HL 32: Spintronics

Time: Wednesday 15:00–17:30 Location: H33

HL 32.1 Wed 15:00 H33

Computation of the spin-Hall conductivity from first principles using maximally-localized Wannier functions — •Ji Hoon Ryoo[1], Cheol-Hwan Park[1], and Ivo Souza[2] — [1]Department of Physics, Seoul National University, Seoul, Korea — [2]Centro de Física de Materiales, Universidad del País Vasco, San Sebastián, Spain

Being an essential element of spintronics, the spin Hall conductivities of dozens of materials ranging from simple metals and semiconductors to more complicated materials such as metallic alloys and topological insulators have been measured experimentally and calculated theoretically during the last decade. In this regard, it is important to compute spin-Hall conductivities of a material accurately from first principles. Often, however, the high cost for computing several matrix elements of spin-current and velocity operators between Bloch states has been considered as a bottleneck that significantly slows down the calculation. We discuss a computationally efficient method of computing spin-Hall conductivities from first principles through an interpolation of matrix elements and energy eigenvalues using maximally-localized Wannier functions and its application for computing the spin-Hall conductivities of platinum and gallium arsenide.

HL 32.2 Wed 15:15 H33

Investigation of spin-orbit interaction in the regime of the persistent spin helix — •Sven Gelfert[1], Christian Frankerl[1], Christian Reichl[2], Dieter Schuh[1], Gian Salis[3], Werner Wegscheider[2], Dominique Bougeard[1], Tobias Korn[1], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, University of Regensburg, 93040 Regensburg, Germany — [2]Laboratory for Solid State Physics, ETH Zurich, 8093 Zurich, Switzerland — [3]IBM Research-Zurich, 8803 Rüschlikon, Switzerland

In our experiments, low-energy intrasubband spin-density excitations (SDE) are driven by resonant inelastic light scattering experiments in 12-nm-wide (001)-oriented GaAs-AlGaAs single quantum wells with balanced Rashba and Dresselhaus spin-orbit interaction strengths. The resulting symmetry of the effective spin-orbit field supports the persistent spin helix. Spin-flip intrasubband SDE transitions in the conduction band show a highly anisotropic splitting and can be accessed by two different measurement geometries where a wave-vector transfer into the two-dimensional electron system is required. In backscattering and grazing incidence geometry we can precisely map the anisotropic spin splitting for arbitrary crystal directions by rotating the sample on a piezo-driven rotary stage. With external magnetic fields (up to 6 Tesla) a superposition of the intrinsic spin-orbit field and the external field occurs, which allows us to deduce the spin-orbit field strength, the electron g factor and the single-particle relaxation time from our observations.

HL 32.3 Wed 15:30 H33

Acoustic spin transport in planar GaAs quantum wires — •Paul L. J. Helgers[1,2], Klaus Biermann[1], Haruki Sanada[2], Yoji Kunihashi[2], and Paulo V. Santos[1] — [1]Paul-Drude Institut, Leibniz-Institut im Forschungsverbund Berlin e.V., Germany — [2]NTT Basic Research Laboratories, NTT Corporation, Atsugi, Japan

We investigate a concept for single-photon sources, based on planar GaAs quantum wires (QWR). The QWRs form during anisotropic overgrowth of a 10 nm quantum well (QW) on pre-patterned GaAs(001) substrates by molecular beam epitaxy. The fabrication process results in potential fluctuations along the QWR axis due to line-edge-roughness (LER). LER potentially leads to Elliot-Yafet spin relaxation. We measure LER to be small as compared to the QWR width and expect it to play only a minor role during spin transport.

We study charge transport in the QWRs by a surface acoustic wave (SAW) over tens of microns. Moreover, we detect SAW-assisted carrier transfer between the QWR and the surrounding QW, which is otherwise prevented by a potential barrier. The one-dimensionality of the QWR reduces Dyakonov-Perel (DP) spin dephasing, leading to enhanced spin lifetimes with respect to the QW. We observe acoustic spin transport up to at least 15 micron. During transport, the spins rotate around the Dresselhaus field with a precession length corresponding to the calculated one for these QWRs, proving that the spin transport takes place in the QWRs rather than in the surrounding QW.

