SYSC 1: Spin Coherence in Solids

Time: Wednesday 9:30–12:30 Location: BAR SCHÖ

Invited Talk SYSC 1.1 Wed 9:30 BAR SCHÖ

Optical Pumping of Nuclear Spins in Semiconductor Quantum Dots — •X. Marie[1], B. Urbaszek[1], T. Amand[1], O. Krebs[2], A. Lemaître[2], P. Voisin[2], B. Eble[3], C. Testelin[3], and M. Chamarro[3] — [1]University of Toulouse, INSA-CNRS-UPS, — [2]LPN-CNRS, Marcoussis, — [3]INSP-CNRS, Paris, France

Numerous proposals for future spintronic and quantum information devices are based on manipulating or storing information in the form of the electronic or nuclear spin polarization in semiconductor quantum dots (QD). An electron spin confined to a quantum dot is not subject to the classical spin relaxation mechanisms known for free carriers but it strongly interacts with the nuclear spin system via the hyperfine interaction [1,2]. By analysing the polarization state of photons absorbed or emitted by the dot, we show how optical pumping of electron spins in individual self assembled InAs QDs in GaAs leads to strong nuclear polarisation that can be measured via a drastic change in the Zeeman splitting (the Overhauser shift) in magneto-photoluminescence experiments. We will show that the nuclear magnetic fields, in the order of a few Teslas, created through optical pumping are bistable and can be controlled through a slight variation of an experimental parameter such as the excitation laser polarization or external magnetic field [3-5]. Finally the interaction of hole spin with nuclei in QDs will be discussed. [1] Merkulov et al, PRB 65, 205309 (2002) [2] Braun et al, PRL 94, 116601 (2005) [3] Eble et al, PRB 74, 081306(R), (2006) [4] Urbaszek et al, PRB 76, 201301(R),(2007) [5] Belhadj et al, PRB 78, 205325 (2008)

Invited Talk SYSC 1.2 Wed 10:00 BAR SCHÖ

Dyakonov-Perel' Spin-Dynamics in GaAs Quantum Wells — •Richard Harley — School of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, UK

The development of semiconductor spintronic devices calls for long electron spin memory combined with an ability to control and tune the spin with external gate voltage at room temperature. Two-dimensional III-V structures appear to have the potential for room temperature electron spin memory in the nanosecond range, comparable to silicon, but tuneable down to tens of picoseconds. This is because the Dyakonov-Perel' (DP) spin relaxation mechanism, which relies on the spin-orbit splitting of the conduction band as the driving force for spin reorientation, is usually dominant in such systems and there is considerable potential for manipulation and tuning the spin-orbit splitting in 2D systems. This talk will describe recent ultra-fast optical experiments which have been aimed at understanding the DP mechanism in depth in GaAs quantum wells. These include investigations of the transition from the weak to the strong scattering regimes in 2DEGs, of the suppression of the DP mechanism in (110)-grown quantum wells, and of tuning the DP mechanism by means of in-built asymmetry and applied electric field.

Invited Talk SYSC 1.3 Wed 10:30 BAR SCHÖ

Quantum dot spins in optical microcavities — •Rudolf Bratschitsch — Department of Physics and Center for Applied Photonics, University of Konstanz, D-78457 Konstanz, Germany

Spins in semiconductor quantum dots are promising candidates for qubits in quantum information processing. Photons might mediate an effective exchange interaction between quantum dot spins, if they were embedded in a strong-coupling optical cavity. Ultrafast all-optical quantum processing devices operating with femtosecond light pulses and without electrical contacts may be envisioned. Requirements for a successful experimental implementation of this concept are long spin coherence times and high cavity Q-factors.

In this talk we describe our efforts to reach this goal. We investigate the ultrafast spin dephasing of wide bandgap colloidal ZnO quantum dots [1], which are promising for room-temperature operation. Furthermore, they allow for spin coherence control via isotope engineering. High-quality optical microcavities with embedded colloidal quantum dots are fabricated [2, 3]. Finally, we present routes to the monolithic integration of semiconductor quantum dots and optical cavities via sputtering techniques [4].

