Fifth International Conference on Physics and Applications of Spin-related Phenomena in Semiconductors (PASPS-V)

PASPS-V

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ABSTRACT BOOK




August 03-06, 2008
Foz do Iguaçu, Paraná, Brazil

Fifth International Conference on Physics and Applications of Spin-related Phenomena in Semiconductors (PASPS V)

August 3 – 6, 2008
Foz do Iguaçu, PR, Brazil

In recent years, spin-related effects have emerged as the key ingredient underlying many fundamental spin-dependent phenomena in nanoscale condensed-matter systems. The fifth edition of PASPS will focus on fundamental spin-dependent phenomena arising from spin-related effects in semiconductors and magnetic nanostructures. PASPS V will highlight the latest theoretical and experimental developments in new semiconductor spintronic materials and devices as well as advances in metallic magnetoelectronics.

Overview and scope

The 5th International Conference on Physics and Applications of Spin-related Phenomena in Semiconductors (PASPS V) follows the successful series of conferences held in Sendai (2000, 2006), Würzburg (2002), and Santa Barbara (2004). Following the trend in its previous edition, PASPS V shall further stimulate the cross fertilization between the fields of semiconductor and magnetic nanosystems and should provide an ideal forum for identifying (new) challenges, open questions and opportunities in spintronics.

Some areas of interest

1. Magnetic semiconductors
2. Coherent spin dynamics, spin relaxation and dephasing in nanostructures
3. Spin injection, spin accumulation and the spin Hall effects
4. Spin-orbit coupled confined electron systems
5. Spin entanglement: production, detection & manipulation
6. Spin effects in quantum dots
7. Spintronic and magnetoelectronic devices and applications
8. Spin-based quantum information processing, novel spin logic architectures
9. Nuclear spins in semiconductors: manipulation and hyperfine coupling
10. Nanomagnetics: spin transfer and spin torque, magnetic switching
11. Optical & electrical spin injection & transport in magnetic systems
12. Domain wall motion in magnetic systems
13. TMR & GMR effects
14. Theoretical modeling and simulations of spintronic devices and materials
15. Spin imaging: Mn ions, spin flow and accumulation
16. Novel spintronic systems (e.g., graphene, carbon nanotubes)

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Invited Speakers

Peter Adams
Physical Review B - tutorial

Daichi Chiba
Tohoku - seminar

Albert Fert
CNRS-Thales - plenary

Joshua Folk
Vancouver - seminar

Charles Gould
Würzburg - seminar

Paul M. Koenraad
Eindhoven - seminar

Daniel Loss
Basel - seminar / tutorial

Laurens Molenkamp
Würzburg - seminar

Hideo Ohno
Tohoku - tutorial

Seigo Tarucha
Tokyo - seminar

Daniel Ucko
Physical Review Letters - tutorial

Giovanni Vignale
Missouri - seminar

Stuart Wolf
Virginia - tutorial

Social Program

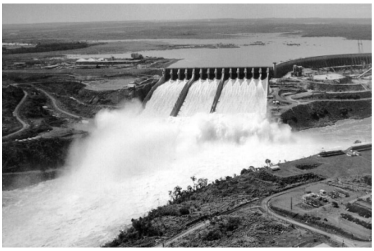
Cocktail
Sunday, August 03, 19:00

Banquet
Tuesday, August 05, 20:30

Excursions
Tuesday, August 05, afternoon

(option 1)
Iguaçu Falls


(option 2)
Itaipu hydroelectric power plant




Meet the Editors of PRB & PRL: Tutorial for Authors and Referees

Monday, August 04, 16:00 - 16:30

As as special event within PASPS V (especially for young researchers), two Editors of Physical Review B (Dr. Peter Adams) and of Physical Review Letters (Dr. Daniel Ucko) will present a tutorial for authors and referees. The editors will provide useful information and tips for less experienced referees and authors. The information presented will be relevant to anyone who is looking to submit to or review manuscripts for any of the APS journals, or to anyone who would like to add to their knowledge and experience of the authoring and refereeing processes. Topics for discussion will include:

- how to write good manuscripts and useful referee reports;
- differences between manuscripts and referee reports for PRL & PR;
- the roles of authors and referees in the review process, etc.

Following a short presentation from the editors, there will be a moderated discussion of these and other topics. Questions from the audience will be most welcome.

Invited Talks 1

Contributed talks 9

Monday Poster Session

Tuesday Poster Session

Invited Talks

INV 1: Monday, 08:30 - 09:30

Variations on Themes in Spintronics: Semiconductors, Carbon Nanotubes, and SHE with Metals

Albert Fert[1], A. Friederich[1], Jean-Marie George[1], Henri Jaffrès[1], Richard Mattana[1], Luis E. Hueso[2], Neil D. Mathur[2], Amir Hamzic[3]

[1] *Unité Mixte de Physique CNRS/Thales, 91767 Palaiseau, and Université Paris-Sud, 91405 Orsay, France*
[2] *Department of Materials Science, University of Cambridge, Cambridge, UK*
[3] *University of Zagreb, Zagreb, Croatia*

I will focus mainly on two important themes in spintronics today: spin transport between source and drain in semiconductors or carbon nanotubes (CNT), and Spin Hall Effect (SHE).

1) Spin transport in a nonmagnetic lateral channel between a spin-polarized source and a spin-polarized drain is at the basis of several concepts of spin transistor. So far, the problem has been mainly studied for structures in which the lateral channel is a classical semiconductor [1]. Spin injection into a semiconductor from a spin-polarized electrode is well mastered. More difficult is the transformation of the spin information – related to the magnetic configuration of the electrodes- into a large electrical signal, ideally $\Delta V/V \approx 1$ or larger, where V is the bias voltage between source and drain and ΔV is a voltage variation induced by a change of the magnetic configuration.

In experiments on structures in which the lateral channel is a semiconductor, $\Delta V/V$ does not generally exceed a few %[1]. In contrast, in experiments on CNT between ferromagnetic contacts I will present, high values of $\Delta V/V$ (above 70%) and large ΔV (above 50 mV) can be obtained [2]. After a description of the theoretical background, I will discuss the origin of the difficulties for semiconductors and explain why large values of $\Delta V/V$ and ΔV can be easily obtained with CNT. I will emphasize the potential of carbon CNT, graphene and other molecules for spintronics, and conclude by presenting some next challenges for molecular spintronics.

2) I will report on very large (giant ?) SHE effects we found in dilute alloys, typically Cu with Ir or Ta impurities. This SHE can be ascribed to resonant scattering on spin-orbit-split impurity states. I will discuss the selection rules of this type of SHE and its potential to obtain large SHEs.

[1] Jonker, B.T. and Flatté, M.E.F. Electrical spin injection and transport in semiconductors, in Nanomagnetism (eds. Mills D.L. & Bland J.A.C.) (Elsevier, 2006).

[2] Hueso, L. E., Pruneda J-M., Ferrari V., Burnell G., Valdés-Herrera J.P., Simons B.D., Littlewood P.B., Artacho E., Fert A. and Mathur N.D. Transformation of spin information into large electrical signals via carbon nanotubes, Nature 445, 410 (2007).

INV 2: Monday, 09:30 - 10:15

Spintronics a Retrospective and Perspective

Stuart Wolf

Director, NanoSTAR Institute, Dept of materials Science and Engineering, 395 McCormick Road, P.O. Box 400745, Charlottesville, VA 22904-4745

Research and technology developments in the field of spintronics have grown tremendously in the past 10-15 years and already have had a major impact on the data storage industry. The future looks even brighter as many new spintronic discoveries have been recently made that promise an even bigger impact in the future. This article will summarize the past accomplishments, describe some of the major discoveries that will have a lasting impact on the field and describe some of the exciting technologies that will revolutionize information technology (IT) in the next few decades making spintronics truly the future of IT.

INV 3: Monday, 10:45 - 11:30

Spin Qubits and Nuclear Spins in Quantum Dots and Interacting 2DEGs

Daniel Loss

Department of Physics, University of Basel, Switzerland

One of the most important decoherence source for spins in GaAs quantum dots are the nuclear spins with which the electron interacts via the contact hyperfine interaction [1] . This problem has been analyzed in great detail over the last few years, and I will present a summary of our current understanding and open problems, and also present recent findings that show that after an initial power law behavior the decoherence crosses over into an exponential (Markovian) decay [2]. There are several strategies which have been proposed to reduce the decoherence effect due to nuclei, such as nuclear state narrowing by transport or optical methods. Another strategy is to fully polarize the nuclear spins, either dynamically or via a thermodynamic phase transition [3] . Mapping the problem onto a Kondo lattice I will show that the nuclear spin system within an interacting two-dimensional electron gas (2DEG) undergoes a ferromagnetic phase transition at finite temperatures. For this it turns out that electron-electron interactions and non-Fermi liquid behavior in the 2DEG are crucial. The nuclear spin Curie temperature can be dramatically enhanced, up into the mK range, by decreasing the electron density of the 2DEG. Depending on the sign of the spin susceptibility change (as function of wave vector) of the 2DEG, the nuclear spins order ferromagnetically or helically [4].

[1] W. A. Coish and D. Loss, Chapter in vol. 5 of the Handbook of Magnetism and Advanced Magnetic Materials, Wiley; cond-mat/0606550.

[2] W. A. Coish, J. Fischer, and D. Loss, Phys. Rev. B **77**, 125329 (2008).
[3] P. Simon and D. Loss, Phys. Rev. Lett. **98**, 156401 (2007).
[4] P. Simon, B. Braunecker, and D. Loss, Phys. Rev. B **77**, 045108 (2008).

INV 4: Monday, 14:00 - 14:30

Recent Advances on Electric-Field Control of Magnetic Properties in (Ga,Mn)As

Daichi Chiba[1,2], Y. Nishitani[2], M. Endo[2], F. Matsukura[2,1], M. Sawicki[2,3], Y. Nakatani[4], H. Ohno[2,1]

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[3] *Institute of Physics, Polish Academy of Sciences, Al. Lotnikow 32/46, PL-02668, Warszawa, Poland.*
[4] *University of Electro-communications, Chofugaoka 1-5-1, Chofu,Tokyo, 182-8585, Japan.*

Electric-field E control of ferromagnetism adds a new dimension to the future spin based information processing methods. We have been studying E control of the Curie temperature T_C and the coercivity in thin (In,Mn)As and (Ga,Mn)As with hole-induced ferromagnetism, using an insulating-gate field-effect transistor (FET) structures [1-3]. A large modulation of hole concentration p (Δp) is preferred to look into the physics of magnetic phase transitions. It is particularly interesting to see how T_C depends on p for a given Mn concentration, in view of finding a route to increase T_C further. To this end, we have employed high-κ gate-insulators (Al_2O_3, HfO_2, and ZrO_2) and investigated the (Ga,Mn)As channel thickness dependence of the modulated magnetic properties [4]. We have also studied the properties of (Ga,Mn)As FETs with high Mn compositions ($> 10\%$) [5]. A relation $\Delta T_C/T_C = \alpha \Delta p/p$ ($\alpha \approx 0.2$) is found, indicating that T_C is proportional to $p^{0.2}$ in these devices. Finally, we discuss about the magnetic anisotropy modulation by applying E, which opens a route to electric-field induced magnetization reversal [6].

[1] H. Ohno et al., Nature 408, 944 (2000).
[2] D. Chiba et al., Science 301, 943 (2003).
[3] D. Chiba et al., Appl. Phys. Lett. 89, 162505 (2006).
[4] M. Endo et al., J. Supercond. Nov. Magn. 20, 409 (2007).
[5] Y. Nishitani et al., J. Appl. Phys. 103, 07D139 (2007).
[6] D. Chiba et al., unpublished.

