HL 24 Ultra fast phenomena

Time: Tuesday 15:15–18:00 Room: POT 151

HL 24.1 Tue 15:15 POT 151

Microscopic analysis of extreme nonlinear optics in semiconductors — •Daniel Golde, Torsten Meier, and Stephan W. Koch — Department of Physics and Material Sciences Center, Philipps University, Renthof 5, D-35032 Marburg

Extreme nonlinear optics denotes the regime where the Rabi frequency is comparable to or even larger than the band gap frequency. This regime can be reached experimentally by using intense ultrashort laser pulses which have a duration of just a few femtoseconds, see, e.g., [1]. As shown in [2] for the case of a two-level system, a theoretical analysis of extreme nonlinear optics requires one to describe the dynamics on ultrashort time scales beyond the rotating-wave approximation. Such calculations describe, e.g., the generation of higher harmonics and Mollow tripletts [1,2]. Here, we use a microscopic model of a two-band semiconductor with Coulomb interaction to analyze the regime of extreme nonlinear optics. It is, in particular, shown that the importance of excitonic effects which are known to dominate the nonlinear optical response at moderate excitation intensities become less important at largely elevated intensities [3].

[1] Q.T. Vu, H. Haug, O.D. Mücke, T. Tritschler, M. Wegener, G. Khitrova, and H.M. Gibbs, Phys. Rev. Lett. **92**, 217403 (2004).
[2] T. Tritschler, O.D. Mücke, and M. Wegener, Phys. Rev. A **68**, 033404 (2003).
[3] D. Golde, T. Meier, and S.W. Koch, unpublished.

HL 24.2 Tue 15:30 POT 151

Decay of non-equilibrium states created by half-cycle pulses in mesoscopic semiconductor rings — •Andrey Moskalenko, Alex Matos-Abiague, and Jamal Berakdar — Max-Planck Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

Picosecond half-cycle electromagnetic pulses can be utilized for the ultrafast generation of non-equilibrium states in mesoscopic semiconductor rings [1,2,3]. We investigate the relaxation processes of these states towards equilibrium using the density matrix formalism. We show that for low temperatures and clean rings the characteristic relaxation times can be much longer than the pulse duration and long enough to observe the characteristic properties of the non-equilibrium states.

[1] A. Matos-Abiague, J. Berakdar, Phys. Rev. B 70, 195338 (2004).
[2] A. Matos-Abiague, J. Berakdar, Europhys. Lett. 69, 277 (2005).
[3] A. Matos-Abiague, J. Berakdar, Phys. Rev. Lett. 94, 166801 (2005).

HL 24.3 Tue 15:45 POT 151

Transient gain spectroscopy in III-V semiconductor structures — •Kapil Kohli[1], Sebastian Borck[1], Christoph Lange[1], Sangam Chatterjee[1], Kerstin Volz[1], Wolfgang Stolz[1], Lutz Geelhaar[2], Henning Riechert[2], Klaus Köhler[3], and Wolfgang Rühle[1] — [1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Infineon Technologies AG, Corporate Research Photonics, D-81730 Munich, Germany — [3]Fraunhofer Institute for Applied Solid-State Physics, Tullastraße 72 D-79108 Freiburg, Germany

The temporal dynamics of absorption and gain spectra after optical excitation with femtosecond pump pulses are measured on a femto- to picosecond time-scale by white-light probe pulses. The material systems under investigation are GaAs and (GaIn)(NAs). Both, multi quantum well structures and bulk material, are studied.

HL 24.4 Tue 16:00 POT 151

Femtosecond formation of collective modes due to meanfield fluctuations — •K. Morawetz[1,2], B. Schmidt[1], M. Schreiber[1], and P. Lipavsky[3] — [1]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [2]Max-Planck-Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany — [3]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, 12116 Prague 2

Starting from a quantum kinetic equation including the mean field and a conserving relaxation-time approximation we derive an analytic formula which describes the time dependence of the dielectric function in a plasma created by a short intense laser pulse. This formula reproduces universal features of the formation of collective modes seen in recent experimental data of femtosecond spectroscopy. The presented formula offers a tremendous simplification for the description of the formation of quasiparticle features in interacting systems. Numerical demanding treatments can now be focused on effects beyond these gross features found here to be describable analytically.