References: [1] N. Janßen et al., Nano Lett. 8, 1991 (2008), [2] M. Kahl et al., Nano Lett. 7, 2897 (2007), [3] T. Thomay et al., Opt. Expr. 16, 9791 (2008), [4] G. Mayer et al., Nanotechnology, in press (2008).

Invited Talk SYSC 1.4 Wed 11:00 BAR SCHÖ

Spin relaxation in quasi-one-dimensional electron systems: transition from 2D to 1D — •Alexander Holleitner — Walter Schottky Institut and Physik Department, Technische Universität München, Am Coulombwall 3, 85748 Garching.

For potential information processing schemes which combine quantum mechanical and classical data, it is of particular interest to manipulate and to control carrier spin dynamics in non-magnetic materials by utilizing the spin-orbit interaction [1]. In three- and two-dimensional (3D and 2D) carrier systems, spin-orbit coupling creates a randomizing momentum-dependent effective magnetic field; the corresponding relaxation process is known as the D*yakonov*Perel (DP) mechanism. In an ideal 1D system, a complete suppression of the DP spin relaxation has been predicted, if the lateral width of a 2D channel is reduced to be on the order of the electron mean free path. For the regime approaching the 1D limit, we recently reported a progressive slowing of the spin relaxation in InGaAs channels, which is in agreement with a dimensionally constrained DP mechanism [2,3]. The dimensional crossover can be understood in terms of an interplay between the channel width, the spin precession length over which the electrons remain spin polarized, and the effect of spin scattering at the boundaries of the channels.

[1] D.D. Awschalom and M. Flatte Nature Phys. 3, 153 (2007).

[2] A.W. Holleitner, V. Sih, R.C. Myers, A.C. Gossard, and D.D. Awschalom, Phys. Rev. Lett. 97, 036805 (2006).

[3] A.W. Holleitner, V. Sih, R.C. Myers, A.C. Gossard,and D.D. Awschalom, New J. of Phys. 9, 342 (2007).

Invited Talk SYSC 1.5 Wed 11:30 BAR SCHÖ

Triggering phase-coherent spin packets by pulsed electrical spin injection across an Fe/GaAs Schottky barrier — •Bernd Beschoten — II. Physikalisches Institut, RWTH Aachen University, Templergraben 55, 52052 Aachen

The precise control of spins in semiconductor spintronic devices requires an electrical means for generating spin packets with a well-defined initial phase. So far, ultrafast laser pulses have successfully been used to trigger the ensemble phase of optically generated spin packets. Their spin coherence properties have been probed spatiotemporally by time-resolved magneto-optics. However, electrical methods for ensemble phase triggering remain challenging. Here, we use fast current pulses to inject phase triggered electron spin packets across an Fe/GaAs Schottky barrier into n-GaAs. We demonstrate phase coherence by the observation of multiple Larmor precession cycles for current pulse widths down to 500 ps at 20 K. We show that the current pulses are broadened by the charging and discharging time of the Schottky barrier. At high frequencies, the observable spin coherence is limited only by the finite band width of the current pulses, which is on the order of 2 GHz. These results therefore demonstrate that all-electrical injection and phase control of electron spin packets at microwave frequencies is possible in metallic ferromagnet/semiconductor heterostructures.

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Invited Talk SYSC 1.6 Wed 12:00 BAR SCHÖ

Quantum Spin Hall Effect in HgTe Quantum Well Structures — •Hartmut Buhmann — Physikalisches Institut, EP3, Universität Würzburg, Germany

Spin polarization, manipulation and detection are the most challenging topics in current semiconductor research. Apart from the use of magnetic materials spin obit effects have become a promising alternative especially for the use of electric fields to control spin currents and polarizations. Recently, we demonstrated a new type of spin selective transport which exists in semiconductor structures with an inverted subband ordering [1,2]. Due to a very strong spin orbit splitting HgTe is a prototype material for the experimental observation of this so-called Quantum Spin Hall Effect. In this talk I will present the fundamental experimental observations of the quantum spin Hall effect (QSHE). I will discuss the limits of its stability and considerations for an application as injector and detector for spin polarized currents.

[1] M. König et al., Science 318, 766 (2007).
[2] M. König et al., J. Phys. Soc. Japan 77, 031007 (2008).