INV 5: Monday, 15:30 - 16:00

The Physical Review: A Brief History – How to Deal with the Publication Process AND Feel Good About It

Peter Adams

Physical Review B

The Physical Review was created in 1893 and has grown considerably in size and sophistication since then. This talk will focus on the last $\tilde{4}0$ years of Phys Rev B in particular. It will discuss the the history of the journal and explain how decisions regarding acceptance or otherwise of submitted articles are made. The ethics of performing research and the preparation of subsequent submissions to journals will be debated. The essential role played by referees in maintaining the standards of journals will be presented.

INV 6: Monday, 18:15 - 19:05

PRL @ 50: A history of moving physics forward

Daniel Ucko

Physical Review Letters

Physical Review Letters was founded in July 1958 out of the Letters to the Editor. Since then it has grown to be the most prestigious physics journal in the world, with more than 11 000 direct submissions in 2008. It continues to publish important physics results, including many Nobel-Prize-winning discoveries in all fields of physics. I will look back at the last fifty years, examining what has changed and what has not changed, as well as giving the audience a glimpse behind the scenes to shine some light into the black box of PRL.

INV 7: Tuesday, 08:30 - 09:00

Spin Currents in a 2D Electron Gas

Joshua Folk

Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada.

We report measurements of pure spin currents in a GaAs 2D electron gas, generated and detected electrically using quantum point contacts in a magnetic field. The currents propagate down quasi-1D channels for distances up to 50 microns. The relaxation rate is strongly anisotropic, reflecting anisotropy both in the channel geometry and in the spin-orbit interaction. A ballistic spin resonance effect, mediated by spin-orbit interaction, is observed when the bouncing frequency of electron trajectories down the channel matches the ESR frequencies defined by the external magnetic field.

INV 8: Tuesday, 09:00 - 09:30

Two Spin Qubit Operation with Quantum Dots Using a Micro-magnet Technology

Seigo Tarucha

Department of Applied Physics, University of Tokyo, Tokyo, Japan
ICORP Spin Information Project, Japan Science and Technology Agency, Tokyo, Japan
Institute for Nano Quantum Information Electronics, University of Tokyo, Tokyo, Japan
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Detection and manipulation of electronic spin is the heart of spin-based quantum computing with quantum dots (QDs). Magnetic technique or electron spin resonance (ESR) is usually employed for addressing the electronic spins for the ensemble but not for individual quantum dots. I will present a novel technique for manipulating and probing a single electron spin in QDs using a micro-magnet technology.

Single electron spin resonance (SESR) can be implemented by applying a local ac magnetic field to a QD in the presence of a global static magnetic field. A straightforward approach to generate the local ac field is to send an ac current to an on-chip coil attached to a QD (current-induced SESR). However, this technique accompanies problems for making multiple qubits such as device heating and device design limitation. One of the ways to solve these problems is to use voltage-induced SESR or EDSR. We previously proposed voltage-induced SESR using a slanting Zeeman field, which is imposed by a micro-magnet [1, 2]. The SESR is performed by letting an electron in a QD to oscillate in the slanting Zeeman field. The qubit is then defined as a hybrid orbital and spin state. I will show our recent experiment on this SESR technique, including qubit robustness, two spin qubit operations or two Rabi oscillations at different resonance frequencies, dephasing due to hyperfine coupling to nuclei, and qubit scalabilty [3].

[1] Y. Tokura et al. Phys. Rev. Lett. 96, 047202 (2006).
[2] M. Pioro-Ladriere et al. Appl. Phys. Lett. 90, 024105 (2007).
[3] M. Pioro-Ladriere et al. Submitted to Nature Physics (2008).

INV 9: Wednesday, 08:15 - 09:00

Ferromagnetic III-V Semiconductors - Physics and Material Science

Hideo Ohno

Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

Ferromagnetism in Mn-doped III-V semiconductors is hole-induced and thus its magnetism, for example, ferromagnetic phase transition, coercivity and magnetic anisotropy, are all dependent on carrier concentration. It has also been shown that spin-current flowing along with the electric current in these materials exerts torque on localized Mn spins, resulting in current induced switching and domain wall motion. This tutorial presentation reviews the understanding of the properties, related physics, and material science of ferromagnetic III-V semiconductors.

Part of work was supported by the Research and Development for Next-Generation Information Technology Project of MEXT, Japan.

INV 10: Wednesday, 09:00 - 09:30

STM Analysis of Magnetic Impurities and Magnetically Doped Nanostructures in GaAs

Paul M. Koenraad

COBRA, Eindhoven University of Technology, P.O.Box 513, 5600 MB, The Netherlands
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We have shown that one can spatially resolve the shape of the wavefunction of a single hole bound to a single Mn-impurity by using Cross-sectional Scanning Tunneling Microscopy (X-STM) [1,2]. Such information about the wavefunction is very valuable as it allows a direct identification of the character of the electronic state and visualization of the interaction between Mn-impurities. This interaction plays an essential role in the magnetic properties of GaMnAs as the magnetic coupling between the localized spin of the Mn-acceptors is assumed to be hole-mediated. In this presentation we will review our recent results on wavefunction imaging of single Mn-impurities, strained Mn-impurities, overlapping pairs of Mn-impurities and Mn-impurities in self-assembled InAs quantum dots.

The X-STM measurements were performed at room temperature in UHV ($P < 2 \times 10^{-11}$ torr) at the cleaved (110) surface of GaAs. By changing the tip polarity we were able to the change the charge state (A^-/A^0) of individual Mn-acceptors in lightly doped (3×10^{18} cm^{-3}) Mn:GaAs. In the neutral state (A^0) the X-STM images clearly showed that Mn in GaAs acts as an effective mass acceptor where a single hole is bound to a Mn^{2+} $3d^5$ core. The strong anisotropy that was observed could be related to the cubic symmetry of the GaAs and was successfully reproduced in both envelope function, effective mass model (EFM) and tight binding model (TBM) calculations. This conclusion is further supported by the STM analysis of a range of other deep acceptors in III/V materials such as Cd in GaP and low temperature spectroscopic STM measurements on Mn doped GaAs.

Recently we analyzed the effect of strain on the shape of the acceptor wavefunction [3]. In a structure where we were able to image a Mn-impurity close to an InAs-self-assembled quantum dot we could observe how the strain profile in the close neighborhood of dot affects the acceptor state. The images showed a surprisingly strong symmetry breaking of the shape of the wavefunction if the strain was aligned in a (111) direction. The TBM and EFM calculations confirmed the strong effect of strain on the wavefunction symmetry. Finally I will show some recent observations of InAs self-assembled nanostructures where Mn impurities were incorporated during the their growth.

[1] A. Yakunin et al. PRL 92, 216806 (2004)
[2] A. Yakunin et al. PRL 95, 256402 (2005)
[3] A. Yakunin et al Nature Materials 6, 513 (2007)

INV 11: Wednesday, 10:45 - 11:15

Novel Spintronic Devices Using Local Anisotropy Engineering In (Ga,Mn)As

Charles Gould, J. Wenisch, K. Pappert, S. Hümpfner, M. J. Schmidt, C. Kumpf, K. Brunner, G. Schmidt, and L.W. Molenkamp

Physikalisches Institut, Universität Würzburg, D97074, Würzburg, Germany

(Ga,Mn)As has become the prototypical ferromagnetic semiconductor for use as a test bed for investigating spintronic devices, in large part because of its very rich magnetic and transport anisotropies. The lack of a method of local control of the anisotropy has, until recently, imposed significant limitations on device design options, as all elements of the device inherited the anisotropy of the parent layer. More complex devices of course require that the various functional elements have individual anisotropies. Shape anisotropy, which is often used in ferromagnetic metal devices, is ineffective in magnetic semiconductors due to their relatively low volume magnetization and strong crystalline anisotropies. As such, a new approach was required to locally control the magnetic properties.

In this talk, I report on our discovery of anisotropy control [1] through lithographically engineered strain relaxation [2]. Using high resolution lithographic techniques, we strategically pattern the layer (which is grown pseudomorphically strained on a GaAs substrate), leading to local and anisotropic strain relaxation. This causes a controlled deformation of the crystal structure, which, because of the strong spin orbit coupling linking the magnetic and crystal properties, leads to a new anisotropy term that can be tuned independently for each element of a compound device.

To demonstrate this method in a device, I will discuss a non-volatile memory element [3] comprised of two nanobars engineered with mutually orthogonal magnetic easy axis, and electrically joined through a constriction. Such a device has several modes of operations depending on the constriction size as well as domain configuration. I will detail the physical origins of these multiple functionalities, and their ramifications for spintronic devices.

[1] Hümpfner et al., Appl. Phys. Lett. 90, 102102, (2007)
[2] Wenisch et al., Phys Rev. Lett. 99, 077201, (2007)
[3] Pappert et al., Nature Phys. 3, 373 (2007)

INV 12: Wednesday, 14:00 - 14:30

Spin Hall effects in HgTe Quantum Well Structures

Laurens W. Molenkamp

Physikalisches Institut (EP3) der Universität Würzburg Am Hubland, 97074 Würzburg, Germany

Spin-orbit interaction (SOI) in 2DEGs causes many interesting and potentially useful effects, such as the generation of an intrinsic spin accumulation polarized normal to the 2DEG at the edges, caused by the presently very topical spin-Hall effect [1]. So far no direct evidence for the intrinsic SHE has been obtained by transport experiments. Here, we demonstrate that in specially designed nanostructures [2], which are based on narrow gap HgTe type-III quantum wells (QW), a detection of the spin signal is possible via voltage measurements.

Recently, it was pointed out that inverted HgTe QW structurescan be regarded as non-trivial insulators[3], in which the quantum spin Hall insulator state[4] should occur. In this state, a pair of spin polarized helical edge channels develops when the bulk of the material is insulating, leading to a quantized conductance. We will discuss our recent transport measurements on gated low density HgTe QWs that yield a first evidence for the existence of this effect[5].

[1] S. Murakami et al., Science 301 (2003) 1348; J. Sinova et al., Phys. Rev. Lett. 92 (2004) 126603; Y. Kato et al., Science 306 (2004) 1910 .
[2] E.M. Hankiewicz, et al., Phys. Rev. B 70 (2004) 241301(R)
[3] B.A. Bernevig et al., Science 314 (2006) 1757
[4] C.L. Kane and E.J. Mele, Phys. Rev. Lett. 95 (2005) 146802.
[5] M. König et al., Science 318, 766 (2007).

INV 13: Wednesday, 14:30 - 15:00

Direct and Inverse Spin Hall Effect in Doped Semiconductors and Metals

Giovanni Vignale

Department of Physics, University of Missouri-Columbia

In this talk I survey the theory of the spin Hall effect in doped semiconductors and metals in the light of recent experiments on both kinds of materials. After a brief introduction on the nature of the spin-orbit interaction in these systems, I describe in detail the three conceptually distinct mechanisms that are known to contribute to the spin Hall effect, namely “skew-scattering”, “side jump”, and “intrinsic mechanism”. The skew-scattering mechanism is shown to be the dominant one in clean two-dimensional systems (e.g. certain specially oriented n-type GaAs quantum wells) in which one component of the spin is conserved. In such systems the side-jump mechanism is subdominant, but universal in form, and can become dominant if the electron mobility is reduced by going, for example, to higher temperatures. Both skew-scattering and side-jump contributions are generally suppressed by spin precession, which is a generic feature of spin-orbit coupled systems. The supp! ression is complete in the linear Rashba model of spin-orbit coupling, in the absence of magnetic fields. Different models of spin-orbit coupling can, however, sustain an intrinsic spin Hall effect. The experimental evidence for the intrinsic spin Hall effect is critically examined.

Work supported by NSF Grants No.DMR-0313681 and DMR-0705460.

Contributed talks

CT 1: Monday, 11:30 - 11:45

Electrically Tunable Spin Polarization in a Carbon-nanotube Spin Diode

Christopher A. Merchant, Nina Markovic

Johns Hopkins University

We have studied the current through a carbon nanotube quantum dot with one ferromagnetic and one normal-metal lead. For the values of gate voltage at which the normal lead is resonant with the single available non-degenerate energy level on the dot, we observe a pronounced decrease in the current for one bias direction. We show that this rectification is spin-dependent, and that it stems from the interplay between the spin accumulation and the Coulomb blockade on the quantum dot. We also observe that the shot noise is suppressed below the theoretical minimum value based on a master equation approach. Our results imply that the current is spin-polarized for one direction of the bias, and that the degree of spin polarization is fully and precisely tunable using the gate and bias voltages. As the operation of this spin diode does not require high magnetic fields or optics, it could be used as a building block for electrically controlled spintronic devices.

