# HL 39: Optical properties

Time: Tuesday 10:15–12:45 Location: H13

HL 39.1 Tue 10:15 H13

**Optical properties of $Ga_{1-x}Mn_xAs$ from large scale ab initio calculations** — •Jerome Jackson, Ricardo Cárdenas, and Gabriel Bester — Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, Germany.

The properties of Mn impurities in GaAs are revisited employing a new methodology based on atomic effective potentials (AEPs [1]) which yields LDA accuracy at considerably reduced computational expense. We consider the case of very low Mn concentrations that cannot be considered using conventional ab initio methods and discuss the metal/insulator transition in terms of the Mn-d band localisation and its interpretation as a shallow acceptor. We discuss practical methods to improve upon the LDA bandgap in GaAs together with the excessive delocalisation of the Mn states. Using a configuration-interaction technique we calculate the optical spectra of $Ga_{1-x}Mn_xAs$ including the fine-structure (FSS) splitting which is of importance to the development of quantum computing devices based upon magnetic impurities in semiconductors[2].

[1] J. R. Cárdenas and G. Bester, Phys. Rev. B **86**, 115332 (2012)
[2] D. E. Reiter, T. Kuhn and V.M. Axt, Phys. Rev. B **83**, 155322 (2011)

HL 39.2 Tue 10:30 H13

**Raman scattering study of phonon-polaritons in wurtzite GaN** — •Christian Röder, Gert Irmer, Cameliu Himcinschi, and Jens Kortus — TU Bergakademie Freiberg, Institute of Theoretical Physics, Leipziger Str. 23, D-09596 Freiberg, Germany

Reports on Raman measurements of polaritons in uniaxial semiconductors are scarce. However, the Raman scattering efficiency of polaritons can be described taking both into account, an atomic displacement term and an electro-optic contribution which depends very strongly on the polariton frequency. The relation between the atomic displacement tensor components and the electro-optic ones is expressed using the Faust-Henry coefficients. According to the symmetry of wurtzite GaN three different Faust-Henry coefficients are implied. In order to specify charge carrier concentration and mobility in GaN by Raman spectroscopy the values of these parameters are required but they are still debated. In this work we present Raman scattering results on phonon-polaritons in single crystals of wurtzite GaN. The experiments were conducted in near-forward scattering geometry. Measurements of ordinary and extraordinary polaritons with defined symmetry could be performed. The observed dispersion curves and scattering efficiency results are compared with theoretical ones. The authors would like to thank the European Union (EFRE) as well as the Free State of Saxony for financial support within the ADDE project.

HL 39.3 Tue 10:45 H13

**Intensity fluctuations of a semiconductor laser at threshold - accessing critical dynamics with higher order noise spectroscopy** — Sebastian Starosielec, Jörg Rudolph, and •Daniel Hägele — AG Spektroskopie der kondensierten Materie, Ruhr-Universität Bochum, Bochum, Germany

We investigate the intensity fluctuations $I(t)$ of an electrically driven single mode vertical cavity emitting laser that serves as a model system for critical dynamics at a second order phase transition [1]. Simulations of the fourth order frequency resolved correlation spectrum $S^{(\mathrm{corr})}(\omega,\omega') = \langle I_\omega I_\omega I_{\omega'} I_{\omega'}\rangle - \langle I_\omega I_\omega\rangle\langle I_{\omega'} I_{\omega'}\rangle$ reveal a characteristic structure in the spectrum at threshold and almost no structure below and above threshold. Measurements of $S^{(\mathrm{corr})}(\omega,\omega')$ with a bandwidth of 90 MHz and real time data processing (see [2]) are in good agreement with theory for all investigated lasers. Making use of modern electronics and data processing, we resolve for the first time pump-dependent features in a fourth order spectrum that were inaccessible before. Our experimental approach may open new routes for investigating temporal fluctuations at phase transitions in many systems including magnets and superconductors.