HL 32.4 Wed 15:45 H33

Electron and Nuclear Spin Interaction in n-GaAs: Impact of Doping and Temperature — •Lida Abaspour, Pavel Serin, Jan Gerrit Lonnemann, Eddy Rugeramigabo, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

The mutual interaction of nuclear and electron spins in semiconductors has been identified as a major source of nuclear and electron spin relaxation (SR). Doping-dependent optical measurements and magneto-transport of the electron SR time in n-doped bulk GaAs structures reveal competing SR mechanisms (variable range hopping (VRH), hyperfine interaction (HF) and the Dyakonov Perel effect (DP)) below and around the metal to insulator transition (MIT) [1, 2]. At the onset of the transition to the DP effect, temperature-dependent measurements show the effect of non-degenerate DP for higher temperatures while VRH and HF affect the SR at low temperature.

Moreover, we measure the doping dependence of the nuclear spin dynamics for different n-GaAs samples. The number of localized electrons increases with increasing doping concentration below the MIT where hyperfine interaction reduces the SR time. In the metallic regime, delocalized electrons reduce the SR time. Furthermore, for the lowest doped sample, temperature dependent measurements allow distinguishing the mutual impact of the different mechanism involved.

[1] R. I. Dzhioev, et. al., Phys. Rev. B 66, 245204 (2002).
[2] J. G. Lonnemann, et. al., Phys. Rev. B 96, 045201 (2017).

HL 32.5 Wed 16:00 H33

Thermal fluctuations cause spin-polarized states in the semiconducting lead halide perovskite $(CH_3NH_3)PbI_3$ — •Daniel Niesner[1], Martin Hauck[2], Shreetu Shrestha[3], Ievgen Levchuk[3], Gebhard Matt[3], Andres Osvet[3], Miroslaw Batentschuk[3], Christoph Brabec[3], Heiko Weber[2], and Thomas Fauster[1] — [1]Lehrstuhl für Festkörperphysik, Univ. of Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen — [2]Lehrstuhl für Angewandte Physik, Univ. of Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen — [3]i-Meet, Department of Materials Science, Univ. of Erlangen-Nürnberg, Martensstr. 7, D-91058 Erlangen

$(CH_3NH_3)PbI_3$ is the prototypical lead halide perovskite used in thin-film photovoltaics. It is a direct semiconductor with single, non-degenerate valence and conduction bands. At 165 K, it undergoes a phase transition from a structure with antiferroelectric order into a phase with polar disorder and inversion symmetry on average. Performing photocurrent experiments with circularly polarized light, we find a circular photogalvanic effect in this phase, i. e. the current depends on the light helicity [1]. This implies the optical excitation of spin currents, an unexpected process for a centrosymmetric crystal. The effect gets stronger with increasing temperature, pointing towards a dynamical Rashba effect, i. e. a local symmetry breaking due to thermal fluctuations caused by large-amplitude, soft phonon modes. The dynamical Rashba effect is expected to be general to centrosymmetric materials with large-amplitude phonon modes containing heavy elements.

[1] D. Niesner et al., Proc. Natl. Acad. Sci. 115, 9505 (2018)

15 min. break

HL 32.6 Wed 16:30 H33

Long-lived photon echoes from localized trions and donor-bound excitons in CdTe/(Cd,Mg)Te quantum well — •Alexander Kosarev[1,3], Sergey Poltavtsev[1,2], Ilya Akimov[1,3], Leonid Golub[3], Mikhail Glazov[3], Grzegorz Karczewski[4], Maciej Wiater[4], Tomasz Wojtowicz[4,5], Matthias Salewski[1], Nikolai Kozyrev[3], Evgeny Zhukov[1], Dmitri Yakovlev[1,3], and Manfred Bayer[1,3] — [1]TU Dortmund, Dortmund, Germany — [2]Spin Optics Laboratory, St. Petersburg University, St. Peterburg, Russia — [3]Ioffe Institute, St. Petersburg, Russia — [4]Institute of Physics, Polish Academy of Sciences, Warsaw, Poland — [5]International Research Centre MagTop, Warsaw, Poland

