HL 41 Heterostructures

Time: Thursday 11:00–12:45 Room: BEY 154

HL 41.1 Thu 11:00 BEY 154

Spin transport in semiconductor heterostructures with Rashba spin-orbit interaction in an electric field — •Olaf Bleibaum — Institut für Theoretische Physik, Otto-von-Guericke Universität, 39016 Magdeburg, PF 4120

Investigations on the impact of an electric field on spin transport processes are of much current interest. Particular attention is paid to systems with Rashba spin-orbit interaction. We have derived a system of diffusion equations, which also take into account the coupling between spin transport and charge transport, to get further insight into the impact of the electric field on the transport properties of such systems. In the talk we discuss the structure of these equations and investigate special solutions. Doing so, we pay particular attention to quantum and spin-charge coupling effects.

HL 41.2 Thu 11:15 BEY 154

Electrical Spin Injection from ZnMnSe into InGaAs/GaAs Quantum Dots — •W. Löffler[1,2], D. Tröndle[1,2], J. Fallert[1], H. Kalt[1,2], D. Litvinov[3,2], D. Gerthsen[3,2], J. Lupaca-Schomber[1,2], T. Passow[1,2], B. Daniel[1,2], J. Kvietkova[1], and M. Hetterich[1,2] — [1]Institut für Angewandte Physik, Universität Karlsruhe (TH), D-76128 Karlsruhe (Germany) — [2]DFG Center for Functional Nanostructures (CFN), Universität Karlsruhe (TH), D-76128 Karlsruhe (Germany) — [3]Laboratorium für Elektronenmikroskopie, Universität Karlsruhe (TH), D-76128 Karlsruhe (Germany)

We report on efficient injection of spin-polarized electrons into InGaAs quantum dots (QDs) embedded in a p-i-n light-emitting diode structure. For electron spin alignment we made use of a semi-magnetic spin-aligner layer (ZnMnSe) on top. The spin-LEDs have been grown by molecular-beam epitaxy and show a nearly perfect III-V/II-VI interface in transmission electron microscopy. In an external magnetic field, we find a circular polarization degree of up to 75% for the electro-luminescence of the QDs. We can clearly attribute this polarization degree to be due to recombination of spin-injected electrons (with unpolarized holes) by comparison with results from reference devices without spin aligner and all-optical measurements. The robustness of this injection scheme is characterized with respect to sample temperature and current density. From that, we deduce that this combination of nearly perfect spin-alignment in ZnMnSe and ultra-long spin lifetimes in InGaAs/GaAs QDs is a very promising candidate for spintronics applications.

HL 41.3 Thu 11:30 BEY 154

Simulated strain-energy minimization in oxygen, SiO_2 and GeO_2 monolayer quantum wells in Si(001) — •D Quinlan[1] and R Tsu[2] — [1]Universität Göttingen, IV. Physikalisches Institut, Germany — [2]University of North Carolina at Charlotte

We simulate the hypothetical structural feasibility of three quantum wells that could be grown in bulk Si(001). The most basic QW geometry consists of a single monolayer of oxygen forming a set of “bridge bonds” separating two volumes of silicon (i.e. [Si]−O−[Si] in the 001-direction). SiO_2 or GeO_2 can be formed by two of these oxygen monolayers enclosing a single layer of germanium or silicon ([Si]−O−X−O−[Si], where X = Si or Ge). Relaxation of the QW geometry is performed using the Keating model, which defines total strain energy as a summation of contributions based on bond-length and bond-angle deviations from equilibrium values. This yields an atomic structure that defies bulk crystalline silicon symmetry. The result is consistent with knowledge of similar (001)-terminations of crystalline silicon, including clean silicon surface reconstruction and the Si-$\alpha$$SiO_2$ interface, where the new periodicity requires a larger pattern to properly define.

[1] PN Keating, Phys. Rev. **145**, 637 (1966).
[2] F Wooten, K Winer and D Weaire, Phys. Rev. Lett. **54**, 1392 (1985).
[3] H Over, J Wasserfall, W Ranke, C Ambiatello, R Sawitzki and W Moritz, Phys. Rev. B **55**, 4731 (1997).
[4] Y Tu and J Tersoff, Phys. Rev. Lett. **84**, 4393 (2000).

HL 41.4 Thu 11:45 BEY 154

Mesoscopic systems of cold indirect excitons in traps — •Alexei Filinov[1], Yurii Lozovik[2], Jens Boning[1], and Michael Bonitz[1] — [1]Institut fur Theoretische Physik und Astrophysik, Leibnizstrasse 15, 24098 Kiel — [2]Institute of Spectroscopy RAS, Troitsk, 142190, Russia

Experimental studies of cold excitonic gases in heterostructures attract now high interest due to the predicted possibility to observe Bose condensation of indirect excitons. If the excitons have an intrinsic dipole moment produced from specially engineered quantum well bandstructure or an applied electric field, the repulsive dipole-dipole interaction can be a dominant effect which should be taken into account in theoretical considerations. Here we study with Path Integral Monte Carlo (PIMC) simulation recent experimental realizations of indirect excitons in GaAs/AlGaAs coupled QWs [1] and in a single QW in high electric fields influenced in addition by a lateral confinement producing a 3D trap. First, using pre-compiled effective dipole moment, we consider the excitons as 2D bosonic particles. We analyze the possibility to observe an exciton supersolid [2] in mesoscopic systems (N=10..40) and present simulation results for the condensate fraction and the superfluidity. Second, by varying exciton density and temperature we compare these results with full 3D simulations where the excitons are composed from electrons and holes. This comparison allows for a rigorous check of the applicability and limits of the bosonic model of dipoles.

