Intra-excitonic extreme nonlinear optics

**Martin Wagner**, **Khitrova** (2010).

Beyond the rotating-wave approximation. We have observed distinct intensity- and wavelength-dependent Rabi sidebands of the heavy-hole hh(1s) exciton resonance. All these features are fully explained by our quantum-mechanical many-body theory.

Localization of light-modes in disordered ZnO nanoneedle-arrays — **David Leipold** and **Erich Runge** — Technische Universität Ilmenau, 98693 Ilmenau, Germany

Whereas Anderson localization of electrons and excitons in solids is well established for about half a century, the localization of light is notoriously hard to observe in experiments due to weak variations of the optical properties and the presence of absorption.

We present calculations of localized light-modes in dense random arrays of vertically aligned ZnO nanoneedles. This material provides strong scattering accompanied by low absorption and enables experiments to map the localized wavefunction. We present results of full 3D solutions of Maxwell’s equations for our model system. We observe light modes whose intensity is concentrated in small spatial areas and, correspondingly, non-Gaussian intensity histograms. Positive correlation between long lifetimes and the degree of localization is observed. The correlation is strongest for the most localized modes.

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Control of transverse polaron patterns in semiconductor microcavities — **Przemyslaw Lewandowski**, **Mackillop**, **Sangam Chatterjee**, **Mackillop**, **Mackillop**, **David Leipold**, **Jure Demsar**, and **Erich Runge** —Technische Universität Ilmenau, 98693 Ilmenau, Germany

Transverse optical patterns are suitable for realising very efficient all-optical switches in atomic vapour systems [1], e.g. Rubidium. Here, we theoretically analyse to which extent the underlying concept of wave-mixing induced coherent transverse patterns and their control can be transferred to a semiconductor-based system. We study quantum-well based planar semiconductor microcavities as promising candidates.

Our theoretical investigation of the coherently-driven nonlinear polaron dynamics is based on a direct time-domain solution of the Maxwell and semiconductor Bloch-equations in the coherent limit and mean-field approximation for the excitonic component (resembling an extended two-component Gross-Pitaevskii-type equation). We (i) analyse in detail the stability and bistability of the spatially homogeneous stationary solutions of these nonlinear equations and (ii) present fully two-dimensional numerical calculations showing transverse pattern formation in spatially anisotropic systems. We also demonstrate the all-optical control of these patterns in analogy to what was achieved in atomic vapour systems before [1].

Femtosecond thermomodulation in Cu — **Johanna Flock**, **Markus Beyrer**, **Manuel Obergfell**, **Christian Monachon**, **Thomas Dekorsy**, and **Jure Demsar** — 1Dept. of Physics and CAP, Univ. of Konstanz, D-78547 — 2Laboratory for Mechanical Metallurgy, EPFL CH-1015 — 3Complex Matter Dept., Jozef Stefan Institute, SI-1000

Since discrepancy between the two temperature model[2] in the thermomodulation (TM) scenario[2] and experimental data exist[3], we have performed systematic measurements of the time-evolution of the dielectric function in Cu thin films over broad spectral range (1.5-2.5eV) as a function of photoexcitation energy (1.55eV and 3.1eV) and density. Here excitation with 1.55eV results in intraband transitions within the sp-band while in the case of 3.1eV interband processes from the narrow d-band below the Fermi level to the sp-band dominate. For both excitation energies the spectral changes are consistent with the fs-TM scenario. Only for the case of the intraband excitation the predicted excitation density dependence of the e-ph thermalization rate[1] is observed. For 3.1eV excitation energy the relaxation dynamics is excitation density independent. These results imply that the relaxation strongly depend

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Time-resolved vibrational dynamics in a single Si$_3$N$_4$ Nanosstructure — ©Oliver Ristow, Martin Grossmann, Mike Hettnach, Elaine Barretto, Martin Schubert, Axel Bruchhausen, Elke Scheeren, and Thomas Dekorsy — Department of Physics and Center of Applied Photonics, University of Constance, D-78457 Konstanz, Germany

