TT 97: Spintronics (joint session HL/TT)

Time: Thursday 15:00–17:30 Location: EW 201

TT 97.1 Thu 15:00 EW 201

Anisotropic Spin Diffusion and Spin Helix Dynamics in a CdTe Quantum Well — •Felix Passmann[1], Sergiu Anghel[1], Alexander Valerievich Poshakinskiy[2], Sergey Anatolyevich Tarasenko[2], Alan Douglas Bristow[3], and Markus Betz[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, Otto-Hahn-Straße 4a, D-44227 Dortmund, Germany — [2]Ioffe Institute, St. Petersburg 194021, Russia — [3]Department of Physics and Astronomy, West Virginia University, Morgantown, WV 26506-6315, USA

In the recent past various experiments conducted on zinc-blende type III-V semiconductor quantum wells like GaAs have revealed the dynamics of persistent electron spin helices. However, similar investigations in a doped CdTe single quantum well remained unexplored. Here, we employ ultrafast two-color Kerr rotation spectroscopy to study the spatio-temporal evolution of a photo-excited spin distribution into a long living spin helix (SH). The evolution is governed by the spin-orbit interaction related to bulk and structural inversion asymmetries which manifests as an effective magnetic field. We directly extract the Dresselhaus and Rashba contributions via the coherent spin precession of the diffusing electrons. Further investigations of the SH evolution in the presence of in-plane magnetic fields reveal a so far unseen and theoretically unexpected behavior that we attribute to spatial and temporal gradients of the electron density. The experiments are well supported by corresponding theoretical simulations.

TT 97.2 Thu 15:15 EW 201

Magnetoconductance correction in zinc-blende semiconductor nanowires with spin-orbit coupling — •Michael Kammermeier[1], Paul Wenk[1], John Schliemann[1], Sebastian Heedt[2], Thomas Gerster[2], and Thomas Schäpers[2] — [1]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Peter Grünberg Institute (PGI-9) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, 52425 Jülich, Germany

We study the effects of spin-orbit coupling on the magnetoconductivity in diffusive cylindrical semiconductor nanowires [1]. Following up on our former study on tubular semiconductor nanowires [2], we focus now on nanowire systems where no surface accumulation layer is formed but instead the electron wave function extends over the entire cross-section.The derived model is fitted to the data of magnetoconductance measurements of a heavily-doped back-gated InAs nanowire [3] and transport parameters are extracted. At last, we compare our results to previous theoretical and experimental studies and discuss the occurring discrepancies.

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[1] M. Kammermeier *et al.*, arXiv:1709.02621 (2017).
[2] M. Kammermeier *et al.*, PRB **93**, 205306 (2016).
[3] S. Heedt *et al.*, Nanoscale **7**, 18188 (2015).

TT 97.3 Thu 15:30 EW 201

Measuring Anisotropic Spin Relaxation in Graphene — Sebastian Ringer, Stefan Hartl, Matthias Rosenauer, Tobias Völkl, Maximilian Kadur, Franz Hopperdietzel, Dieter Weiss, and •Jonathan Eroms — Institute of Experimental and Applied Physics, University of Regensburg, Germany

To measure the anisotropy of the spin-lifetime in graphene, the most notable experiments are out-of-plane rotation of the ferromagnetic electrodes and oblique spin precession. We present a third method which is a Hanle experiment where the electron spins precess around either a magnetic field perpendicular to the graphene plane or around an in plane field. In the latter case, electrons are subject to both in-plane and out-of-plane spin relaxation.

To fit the data, we use a numerical simulation that can calculate precession with anisotropies in the spin-lifetimes under magnetic fields in any direction. Our data show a small, but distinct anisotropy that can be explained by the combined action of isotropic mechanisms, such as relaxation by the contacts and resonant scattering by magnetic impurities, and an anisotropic Rashba spin-orbit based mechanism.

We also perform oblique spin precession on our sample and compare it to our experiment of in-plane/out-of-plane Hanle in terms of reliability and precision. We find a non-trivial magnetization in our contacts that was only detected in the in-plane/out-of-plane Hanle experiment but is essential for a correct analysis of the oblique spin precession data. We conclude that the in-plane/out-of-plane Hanle experiment is the most reliable and precise method to measure the anisotropy.

TT 97.4 Thu 15:45 EW 201

Magneto-Raman spectroscopy and theoretical modelling of spin-density excitations in (001)-grown GaAs-AlGaAs quantum wells — •Sven Gelfert[1], Christian Frankerl[1], Christian Reichl[2], Dieter Schuh[1], Werner Wegscheider[2], Dominique Bougeard[1], Tobias Korn[1], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Laboratory for Solid State Physics, ETH Zürich, 8093 Zürich, Schweiz

We performed inelastic light scattering experiments on 12-nm-wide (001)-oriented GaAs-AlGaAs single quantum well samples in the presence of an external applied magnetic field. The investigated systems are Si doped to obtain a balanced Rashba and Dresselhaus SOI contribution (α=β). The resulting effective spin-orbit field is either parallel or antiparallel to the relevant in-plane crystal directions which leads to a highly anisotropic spin splitting of intrasubband transitions in the conduction band.

In order to get deailed insights on the behavior of the spin splitting we perform magnetic field series in different crystal directions. The intrinsic spin-orbit field strength and the electron g-factor can be deducted from our observations. We also provide theoretical considerations which quantitatively predict the modified spin splitting under these experimental conditions.

