MA 27: Spintronics 1 (with HL/TT)

Time: Wednesday 10:15–12:00 Location: POT 006

MA 27.1 Wed 10:15 POT 006

Spin dynamics on the metallic side of the metal to insulator transition — •Jan G. Lonnemann, Kim Niewerth, Jens Hübner, and Michael Oestreich — Leibniz Universität Hannover - Abteilung Nanostrukturen, Hannover, Germany

Several theoretical works treat the spin dynamics in zinc-blende semiconductors, like GaAs, around the metal-to-insulator transition. Most of them fail to explain the extremely long lifetimes experimentally observed [1]. Recently, it was argued that the Dyakonov-Perel mechanism (DP), usually only applicable in the conduction band, can be extended towards hopping transport (HT) present in the impurity band [2]. The theoretical calculations predict a dependence on the carrier density differing strongly from the DP spin relaxation expected for the conduction band electrons. We present extremely low excitation Hanle depolarization measurements on precisely n-doped MBE grown samples in the range of carrier concentrations from 2 to $10 * 10^{16}$ cm^{-3}. The density dependence of the spin lifetimes extracted from our measurements indicates that the dephasing due to HT is not the dominant mechanism. Remarkably, there is no significant difference in the spin lifetimes obtained from measurements on MBE material, with extremely low compensation ratios, as compared with samples from commercial wafers. This further indicates that dephasing due to HT is not the dominant mechanism, since HT depends strongly on the compensation ratio.

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

MA 27.2 Wed 10:30 POT 006

Nanomechanical read-out and manipulation of a single spin — •Heng Wang and Guido Burkard — University of Konstanz, Department of Physics

The single electron spin in quantum dot is a promising candidate as a qubit for quantum computation and quantum information. We investigate detection as well as manipulation of the single spin in a suspended carbon nanotube quantum dot. The detection and the manipulation are based on the spin-mechanical coupling induced from the intrinsic spin-orbit coupling. We use a Jaynes-Cummings model with a quantized flexural mode of the resonator to describe the system. An external electric field is used to drive the resonator and to induce an the interaction between the single electron in the quantum dot and the external driving field. The spin states can be identified by measuring the mechanical motion of the nanotube, which is detected by observing the current through a nearby charge sensor. Arbitrary-angle rotations about arbitrary axes of the single electron spin can be achieved by varying the frequency and the strength of the external electric driving field.

MA 27.3 Wed 10:45 POT 006

Time-resolved electrical detection of the inverse spin Hall Effect after ps optical excitation — •Manfred Ersfeld[1], Ivan Stepanov[1], Sammy Pissinger[1], Christopher Franzen[1], Sebastian Kuhlen[1], Mihail Lepsa[2], and Bernd Beschoten[1] — [1]2nd Institute of Physics, RWTH Aachen University, Germany — [2]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich GmbH, Germany

Electrical detection of spin currents give an insight into the microscopic mechanisms of spin transport and play an important role in spin electronics. In previous experiments spin currents due to spin Hall effect have been imaged in optical measurements as spin accumulation.[1]

Here we report on the first time-resolved electrical detection of spin precession in n-InGaAs in time-resolved measurements of the inverse spin Hall effect. Net spin currents are achieved by applying electric fields and by polarization of the electrons with circularly polarized picosecond laser pulses. Electron spin precession in an external magnetic field can be monitored using a phase-triggered sampling oscilloscope as an oscillating voltage perpendicular to the applied electric field. Temperature dependent measurements of the spin Hall effect are presented. Time-resolved Faraday rotation measurements on the same sample under identical experimental conditions show good agreement between the measured spin dephasing times and the g-factor in the spin Hall measurements.

This Work has been supported by DFG through FOR 912

[1] Y. K. Kato et al., Science 306, 1910 (2004)

MA 27.4 Wed 11:00 POT 006

Terahertz out-of-plane resonances due to spin-orbit coupling — •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

A microscopic kinetic theory is developed which allows to investigate non-Abelian SU(2) systems interacting with mean fields and spin-orbit coupling under magnetic fields in one, two, and three dimensions. The coupled kinetic equations for the scalar and spin components are presented and linearized with respect to an external electric field. The dynamical classical and quantum Hall effect are described in this way as well as the anomalous Hall effect for which a new symmetric dynamical contribution to the conductivity is presented. The coupled density and spin response functions to an electric field are derived including arbitrary magnetic fields. The magnetic field induces a staircase structure at frequencies of the Landau levels. It is found that for linear Dresselhaus and Rashba spin-orbit coupling a dynamical out-of-plane spin response appears at these Landau level frequencies establishing terahertz resonances. (EPL, 104 (2013) 2700)

MA 27.5 Wed 11:15 POT 006

Resonant spin amplification in intrinsic bulk germanium — •Jan Lohrenz, Timo Paschen, and Markus Betz — Experimentelle Physik 2, TU Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund

Recent experiments have revealed the possibility to optically orient electron spins in bulk germanium via indirect optical transitions. However, the temporal limitations to both the spin lifetime and the coherence of photogenerated electrons have remained unexplored so far. Here we demonstrate resonant spin amplification in intrinsic bulk germanium using a 90 MHz femtosecond pulse train at 0.8 eV central photon energy. Most importantly, we find remarkably long spin lifetimes exceeding 50 ns at temperatures of up to 60 K, limited by Elliott Yafet type processes. Consistent with model simulations we also find pronounced signatures of the g-factor anisotropy in germanium in the resonant spin amplification data.

MA 27.6 Wed 11:30 POT 006

Ultrahigh Bandwidth Spin Noise Spectroscopy — •Fabian Berski, Hendrik Kuhn, Jan G. Lonnemann, Jens Hübner, and Michael Oestreich — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

We advance all optical spin noise spectroscopy (SNS) in semiconductors to detection bandwidths of several hundred gigahertz by employing a sophisticated scheme of pulse trains from ultrafast laser oscillators as an optical probe [1]. The ultrafast SNS technique avoids the need for optical pumping and enables nearly perturbation free measurements of extremely short spin dephasing times. We apply the technique to highly-n-doped bulk GaAs where magnetic field dependent measurements show unexpected large g-factor fluctuations. Calculations suggest that such large g-factor fluctuations do not necessarily result from extrinsic sample variations but are intrinsically present in every doped semiconductor due to the stochastic nature of the dopant distribution.

[1] Berski, F., et al., Phys. Rev. Lett. **111**, 186602 (2013).

MA 27.7 Wed 11:45 POT 006

Effect of Nuclear Quadrupole Moments on Electron Spin Coherence in Semiconductor Quantum Dots — •Erik Welander[1], Evgeny Chekhovich[2], Alexander Tartakovskii[2], and Guido Burkard[1] — [1]Department of Physics, University of Konstanz, Germany — [2]Department of Physics and Astronomy, University of Sheffield, United Kingdom

We theoretically investigate the influence of the fluctuating Overhauser field on the spin of an electron confined to a quantum dot. The fluctuations arise from nuclear spin being exchanged between different nuclei via the nuclear magnetic dipole coupling. We focus on the role of the nuclear interaction from electric quadrupole moments (QPM), which generally cause a reduction in internuclear spin transfer efficiency. By dividing the nuclear problem into subcells we are able to describe $10^4 - 10^5$ nuclei, which are realistic numbers for a quantum dot. The effects on the electron spin coherence time are studied by modeling an electron spin echo experiment. We find that the QPM cause an increase in the electron spin coherence time and that an inhomogeneous distribution, where different nuclei have different QPM, causes an even larger increase than a homogeneous distribution.