CT 2: Monday, 11:45 - 12:00

Boundary Effects in the Rashba Splitting for Electrons in III-V Semiconductor Heterojunctions

M. A. Toloza Sandoval[1], A. Ferreira da Silva[1], E. A. de Andrada e Silva[2], G.C. La Rocca[3]

[1] *Instituto de Física, Universidade Federal da Bahia, Salvador, Bahia, Brazil*

[2] *Instituto Nacional de Pesquisas Espaciais, São José dos Campos, São Paulo, Brazil*

[3] *Scuola Normale Superiore and CNISM, Pisa, Italy*

The desired control, as in the Datta & Das spin transistor, of the spin-orbit splitting (or effective magnetic-field) for 2DEGs in III-V semiconductor heterojunctions, has not been achieved yet. Multi-band envelope-function analytical results [1] in the infinite barrier approximation clearly tend to underestimate the Rashba spin-splitting. Numerical calculations show that indeed interface and barrier penetration effects increase such splitting. It has not

been possible though to clearly identify or separate these effects. Using the 8x8 Kane model for the bulk, we propose here a new spin-dependent variational solution which does that. With spin dependent boundary conditions applied to the modified Fang-Howard wavefunction, analytical expressions are obtained for the subband spin-dependent dispersion relations. Well known results [1] are exactly reproduced in the limit of a perfect insulating barrier. The resulting spin-orbit splitting is calculated for GaAlAs/GaAs, InAlAs/InGaAs and InAs heterojunctions and compared to the experiment; the agreement is quite good so to expect this solution to be helpful in the development of semiconductor spintronics.

[1] E.A. de Andrada e Silva, G. C. La Rocca and F. Bassani, Phys. Rev. B 50, 8523 (1994); E.A. de Andrada e Silva, Phys. Rev. B 46, 1921 (1992).

CT 3: Monday, 12:00 - 12:15

Spin Injection, Transport and Manipulation in Graphene

Csaba Jozsa, Mihaita Popinciuc, Nikolaos Tombros, Harry T. Jonkman, Bart J. van Wees

Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

Recently we have reported successful electrical spin injection and transport in single-layer graphene using a lateral spin valve geometry[1]. A room temperature spin relaxation length of 1.5 to 2 μm was confirmed by Hanle-type spin precession measurements.

As a next step in controlling spin transport in graphene devices we will present our latest results on carrier drift enhanced transport. Under the influence of DC electric fields of 70 kV/m a spin drift-diffusion was observed, with an 80% change of the spin relaxation length for both the electron and hole conduction regimes[2].

We have also studied the (an)isotropy of spin relaxation in the 2-dimensional graphene layer, comparing the transport of spins injected parallel and perpendicular to the graphene plane. A clear evidence for a 20% shorter spin relaxation time was found for the latter case[3]. Furthermore, the initial injection efficiency of our Co electrodes (10%) was increased by applying a DC current bias on them, yielding spin valve signals as high as 100 Ω[4]. These results indicate an Elliot-Yafet type impurity scattering mechanism limiting the spin relaxation length. With the current technology available to increase the carrier mobility in our graphene, a spin relaxation length exceeding 10 μm is feasible.

[1] N.Tombros et al, Nature 448, 571 (2007)
[2] C.Jozsa et al, subm. to Phys.Rev.Lett.
[3] N.Tombros et al, subm. to Phys.Rev.Lett.
[4] C.Jozsa et al, subm. to Appl.Phys.Lett.

CT 4: Monday, 12:15 - 12:30

Polarization Controlled Optical Gates Based on the Interference of Polariton Condensates

T. C. H. Liew[1], A. V. Kavokin[1], I. A. Shelykh[2], C. Leyder[3], M. Romanelli[3], J.-Ph. Karr[3], E. Giacobino[3], A. Bramati[3]

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With the recent experimental confirmation of Bose-Einstein condensation (BEC) in semiconductors microcavities [1-3], the use of coherent interference in these systems to construct new devices becomes a realistic task. We demonstrate, theoretically and experimentally, a polarization-controlled optical gate based on a degenerate polariton-polariton scattering process occurring in semiconductor microcavities.

Due to the interference of the input polaritons, a preferential scattering to directions orthogonal to the pump wavevectors takes place[4]. Whilst this effect is useful for the separation of the signal, it is unexpected from classical considerations of energy-momentum conservation alone. Its theoretical description requires an account of the wave-like nature of polariton fields, which can be made using the spinor Gross-Pitaevskii equations (a mean-field approximation).

The scattering process is also polarization sensitive, which causes the system to function as an XNOR binary logic gate[5]; under cross-linearly polarized pumps scattering is suppressed. Due to the high strength of polariton interactions, optimization of the device is expected to result in competitive operation powers and response times.

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[3] C. W Lai, et al., Nature, 450, 529 (2007).
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CT 5: Monday, 14:30 - 14:45

Extremely Large Magnetoresistance in Silicon

J.J.H.M. Schoonus, F.L. Bloom, H.J.M. Swagten, B. Koopmans

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Silicon holds exceptional promise for magnetoelectronics, by virtue of its long spin coherence and compatibility with the current CMOS technology. As a possible implicit contribution for future silicon based spintronics devices, we show for the first time, using non magnetic materials, a robust low temperature positive resistance change up to eight orders of magnitude at a magnetic field of 500 mT in lateral boron-doped Si/SiO2/Al devices [1].

Systematic investigation of the role of the thin silicondioxide layer shows that the charge acceleration across the barrier provides the energy to trigger an autocatalytic process of impact ionization. A small magnetic field causes shrinkage of the acceptor wave functions and the overlap by the tails is reduced. Thereby, the acceptor energy level increases with respect to the valence band, as verified by admittance spectroscopy, by which the activation energy for impact ionization significantly increases, strongly suppressing the current.

A macroscopic transport model is introduced that is able to describe how the magnetoresistance is controlled by voltage, direction of the magnetic field, electrode spacing and oxide thickness. By choosing deeper acceptor states, these huge magnetoresistance effects might be scaled up to higher temperature, where the device could be suitable as a magnetoresistive sensor or to construct spin logic.

[1] J.J.H.M. Schoonus, H.J.M. Swagten, B. Koopmans et al., Phys. Rev. Lett. 100 (2008) 127202

CT 6: Monday, 14:45 - 15:00

Conductivity of Graphene: How to Distinguish Between Samples With Short and Long Range Scatterers

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To understand the spectacular transport properties of graphene [1] one has to know which kind of scatterers dominates in a given sample. We demonstrate that the diversity of the conductivity behaviour observed in graphene (cf. [2] and [3]) can be naturally described employing the concentrations of long and short range scatterers as parameters. According to our microscopic model, the conductivity measurements upon potassium doping [2] obviously suggest strong domination of the long range scattering potential, whereas the conductivity of suspended graphene after annealing [3] is governed by short range scatterers such as nano-sized ripples and other imperfections. In the first case, the width of the minimum conductivity region is rather broad, with a well defined plateau, and the residual conductivity defined by the linear fit keeps constant upon doping. In the opposite limit, the conductivity demonstrates a very sharp dip at zero carrier concentrations (i. e. no plateau is unambiguously visible), and the residual conductivity can acquire a wide range of values depending on the scattering parameters. Our semiclassical approach [4] fully incorporates the chiral nature of electronic states in graphene which is crucial for a correct description of transport properties mentioned above.

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[2] Chen, J. H., et al. arXiv:0708.2408.
[3] Bolotin K. I., et al. arXiv:0802.2389.
[4] Trushin M. and Schliemann J. arXiv:0802.2794.

CT 7: Monday, 15:00 - 15:15

Detection of Electronic Entanglement in Mesoscopic Conductors

Diego Frustaglia[1,2], Vittorio Giovannetti[2], Fabio Taddei[2], Rosario Fazio[2]

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We present a proposal [1] for the detection of entangled electron currents in nanoestructured conductors. The detection scheme is based on the measurement of cross current correlations. We show that an appropriate data processing can be used to identify electronic entanglement in fairly general input states generated from a generic entangler device. Our approach overcomes the restrictions present in previous proposals [2-5] demanding entanglers that guarantee the production of spatially separated electron pairs (an unlikely situation in the realm of mesoscopic conductors). The proposed scheme allows to identify different kinds of entanglement separately, discriminating between occupation-number and degree-of-freedom entanglement [6], or between orbital and spin entanglement.

[1] V. Giovannetti, D. Frustaglia, F. Taddei, and R. Fazio, Phys. Rev. B 75, 241305(R) (2007).
[2] G. Burkard, D. Loss, and E.V. Sukhorukov, Phys. Rev. B 61, R16303 (2000).
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[5] V. Giovannetti, D. Frustaglia, F. Taddei, and R. Fazio, Phys. Rev. B 74, 115315 (2006).
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CT 8: Monday, 15:15 - 15:30

Two-photon Coherent Spin Flip and Polarization Rotation of Excitons in Quantum Dots

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An optical spin control scheme for an exciton confined in a quantum dot is studied theoretically. It is shown that the spin orientation and polarization of an exciton confined in a QD can be controlled via two-photon transitions, by virtually coupling the single-exciton states to the detuned ground and biexciton states. In this way, coherent Rabi oscillations of the exciton polarization can be induced.

Furthermore, phonon-induced dephasing leading to loss of fidelity in the two-photon optical control schemes is studied using the time-convolutionless equation [1] and a perturbation expansion [2]. Optimal driving conditions and electronic structure (bound vs. antibound biexcitons) are identified. It is shown that exciton spin flip can be performed with fidelities as high as 10^{-3}.

The optical spin control discussed here requires the same conditions as the two-photon Rabi oscillations demonstrated in a recent experiment [3]. Therefore, they are feasible with currently available experimental techniques.

The two-photon transitions should also be manifested in non-linear optical experiments.

[1] E. Rozbicki and P. Machnikowski, Phys. Rev. Lett. **100**, 027401 (2008).

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CT 9: Tuesday, 09:30 - 09:45

Transport Properties of Highly Correlated Electron Spins in Nanoscopic Systems

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We present a new method [1] to study the many-body spin phenomenology that results from the electron-electron, electron-phonon an electron-photon interactions present in structures of quantum dots. The system is divided into a cluster exactly solved that contains all the many body terms of the Hamiltonian and the rest of the system. The interaction between these two parts is taken to be the perturbation in a diagrammatic expansion for the Green functions involved. A logarithmic discretization of the density of states of the leads permits a rapid convergence with the size of the cluster exactly diagonalized. Using this formalism we study a system constituted by three connected quantum dots such that two of them interact by the mediation of the central one that acts as a finite reservoir of charge [1]. We analyze the Kondo effect of the external dots under the presence of a spin-spin RKKY interaction, mediated by the central dot. We study as well the transport properties of adsorbed molecules on metallic surfaces. The influence of the interplay between many-body interactions, spin-spin correlations and interferences due to phase conservation resulted to be crucial to obtain a description compatible with the experimental results [2].

[1] Busser, C. et al., E. Phys. Rep. (2008); Martins G. et al., Phys. Rev. Lett. 96, 066802 (2006)

[2] V. Iancu et al., Phys. Rev. Lett. 97, 266603 (2006); A.Zhao et al., Science 309, 1542 (2005)

CT 10: Tuesday, 09:45 - 10:00

Relaxation Mechanism for Electron Spin in the Impurity Band of N-doped Semiconductors

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We propose a mechanism to describe spin relaxation in n-doped III-V semiconductors close to the Mott metal-insulator transition. Taking into account the spin-orbit interaction induced spin admixture in the hydrogenic donor states, we build a tight-binding model for the spin-dependent impurity band. Since the hopping amplitudes with spin flip are considerably smaller than the spin conserving counterparts, the resulting spin lifetime is very large. We estimate the spin lifetime from the diffusive accumulation of spin rotations associated with the electron hopping. Our result is larger but of the same order of magnitude than the experimental value. Therefore the proposed mechanism has to be included when describing spin relaxation in the impurity band.

