HL 13 Spin controlled transport I

Time: Tuesday 11:00–13:15 Room: BEY 118

HL 13.1 Tue 11:00 BEY 118

Dynamics of Spin-Flip Scattering due to the Bir-Aronov-Pikus Mechanism — •Hans Christian Schneider — FB Physik, TU Kaiserslautern

After a brief review of existing theoretical results on electron-hole exchange scattering in semiconductors (Bir-Aronov-Pikus mechanism), numerical results on the dynamics of this scattering mechanism and its interplay with spin-conserving Coulomb scattering are presented. It is shown that for low electron densities a single spin relaxation-time can approximate the results of the full calculation rather well, even though the individual scattering rates are strongly energy-dependent. This spin-relaxation time is evaluated for a wide range of temperatures and densities and is shown to agree well with recent experiments. The results are also compared with widely-used simplified expressions for spin relaxation-times that are only valid for extremely high and low p-doping concentrations. The interesting range of doping concentrations and temperatures around hole degeneracy, which cannot be described by simplified expressions, is discussed in detail.

HL 13.2 Tue 11:15 BEY 118

Spin Relaxation Anisotropy in Semiconductor Quantum Wells — •Leonid Golub, Nikita Averkiev, Alexey Gurevich, Vadim Evtikhiev, Vladimir Kochereshko, Alexey Platonov, Alexey Shkolnik, and Yuri Dolgikh — A.F. Ioffe Physico-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

Spin relaxation of conduction electrons is an important field of research due to rapidly developing semiconductor spintronics. The Dyakonov-Perel spin relaxation process is the dominant spin decoherence mechanism in undoped GaAs-based heterostructures. This mechanism is caused by spin splitting of electron energy spectrum which originate either from the structure inversion asymmetry (Rashba term) or the bulk inversion symmetry (Dresselhaus term). The presence of both Rashba and Dresselhaus spin-splittings results in the electron spin relaxation times anisotropy. A set of triangular and rectangular GaAs (001) quantum wells has been MBE grown on semi-insulating GaAs substrates. Circularly polarized photoluminescence (PL) spectra under circularly polarized excitation have been studied at 77K in magnetic fields up to 0.5T. The magnitude of the optical orientation signal amounts to 10% and is virtually constant within the PL contour. We observe that when the magnetic field is directed along the [110] axis the Hanle curve is about 1.6 times wider than the depolarization curve for [1-10] direction. The observed anisotropy of the Hanle effect is caused by anisotropy of the electron spin relaxation. The analysis shows that the Rashba term is about 4 times stronger than the Dresselhaus term in the studied system.

HL 13.3 Tue 11:30 BEY 118

Polarized Electric Current in Semiclassical Transport with Spin-Orbit Interaction — •P.G. Silvestrov[1] and E.G. Mishchenko[2] — [1]Theoretische Physik III, Ruhr-Universitt Bochum, 44780 Bochum, Germany — [2]Department of Physics, University of Utah, Salt Lake City, UT 84112, USA

Semiclassical solutions of two-dimensional Schrödinger equation with spin-orbit interaction and smooth potential are considered. In the leading order, spin polarization is in-plane and follows the evolution of the electron momentum for a given subband. Out-of-plane spin polarization appears as a quantum correction, for which an explicit expression is obtained. We demonstrate how spin-polarized currents can be achieved with the help of a barrier or quantum point contact open for transmission only in the lower subband.

HL 13.4 Tue 11:45 BEY 118

Optical investigation of spin polarization in semiconductor heterostructures — •Ulrich Niedermeier, Klaus Wagenhuber, Christian Gerl, and Werner Wegscheider — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

Creating spin polarization in low-dimensional semiconductor systems is essential for the realization of new concepts in the field of spintronics. It has been shown that in systems with lifted spin degeneracy due to spin-orbit interaction a new class of spin-related effects can be observed [1]. While the spin-galvanic effect is referred to as a current induced by spin orientation we are investigating the reversed spin-galvanic effect, i.e. a spin orientation induced by a current. Recently, it has been demonstrated by means of optical interband spectroscopy that passing an electric current in lateral geometry through a two-dimensional hole system leads to an orientation of spins [2]. In order to reproduce this effect photoluminescence measurements of modulation doped p-type AlGaAs/GaAs heterojunctions under current flow are performed. The analysis of the circular polarization of the photoluminescence signal should give a low-limit estimate of the spin polarization achieved.

[1] S. D. Ganichev, W. Prettl, J. Phys.: Condens. Matter (Topical Review) **15**, R935 (2003).
[2] A. Yu. Silov et al., Appl. Phys. Lett. **85**, 5929-5931 (2004).

HL 13.5 Tue 12:00 BEY 118

Suppression of Spin Relaxation in n-InGaAs-Wires — •Alexander Holleitner — Center for NanoScience (CeNS), Munich, Germany

The spin dynamics of electrons have been investigated in narrow two-dimensional n-InGaAs channels as a function of the wire width [1]. We find that electron-spin relaxation times increase with decreasing channel width, in accordance with recent theoretical predictions [2]. Surprisingly, the suppression of the spin relaxation rate can be detected for widths that are an order of magnitude larger than the electron mean free path. We find the spin diffusion length and the wire width to be the relevant length scales for explaining these effects. We discuss to which extent confinement, spin-orbit coupling, and structural parameters such as strain explain the observed effects. For the presented work, we acknowledge financial support by AFOSR and ONR. [1] A.W. Holleitner, V. Sih, R.C. Myers, A.C. Gossard, and D.D. Awschalom in preparation (2005). [2] A.G. Malshukov, K.A. Chao, Phys. Rev. B 61, 2413 (2000).