[1] K. Morawetz, P. Lipavský, M. Schreiber, Femtosecond formation of collective modes due to meanfield fluctuations, Phys. Rev. B in press, cond-mat/0506443

HL 24.5 Tue 16:15 POT 151

Observation of coherent acoustic phonons in semiconductors via asynchronous optical sampling — •Florian Hudert[1], Albrecht Bartels[1], Christof Janke[1], Thomas Dekorsy[1], and Klaus Köhler[2] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, D-78457 Konstanz — [2]Fraunhofer-Institut für Angewandte Festkörperphysik, D-79108 Freiburg

We report on the observation of coherent acoustic phonons in bulk semiconductors (GaAs, GaSb) as well as in semiconductor superlattices (GaAs/AlGaAs) via a recently developed femtosecond time resolved pump-probe technique without a mechanical delay line. The experimental setup constitutes of two modelocked femtosecond lasers with a repetition rate of 1 GHz that are coupled at a fixed difference of 11 kHz with one laser providing the pump and the other one providing the probe pulse. This setup allows scanning a measuring window of one nanosecond with 11 kHz and a resolution of about 200 femtoseconds. The measurement of the transient reflectivity reveals coherent longitudinal acoustic phonons over more than a few hundred picoseconds. The frequencies observed agree very well with Brillouin scattering theory. The decay of the coherent amplitude is dominated by propagation of the acoustic modes.

HL 24.6 Tue 16:30 POT 151

Efficient terahertz radiation of a large-area photoconductive device. — •André Dreyhaupt[1], Stephan Winnerl[1], Thomas Dekorsy[2], and Manfred Helm[1] — [1]Institute of Ion-Beam Physics and Materials Research, Forschungszentrum Rossendorf, 01314 Dresden, Germany — [2]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany

We present an approach of photoconductive terahertz (THz) generation providing a broad bandwidth and exceptional electric field amplitude. A large-area interdigitated two-electrode structure is applied to a GaAs substrate to offer high electric fields. Photocarriers excited by a Ti:Sapphire oscillator laser with MHz repetition rate are accelerated there, yielding an intense THz output. An appropriate binary mask covers every second electrode interval and carriers are excited in uniform electric field areas only. Hence contrary carrier acceleration and destructive interference is avoided. The maximum THz field amplitude, detected by electro-optic sampling, is 1.5 kV/cm, which is almost one order of magnitude more of what is achieved with other photoconductive oscillator-excited emitters. For an excitation spot diameter of 300 μm, which corresponds to the central wavelength of the THz pulses, the THz generation is most efficient. An average THz power of 145 μW is generated with a NIR-to-THz power-conversion efficiency of 2×10^{-4}. The THz power can be improved by a sufficient cooling system. The use of LT GaAs instead of semi insulating GaAs can result in larger THz bandwidth.

HL 24.7 Tue 16:45 POT 151

Ultrafast Dynamics at the Quantum Hall Ferromagnet — •Bertram Su[1], Detlef Heitmann[1], Werner Wegscheider[2], and Christian Schüller[2] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg

We report ultrafast spectroscopy experiments at the v = 1 quantum Hall state of a high-mobility two-dimensional electron system (2DES) in a GaAs single quantum well. Via a semitransparent metallic gate, the density of the 2DES can be tuned in a broad range. By spectrally-resolved four-wave-mixing (SR-FWM) experiments we have investigated the coherent dynamics of photo-excited electron-hole pairs. We observe a strong maximum of the SR-FWM signal around v = 1 in the right-circularly polarized spectra, i.e., if we selectively excite into the empty upper spin level. In this situation, the dephasing time T2 is as long as 14 ps. At $v < 1$ and $v > 1$, the dephasing time decreases dramatically, where the decreasing is faster for $v < 1$. We assume that around $v = 1$ the formation dynamics of spin textures is dominating the ultrafast dynamics.

HL 24.8 Tue 17:00 POT 151

Generation of high-frequency transverse polarized monochromatic acoustic phonons by ultrafast optical excitation in gallium arsenide — •D. Lehmann[1], A.J. Kent[2], R.N. Kini[2], N.M. Stanton[2], Cz. Jasiukiewicz[3], and M. Henini[2] — [1]Institute of Theoretical Physics, TU Dresden, D-01062 Dresden, Germany — [2]School of Physics and Astronomy, University of Nottingham, NG7 2RD, Nottingham, UK — [3]Department of Physics, University of Technology, ul. W. Pola 2, PL-35-359 Rzeszow, Poland

There is interest in developing useable sources of THz monochromatic acoustic phonon beams for applications in phonon spectroscopy, acoustic microscopy, probing of nanostructures etc. In recent years, the generation of high intensity pulses of acoustic phonons by ultrafast optical techniques has been demonstrated, but the work has concentrated mainly on longitudinally polarized phonons [1].