[1] V.Negoita, D.W.Snoke, K.Eberl, Phys. Rev. B 60, 2661 (1999); L.V.Butov et al., Phys.Rev.Lett. 86, 5608 (2001). [2] Yu.E.Lozovik, S.Yu.Volkov, and M.Willander, JETP Lett. 79, 473 (2004).

HL 41.5 Thu 12:00 BEY 154

Resonant impurity states in quantum wells and superlattices — •Dominik Stehr[1], Claus Metzner[2], and Manfred Helm[1] — [1]Institute of Ion Beam Physics and Materials Research, Forschungszentrum Rossendorf, P.O. Box 510119, D-01314 Dresden — [2]Technische Physik I, Universität Erlangen, Erwin-Rommel-Str.1, D-91058 Erlangen

Introducing dopant atoms in quantum wells (QWs) and superlattices results in a random impurity potential in addition to the confinement in growth direction. As has recently been demonstrated, their hydrogenic levels form resonant states attached to each QW subband and finally develop into a novel type of impurity band in the case of superlattices[1].

Here we present detailed numerical studies of coupled double and quadruple QW structures with relatively low doping (few 10^{10}cm^{-2} per layer), which can be seen as precursors to superlattices. By treating impurity and QW potential in a unified framework we exactly diagonalize the fully three-dimensional Schrödinger equation and calculate the infrared absorption spectrum. We find that, by varying the lattice temperature, the absorption spectrum changes dramatically, not only in its energetic resonances but also in its electronic origin. Analyzing the 3D-wavefunctions of the electronic states contributing to the final absorption spectra shows that at room temperature mainly delocalized states (intersubband states) contribute to the spectra, whereas at low temperature they are dominated by strongly localized states (impurity states). Hitherto unexplained experimental data of a quadruple QW sample are nearly perfectly reproduced by our calculation.

[1] D. Stehr et al., Phys. Rev. Lett., in print (2005).

HL 41.6 Thu 12:15 BEY 154

Effective Hamiltonian Approach for the Magnetic Band Structure and Novel Oscillations in the Magnetization of Two-Dimensional Lattices in a Magnetic Field — •Manfred Taut, Helmut Eschrig, and Manuel Richter — Leibniz Institute for Solid State and Materials Research, IFW Dresden, POB 270116, 01171 Dresden, Germany

The one-electron Schrödinger equation in a two-dimensional **periodic potential** and an **homogeneous magnetic field** B perpendicular to the plane is solved exactly for rational flux quantum numbers per unit cell $\Phi_c/\Phi_0 = p/q$. For comparison, the spectrum around a certain flux quantum number p_0/q_0 has also been obtained by semi-classical quantization of the exact magnetic band structure (MBS) at p_0/q_0. To implement and justify this procedure, a generalized effective Hamiltonian theory based on the MBS at finite magnetic fields has been established. The **total energy** as a function of Φ_c/Φ_0 shows **series of kinks**, where each kink indicates an **insulating** state. The kinks of each series converge to a **metallic** state. The **magnetization** contains information not only about the band structure (at zero-magnetic-field), but also about the *magnetic* band structures (for finite fields). The **period of the oscillations** in $M\,(1/(B-B_0))$ is determined by the Fermi surface cross sections for the MBS at B_0. The **height of the steps** in $M(B)$ provides the energy gap in the MBS at B. Unlike the standard Lifshitz-Kosevich type approaches, our theoretical de Haas-van Alphen spectra contain the effects of magnetic breakdown, forbidden orbits and inter band coupling implicitly.

HL 41.7 Thu 12:30 BEY 154

Statistics of microcavity polaritons under non-resonant excitation — •Paolo Schwendimann and Antonio Quattropani — Institute of Theoretical Physics, Ecole Polytechnique Fédérale, CH 1015 Lausanne-EPFL

In this contribution we present a model describing polariton amplification and coherence observed in non-resonantly excited polariton systems. We consider a quantum well embedded in a microcavity, excited by a continuous laser field at energy near the conduction band edge. The laser intensity is such that the exciton density in the microcavity remains much smaller than the exciton saturation density. The emission characteristics of this system are described in terms of interacting microcavity exciton-polaritons, which are admixtures of excitons and photons. As it is well known, the pump polariton state decays along the exciton-polariton dispersion curve, until the dispersion flattens. In this energy region a bottleneck effect is observed. We exploit this result by assuming that the polariton modes in the bottleneck may be considered as a thermal reservoir. Since emission is observed into the lowest energy state of the system at k = 0, we derive a master equation describing the evolution of this mode under the influence of the bottleneck reservoir. We show that this mode exhibits a threshold depending on the material parameters and on the injected exciton density. In particular we show that above threshold the statistics of the polaritons approaches that of a laser. As an example, we present the statistics for polaritons obtained in GaAs and CdTe microcavities.