HL 13.6 Tue 12:15 BEY 118

Rashba Spin Splitting in GaN Heterostruckturen — •Wolfgang Weber[1], S.D. Ganichev[1], Z.D. Kvon[2], V.V. Belkov[3], L.E. Golub[3], S.N. Danilov[1], D. Weiss[1], W. Prettl[1], Hyun-Ick Cho[4], and Jung-Hee Lee[4] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg — [2]Institut für Halbleiterphysik, Novosibirsk, 630090, Russland — [3]A. F. Ioffe Physikalisch-Technisches Institut, 194021 St. Petersburg, Russland — [4]Kyungpook Staatliche Universität, 1370, Sankyuk-Dong, Daegu 702-701, Korea

The spin splitting in k-space of the conduction band of low-dimensional GaN-structures was experimentally proved. It is shown, that the excitation of (0001)-oriented GaN quantum wells with infrared or terahertz radiation causes the circular photogalvanic effect. From a microscopical point of view this effect is a consequence of spin-orbit-coupling, which removes the spin-degeneration of the carriers in k-space, and the optical selection rules. The observation leads to a tunable Rashba-like spin splitting, which comes from the built-in asymmetry of the AlGaN/GaN interface. This fact, together with the anticipated high curie temperature under Mn doping and the long spin relaxation times, makes GaN an interesting material for spintronics.

HL 13.7 Tue 12:30 BEY 118

Detection of few phosphorus donors in silicon — •H. Huebl[1], D. R. McCamey[2,3], M. Lunz[1], W. Hutchison[2,4], J. C. McCallum[2,5], A. R. Hamilton[3], R. G. Clark[2,3], and M. S. Brandt[1] — [1]Walter Schottky Institut, Germany — [2]Australian Research Council Centre of Excellence for Quantum Computer Technology — [3]School of Physics, The University of New South Wales, Sydney, Australia — [4]School of Physical, Environmental and Mathematical, University College, The University of New South Wales ADFA,Canberra, Australia — [5]School of Physics, University of Melbourne, Australia

One of the concepts for scalable solid-state based quantum computing is Kane's proposal based on phosphorus donors in silicon. To estimate the sensitivity which is reached with magnetic resonance techniques in the detection of donor spins, we have measured electrically detected magnetic resonance (EDMR) on devices containing a few phosphorus donors only.

In the devices studied phosphorus with a concentration of 2×10^{17} cm^{-3} is implanted at 15 keV into intrinsic silicon in an area of 100×100 nm^2

defined by electron beam lithography. The leads contacting this island are also obtained by implantation with P, however to a concentration above the Mott transition which does not lead to an EDMR signal.

At 5 K and under illumination, a resonant change of the conductivity $\Delta\sigma/\sigma \approx 10^{-5}$ is observed for an island containing 85±10 atoms. From the signal-to-noise ratio, a sensitivity of about 600 P/$\sqrt{\text{number of field scans}}$ can be deduced for the samples investigated so far. This experiments demonstrate the possibilities for investigating the properties of a few of donors and indicates that single spin resolution should be achievable.

HL 13.8 Tue 12:45 BEY 118

Pure Spin Currents by Spin Dependent Electron Phonon Interaction — •Stephan Giglberger[1], S.D. Ganichev[1], S.N. Danilov[1], V.V. Belkov[2], E.L. Ivchenko[2], S.A. Tarasenko[2], D. Weiss[1], W. Prettl[1], W. Janzsch[3], F. Schaffler[3], and D. Gruber[3] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg — [2]A.F. Ioffe Physico-Technical Institute, 194021 St. Petersburg, Russland — [3]Institut für Halbleiter- und Festkörperphysik, Johannes-Kepler-Universität, Linz, Österreich

It is shown that in gyrotropic quantum wells Drude absorption of terahertz radiation leads to a pure spin current. This current is caused by spin dependent electron phonon interaction wich can be described by k-linear terms in their matrix element. Due to these k-linear terms Drude absorption leads to an asymmetric allocation of charge carriers within each subband and hence to a spinpolarised electric current. Due to the fact that direction of this current is antipodal for both spin subbbands the resulting electric net current will be zero, but there will be two spin currents. Here both the theory and the experimental verification of such spin currents will be presented. In experiment the pure spin current was converted to an electric current by applying a small magnetic field parallel to the plane which leads to Zeeman spin splitting and destroys the equilibrium of the opposing spin currents. Experiments were carried out on (001)-oriented asymmetric SiGe quantum wells under excitation with linearly polarised radiation of 140 μm wavelength.

HL 13.9 Tue 13:00 BEY 118

Magnetic anisotropy and antiferromagnetic exchange of Co impurities in ZnO — •Roland Hayn[1], Pascal Sati[1], Anatole Stepanov[1], Roman Kuzian[2], Thomas Chanier[1], Steffen Schäfer[1], Sonia Régnier[1], and Christian Morhain[3] — [1]Laboratoire Materiaux et Microelectronique de Provence, 13397, Marseille Cedex 20, France — [2]Institute for Material Science, Krzhizhanovskogo 3, 03180 Kiev, Ukraine — [3]Centre de Recherche sur l'Hetero-Epitaxie et ses Applications-CNRS, 06560, Valbonne Sophia-Antipolis, France

We report on the magnetic properties of (Zn,Co)O epitaxial thin films with low Co concentration. Magnetic and EPR measurements, combined with crystal field theory, reveal that isolated Co impurities possess a strong single ion anisotropy, which would lead to an easy plane ferromagnetic state when a hypothetical Co-Co interaction would be considered. However, the magnetization measurements show the presence of short-range antiferromagnetic exchange interactions between nearest-neighbor magnetic ions which is supported by LSDA+U calculations.