[1] V. DeGirogio and M. O. Scully, Phys. Rev. A **2**, 1170 (1970)
[2] S. Starosielec *et al.*, Rev. Sci. Instrum. **81**, 125101 (2010)

HL 39.4 Tue 11:00 H13

**Fabrication and characterization of GaAs-based Air-Bragg microcavity structures** — •Jonas Gessler[1], Arkadiusz Piotr Mika[1,2], Julian Fischer[1], Matthias Amthor[1], Alfred Forchel[1], Jan Misiewicz[2], Sven Höfling[1], Christian Schneider[1], and Martin Kamp[1] — [1]Julius Maximilian Universität Würzburg — [2]Wroclaw University of Technology

The high index contrast between Air and Gallium-Arsenide (GaAs) can lead to an enhanced photon confinement compared to GaAs/Aluminum-Arsenide Bragg microcavities. This can be used to reduce the effective mode volume and to enhance light matter coupling effects in a GaAs/Air Bragg system with active quantum well (QW) emitters. We will present the fabrication of freely suspended GaAs/Air structures with Q-factors exceeding 1000. Various strategies for in-plane photon confinement are demonstrated experimentally, resulting in photonic structures with quasi 2D, 1D and 0D characteristics. We finally demonstrate laser emission from weakly coupled QW-GaAs/Air Bragg systems and discuss indications for the formation of QW-exciton polaritons in our novel system.

HL 39.5 Tue 11:15 H13

**Investigation of the strong coupling regime in GaAs microcavities up to room temperature** — •Sebastian Brodbeck[1], Jan-Philipp Jahn[1], Arash Rahimi-Iman[1], Julian Fischer[1], Matthias Amthor[1], Stephan Reitzenstein[1,2], Christian Schneider[1], Martin Kamp[1], and Sven Höfling[1] — [1]Technische Physik, Physikalisches Institut and Wilhelm Conrad Röntgen-Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, 97074 Würzburg — [2]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin

We study the strong coupling regime in a microcavity with GaAs quantum wells in the full temperature region between 4K and room temperature. Pronounced anticrossing of the polariton branches in reflection measurements is observed for all investigated temperatures. The temperature dependence of the vacuum Rabi splitting is reproduced by a simple equation with one fitting parameter. At room temperature we measure a vacuum Rabi splitting of more than 6meV.

The strong coupling regime at room temperature is also observed in an electrically driven sample whose electroluminescence shows two well resolved polariton branches. This device features an innovative pumping scheme where a reversely biased Esaki diode is placed in the cavity region in order to improve the electric pumping of the spatially separated quantum well stacks. The mixed light-matter nature of the emitting states is confirmed in photoluminescence measurements with varying bias where a Stark shift of up to 4meV is observed for both polariton branches.

**Coffee break**

HL 39.6 Tue 11:45 H13

**Rolled-up microtubes for light-matter interaction with colloidal quantum dots** — •Stefanie Kietzmann[1], Christian Strelow[1], Andreas Schramm[2], Jussi-Pekka Penttinen[2], Alf Mews[1], and Tobias Kipp[1] — [1]Institute of Physical Chemistry, University of Hamburg, Germany — [2]Optoelectronics Research Centre, Tampere University of Technolgy, Tampere, Finland

We report on rolled-up AlInP microtube resonators that can be coupled to colloidal nanocrystals emitting in the visible spectral range. These emitters can couple to the evanescent fields of the modes propagating in the very thin microtube walls, leading to sharp optical modes in the emission spectra due to constructive interference. Microtubes are fabricated by utilizing the self-rolling mechanism of expitaxally grown strained layer systems induced by selective chemical undercutting. Three-dimensional light confinement by various axial structurings of the tube geometry allows for a full control over the optical eigenmodes. As the mode energies of the spectra sensitively depend on the refractive index of the tube's filling, microtube resonators can be used as refractive index sensors. We present a successful coupling of colloidal nanocrystals to the evanescent fields of AlInP microtubes shown by sharp resonances in the observed spectrum. Moreover, the refractometer properties of the microtubes are demonstrated by comparing the observed mode shift due to a well-known refractive index change to 2D FDTD simulations [1].

We acknowledge financial support by the DFG via Ki1257/1.

