TT 95: Spintronics: Mobile Electrons and Holes (jointly with HL, MA)

Time: Thursday 10:00–12:30 Location: ER 164

TT 95.1 Thu 10:00 ER 164

Conserved Spin Quantity in Strained Hole Systems with Rashba and Dresselhaus Spin-Orbit Coupling — •Michael Kammermeier[1], Paul Wenk[1], John Schliemann[1], Klaus Richter[1], and Roland Winkler[2] — [1]Universität Regensburg, D-93040 Regensburg, Germany — [2]Northern Illinois University, IL 60115 DeKalb, US

We investigate conditions for the existence of a conserved spin quantity in two-dimensional hole gases in zincblende type semiconductor heterostructures. It is shown that in the presence of shear stress, a symmetric in-plane strain, and both Rashba and Dresselhaus spin-orbit coupling one can find such a conserved quantity. The found optimal parameter-space, for strain and spin-orbit coupling strength, gives the possibility to an experimental access. This is in contrast to previous works which require restrictions on the band model parameters (here the Luttinger parameters) which are either difficult to realize in real materials or even singular ($\gamma_3 = 0$).

* * *

[1] Schliemann *et al.*, PRL **90** 146801 (2003)
[2] Bernevig *et al.*, PRL **97** 236601 (2006)
[3] Kohda *et al.*, PRB **86** 081306 (2012)
[4] Dollinger *et al.* Phys. Rev. B **90**, 115306 (2014)

TT 95.2 Thu 10:15 ER 164

Quantum transport and response with spin-orbit coupling in magnetic fields — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP) Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

Electronic transport in spin-polarized systems with impurity interactions and spin-dependent meanfields is discussed. The coupled quantum kinetic equations for the scalar and spin components for SU(2) are derived with special consideration of spin-orbit coupling and magnetic fields. Linearizing, the RPA spin and density dynamical responses to electric fields (polarized light) are preseented for arbitrary magnetic fields, Several known effects are described: spin-Hall, anomalous Hall and optical Hall effect, spin-heat coupling. New transport coefficients occur due to the selfconsistent precession direction. Clarifying the relative importance of meanfield and scattering correlations, new modes due to magnetic fields and spin-orbit coupling are found. (EPL, 104 (2013) 2700)

TT 95.3 Thu 10:30 ER 164

Spin injection through Fe/GaAs Schottky contacts — •Lennart-Knud Liefeith, Rajkiran Tholapi, Max Hänze, Ann-Kathrin Michel, Taras Slobodskyy, and Wolfgang Hansen — Institut für Festkörper- und Nanostrukturphysik, Hamburg, Hamburg

The understanding of the dominant mechanism of spin injection through the Fe/GaAs interface is crucial for spintronics applications. It was suggested that the spin injection process is controlled by thermal activation of surface states at the ferromagnet/semiconductor interface [1]. To test this theory we investigated the bias dependence of the spin injection efficiency as well as the electrical properties of the interface. The measurements were carried out using non-local spin detection devices at liquid helium temperatures and backed up by magneto optical Kerr effect and magnetic force microscopy measurements on the electrodes. We found that the post growth annealing strongly influences the spin injection efficiency and a notable asymmetry of the spin injection efficiency depending on the applied bias was observed.

[1] Q. U. Hu et. al., „Spin accumulation near Fe/GaAs(001) interfaces: The role of semiconductor band structure“, Physical Review B 84, 085306 (2011)

TT 95.4 Thu 10:45 ER 164

Electric control of spin transport in GaAs (111)B quantum wells — •Alberto Hernández-Mínguez, Klaus Biermann, and Paulo Santos — Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany

The main challenge towards the use of electron spins in semiconductors is the control of the dephasing mechanisms that reduce the spin lifetime below the spin manipulation time. In III-V semiconductors, the main relaxation processes are related to the spin-orbit interaction (SOI). In the case of GaAs(111) quantum wells (QWs), the SOI can be efficiently suppressed for out-of-plane spins by applying an electric field, E_z, transverse to the QW plane. In this case, the contribution to the SOI induced by E_z compensates the intrinsic SOI due to the zinc-blende lattice and spin lifetimes of tenths of ns are observed.

In this contribution, we show experimental studies of both carrier and spin diffusion in a GaAs(111) QW under the effect of vertical electric fields. Spin polarized electron-hole pairs are optically generated in the QW by a tightly focused laser beam. The carrier and spin dynamics are studied by spatially and time-resolved photoluminescence. We show that the enhancement of the spin lifetime due to SOI compensation allows the transport of out-of-plane electron spins over distances exceeding 10 μm. In addition to the spin lifetime, the spin diffusion coefficient D_s also depends on E_z. For the carrier densities and temperatures studied, D_s shows a maximum of approx. 50 cm^2/s at SOI compensation, where it approaches the values observed for the carrier diffusion coefficient under the same experimental conditions.