We have generated coherent transverse polarized acoustic phonons by ultrafast optical excitation of GaAs/AlGaAs superlattices grown on low-index planes of GaAs [2]. The frequency of the generated phonons is determined by the superlattice period. The phonons can leak out of the superlattice and propagate over macroscopic distances as a monochromatic pulse. We show that theoretical estimations and pump probe measurements suggest a Raman scattering process is responsible for the coherent phonon generation.

[1] N.M. Stanton, R.N. Kini, A.J. Kent, M.Henini and D. Lehmann, Phys. Rev. B 68, 113302 (2003)

[2] R.N. Kini et al., submitted to Appl. Phys. Lett.

HL 24.9 Tue 17:15 POT 151

Ultrafast dynamics of the mid-infrared response of carbon nanotubes and graphite — •Christian Frischkorn, Tobias Kampfrath, Luca Perfetti, and Martin Wolf — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

We report on time-resolved measurements of low-energy excitations in 1- and 2-dimensional solids like carbon nanotubes and thin graphite films. The mid-infrared response of these systems has been obtained from time-resolved THz spectroscopy data in the 10 - 30 THz spectral range. For carbon nanotubes, we find essentially two processes governing an electronic current dynamics [1]. First, strongly bound excitons are the main photoproduct in large-band gap tubes and thus prevent a typical free-carrier response, while in small-gap and metallic tubes carrier localization due to defects is observed as manifested in a substantial dichroism. In these measurements, the reduced polarizability perpendicular to the tube axis is exploited. In the case of graphite, a 2-dimensional semimetal, our results show that strongly coupled optical phonons in the graphite layer dominate the ultrafast energy and transport relaxation dynamics after optical excitation [2]. These phonon modes heat up on a femtosecond time scale and cool down with a time constant of several picoseconds. Moreover, the observed pronounced increase in the Drude relaxation rate significantly originates from these few active lattice vibrations. Our findings for both carbon nanotubes and graphite are of fundamental importance for technological applications in nanoelectronics. - [1] PRL (submitted); [2] PRL **95**, 187403 (2005).

HL 24.10 Tue 17:30 POT 151

Intersubband relaxation dynamics in narrow InGaAs/AlAsSb and InGaAs/AlAs quantum well structures using pump-probe spectroscopy — •C V-B Tribuzy[1], S Ohser[1], J Neuhaus[2], T Dekorsy[2], S Winnerl[1], H Schneider[1], M Helm[1], K Biermann[3], H Künzel [3], M.P Semtsiv[4], and W.T Masselink[4] — [1]Inst of Ion Beam Phys and Mat Res, Fz-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [2]Dep Phys, Univ Konstanz, 78457 Konstanz, Germany — [3]FI für Nachrichtentechnik-HHI, 10587 Berlin, Germany — [4]Dep Phys, Humboldt-Univ. of Berlin, 12489 Berlin, Germany

Intersubband (ISB) transitions in semiconductor quantum wells (QWs) can be employed for various mid-infrared optoelectronic devices. Presently there is strong interest to extend the available wavelength range into the near infrared, by using materials with a large conduction band offset. To achieve such short wavelengths thin QWs are required, where the first excited state inside the QW may lie higher than some state related to indirect valleys. Examples for such material systems are strained InGaAs/AlAs or lattice matched InGaAs/AlAsSb, both grown on InP. We have studied the ISB relaxation dynamics in multi QWs of both material systems by femtosecond pump-probe measurements. The transient transmission as a function of the pump-probe delay does not show a single-exponential decay, indicating a more complicated relaxation dynamics. This can be caused by transfer of electrons to X- or L- states in the QWs or the barriers. We will show results on samples with different QW thicknesses and compare them to simulations based on rate equations.

HL 24.11 Tue 17:45 POT 151

Ultrafast near resonant nonlinear propagation in GaAs - a theoretical model study — •Martin Schaarschmidt, Jan Kloppenburg, and Andreas Knorr — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Pulse propagation close but well below the semiconductor excitonic resonance is investigated. In this spectral region the excitonic resonance often dominates over most off-resonant material resonances. We discuss the suitability of different model systems for the description of occuring material nonlinearities ranging from Kerr nonlinearity, excitonic Pauli-Blocking up to semiconductor Bloch equations (SBE) including many particle effects. The differences between the nonlinear Schrödinger equation with Kerr-type nonlinearity usually applied for propagation far from the resonance, the optical Bloch equations known from propagation in atomic gases and the Maxwell semiconductor Bloch equations are studied and compared with recent experiments.