[1] Ch. Strelow et.al., Appl. Phys. Lett. 101, 113114 (2012)

HL 39.7 Tue 12:00 H13

**Theory of Metal Nano-Particle Affected Optical Properties of Supramolecular Complexes** — •Yaroslav Zelinskyy, Gerold Kyas, Yuan Zhang, and Volkhard May — Institut für Physik, Humboldt Universität zu Berlin, Newtonstrasse 15, D-12489 Berlin, Germany

Optical and transport properties of supramolecular complexes (SC) placed in the vicinity of a metal nanoparticle (MNP) are investigated by applying a density matrix approach. This enables a nonperturbative consideration of the excitation energy transfer coupling in the SC as well as between the SC and the MNP. The coupling can be described in terms of a shift and a broadening of all Frenkel exciton levels together with a remarkable oscillator strength change. In particular the latter effect becomes clearly observable in absorption and emission spectra and explains the MNP induced enhancement of molecular spectra. Resulting from the absorption enhancement sub-picosecond laser pulse induced spatio-temporal excitation energy localization in the SC near a MNP is predicted. The importance of MNP multipole excitations is underlined at several places. The exact description of the interacting SC MNP coupling is confronted with a mean–field approximation which directly leads to a local field description of the effect of the MNP on an individual molecule. (Y. Zelinskyy, Y. Zhang and V. May, J. Phys. Chem. A 116, 11330 (2012), G. Kyas, Y. Zelinskyy, Y. Zhang, V. May, Ann. Phys. (in press), Y. Zelinskyy, Y. Zhang and V. May, J. Chem. Phys. (submitted)).

HL 39.8 Tue 12:15 H13

**Photoconductance properties of gold nanorod arrays** — •Sandra Diefenbach[1], Daniela Iacopino[2], Johannes Schopka[1], and Alexander Holleitner[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4a, 85748 Garching b. München, Germany — [2]Tyndall National Institute, Lee Maltings, University of Cork, Ireland

Gold nanorods are fabricated by dielectrophoretic self-assembly [1] and contacted by gold contacts. Conductance measurements in the dark confirm thermally activated transport at room temperature. At low temperature, a dominating Coulomb blockade is observed [2]. The photoconductance of the nanorod arrays depends linearly on laser power and exponentially on temperature. The photoconductance experiments allow us to clarify the impact of the longitudinal plasmon frequency of the nanorods on the optoelectronic properties of the arrays. Financial support by the grant HYSENS is acknowledged.

[1] A. Pescaglini et al. J. of Phys. Conf. Ser., 307, 012051 (2011).
[2] M. Mangold, M. Calame, M. Mayor, A.W. Holleitner, ACS Nano 6, 4181 (2012).

HL 39.9 Tue 12:30 H13

**Giant enhancement of Pentacene (PEN) Raman scattering and fluorescence emission induced by plasmonic properties of gold Fischer patterns** — Jan Rogalski, Andreas Kolloch, Paul Leiderer, Katharina Broch, Frank Schreiber, Alfred J. Meixner, and •Dai Zhang — Institute of Physical and Theoretical Chemistry, Uni. Tübingen, Tübingen

Fischer patterns are metallic nanostructures composed of a network of hexagonal aligned triangles. We studied the plasmonic effects of gold Fischer patterns regarding the substrate and its polarization effects via monitoring the photoluminescence (PL) spectral profile and intensity. The excitation of the Fischer patterns shows strong substrate dependence. On silicon substrates, the PL of Fischer patterns is much weaker than on glass substrates. By using a radially or azimuthally polarized laser beam, we selectively excite the center or corner plasmonic modes of the nanotriangles that make up the Fischer patterns. PEN is a commonly studied optoelectronic material which has found wide-spread application in light emitting diodes or solar cell research. Our experiments clearly show a giant enhancement of the Raman scattering and PL signal from PEN deposited on a Fischer pattern surface. A detailed analysis, entailing the enhancement factor and the plasmon-polariton coupling between the Fischer pattern and the PEN thin film will be presented.