We perform time-resolved photon echo and pump-probe Kerr-rotation spectroscopy on molecular-beam epitaxy-grown single 20 nm CdTe/(Cd,Mg)Te quantum well at low temperatures under resonant excitation of donor-bound excitons and trions. We observe spin precession of donor-bound electrons and electrons localized at potential fluctuations in the applied transverse magnetic field through the dynamics of the stimulated three-pulse photon echo and pump-probe ellipticity signals. Spectral dependences of the homogeneous and inhomogeneous spin phase relaxation times by means of both techniques are obtained. Theoretical model, which takes into account different spin dephasing mechanisms including electron hopping, is developed.

HL 32.7 Wed 16:45 H33

Analysis of electronic bands in metal halide perovskite single crystals via angular-resolved photoelectron spectroscopy — •Maryam Sajedi[1,2], Dmitry Marchenko[1], Maxim Krivenkov[1,2], Andrei Varykhalov[1], Jaime Sánchez-Barriga[1], Eva Unger[1], and Oliver Rader[1] — [1]Helmholtz Zentrum Berlin für Materialien und Energie, Albert Einstein Str 15, D-12489, Berlin, Germany — [2]Department of physics, Potsdam University, Am Neuen Palais 10, D-14415, Potsdam Germany

Owing to their tunable optoelectronic characteristics, high carrier mobility, and lifetime, metal halide perovskites evoked phenomenal interest in versatile applications like photovoltaics and photodetectors. Likewise, they are fascinating novel materials for future spintronics, due to the strong spin orbit coupling in their structure. By angle-resolved photoemission spectroscopy we have attained the electronic band structures from cleaved (001) faces of two Br-based perovskite single crystals, namely MAPbBr3 and CsPbBr3. Our results reveal the four-fold symmetry, and highly reproducible and stable parabolic dispersive features of the valence band maximum, much more pronounced than in any published data. The time-dependent surface elemental composition was investigated by means of high resolution x-ray photoemission spectroscopy and showed reasonable radiation stability of inorganic CsPbBr3, and organic I-based MAPbI3, which is a precondition for enduring ARPES measurements.

HL 32.8 Wed 17:00 H33

Analysis of electronic bands in metal halide perovskite single crystals via angular-resolved photoelectron spectroscopy — •Maryam Sajedi[1,2], Dmitry Marchenko[1], Maxim Krivenkov[1,2], Andrei Varykhalov[1], Jaime Sánchez-Barriga[1], and Oliver Rader[1] — [1]Helmholtz Zentrum Berlin für Materialien und Energie, Albert Einstein Str 15, D-12489, Berlin, Germany — [2]Department of physics, Potsdam University, Am Neuen Palais 10, D-14415, Potsdam Germany

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HL 32.9 Wed 17:15 H33

Spin noise spectroscopy of resident carriers in InGaAs/GaAs self-assembled QD in DBR — •Aleksandr Kamenskii, Alex Greilich, and Manfred Bayer — Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany

Spin noise spectroscopy is a developing method, that allows measurement of spin relaxation times by measurements of correlations of stochastic spin fluctuations with low perturbation. We apply this method to study the spin noise signal formation in n-doped quantum dots placed in DBR microcavity and use homodyne detection scheme to enhance the detection sensitivity. Due to DBR structure, the light-matter interaction becomes enhanced, and the Faraday rotation noise increases by Q-factor of DBR. In this way, the study of fine effects becomes available. We demonstrate and proof that spin noise information is carried by scattered light, as Gorbovitskii-Perel theorem predicts.