CT 11: Tuesday, 10:00 - 10:15

Roles of Spin in a Molecular State of Correlated Electrons in a Quantum Dot

Massimo Rontani

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The electron-electron interaction is predicted to fundamentally affect electron states in semiconductor quantum dots, giving rise —at sufficiently low density— to a “molecule” made of electrons. In the molecular state inter-electron distances are rigidly fixed like those of nuclei in conventional molecules. Evidence for such electron molecule has recently been reported in AlGaAs/GaAs quantum dots with four electrons [1]. The evidence for the electron molecular state relies on the measurements of spin excitations by inelastic light scattering methods. The full interpretation of the experiments requires modeling the highly correlated state of electrons in the quantum dot and its spin excitations by means of state-of-the-art configuration-interaction numerical methods. This research creates venues for the understanding and manipulation of electronic states at the nanoscale. This talk presents an overview of these studies of the roles of the spin degree of freedom and of correlation in nanofabricated quantum dots with very few electrons.

This work is done in collaboration with: S. Kalliakos, V. Pellegrini, C. P. García, A. Pinczuk, G. Goldoni, E. Molinari, L. N. Pfeiffer, and K. W. West.

[1] S. Kalliakos, M. Rontani, V. Pellegrini, C. P. García, A. Pinczuk, G. Goldoni, E. Molinari, L. N. Pfeiffer, and K. W. West, *A Molecular State of Correlated Electrons in a Quantum Dot*, Nature Physics advance online publication, 20 April 2008 (doi:10.1038/nphys944).

CT 12: Wednesday, 09:30 - 09:45

Photo-Induced Precession of Ferromagnetically-Coupled Mn Spins in (Ga,Mn)As

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Precession of magnetization induced by the excitation with femto-second light pulses has been one of the phenomena that could be analyzed based on the gyromagnetic theory. Using pump-and-probe technique for a ferromagnetic (Ga,Mn)As layer with different Mn contents, we have recently established that the $non-thermal$ influence of the optical excitation was responsible for this phenomenon [1].

In the present study, we demonstrate that photo-induced magnetization precession could be observed reproducibly for annealed samples with $x = 0.02$ - 0.11 for wide range of temperatures and pump power. One of the most interesting findings is that the period of precessional oscillation becomes longer with increasing the x value, indicating a decrease in an internal anisotropy field. Assuming $H_{eff} = J_{pd} < s >$ with constant J_{pd}, the observed trend suggests the reduction in the hole spin density $< s >$ with increasing x value.

Another very exciting finding is the coherent control of magnetization with multiple pump pulses. We have found that the magnetization precession could be accelerated or decelerated depending on the timing of the pump with respect to the phase of precession. This is the first time that such experimental demonstration has been accomplished in ferromagnetic system via the excitation of free carrier system.

References
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CT 13: Wednesday, 09:45 - 10:00

Exchange-Mediated Anisotropy of (Ga,Mn)As Valence-band Probed by Resonant Tunneling Spectroscopy

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The growth of semiconductor heterostructures incorporating ferromagnetic material is a challenge for today's spintronic. We will report on GaMnAs/III-V tunnel junctions that fulfill this condition. In the case of GaMnAs related junctions, the complexity of the transport mechanisms associated with spin-orbit coupled states make this material a powerful means for finding novel effects and provides new challenges for theoretical understandings. This includes tunnel magnetoresistance (TMR) across single and double barriers, spin torque effect and tunnel anisotropic magnetoresistance (TAMR). As an illustration we will show how the resonant TAMR on a GaAs quantum well can be used as a probe of the GaMnAs valence band anisotropy[1]. The oscillation of the TAMR associated to the resonance on the level of the quantum well can be well described in a kp theory and Laudauer formalism. The theory and experiment confrontation leads to an analysis of the sub band contribution at the origin of the TAMR oscillation.

[1] M. Elsen et al. Phys. Rev. Lett. 99, 127203 (2007)

CT 14: Wednesday, 10:00 - 10:15

Spin Flip Wave Generation in Semimagnetic Doped Quantum Wells

Paul Jacobs[1], Florent Perez[2], Cynthia Aku-Leh[4], Grzegorz Karczewski[3], Roberto Merlin[1]

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Recently, two dimensional electron gases (2DEG) embedded in semimagnetic Cd(1-x)Mn(x)Te quantum wells have been introduced as a model system for spin-polarized 2DEG (SP2DEG) where spin effects dominate over orbital quantization thanks to the giant Zeeman splitting fields. Using Raman spectroscopy, both spin-flip wave (SFW) and single-particle spin excitations have been observed in such SP2DEG [1].

We have used ultrafast pump-probe spectroscopy to study spin-flip excitations in this SP2DEG. Oscillations due to the zone center SFW were generated by circularly-polarized pump pulses and detected by Kerr rotation of linearly-polarized probe pulses. The SFW lifetime has a strong dependence on the applied magnetic field, Mn concentration, and exciting photon energy. Heating due to laser absorption also affects the lifetime of the SFW. The dependence of the lifetime on wavelenght and magnetic field indicate that the optically-excited heavy holes and their spin orientation play an important role in the SFW decay. By narrowing the pump pulseś spectrum, we have studied the generation mechanism as well. The narrowed pulse spectrum allowed us to generate SFW while having the excitation wavelength below the absorption edge. This reduces the amount of holes photocreated, increases the SFW lifetime and indicates the presence Raman mechanism in the generation process.

[1] F. Perez et al., Phys. Rev. Lett. 99, 026403 (2007). B. Jusserand et al., Phys. Rev Lett. 91, 86802 (2003)

CT 15: Wednesday, 11:15 - 11:30

Spin Transport in (110) GaAs Based Cavity Structures

K. Biermann, O. D. D. Couto, Jr., E. Cerda, H. B. de Carvalho, R. Hey, P. V. Santos

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The specific structural symmetry of quantum wells (QWs) grown on (110) GaAs substrates prevents the dephasing of the out-of-plane spin-polarized electrons by means of the Dýakonov-Perel (DP) mechanism. On the other hand, when surface acoustic waves (SAWs) are excited, a type-II modulated piezoelectric potential is induced. The latter leads to the spatial separation of optically generated electrons and holes, which diminishes the Bir-Aronov-Pikus (BAP) spin-dephasing mechanism. The combined suppression of both dephasing-mechanisms allows for very long spin lifetimes at T=15K [1].

Here, we demonstrate spin transport in (110) GaAs QWs up to T=80K using spatially-resolved photoluminescence (PL). The sample consists of a 20nm-thick QW embedded in a high-quality microcavity grown by MBE [2].

We show that at T=80K z-oriented spins can be transported by SAWs over distances of about 24 μm, which correspond to lifetimes τ_z of at least 8 ns. As only the out-of-plane component is not subject to the DP mechanism, the in-plane spin lifetime τ_y is expected to be much shorter. Using the Hanle effect, we determined that its value is on the order of 1 ns. The influence of an in-plane magnetic field as well as the effect of the SAW fields on the spin dynamics are also discussed.

[1] O. D. D. Couto, et al., Phys. Rev. Lett. 98, 036603 (2007)
[2] R. Hey, et al., phys. stat. sol., ISCS2007 conf. proc.

CT 16: 11:30 - 11:45

Spin Dynamics in ZnO-based Materials

W.M. Chen[1], I.A. Buyanova[1], T. Furuta[2], A. Murayama[2], D. P. Norton[3], S.J. Pearton[3], A. Osinsky[4], J. W. Dong[4]

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The demonstration of room temperature ferromagnetism in diluted magnetic semiconductors based on ZnO has shown the potential of this material system for future applications in spintronics. Progress in this research field has unfortunately been hindered by rather poor understanding of the spin-dependent phenomena in the materials, apart from the difficulties in material preparation and control. In this work, we address the issue of spin relaxation and its relevance to spin detection in ZnO-based materials, by spin-polarized, time-resolved optical orientation and magneto-optical spectroscopy. We have found that spin relaxation is very fast, i.e. about 120 ps for donor bound excitons in wurtzite ZnO, despite of a weak spin-orbit interaction. For free excitons, spin relaxation is expected to be even faster. We also reveal that alloying of ZnO with Cd and Mg further enhances spin relaxation, prohibiting ZnCdO/ZnO and ZnO/ZnMgO structures for efficient optical spin detection. On the other hand, a variation in strain field induced by lattice mismatch with substrates does not seem to lead to a noticeable change in spin relaxation. The observed fast spin relaxation, together with the limitation imposed by the band structure, are thus identified as the two most important factors that limit the efficiency of optical spin detection in the studied ZnO-based materials.

CT 17: Wednesday, 11:45 - 12:00

Annealing Effect in Gadyn on Optical and Magnetic Properties

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We have reported the magnetic properties for the first time in thin film of rare-earth (RE)-doped GaN such as GaGdN, GaEuN, GaTbN, GaDyN. They all exhibited ferromagnetism at room temperature. In order to control the ferromagnetism in DMSs, we studied and reported (1) the surperlattice structures of thin ferromagnetic semiconductor GaGdN layers sandwiched with nonmagnetic GaN spacers and (2) the low-temperature-grown GaGdN layers with high Gd concentration. We found that RE and carrier (electron) concentrations are important parameters influencing the magnetic properties. In addition to these parameters, the magnetic moment value of RE ion incorporated into GaN is also important parameter. Dy ion has the largest magnetic moment among RE elements, so GaDyN are also expected has the largest magnetic moment, compared with the other RE-doped GaN for the same RE concentration.

GaDyN layers were grown on SiC substrates at 700°C by RF-MBE. They were annealed at 900°C and 1000°C for 1 min. Obvious changes were observed by high temperature annealing in PL spectra and M-H curves. Fig. 1 shows the M-H curves for the GaDyN sample (a) as grown, and annealed at (b) 900°C and (c) 1000°C for 1 min. The magnetization becomes small at the same magnetic field with increasing annealing temperature. PL intensity, originated from defects, was also decreased by increasing annealing temperature. It is considered that the formation of defects influences the ferromagnetism in Dy-doped GaN.

CT 18: Wednesday, 12:00 - 12:15

Model Calculations of the Anisotropic Magnetoresistance in (Ga,Mn)As and Other III-V Materials

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The anisotropic magnetoresistance (AMR) in magnetic metals and semiconductors is one of consequences of the spin-orbit interaction. We theoretically study the AMR within the p-d kinetic exchange model of ferromagnetism in the valence band of (Ga,Mn)As combined with the semiclassical Boltzmann formula, and identify three main paths along which the anisotropy may enter. These are (a) anisotropic Fermi velocities, and scattering rates with an anisotropy due to (b) the scatterer or (c) the wave functions as exemplified in Fig. 1 on a sketch of the two heavy-hole Fermi surfaces of GaAs in spherical approximation (arrows indicate the expectation value of the spin). We find the 'anisotropic scatterer mechanism' (shown in Fig. 1b) to be the dominant one in the range of material parameters relevant to highly doped (Ga,Mn)As [1]. An essential component of the model is that the Mn ions, being the most frequent source of scattering, are described by a coherent sum of the spin-dependent (due to their magnetic moment) and electrostatic potentials (they are acceptors). We briefly review the analysis of our model which highlights the importance of this mechanism.

We then discuss the effect of Mn atoms in interstitial positions on the AMR, investigate the trends in other III-V materials and also give an outlook to Mn-doped II-VI compounds.

[1] A.W. Rushforth et al., Phys. Rev. Lett. 99, 147207 (2007).