TT 95.5 Thu 11:00 ER 164

Time and space resolved visualization of spin diffusion and drift in GaAs based two-dimensional electron gases — •Markus Schwemmer[1], Roland Völkl[1], Tobias Korn[1], Sergey Tarasenko[2], Dieter Schuh[1], Dominique Bougeard[1], Mariusz Ciorga[1], Werner Wegscheider[3], and Christian Schüller[1] — [1]Institute of Experimental and Applied Physics, Faculty of Physics, University of Regensburg, Germany — [2]A. F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia — [3]ETH Zurich, Switzerland

The combination of a femtosecond pulsed TiSa-Laser system with a magneto-optical Kerr effect microscope setup allows us to study time and space resolved propagation of an optically injected electron spin packet in a resident two-dimensional electron gas based on a modulation-doped AlGaAs/GaAs quantum well. The interplay between the Dresselhaus and Rashba fields according to crystallographic orientation and layer structure of the sample determines the electron spin dynamics. On one hand we present diffusive and current-driven motion of a spin packet in a sample in which the orientation of the optically injected spins point along the effective spin orbit field. Therefore D'yakonov-Perel spin dephasing is suppresed and a long spin coherence time can be attained. On the other hand the diffusive spreading of the initial spin packet in a sample with a spin-orbit interaction close to the spin helix regime is monitored, whereby a direct visualization of the helix pattern is achieved. Financial support by the DFG via SFB 689 and SPP 1285 is gratefully acknowledged.

Coffee break

TT 95.6 Thu 11:30 ER 164

Hole spin coherence in coupled GaAs/AlAs quantum wells — •Christian Gradl, Johannes Holler, Michael Kempf, Dieter Schuh, Dominique Bougeard, Christian Schüller, and Tobias Korn — Universität Regensburg, D-93040 Regensburg, Germany

We performed time-resolved Kerr rotation (TRKR) measurements on an undoped [113]-grown double quantum well (QW) structure to resolve the spin dynamics of hole ensembles at low temperatures. Our gated system consists of two QWs with different well widths, which we use for the spatial separation of the optically excited electron-hole pairs. Thus, we are able to create hole ensembles with spin dephasing times of several hundreds of picoseconds in the broader QW without any doping.

This allowed an unexpected observation of a non-precessing component in the TRKR signal in the presence of an applied magnetic field perpendicular to the spin polarization. These measurements also show the non-precessing component to be a part of the optically generated hole spin polarization. This effect might arise from a tilting of the quantization axis with respect to the applied magnetic field due to a large anisotropy between the in- and out-of-plane hole g factor.

TT 95.7 Thu 11:45 ER 164

Inelastic light scattering in a two-dimensional electron gas under external magnetic fields — •Christoph Schönhuber, Dieter Schuh, Dominique Bougeard, Tobias Korn, and Christian Schüller — Universität Regensburg, 93040 Regensburg, Germany

We present inelastic light scattering measurements of a 12-nm-wide (001)-oriented GaAs/AlGaAs QW under external magnetic fields. The investigated system is single-side Si doped to reach a balanced Rashba and Dresselhaus SOI contribution.

The performed measurements on intrasubband transitions of the conduction band reveal for B=0 a double peak structure for the [1-1] direction due to spin splitting, while the [11] direction features only a single peak. For small magnetic fields, the wave vector appears to be conserved in the scattering process while both directions aim to assimilate the excitation with increasing field strength. At higher perpendicular magnetic fields, the anisotropic behaviour has vanished and the spectra are characterized by inter-Landau excitations.

TT 95.8 Thu 12:00 ER 164

Impurity band spin dynamics in GaAs directly above the metal-to-insulator transition — •Jan Gerrit Lonnemann[1], Eddy Patrick Rugeramigabo[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany — [2]Laboratory of Nano and Quantum Engineering, Leibniz Universität Hannover, Schneiderberg 39, D-30167 Hannover, Germany

Several theoretical works treat the spin dynamics in zinc-blende semiconductors. We present extremely low excitation Hanle depolarization measurements on well characterized n-doped MBE grown GaAs in the vicinity of the metal-to-insulator transition (MIT). The doping concentrations range from the MIT at $2 * 10^{16}$ cm^{-3}, where extremely long spin lifetimes are experimentally observed [1], up to the merging of impurity and conduction band at $8 * 10^{16}$ cm^{-3}, where for conduction band electrons the spin relaxation is typically dominated by the Dyakonov-Perel mechanism (DP). We conclude from our measurements that DP is also dominating the impurity band regime in slightly metallic samples. Furthermore the measurements show no indication of spin relaxation by hopping transport (HT) that has recently been predicted as the main mechanism of relaxation for the impurity band regime [2]. In contrast our measurements of the spin dynamics indicate a metal-like behavior of the electrons in the impurity band.

[1] M. Römer et al.; *Phys. Rev. B*, **81**, 075216 (2010).
[2] G.A. Intronati et al.; *Phys. Rev. Lett.*, **108**, 016601 (2012).

TT 95.9 Thu 12:15 ER 164

Boundary dependent spin manipulation via Rashba-SOC — •Phillipp Reck and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

Besides spin injection, controlled spin manipulation is a major aspect of active spintronic devices such as spin transistors. In a two dimensional electron gas (2DEG), this manipulation is often achieved by Rashba spin orbit coupling (SOC).

We study numerically the effects of a non-trivial deformation of a wire (quasi 1DEG) on the spin evolution of an initially spin polarized wave packet exposed to Rashba SOC. To make sure that the wave packet follows the deformation, we apply additionally a magnetic field to get edge states, which are resistant to impurity scattering. The benefit of the deformation is the higher variability of the spin state: Without the deformation, the spin precesses on the Bloch sphere around one fixed axis, whereas the deformation changes continuously the orientation of the precession axis leading to a more complex spin evolution. Thus, it is possible, e. g., to create either a x-, y- or z-spin polarization by only changing the Rashba SOC, but not the geometry.

A generalization is a wire with a periodic deformation. Because of the constant out-of-plane magnetic field and an in-plane rotating effective magnetic field due to SOC, one could engineer spin resonance effects.