Interaction of intersubband transitions and ponderomotive response in doped GaAs/AlGaAs multiple quantum wells at the THz regime — Matthias Baudschi, Martin Wagner, Manfred Helm, and Dominik Stehr — Institute for Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P.O. Box 50119, 01314 Dresden, Germany.

In the present work we investigate the line shape of the broadband terahertz (THz) response in doped multiple quantum wells by means of field-resolved detection. In an optically excited structure we recently observed a Fano-like shape of the THz response [1]. This results from the superposition of the broad continuous ponderomotive response and the sharp intersubband transition. The first originates from the force that takes effect on carriers in an oscillating electromagnetic field.

The applied spectroscopy technique is time-resolved ultrabroadband THz spectroscopy. The THz radiation is generated by phase-matched optical rectification of 10 fs near-infrared pulses in 50 pm thick GaSe crystals. The pulses are tuneable in a range from 15 to 40 THz with a width (FWHM) of up to 15 THz. The field-resolved detection is done by phase-matched electro optic sampling. The applied detection method is crucial for observing the effect since the ponderomotive current can only be seen as a lossless phaseshift of the transmitted THz radiation while the intersubband transition leads to an absorption. Thus we are able to observe directly the superposition of ponderomotive current and intersubband transition in the time-domain.


Ultrafast Dynamics of ZnO and ZnO-BaTiO₃ thin films — Sumedha Choute, Matthias Baudschi, Tammie Bönning, Rüdiger Schmidt-Grund, Marius Grundmann, and Gerhard Seifert — 1Institute of Physics, Martin-Luther-University, Halle-Wittenberg, Von-Danneelmann Platz 3, D-06120, Halle, Germany. — 

Femtosecond pump-probe spectroscopy was performed at room temperature on ZnO thin film and a double layer thin film structure of BaTiO₃/ZnO, to investigate coupling between the layers via the charge carrier dynamics. Frequency-doubled Ti:Sapphire laser pulses (150fs, 400nm) were used as pump; induced transmission changes were probed by supercontinuum (320-600nm) fs pulses. For ZnO, two photon absorption as well as direct excitation to the trap states close to the conduction band edge leads to transfer of carriers to the conduction band. The displaced carriers relax rapidly to the bottom of conduction band, and bleeding at 375nm attributed to population of discrete exciton A is observed. Further increase in the density at exciton levels lead to a stimulated emission at 790 nm within the visible. Changes in refractive index induced by pump-pulse generates interferometric transmission changes between 400-600 nm. Similar contributions to the transient spectra are observed in BaTiO₃/ZnO. BaTiO₃ does not show any femtosecond response. Difference in the dynamical behaviour of the contributions in ZnO and BaTiO₃/ZnO gives an indication of coupling between ZnO and BaTiO₃.

We observe a strong modulation of the PL intensity under pulsed and steady state PL excitation conditions, due to the strain-pulse perturbation. In the latter case we are able to decrease the PL intensity by a factor of 20 and later increase it up to a factor of 6 for ~100 ps.

15 min. break

Extreme Nonlinear Optics in Semiconductors with Shaped Laser Pulses — Matthias Reichelt, Andrea Wuellner, and Torsten Meier — 1Department of Physics and CeOPP, University of Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany — 2Institut für Mathematik, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany.

If a two-level system is excited with an intense light field of several times the Rabi frequency, the well-known Mollow triplets appear in the emitted radiation spectrum. [1] We show that the pattern of the emission spectrum can be changed by using appropriately shaped [2] laser pulses. The effect is also observable for a more realistic description of a semiconductor system [3].
Coulomb-induced relaxation dynamics in single-walled carbon nanotubes — Eike Verdenhalven, Andreas Knorr, and Ermin Malić — Institut für Theoretische Physik, Technische Universität Berlin, Germany

We investigate the ultrafast Coulomb-induced relaxation dynamics of optically excited charge carriers in arbitrary single-walled carbon nanotubes. Using a density-matrix formalism we derive a corresponding Boltzmann equation in Born-Markov approximation. The bandstructure is obtained using the zone-folded tight-binding wave functions of graphene. Complying with the low dimensionality of nanotubes the Coulomb interaction is treated by a parametric interaction potential. Our approach allows to track (time- and momentum resolved) the relaxation paths of non-equilibrium electrons in metallic and semiconducting nanotubes of arbitrary chirality.

Microscopical calculation of non-linear polarization spectra of light-harvesting complexes — Mario Schoth1, Marten Richter1, Thomas Renger2, and Andreas Knorr3 — 1Institut für Theoretische Physik, Niethäne Optik und Quantenelektronik, Technische Universität Berlin, Germany — 2Institut für Theoretische Physik, Theoretische Biophysik, Johannes Kepler Universität Linz, Austria

Ultrafast spectroscopic techniques, such as nonlinear polarization spectroscopy [1], are used to investigate photosynthetic systems of higher plants. Performed in the frequency domain, non-linear polarization spectroscopy (NLPF) permits simultaneous measurements of dephasing and energy relaxation rates down to tens of femtoseconds. Within a Bloch equation approach [2], we calculate NLPF spectra of light-harvesting complexes such as the water-soluble chlorophyll binding protein complex (WSCP) microscopically. Hereby, we include self-consistently structural data for the excitonic couplings of pigments and protein complex (WSCP) microscopically. Hereby, we include self-consistently structural data for the excitonic couplings of pigments and

First principles of phonon squeezing in silicon — Michael Pochwala, Huynh Thanh Duc, Jens Förstner, and Torsten Meier — Department of Physics and CoOPP, University of Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

We numerically investigate the intensity dependence of electron charge currents generated by perpendicular circularly polarized femtosecond laser pulse in (110)-grown semiconductor quantum wells GaAs/AlxGa1-xAs. Our analysis is based on a 14 band kp model [1] in combination with multisubband semiconductor Bloch equations [2-4]. The analysis shows that the generated electron charge currents depend on the intensity of the incident laser pulse in a highly nonlinear fashion. Oscillatory behavior of the electron charge current transients is predicted and explained.

Intensity dependence of optically induced electron charge currents in quantum wells — Michał Pochwala, Huynh Thanh Duc, Jens Förstner, and Torsten Meier — Institut für Theoretische Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

When silicon is excited by an intense ultrashort laser pulse, an extreme nonequilibrium state is induced, which consists of hot electrons (several 1000 K) and cold ions (near room temperature). The excited carriers change the potential energy surface seen by the ions, leading to a softening of the phonon modes and phonon squeezing. On the basis of density functional theory we perform a study of these effects, treating the phonons both quantum mechanically and classically, including anharmonic effects in the latter case by means of large-scale molecular dynamics simulations. Our results indicate that the initial ionic temperature before the laser excitation should not exceed approximately 77 K in order to observe quantum effects. At higher temperatures the anharmonicities amplify the classical phonon squeezing and cannot be ignored.