CT 19: Wednesday, 12:15 - 12:30

Interaction Between Mn Ions and a Two-dimensional Hole-gas

A. L. Gazoto[1], M. J. S. P. Brasil[1], F. Iikawa[1], E. Ribeiro[2], Yu. A. Danilov[3], M.V. Dorokhin[3], O.V. Vikhrova[3], B.N. Zvonkov[3], Yu. N. Drozdov[4], M.V. Sapozhnikov[4]

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The interaction between magnetic ions and carriers on semimagnetic-semiconductor structures is a fundamental point for spintronic applications. We report on the effects of the presence of nearby Mn ions on a two-dimensional hole-gas (2DHG). Our structure consists of an InGaAs/GaAs quantum well (QW) with a Mn planar layer at the GaAs barrier close to the QW. An additional C planar-doped layer is included in the opposite GaAs barrier for increasing the 2DHG density in the well. We studied a series of samples with different Mn concentrations including reference samples without Mn. 2DHG densities were determined by Shubnikov-de-Haas oscillations and are consistent with Stokes-shift energies obtained from optical results. The energy shift of the QW emission as a function of the magnetic field from structures containing Mn ions showed an anomalous oscillatory behavior. No oscillations were observed, however, for reference samples without Mn. The oscillatory effect is very sensitive to temperature, vanishing around 20 K. Under an external magnetic field and non-resonant excitation, the presence of Mn induces a slightly increase of the circular-polarization degree of the QW emission. Zero-field resonant measurements indicated, however, that Mn ions have no effect on the spin relaxation time of the photocreated minority electrons in the QW. We discuss the origin of the remarkable oscillatory behavior considering the coupling between the 2DHG and the nearby Mn ions.

CT 20: Wednesday, 15:00 - 15:15

Rashba Conduction Band Spin Splitting for Asymmetric Quantum Well Potentials

P.S. Eldridge[1], W.J.H Leyland[2], J. Mar[2], P.G. Lagoudakis[1], R. Winkler[3], O.Z. Karimov[1], M. Henini[4], D Taylor[4], R.T. Phillips[2], R T Harley[1]

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Electronic spin in quantum wells can be manipulated with electric fields via the Rashba interaction. A common belief is that asymmetric alloy composition will also induce Rashba splitting. But the theoretical basis for this is controversial and a definitive experimental test is lacking. Accordingly, we have compared measured spin-splittings in undoped (110) GaAs/AlGaAs quantum wells with one abrupt and one graded interface with those in symmetric wells under transverse applied electric field. Spin splittings were obtained optically by combining measured Dyakonov-Perel-dominated spin relaxation along the growth axis with electron scattering time from spin grating decays. Use of (110) wells discriminates against the Dresselhaus component of spin splitting. Undoped wells distinguish effect of alloy composition asymmetry itself from that of electric field due to separation of free charges induced by the asymmetry. The Rashba splitting for asymmetric wells with one graded interface equivalent to conduction band potential gradient 100 kV/cm was unmeasurably small, much less than that for applied electric field of 80 kV/cm on symmetrical wells. This accords with a theoretical argument that correctly considers both valence and conduction band confining potentials on the electrons. The surprising conclusion is that alloy asymmetry alone cannot control spin via Rashba splitting, a splitting requires an electric field applied externally or generated internally by charge separation.

CT 21: Wednesday, 15:15 - 15:30

Direct Optical Detection of Pure Spin Current in Semiconductors

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Generating spin population in semiconductors is one of central goals of spintronics and has attracted a rapidly growing interest for its potential application in spintronic devices. The pure spin current can be generated utilizing the spin Hall effect (SHE),[1, 2] optical quantum mechanical interference control between one- and two- photon excitations[3,4]. The vanishing charge current and total spin make direct experimental measurement of spin current is an extremely challenging task. We suggest a new practical scheme for the direct detection of pure spin current by using the two-color Faraday rotation of optical quantum interference process (QUIP) in a semiconductor system[5]. We demonstrate theoretically that the Faraday rotation of QUIP depends sensitively on the spin orientation and wave vector of the carriers, and can be tuned by the relative phase and the polarization direction of the

w and 2w laser beams. By adjusting these parameters, the magnitude and direction of the spin current can be detected.

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[5] J. T. Liu and Kai Chang, arXiv:0801.0180.

Monday Poster Session

16:45 - 18:15

MON 1:

Spin-Assisted Interlayer Percolation in Quantum Hall Multi-layer Systems

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The influence of the interlayer coupling on formation of the quantized Hall phase was studied in the multilayer GaAs/AlGaAs heterostructures. The insulated (the interlayer tunneling energy t = 0), weakly-coupled (t = 1 meV) and strongly-coupled (t = 55 meV) multi-quantum well structures were studied. The distinct zero-resistant states corresponding to the quantized Hall phases were found at the filling factor nu = 2 in the insulated and weakly-coupled structures. The quantized Hall phases of the weakly-coupled multilayers emitted the asymmetrical photoluminescence line. We demonstrated that the observed asymmetry is caused by a partial population of the extended electron states formed in the insulating quantized Hall phase of the weakly-coupled multilayer system. In such a case, the shape of the high-energy side of the asymmetrical PL line is determined by the broadenings of the electron states on the Fermi surface. The electron single-particle scattering time at the Fermi energy was determined as a function of the magnetic field. We demonstrated that the extended electron states observed in the quantized Hall phase of the weakly-coupled multilayer system are caused by the theoretically predicted disorder driven spin-assisted interlayer tunneling. Both the tunneling strength and the interlayer coherence were shown to significantly influence formation of these extended states. The observed effect manifests to the formation of the Fermi surface in the quantized Hall phase.

MON 2:

Optimization of Optical Orientation and Electron Spin Transport in AlInGaAs/AlGaAs Superlattice

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In the present work we developed the optimized photocathode structure with working layer based on the AlInGaAs/AlGaAs Superlattice (SL) with strained quantum wells. It consists of a 500nm thick $Al_{0.35}Ga_{0.65}As$ buffer layer, $Al_xIn_yGa_{1-x-y}As/Al_zGa_{1-z}As$ SL working layer and surface GaAs layer for BBR. The superlattice contains 12 pairs of strained $Al_{0.19}InGa_{0.61}$ as quantum well layers and unstrained $Al_{0.4}Ga_{0.6}$ as barrier layers. The layer compositions and thickness were optimized to achieve the maximal valence band spitting with minimal risk of stain relaxation and structural defects and sufficient electron mobility along the SL axes. The Sls energy spectrum has been calculated using the multiband Kane model. Activation of the GaAs surface produces the negative electron affinity and, hence, determines the band bending value and transparency of photocathode surface for the emitted electrons. We report the highest level of polarization of the photoelectrons P=92% in combination with the largest quantum efficiency at polarization maximum QE=0.85%. The obtained results are the best up to date achieved parameters of the polarized electron sources under operation at room temperature.

MON 3:

Spin Dynamics in Rolled-up Two Dimensional Electron Gases: An Experimental Proposal

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We consider a rolled-up two dimensional electron gas (see e.g. [1]) with spin-orbit (SO) interactions due to the radial confinement asymmetry. At certain relation between the SO coupling strength and curvature radius the tangential component of the electron spin becomes a conserved quantity for any spin-independent scattering potential [2]. Here we extent our earlier work to a proposal how to observe this effect. Our proposal uses presentday technology and can be outlined as follows: (1) To tune SO coupling a metallic gate (wire) is placed into the tube, as it is shown in the figure attached. (2) To avoid a complex problem of spin injection, the heterostructure is grown as a whole at the ferromagnetic substrate. Note, that the curved part of the system turns out to be spatially separated from the substrate. Here, the spin dynamics is governed by the electric field (via SO coupling) rather than by the magnetic moment of the substrate. Such special geometry of the setup allows us to observe the effect of SO interactions and finite curvature of the sample in transport measurements.

[1] S.Mendach et al. 2004 Physica E 23, 274.
[2] M.Trushin et al. 2007 New J. Phys. 9, 346.

MON 4:

Optical Circuits Based on Exciton-polaritons in Semiconductor Microcavities

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It is well known that polariton-polariton interactions provide the necessary non-linearity for a semiconductor microcavity to demonstrate bistability under a coherent optical excitation that is tuned slightly above the bare polariton eigenmodes. In recent work[1], an appreciation for the polarization degree of freedom of polaritons revealed that the system can actually exhibit multistable behaviour, that is, under a given set of conditions the system can be found in one of four stable states, depending on its history. Under a continuous wave pump suitable for multistability, the switching of a region in space from a low intensity state to a higher intensity state can be activated by an additional localized pulsed excitation. The in-plane propagation of polaritons allows the consecutive switching of neighboring regions in space, which allows the spreading of an excited domain. This spreading can be confined along channels by patterning the potential experienced by polaritons and this provides the "wires" needed for optical circuits working in the microcavity plane. Due to the long coherence time of polaritons in the system, they can be studied using the spinor Gross-Pitaevskii equations[2]. At a junction of two channels, the interaction of two spreading signals is polarization sensitive, which allows a binary logic gate to be naturally realized.

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MON 5:

Symmetry Breaking Induced by the Spin-orbit Interactions in Mesoscopic Rings

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In recent years, the spin-orbit interaction (SOI) in low-dimensional semiconductor structures has attracted considerable attention due to its potential applications in spintronic devices. [1] Among all other low-dimensional structures, Quantum ring exhibits the intriguing spin interference phenomenon because of its unique topology. We investigated theoretically electron spin states in mesoscopic rings in the presence of both the Rashba spin-orbit interaction (RSOI) and the Dresselhaus spin orbit interaction (DSOI) in a perpendicular magnetic field. Our theoretical results show that the interplay between the RSOI and DSOI results in an effective periodic potential, which breaks the cylindrical symmetry and consequently leads to gaps in the energy spectrum [2]. This periodic potential also weakens and smoothens the oscillations of the persistent charge current and spin current and results in the localization of electrons. The interplay also leads to the anisotropic spin transport in open

mesoscopic ring . The conductance is very sensitive to the positions of the incoming and outgoing leads due to the broken cylindrical symmetry [3]. The anisotropic spin transport can survive in the presence of disorder caused by impurity elastic scattering in a realistic system.

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[2] J. S. Sheng and Kai Chang, Phys. Rev. B 74, 235315 (2006).
[3] M. Wang and Kai Chang, Phys. Rev. B (in press)

MON 6:

Design of Dilute Magnetic Semiconductors by Controlling Spinodal Decomposition

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Owing to the recent development of the first-principles method for calculating magnetic properties of dilute magnetic semiconductors (DMS), it has been recognized that the magnetic percolation effect is disastrous to the high temperature ferromagnetism in DMS in particular for low concentrations [1]. The exchange interactions calculated from first-principles are strong for nearest neighbors, but those interactions are short ranged and can not play an important role for realizing high- TC because the solubility of magnetic impurities into DMS is too low to achieve magnetic percolation. To overcome this difficulty and realize room temperature ferromagnetism, firstly, we focus on the spinodal decomposition in DMS, and suggest that by controlling the spinodal decomposition high blocking temperature can be realized leading to ferromagnetic behaviour at high temperature [2]. As another approach for realizing high-Tc DMS we propose co-doping method to increase solubility limit of transition metal impurities in DMS [4].