In this work we present time domain all-optical investigations of single Si$_3$N$_4$ nanostructures using high-speed asynchronous optical sampling (ASOPS). In order to achieve a high spatial resolution a microscope objective is used with the ASOPS system, which allows for resolving and addressing single nanostructures as well as to scan over large sample areas. We demonstrate the capabilities to investigate two dimensional confined nanostructures, such as nanomechanical systems (NEMS). As one example we show the results of pump-probe experiments analyzing the time-resolved vibrational properties of the nanomechanical resonators’ beam based on Si$_3$N$_4$ and gold. The typical dimensions of such a nanostructure are 100 nm by 100 nm in cross section and 2-3 micron in length. These systems constitute an ideal model system for the investigation of phonon dissipation in NEMS. With this all optical method especially the high frequency range (GHz) is accessible. Due to the high spatial resolution of our system we are able to accurately address different parts of the structures and investigate in the spatial distribution of the different vibrational modes. By combining the measurements with finite element simulations we obtain a good insight on the acoustical dynamics of these structures.

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Squeezed thermal phonons precurse nonthermal melting of silicon — ©Tobias Zier, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretical Physics, University of Kassel, Germany

Femtosecond laser pulses can be used to practically instantaneously manipulate bonds in solids through the creation of a hot electron plasma. At sufficiently high fluences, some phonon modes may even become unstable, causing acceleration of the atoms, followed by a disordering within several 100’s of femtoseconds. This ultrafast solid-to-liquid phase transition is called nonthermal melting and has been observed in silicon, germanium, gallium arsenide, indium antimonide, and bismuth. It is, however, not known which physical process leads up to nonthermal melting at fluences below the melting threshold. Here we show for silicon that in this regime the room temperature phonons move in the same directions during the first stages of nonthermal melting at high fluences and thermal phonon squeezing at lesser fluences. We further found in ab initio molecular dynamics simulations on laser-excited potential energy surfaces that the atoms move in the same directions during the first stages of nonthermal melting at high fluences and thermal phonon squeezing at lesser fluences. Our results demonstrate that thermal phonon squeezing is the precursor to nonthermal melting in silicon. Based on the general nature of the underlying bond softening mechanism we believe that this relation between thermal squeezing and nonthermal melting is not material specific, but should occur in all materials exhibiting the latter process.

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Spectrally resolved photon echo measurements in CdTe QWs — ©L. Langri1, S. Poltavtsev2, I. A. Yugova3, 4, G. Karcewski3, T. Woltowicz1, J. Kossut1, D. R. Yakovlev1, 3, I. A. Arkin1, 3, and M. Bayer1 — 1Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany — 2Physical Faculty of St. Petersburg State university, 198504 St. Petersburg, Russia — 3Institute of Physics, Polish Academy of Sciences, 02086 Warsaw, Poland — 4A.F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

We report on trion and exciton decoherence in epitaxially grown, 20 nm thick CdTe/CdMgTe quantum wells using degenerate transient four wave mixing (TFWM) technique with heterodyne detection. Use of spectrally narrow picosecond pulses allows measuring the FWM signal for exciton and trion resonances separately. Time-resolving the FWM signal provides direct information on reversible and irreversible dephasing in the system under study. The measured photon echo behavior for both inhomogeneously broadened exciton- and trion resonances reveals decoherence times of $\tau_X = 5$ ps and $\tau_T = 24$ ps at temperature $T = 2$ K. Depending on the polarization configuration of two beams, different light induced gratings can be generated. For colinearly polarized beams, a population grating is induced while for crossed-linearly polarized beams a spin grating is formed. While a magnetic field of up to 0.7 T applied in Voigt geometry does not alter the population grating, the spin grating’s FWM signal is modulated at the Larmor frequency.