TT 97.5 Thu 16:00 EW 201

Spin valley coherent transport in Graphene — •Saber Rostamzadeh — Sabanci University, Orta Mahalle, Universite Caddesi No:27, 34956 Orhanli/Tuzla/Istanbul

Due to the advent of Spintronics, which attempts to perform calculations and store information using the spin instead of charge, there is a gradual increase in investigating methods to manipulate the spin degree of freedom of electrons in quantum confined structures to propose a surrogate for conventional electronic devices.

It has been shown that spin orbit coupling in Graphene plays a major role in generating and manipulating of spin polarized currents which found useful in spintronics applications.

Extra degree of freedom such as valley index in Graphene always adds to the functionality of the system and in a sense enlarges the parameter space of the system and works as an additional control parameter without the effort to make one.

In this work we demonstrate the effect of Rashba spin orbit interaction in Graphene induced by adatoms and show that it produces spin-valley coupling. This feature is useful in manipulating spin degree of freedom via valley index and furthermore we illustrate and theoretically set up a formalism which suggest the extraction of spin current form a valley current.

15 min. break.

TT 97.6 Thu 16:30 EW 201

Calculation of Spin Diffusion Equations in Spin/Orbital Polarized Systems — •Vincent Sacksteder[1] and Yasufumi Araki[2] — [1]Royal Holloway University of London, UK — [2]Tohoku University, Japan

This talk is about how to derive coarse-grained spin diffusion equations suitable for modeling a spintronics device from realistic Hamiltonians describing spin and scattering at the atomic scale. The standard formalism for obtaining diffusion equations requires performing an average over the Fermi surface, weighted by the scattering time. In spin or orbital-polarized systems the scattering time depends on spin and/or the orbital index; we describe the consequences for spin diffusion. This is important for modeling new memory devices which combine spin-orbit interactions with magnetization.

TT 97.7 Thu 16:45 EW 201

Gate-controllable large magnetoresistance in a 2DES based spin valve device — •Franz Eberle, Martin Oltscher, Thomas

Kuczmik, Andreas Bayer, Dieter Schuh, Dominique Bougeard, Mariusz Ciorga, and Dieter Weiss — Universität Regensburg, Regensburg, Germany

The realization of sFET like devices requires the presence of large local spin signals, which can be tuned by an electric field. In typical semiconductor structures, however, values of the magnetoresistance (MR) of only up to 1% have been observed. In this contribution we present the exceptionally large MR we observe in local two-terminal devices with the channel defined within a two-dimensional electron system (2DES) at an inverted GaAs/(Al,Ga)As interface.[1] Spin aligning source and drain contacts are based on a spin Esaki diode structure, consisting of ferromagnetic (Ga,Mn)As and n-doped GaAs. Depending on the applied bias, we observe MR ratios of up to 80%, which correspond to a signal height ΔR in the order of 1kΩ. We tune these large local signals by an electric gating scheme which, contrary to typical sFET proposals, is not based on the manipulation of spins due to the spin-orbit coupling. Instead, we use gates placed outside the current path to control confinement of spins in the region between the leads. With this method we can tune the MR in these devices by up to 14%.

The work was supported by the German Science Foundation through the project SFB 689.

[1] M. Oltscher et al., Nature Communications **8**, 1807 (2017)

TT 97.8 Thu 17:00 EW 201

Giant Bulk Rashba Splitting — •Louis Ponet and Sergey Artyukhin — Via Morega 30, 16163 Genova, Italy

Spintronics has been an exciting area in the last decades, due to a promise for devices that exploit the existence of spin-polarized states [1]. Important applications include storage media, where the use of spins to store data has been widespread since the earliest days of computing. An important challenge is the control of these states. Magnetic field control precludes further miniaturization. Possible solutions may include spin torques provided by spin-polarized currents. For use in electronic applications, there is a pressing need for electric control of the states, which was recently demonstrated in materials that showcase an anomalously large Rashba-effect [2]. Our research focused on quantitative description of the orbital Rashba-effect [3], an electrostatic effect that couples orbital angular momentum to the polarization. Due to its non-relativistic nature, the effect can be many orders of magnitude larger than would be expected from the spin Rashba-effect. We used model Hamiltonians and ab-initio calculations to examine the effect and outline the design principles for promising compounds.

References [1] S. D. Bader and S. S. P. Parkin, Spintronics Ann. Rev. Cond. Matt. Phys. 1, 71 (2010). [2] D. Di Sante, P. Barone, R. Bertacco, S. Picozzi, Advanced Materials, 25, 509 (2013). [3] Park J. H., Kim C. H., Rhim J. W., Han J. H., Phys. Rev. B 85, 195401 (2012).

TT 97.9 Thu 17:15 EW 201

Spin-transfer torques generated by strained 3D HgTe TI — •Graciely Santos, Simon Hartinger, Christian Jünger, Erwann Bocquillon, Charles Gould, and Laurens Molenkamp — Julius-Maximilians-Universität Würzburg, Würzburg - Germany

Strained bulk HgTe is a well known topological insulator (3D TI) showing the coexistence of an insulating bulk with metallic Dirac surface states presenting intrinsic spin-momentum locking. By applying an electric current through the surface states of a 3D TI, a spin-polarized current can be generated allowing transfer of angular momentum to an adjacent ferromagnetic layer. Preliminary spin-pumping ferromagnetic resonance (FMR) measurements on the HgTe 3D TI coupled to a ferromagnet island showed a background contribution in the measured voltages. In this work we report on spin-transfer torque ferromagnetic resonance (STT-FMR) measurements in order to better understand the previous results in this system.