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[2] K. Sato et al., Jpn. J. Appl. Phys. 46, L682 (2007)
[3] K. Sato et al., Jpn. J. Appl. Phys., 44, L948 (2005), T. Fukushima et al., Jpn. J. Appl. Phys., 45, L416 (2006)
[4] K. Sato et al., Jpn. J. Appl. Phys. 46 L1120 (2007)

MON 7:

Fractional Quantization of Ballistic Conductance in 1D Electron and Hole Systems

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We present our recent results in the field of 0̈.7 anomalyänd related phenomena in 1D electron and hole systems. We introduce the concept of a fractional quantization of the ballistic conductance arising from an exchange interaction of the Heisenberg type between the carrier localized in the region of the quantum point contact (QPC) and freely propagating carriers and show that the conductance pattern is qualitatively different for electron and hole systems. In n-type systems, we analyze the conductance of a QPC containing a large localized spin J. We show that the additional änomalousp̈lateu is formed on a ballistic staircase if only one propagating channel is rendered conducting. The conductance value of this plateu is shown to depend strongly on J and, for an exchange ferromagnetic interaction, decrease from $3e^2/2h$ to e^2/h when J increases from 1/2 to infinity, which is in a good agreement with the experimental observation. For acceptor-doped Si and GaAs QPCs the particular spin structure of the conduction band results in a ballistic conductance pattern qualitatively different from the electronic case. The value of the conductance at the additional plateaux depends on the offset between the bands of the light and heavy holes, and the sign of the exchange interaction constant. For small offsets several additional plateaux can be observed. For large offsets the single plateau is formed at e^2/h.

MON 8:

Magnetic Properties of Co-doped ZnO by Monte Carlo Simulations

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The magnetic properties of Co-doped ZnO were investigated by Monte Carlo simulations assuming indirect exchange interaction through two different and competing mechanisms: antiferromagnetic superexchange and an oscillating carrier-mediated interaction. The calculations were performed for p- and n-type conductions. The Co was taken as a substitutional impurity and its concentrations was varied from 3% to 20%. The carrier concentrations (holes or electrons) were tested in the range of 1×10^{16} to 1×10^{20} cm^{-3}. The p-type samples show predominance of carrier induced ferromagnetism, wile n-type behave like a paramagnet for all samples with Mn concentration under 20%. The magnetic order in the p-type samples is governed by the carrier induced exchange when the hole concentration is about 1×10^{19} cm^{-3} or above, where T_C can reach 250 K. For hole concentrations lower than that, the competition between the anti-ferromagnetic superexchange and the ferromagnetic carrier induced interaction makes the exchange between Mn ions weak and the samples are, then, paramagnetic. The magnetism of the n-type samples, on the other hand, do not depend on the carrier concentration, and the paramagnetic behavior persists till the Mn concentration increases above the threshold value, when the short-ranged super-exchange interaction produces a long range order in the samples.

MON 9:

Variational Integrator for the Delay Equations of Motion of the Electromagnetic Two-body Problem

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We give a numerical method for the state-dependent delay equation of the electromagnetic two-body problem. This mixed-type delay equation involves two singular denominators, one in the future light-cone and one in the past light-cone. The denominators span a nontrivial qualitative dynamics with a (stiff) fast-timescale and are the main hindrance for a numerical integration as an algebraic-differential neutral-delay equation. We discuss a use of the variational principle of Fokker´s action to solve the delay equations as a mixed-type boundary-value problem and discuss the variational integrator. The variational structure still includes the denominators, which appear inside an integral, a form much easier to regularize than the original mixed-type equations of motion.

MON 10:

Ab-initio Electronic Structure Calculations of (Ti, Co)O_2 Within Self-interaction-corrected LDA

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Electronic structure of TiO_2 (rutile) based dilute magnetic semiconductors (DMS) are investigated by *ab-initio* calculations within self-interaction-corrected local density approximation (SIC-LDA). These results are compared with those calculated within standard LDA. We employ the Korringa-Kohn-Rostoker method combined with coherent potential approximation. It is found that the calculated band-gap energy and energetic position of O 2p bands in the host TiO_2 are different in the LDA and the SIC-LDA, low-spin state in (Ti, Co)O_2 is predicted in the LDA and inter-mediate spin state in (Ti, Co)O_2 is predicted in the SIC-LDA. For the realistic calculation, we take the oxygen vacancies in (Ti, Co)O_2 into account. We find that non-magnetic spin state in (Ti, Co)O_2 with O vacancy is predicted in the LDA and high-spin state in (Ti, Co)O_2 with O vacancy is predicted in the SIC-LDA. Actually, Mamiya et al. observed the Co^{2+} high-spin state in the D2h-symmetry crystal field at the Ti site by means of the x-ray absorption spectroscopy and soft x-ray magnetic circular dichroism measurements in (Ti, Co)O_2. In addition, the electronic structure in (Ti, Co)O_2 with O vacancy within SIC-LDA reproduces x-ray photoelectron spectroscopy spectrum. As a result, we find that O vacancy in (Ti, Co)O_2 is the origin of Co^{2+} high-spin state and SIC-LDA is indispensable to describe the correct electronic structure and spin state of TiO_2-based DMS.

MON 11:

Epitaxial Heusler Alloy Co_2FeSi Films on GaAs Substrates for Spin Injection

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The Heusler alloy Co_2FeSi is a promising ferromagnetic material for spintronic applications due to its high Curie temperature (far above room temperature) and the theoretically expected half-metallic behavior. However, long-range atomic ordering and a high interface quality are of fundamental importance for such applications of ferromagnet-semiconductor heterostructures. The long-range atomic ordering within the Co_2FeSi film increases with increasing the growth temperature T_G as evidenced by a comparison of the experimental transmission electron microscopy images with those of contrast simulations. For T_G above 200 C, interfacial reactions set in, which are dominated by a Co in-diffusion into the GaAs substrate. To circumvent the in-diffusion, we investigated the influence of thermal annealing on the characteristics of the Co2FeSi films on GaAs substrates grown by molecular beam epitaxy at low T_G (100 C). The films are apparently stable for annealing up to 425 C for 10 min. On the other hand, secondary ion mass spectroscopy investigations reveal a remarkable in-diffusion of Co and also Fe and Si into the substrate already at a low T_G of 100 C. Surprisingly, the best results with respect to spin injection are however obtained for a Co_2FeSi layer grown at 300 C on top of a GaAs/(Al,Ga)As spin light emitting diode (spin-LED), where a considerable in-diffusion of Co and Fe into the underlying spin-LED is observed.

MON 12:

Control of Spinodal Decomposition in (Ga, Mn)As by the Interstitial Impurity Co-doping

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One of the most important material issues for realizing the semiconductor spintronics is to fabricate dilute magnetic semiconductors (DMS) with high Curie temperature (Tc). However, the solubility of magnetic impurities in DMS is very low and it is difficult to dope magnetic impurities up to high concentrations with keeping good crystal quality. Therefore, normally Tc of DMS is low due to the missing of the magnetic percolation. In this paper, based on the first principle calculations by using the Korringa-Kohn-Rostoker coherent potential approximation method, we propose the interstitial impurity co-doping method to increase the solubility of Mn in (Ga, Mn)As. The calculations show that In (Ga, Mn)As, the mixing energy of Mn shows convex concentration dependence. This means the crystal shows spinodal decomposition into GaAs and MnAs in thermal equilibrium. By introducing interstitial

impurities, such as H, Li, Be, Na and Mg, due to the compensation between Mn and interstitial impurities, the mixing energy shows transition from convex to concave concentration dependence. This means suppression of the spinodal decomposition. Thus, we can achieve homogeneous high concentration doping of Mn in (Ga, Mn)As. Removing compensating interstitial impurities from the crystal by annealing after the crystal growth, the holes introduced by Mn revive and ferromagnetism recovers to realize high Tc DMS.

MON 13:

Numerical Renormalization Group and Kondo Description of 0.7 Conductance Anomaly.

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The conductance of the quantum point contacts (QPCs) and quantum wires in the ballistic regime is proportional to the elementary conductance quanta $2e^2/h$ and a number of the open propagating modes. Tuning the gate voltate, a quantum conductance staircase can be thus experimentally observed. However, in the small- density region a mysterious additional plateau around 0.7 of the standard conductance quantum appears (0.7 anomaly). Several experimental facts suggest a connection of this phenomenon with a formation of spontaneously polarized state in the region of QPC. Besides, it was claimed that there exist certain similarities between the conductance patterns of Quantum Dots (QD) in the Kondo regime and QPCs in the regime of 0.7 anomaly. Basing on experimental observations, we investigate a modified Anderson impurity model for a description of QPCs in the regime of 0.7 anomaly (first proposed by Y. Meir and coauthors). Differently from original Anderson model, the hybridizations between the QPC and the laeds are treated as being dependent on the occupation of the contact. The present work puts this model to the test by non- perturbative analysis using numerical renormalization group (NRG) procedure. We show that the results of such non-perturbative calculation contradict the experimental data and thus the interplay between Kondo effect and 0.7 anomaly should be revised.

MON 14:

Spin-torque Contribution to the AC Spin Hall Conductivity

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It is well known that the electron spin is not a conserved quantity in spin-orbit coupled systems. There is recent proposal by Shi et al. [1] of a dubbed *proper* definition of a *conserved* spin-current density. Such definition is indeed physically appealing and deserves close examination. Using this recently proposed definition of a conserved spin-current operator, we explore the frequency dependent spin Hall conductivity for two-dimensional electron [2] and hole [3] gases with Rashba and Dresselhaus spin-orbit interaction in response to an oscillating electric field. We show that (for both cases, electrons and holes) the optical spectrum of the spin Hall conductivity exhibits

remarkable changes when the definition of a conserved spin current is applied. Such behavior is mainly due to a significant contribution of the spin-torque term which is absent in the conventional form of the spin current. In addition, it is observed that the magnitude and direction of the dynamic spin Hall current strongly depend on the electric field frequency as with the interplay of the spin-orbit coupling strengths. These results may encourage experimentalists to envision ways to measure the spin Hall accumulation in the frequency domain. Work supported in part by DGAPA-UNAM project 1N113-807-3.

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[3] A. Wong and F. Mireles (in preparation).

MON 15:

Time-energy Uncertainty Relation Applicability for Quantum Transport of Spin-related Wave Packets

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We study the wave packetś (WP) motion for Q-1D system with spin-orbit (SO) coupling by means of Heisenbergś inequalities. An accurate gedanken experiment was carefully proposed, mainly based on spin-related effects and considering several known approaches on quantum mechanical limited determinism [1]. We verified the time-energy uncertainty relation (TEUR) during electronic WP evolution and qualitative information of the systemś dynamic is found. We solved the Schrödinger equation with SO coupling of Rashba-type [2] to obtain expected individual values of energy and applied the TEUR. The stationary phase method (SPM) is used to guarantee robust coherence for WP, which implies restrictions on the incident energy values for both tunneled and transmitted cases. The SPM advantages and applicability to quantum transport have recently attracted attention [3, 4]. Tailoring input parameters, we observed appealing effects while the WP evolves. For certain barrier thicknesses, some values dropped into the forbidden area regarding a clear theoretical limit imposed by the TEUR, which resolves correctly the electron?s spin-splitting. We are grateful FICSAC-UIA.

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MON 16:

Thermoelectric Transport Properties of a Quantum Wire, Coupled to a Quantum Dot: Finite Band Effects.

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The thermoelectric effects in semiconductor nano-structures have gained renewed interest during the last years; recently, experimental and theoretical works treat the contribution of the Kondo effect spin-fluctuations in quantum dots (QDs), to the thermoelectric transport properties [1]. In this work we compute the thermopower, thermal conductance and the thermoelectric figure of merit, for a gate defined QD, coupled to a quantum wire (QWW), using the impurity Anderson model (AIM) in the strong Coulombian repulsion case and the X-boson treatment for the AIM [2], we discuss all the regimes of the system as function of the QD energy for different temperatures; our results shows that at intermediate temperatures, the product between the thermoelectric figure of merit (Z) and the temperature (T) (ZT) achieves important values, what should indicates possible practical applications in cooling process, also is present a thermal activated resonance in the thermal conductance for values of the QD energy at the edge of the conduction band, linked to the van-Hove singularities for the QWW, this resonance shows a strong Fano character, similar to the reported in the electronic transport case, for a T-coupled QD.

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[2] R. Franco et al, Phys Rev. B 73, 195305 (2006); Phys. Rev. B 66, 045112 (2002).

