfas imaging, Hamburg, Germany

Semiconductor nanocrystals have drawn significant interest due to their light absorption and electron transport properties which are mostly used for solar cells materials. Electron transfer and light absorption in very small CdSe quantum rods (QRs) (diameter of 1.8 nm) coupled with electron acceptors Methyl Viologen (MV+2) were investigated by Transient Absorption spectroscopy.

HL 16.4 Mon 15:45 POT 51

Quantum descriptions of spatio-temporal dynamics in carrier-capture processes: comparison between approaches — •Roberto Rosati, Doris E. Reiter, and Tilmann Kuhn — Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Due to the ultrashort spatial and temporal scales involved, carrier capture processes in nanostructures are genuine quantum processes. While a density matrix-based quantum kinetik (QK) approach has been successfully applied to describe phonon-induced carrier capture from a GaAs quantum wire into an embedded quantum dot [1], due to the numerical complexity extensions of this approach to higher dimensional systems, to longer times and to phenomena involving different interaction mechanisms remain difficult. By properly tailoring a recently proposed nonlinear density matrix equation based on a Lindblad superoperator [2], here we present an approach which, thanks to additional approximations, is computationally less demanding and inherently stable. By comparing the two approaches we show that the essential features of the capture dynamics are well reproduced by the Lindblad-based approach.

[1] Glanemann et al., Phys. Rev. B 72, 045354 (2005)
[2] Rosati et al., Phys. Rev. B 90, 125140 (2014)

Coffee Break

HL 16.5 Mon 16:30 POT 51

Material Science applications at ELI Beamlines: VUV transient ellipsometry — •Shirly Espinoza[1], Michael Rübhausen[1,2], and Jakob Andreasson[3] — [1]ELI Beamlines, Institute of Physics, Czech Academy of Science, Na Slovance 2, 182 21 Prague, Czech Republic — [2]Condensed Matter Physics, Department of Physics, Chalmers University of Technology, Kemigården 1, SE-412 96 Göteborg, Sweden — [3]Institute for Nanostructures and Solid State Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

In this talk, an introduction to the ELI Beamlines User Facility, to the material science end stations, and to the VUV transient ellipsometry technique will be presented. ELI Beamlines (ELI-BL) is a user facility being built in Prague, Czech Republic, as one of the three pillars of the transnational European Extreme Light Infrastructure (ELI) project that will hold some of the most intense lasers in the world. At EL-BL, high power lasers drive secondary sources (Plasma X-ray and High Harmonic Generation) that allow the study of transient processes in solid state materials. The planned end stations include Transient X-ray Diffraction, X-ray Absorption Spectroscopy, VUV ellipsometry and Transient Optical Spectroscopy (absorption and Raman). Time-resolved transient measurements are possible in the range of a few femtoseconds to hundred of picoseconds. Currently, experiments with transient absorption and transient ellipsometry in the UV-Visible range are being performed on semiconductor materials. Using these results, the advantages of the time-resolved techniques will be explained.

HL 16.6 Mon 16:45 POT 51

Towards fs-time-resolved spectroscopic ellipsometry — •Oliver Herrfurth[1], Steffen Richter[1], Mateusz Rebarz[2], Miroslav Kloz[2], Shirly Espinoza[2], Jakob Andreasson[2,3], Marius Grundmann[1], and Rüdiger Schmidt-Grund[1] — [1]Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig — [2]ELI Beamlines, Institute of Physics, Czech Academy of Science, Na Slovance 2, 182 21 Prague, Czech Republic — [3]Condensed Matter Physics, Department of Physics, Chalmers University of Technology, Gothenburg, Sweden

We report on recent progress in developing a spectroscopic ellipsometer with femtosecond time-resolution, which can be realised employing a pump-probe technique. The third harmonic of an amplified Ti:Sa laser (6 mJ,35 fs) is used as pump pulse and its fundamental wavelength is used to create a supercontinuum white light probe by focussing onto CaF_2. This method allows to probe a spectral range from 340 nm to 1000 nm with a single shot. The time resolution is set by the temporal width of the probe pulse. Pump-probe reflectometry measurements on a *c*-plane ZnO thin film were successfully conducted yielding first insight in the ultrafast carrier dynamics, which is particularly interesting for understanding the physical processes ruling lasing operation. First results on the respective temporal evolution of the dielectric function will be discussed.

HL 16.7 Mon 17:00 POT 51

Long-life pulse states of exciton polariton condensates in GaAs QWs — •Bernd Berger[1], Daniel Schmidt[1], Marc Assmann[1], Martin Kamp[2], Christian Schneider[2], Sven Höfling[2], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, D-44221 Dortmund, Germany — [2]Technische Physik, Physikalisches Institut, Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, D-97074 Würzburg, Germany

A ring-shaped CW laser is used to non-resonantly excite exciton polaritons in a two dimensional DBR microcavity. Due to phonon scattering and polariton-polariton scattering the exciton polaritons undergo relaxation and a condensate of polaritons is formed. An additional non-resonant pulsed laser is used to perturb the formed condensate. By performing a series of time resolved measurements the spatial and temporal dynamics are studied. In a comprehensive analysis we find an unexpected long living polariton signal after pulsed excitation. Its duration exceeds the polariton lifetime by more than one order of magnitude and could potentially store information for several hundreds of picoseconds.

HL 16.8 Mon 17:15 POT 51

Nonspherical atomic effective pseudopotentials for surface passivation — •Anastasia Karpulevich[1,2], Hanh Bui[1,2], Denis Antonov[3], Peng Han[1], and Gabriel Bester[1,2] — [1]Institute of Physical Chemistry, Hamburg University, Grindelallee 117, D-20146 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, D-22761 Hamburg, Germany — [3]Physics Institute, Stuttgart University, Pfaffenwaldring 57, D-70569 Stuttgart, Germany

The quantum mechanical atomistic calculation of the electronic properties of experimental-size colloidal semiconductor nanostructures remains a challenging task. We present a method to extract accurate pseudopotentials for surface passivants, within the framework of the atomic effective pseudopotential (AEP) method [1]. AEPs are constructed by extracting the local part of the self-consistent effective pseudopotentials from DFT calculations using an analytic connection. For the passivant atoms we retain the imaginary part of the pseudopotential in the construction procedure [2]. This imaginary part reproduces an asphericity of the passivant pseudopotential and allows to model surface dipoles and corresponding band offsets. We show that these surface effects need to be taken into account to model electronic properties of quantum dots accurately. The good level of transferability, without additional computational costs, is demonstrated. The results are directly compared to large-scale DFT calculations.

[1] Cardenas J.R. et al., Physical Review B, 86(11), 115332 (2012)
[2] Karpulevich A. et al., Physical Review B, 94, 205417 (2016)