MON 17:

Curie Temperature Versus Hole Concentration of (Ga,Mn)As

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By utilizing the nature of hole-induced ferromagnetism, the Curie temperature T_C of (Ga,Mn)As channel in a filed effect transistor (FET) can be modulated by changing its hole concentration p through the application of the gate electric field E [1]. In this work, we examined the magnitude of T_C as a function of p varied by E.As channel layer was grown by molecular beam epitaxy on 4 nm GaAs / 4.5 nm $Ga_{0.928}Mn_{0.072}$/30 nm $Al_{0.75}Ga_{0.25}As$ / 420 nm $In_{0.15}Ga_{0.85}As$ / 30 nm GaAs buffer layers from the surface side onto semi-insulating GaAs (001) substrate. The sample was processed into Hall-bar geometry with Al_2O_3 gate insulator (dielectric constant: $\kappa = 7.47$) and a metal gate electrode. The magnetotransport measurement was done under $\mid E \mid$ up to 7.0 MV/cm. $p(E) = [\mu e d R_{\text{sheet}}(E)]^{-1}$ was determined under the assumption of E independent mobility μ (d: channel thickness, e: elemental charge, R_{sheet}: sheet resistance). Magnetic property of the channel was probed thorough the anomalous Hall resistance proportional to magnetization, and T_C was determined from the Arrott plots. We found that the relationship of $T_C \propto p^{0.2}$, and that it holds also for many other samples with different Mn composition and channel thickness.

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MON 18:

Design of High Solubility of Magnetic Impurities for Semiconductor Spintronics by Co-doping Method

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Dilute magnetic semiconductors (DMSs) have been well investigated as useful materials for semiconductor spintronics. The essential point for realization of semiconductor spintronics is to fabricate DMS with room temperature ferromagnetism. However, it has been noted that achieving this goal is very difficult. One important problem is that since the solubility of 3d transition metal in the compound semiconductors is negligibly low, DMS can not have a ferromagnetic order due to the percolation problem. In this paper, based on Korringa-Kohn-Rostoker coherent potential approximation (KKR-CPA) method, we propose co-doping method for increasing solubility of magnetic impurities in DMSs. The concentration dependences of the mixing energy of DMS, such as (Ga,Mn)N, (Ga,Cr)N, (Ga,Mn)As, and (Zn,Cr)Te, show large convexity and these systems have a tendency toward spinodal decomposition. By introducing compensating impurities into these DMS, the mixing energy shows gradual transition from convex to concave concentration dependence resulting in negative mixing energy of magnetic impurities. This observation suggests that the co-doping method dramatically increases the solubility of magnetic impurities in DMS, thus high concentration doping of magnetic impurities into DMS becomes possible. Additionally, by using ab initio results of effective pair interactions and Monte Carlo method, we perform the crystal growth simulation of DMS.

MON 19:

Gate Voltage Control of Nuclear Spin Relaxation in GaAs Quantum Well

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Nuclear spin in semiconductors is one of the promising resources for quantum bit because of its long coherence time. In order to manipulate and detect nuclear spins in semiconductors, one can utilize electrical field-control of coupling between electron and nuclear spins via hyperfine interaction [1,2] as well

as optical approaches which allow us to highly polarize and sensitively detect the local nuclear spins without any specific conditions. In this work, we investigated the nuclear spin relaxation time in a gated GaAs/AlGaAs quantum well (QW) by optical detection of nuclear magnetic resonance.

The sample is an n-doped GaAs/AlGaAs (110) QW. Under a transverse magnetic field, the Larmor precession of the photoexcited electron spins was detected by time-resolved Kerr rotation as a measure of local nuclear magnetic field acting on electron spins [3]. We evaluated the nuclear spin relaxation time by measuring transient dynamic nuclear polarization and Rabi oscillation as a function of the electron density. We have shown that the nuclear spin relaxation time decreases with decreasing electron density, indicating that the nuclear spin relaxation and decoherence are enhanced by hyperfine interaction as the electronic states becomes to be localized in an impurity-doped QW.

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MON 20:

Scanning Kerr Microscopy of the Spin Hall Effect in N-doped Gaas With Various Doping Concentration

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Generation of spin current in semiconductors has attracted growing interest. One of such intriguing phenomena is the spin Hall effect (SHE), which have been theoretically [1,2] and experimentally demonstrated [3,4]. Taking into account the long spin lifetime, electron system is more suitable for manipulation of spin current, and thus it is of great interest to quantitatively investigate SHE in n-type semiconductors. In this work, we evaluated the doping concentration (n) dependence of the extrinsic SHE in n-GaAs. We prepared a series of 2 μm GaAs channel with various n raging from 3×10^{16} to 5×10^{17} cm^{-3}. To observe local spin accumulation, we implemented a high sensitivity scanning Kerr microscopy (SKM). By the SKM measurement, we observed the Kerr signal due to spin accumulation near the channel edges in all the samples. We found that the position and in-plane magnetic field dependence of the Kerr signal vary with n, and analyzed the n dependence of the spin Hall conductivity by taking account of the n-dependent spin lifetime based on drift-diffusion model.

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MON 21:

Time-resolved Cryogenic Kerr Microscope for Studies of Electron Spin Transport in Microstructures

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The properties of electron spins in 3D, 2D and 0D semiconductor structures have been intensively studied to explore new applications of spintronic devices. Spin manipulation, and in particular transport, require a better understanding of the properties of electron spins in quasi-1D wires. To access this regime we built a cryogenic Kerr microscope for high magnetic fields which can operate both in Faraday and in Voigt configurations and has spatial and temporal resolutions of 1 micron and 120 fs. Crucial for spin transport experiments, the instrument has the capability of polarizing and probing spins at different locations on a microstructure. Measurements of spin transport were done on 2D and quasi-1D electrons in a high-mobility GaAs/AlGaAs heterostructure with electron mean free path (mfp) of 10 microns. In experiments on single wire structures we observe spin diffusion for distances down to 4 microns, well within the electron mfp. In these measurements, quasi-1D electrons can be distinguished from electrons in underlying bulk layers solely by small differences in their g-factors. Only at fields greater than about 5 Tesla these small differences in g-factors translate into significant differences in precession frequency allowing to distinguish quasi-1D from bulk spins. Our initial experiments demonstrate the capabilities of the instrument for investigating critical matters in the field of spintronics such as transport of small spin populations in single quasi-1D wires.

MON 22:

Spin Interference in Square and Triangular Antidot Lattices Based on InP / InAaAs Heterostructures

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Antidot lattice provides interesting properties in the electron transport [1] and gives the theoretical prediction of slow spin relaxation under the Rashba spin orbit interaction (SOI) [2]. The arrangement of the antidot such as square (SQ) and triangular (TR) lattices produces different confinement of the electron motion, which affects the quantum interference, i.e. Al'tshuler-Aronov-Spivak (AAS) oscillation [3]. Since the effective magnetic field due to the Rashba SOI provides the spin phase shift in the electrons moving around the antidot, the electron confinement strongly affects the spin interference.

Thus, we have investigated the spin interference effect of SQ and TR andtidot lattices in InP / InGaAs heterostructures by applying the gate bias Vg. The outer diameters of the SQ and TR antidots are 650 and 800 nm, respectively. The AAS oscillations were measured with various Vg at $T = 0.3$ K. In the SQ antidot, due to the weak confinement of the electron motion, the amplitude of the AAS oscillation is monotonically decreased and disappeared as negative Vg decreases. However, in the TR antidot, the amplitude of the AAS oscillations is periodically changed with Vg where the strong electron confinement induces the gate bias control of the spin precession in the TR antidot.

[1] D. Weiss et al., PRL 66, 2790 (1991)
[2] Y. V. Pershin et al., PRB 69, 073310 (2004)
[3] F. Nihey et al., PRB 51, 4649 (1995)

MON 23:

Electrical Injection and Detection of Spin Currents in GaAs Through MgO and Alumina Barriers

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The manipulation of carriers spin angular momentum in semiconductors (SC) is expected to provide additional functionality. Nevertheless the fabrication of a device to inject and detect large spin polarized current in SC has encountered several difficulties in the last decade. Milestone and knowledge have however been achieved in this field. Usually such spin current are generated by current injection from a ferromagnetic metal (FM). To date, it has been established that inserting a tunnel barrier between the FM and the SC is a key element to achieving high efficiency spin injection. We will report on efficient electrical spin injection as well as spin electrical detection on hybrid FM/SC heterostructures with MgO and Alumina tunnel barriers inserted at the interface. In particular we will show how the nature of the MgO barrier (crystallinity and thickness) influences the efficiency of the spin injection which leads to electroluminescence circular polarizations as large as 60% at 120K when injecting in a quantum well. On the other hand, photocurrent measurements are performed under circularly polarized excitation with a GaAs quantum well embedded in the intrinsic region of the diode. The top FM layer thus acts as an efficient spin filter for the electrons flowing from the SC to the FM. We will also discuss the spin current detection condition in an all electrical device related to the dwell time of the carriers in a lateral geometry using this type of tunnel barriers.

MON 24:

Dynamics of Electron and Nuclear Spins in Quantum Dots and Defect Centers

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We show that the coherence of an electron spin interacting with a bath of nuclear spins can exhibit a well-defined purely exponential decay for special ('narrowed') bath initial conditions in the presence of a strong applied magnetic field [1]. We give the relevant decoherence time T_2 explicitly for free-induction decay and find a simple expression with dependence on bath polarization, magnetic field, the shape of the electron wave function, dimensionality, total nuclear spin I, and isotopic concentration for experimentally relevant heteronuclear spin systems.

In addition to electron-spin dynamics, we have analyzed the dynamics of a bath of nuclear spins strongly coupled to a central localized electron spin [2]. We show that a large Overhauser field generated due to nuclear-spin polarization can be preserved in such a system under two conditions: (1) A sufficiently strong applied magnetic field prevents the Overhauser field from decaying to zero and (2) A series of fast measurements on the Overhauser field (quantum Zeno effect) preserves the Overhauser field in more moderate magnetic fields.

[1] W. A. Coish, Jan Fischer, and Daniel Loss, "Exponential decay in a spin bath", Phys. Rev. B 77, 125329 (2008)
[2] D. Klauser, W. A. Coish, and Daniel Loss, "Nuclear spin dynamics and Zeno effect in quantum dots and defect centers", arXiv:0802.2463

MON 25:

Studies of the Effective Magnetic Anisotropy in GaMnAs as a Function of the Mn Implantation Energy

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Magnetic semiconductors have a variety of applications in storage and data processing. In particular, GaAs can exhibit magnetic properties when doped with Mn, either by epitaxial growth or ion implantation. There are discrepancies in literature related to the orientation of the easy axis of magnetization in this type of system, probably due to variations in growth parameters or sample preparation as temperature and annealing time. In this work, Mn and As ions were co-implanted on semi-insulating GaAs substrates, keeping the Mn and As dose equal in all samples. The As implantation energy

was the same but, as a main parameter for comparative analysis, the Mn energy were varied for each sample. Rapid thermal annealing (RTA) was done at 750°C. Magnetic measurements were made using a commercial SQUID magnetometer.

We have analyzed the dependence of the effective anisotropy regarding the Mn implantation energy. Hysteresis cycles have shown that sample magnetization depends on the crystallographic direction, changing the effective easy axes orientation. TEM measurements help us to understand some of the magnetic behavior. (Supported by: CNPq and FAPESP)

MON 26:

Metalorganic Vapor Phase Epitaxy of InMnSb Magnetic Thin Films

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InMnSb alloy system was developed for its potential application as a room temperature spintronic material. Epitaxial $In_{1-x}Mn_xSb$ semiconductor films were deposited using metal-organic vapor phase epitaxy. A series of $In_{1-x}Mn_xSb$ epitaxial films with x = 0.01 to 0.05 were deposited on InSb(001) and GaAs(001) oriented substrates. Films were nominally single phase as determined by x-ray diffraction. The phase composition and epitaxy were supported by transmission electron microscopic analysis. Extended x-ray absorption fine structure analysis indicated that the Mn substituted for In on the tetrahedrally co-ordinated sites. Magnetic properties of the films were measured over the temperature range of 5 to 400 K. Field dependence of magnetization of $In_{1-x}Mn_xSb$ films was obtained by SQUID measurements. Well-resolved hysteresis loops are observed at room temperature. For $In_{0.98}Mn_{0.02}Sb$ film, a saturation magnetization (MS) of 4.5 emu/cm^3 was measured with a remanence (Mr) of 1.6 emu/cm^3 and a coercive field (HC) 217 G. With an increase in x to 0.035 the values of MS and Mr increased to 21.8 emu/cm^3 and 4.6 emu/cm^3, respectively. A clear reversibility was observed between the field cooled (FC) and zero field cooled (ZFC) magnetization versus temperature measurements. The temperature dependence of magnetization was well- described by a Brillouin function with a Curie temperature (TC) of 570 K. Recent high temperature magnetization measurements confirmed this value.

MON 27:

Origin of High-field Magnetoresistance in InMnAs/InAs P-N Heterojunctions

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We recently observed a giant junction magnetoresistance in a InMnAs/InAs magnetic semiconductor/nonmagnetic semiconductor heterojunction. A positive junction magnetoresistance of 1300 per cent was measured in magnetic fields up to 9 T, at a temperature of 295 K. A model is proposed here to explain the giant junction magnetoresistance. The valence and conduction bands in InMnAs are split due to the giant Zeeman effect. As a result the holes in the valence band are spin polarized and under forward bias a large, positive junction magnetoresistance is observed. The junction current initially decreases exponentially with field. From this data the value of g factor of 170 for InMnAs was calculated. The conductance of the junction was studied as a function of magnetic field and bias over the temperature range of 40-295 K. The conductance is obtained by considering two spin channels in parallel. The conductance is of the following form: G = [G1exp-E/kT + G2expE/kT]/2cosh(E/kT) where G1 and G2 are the conductances of spin channels 1 and 2 and E is a measure of the magnetic field dependent splitting of the band in the InMnAs layer. This model accounts for the decreasing conductivity with increasing magnetic field and can also be used to extract the g value for the magnetic layer in the junction. Recent junction magnetoresistance measurements at magnetic fields of up to 17 Tesla at the National Magnet Laboratory support the proposed conductance model.

MON 28:

Spin Polarization in Asymmetric N-type GaAs/AlGaAs Resonant Tunneling Diodes

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We investigated the polarization-resolved photoluminescence in an asymmetric n-type GaAs/ AlGaAs resonant tunneling diode[1]. The emission from the GaAs contact layer shows a large constant negative circular polarization. A similar result is observed for the GaAs quantum well, but only when the electrons are injected from the substrate side, while for inverted biases, the polarization tends to become positive for small voltages and large laser excitation intensities. We analyze our results considering the thermal occupation of the Zeeman-split levels at the GaAs contact layers by minority carriers. This occupation results in the large negative polarization for the bulk GaAs emission and it should also have a main role on the polarization of the QW emission, as it determines the dominant spin of the minority holes tunneling into the well. The occupation of the spin-split QW levels may also contribute to the polarization of the QW emission, even tough the QW levels should not follow an equilibrium distribution. A particular and important point concerning our structure is that this occupation can be strongly affected by the large variation of the density of electrons and holes in the QW as a function of the bias voltage, which can even invert the minority carrier character in the QW.

[1] L. F. dos Santos, Y.Galvão Gobato, V.Lopez-Richard, G.E. Marques, M.J.S.P. Brasil, M. Henini, R. Airey, Appl. Phys. Lett. 92, 143505 (2008)

MON 29:

Tunneling Current in Digital Magnetic Barriers

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The Digital Heterostructures or Digital Alloys fabricated by Molecular beam Epitaxy (MBE) is a very effective tool in the study of static and dynamic magnetic properties of diluted magnetic semiconductors (DMS). The investigated system is a triple barrier in which the two external barriers are compounded by $Cd_{1-y}Mg_yTe$. The internal barrier was equally spaced of 33 monolayers (ML) of CdTe from external one. The internal barrier is compounded by 3 ML of $Cd_{1-x}Mn_xTe$. The digital barriers are obtained as fractions of the 3 ML of $Cd_{1-x}Mn_xTe$, considering the same concentration of Mn in each sample. With the introduction of Mn^{+2} ions in the region between barriers the potential profile become dependent of the external magnetic field due the exchange interaction between magnetic moments of Mn^{+2} ions and electrons. An applied magnetic field in the growth direction modulates the interaction potential in such way that this becomes spin dependent. We have investigated the behaviour of the current density in function of the electron spin and the applied magnetic field in growth direction. The invetigated systems are obtained fixing the Mn concentration into the two nonmagnetics barriers and changing your dilution. For this several digital heterostructures we have calculated the current density as a function of the gate potential and the applied magnetic field. We found some systems that can be used as a spin filter.

MON 30:

Enhancement of Rashba Spin-orbit Coupling by Decrease of Quantum Well Thickness

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The strength of the Rashba spin-orbit coupling is affected to a large extent by the choice of material system and the particular layer sequence of the heterostructure. In this work, first, heterostructures based on the InGaAs/InP material system are analyzed theoretically with the result that the strength of the Rashba effect is enhanced considerably by reducing the quantum well width. We identified the larger electron probabilities at the InGaAs/InP interface for smaller quantum well thicknesses as the main reason for the enhancement of spin-orbit coupling. In addition to the Rashba effect, we also assessed the Dresselhaus contribution for different quantum well widths. In order to confirm our theoretical predictions, we fabricated GaInAs/InP heterostructures, where the quantum well thicknesses was systematically increased from 2 to 10 nm. For two-dimensional electron gases the strength of spin-orbit coupling was extracted by analyzing the characteristic beating pattern in the Shubnikov-de Haas oscillations and the weak antilocalization effect. Both kinds of measurements confirmed that for decreasing width of the strained layer the Rashba effect is increased considerably. The measurements were supplemented by studying wires with widths ranging from 1000 nm to 200 nm. These measurements revealed a transition from weak antilocalization to weak localization if the wire width is decreased. This observance is attributed to confinement effects.

MON 31:

Spin-wave Theory for the Magnetic Damping in Microwave Nano-oscillators

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Here we present a theory for the spin-wave linewidth that is generated when a spin valve nanostructure is traversed by a high-density spin-polarized direct current. In this model, the magnetization excitations are considered to be standing spin-wave modes interacting through the four-magnon processes. Due to the demagnetizing field, the nonlinear contributions to the relaxation rate can lead to a behavior of the magnetic system that is qualitatively different from the behavior predicted by the standard Landau-Lifshitz-Gilbert approach. The theory is applied for the general case of the external magnetic field applied in an arbitrary direction.

MON 32:

First-principle Calculations of Multi-channel Spin-polarized Transport in Fe/MgO/Fe Hetero-junction

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In this work we studied spin-polarized multi-channel tunneling through an Fe/MgO/Fe hetero-junction barrier. For this purpose we considered as the hetero-junction barrier both parallel and anti-parallel spin configuration for the Fe leads. The spin parallel and anti-parallel Fe/MgO/Fe(001) hetero-junction employed in this work were obtained by performing density-functional calculations with generalized gradient approximation for the exchange-correlation potential with the use of the full potential-linear augmented plane wave Wien2k code. We modeled the hetero-junctions using super-cells consisting of 17 Fe layers, sandwiched in between 3 MgO layers. We have found that effective potencial is different for the parallel and anti-parallel spin configurations.

To calculate the transmission and reflection amplitudes of Bloch states between the Fe leads of the system we used the transfer matrix technique. Within this formalism the 3D Schrodinger equation which describe both traveling and evanescent solutions being reflected from and transmitted through the barrier is transformed into a set of ordinary second order differential equations. In the subspace of the traveling Bloch states we obtain a scattering matrix. We have identify a process in which the incoming Bloch state preferred not his own channel to perform the reflection. We suggest that this phenomena could be responsable for giant tunnel magnetoresistance.

MON 33:

Ferromagnetic Properties of (Ga1-xMnx)As Nano-wire With High Mn Concentration

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High quality nano-wires have been very attractive as promising candidates for next-generation electronic and photonic devices because of the low power consumption. Diluted magnetic semiconductor (DMS) nano-wires, which combine properties of semiconductor and magnetism, have become particularly attractive because of interest in investigations of the fundamental physical properties (such as confinement effect, correlation effect and etc.) of such structures and in potential applications for many promising spintronic devices.

A new type of (Ga1-xMnx)As DMS nano-wires with high Mn concentration (x=0.18) has been successfully grown by using MBE. The XRD and TEM measurements show that the (Ga1-xMnx)As crystalline nano-wire does not have any defects or dislocations. The observation of the photoluminescence peak for the (Ga1-xMnx)As nano-wires is attributed to improved crystallinity of the (Ga1-xMnx)As nano-wires. The MFM at 300 K and the magnetization curve as a function of the magnetic field at 5 K indicate that ferromagnetism with a single spin domain exist in the (Ga1-xMnx)As nano-wires. These (Ga1-xMnx)As nano-wires grown on GaAs (100) substrates by using the MBE technique offer opportunities for investigations of fundamental physical properties, and they hold promises for potential applications in spintronic devices operating especially at room temperature.

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MON 34:

Observation of Spin Coulomb Drag in Intrinsic GaAs by Ultrafast Pump-probe Spectroscopy

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Spin Coulomb drag is a many-body effect arising from the exchange of momentum between electrons of opposite spin orientations that move with different average velocities. The effect shows up in the propagation of spin pulses, producing a difference between the charge and the spin diffusion constants. It has been recently observed in n-type GaAs. Here we present and analyze new measurements of the spin and charge density of an electron-hole packet in *intrinsic* GaAs, monitored by ultrafast pump-probe spectroscopy. The novel feature of the situation is that a spin-density packet must necessarily involve a hole component in order to ensure charge neutrality. By contrast, in the n-doped case a pure spin density packet is possible – the holes being rapidly eliminated by recombination. The presence of the holes affects profoundly the propagation of the spin-density packet. Our theoretical analysis shows that the evolution of the spin density is controlled by an effective spin diffusion constant, which turns out to be smaller than the ambipolar diffusion constant, and reduces to the former if spin Coulomb drag is neglected. By solving the coupled drift diffusion equations for electron density, electron spin, and hole density we obtain analytic expressions for the time evolution of the spin density, and by comparing these to the experimental measurement of the area covered by the spin packet we are able to determine the value of the spin drag coefficient.

MON 35:

Photon Assisted Current and Spin Measurement in Series Double Dots With a Field Gradient

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Coherent manipulation of quantum two level systems is one of the recent main research targets. The electron spins are gifted with long coherence time in a quantum dot (QD) and thus are assumed as ideal media of quantum information. We recently demonstrated spin manipulation in a QD with magnetic field gradient provided by a micro-magnet. Extending the spin dynamics to double QDs is the most important step to realize "universal gates". Moreover, high-fidelity spin detector is another cardinal component which yet not been brought about.

We investigate electron dynamics in double QDs with an oscillating electric field and a static magnetic field gradient. We also consider a quantum point contact (QPC) electrostatically coupled to the QDs as a charge detector. When the single electron state is stabilized by Coulomb blockade effect, the conductance signal of the QPC provides an ideal spin information when the effective magnetic fields in the QDs are different and collinear. The fidelity of the spin detection is studied when the fields are not collinear. When the two electron state is stabilized, the exchange coupling of two electrons can afford the swap operation. In contrast to the conventional Heisenberg-type exchange coupling without field gradient, the exchange becomes anisotropic with finite field gradient. The QPC signal also provides information of the spin configurations, when zero-one or one-two electron sequential tunneling is predominant.

MON 36:

Symmetry and Spin Dephasing in (110)-grown Quantum Wells

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Quantum wells (QWs) grown in [110] direction are of special interest in spintronics due to their extraordinary slow spin dephasing. The reason for the long spin lifetime of several ns is the crystal orientation: Then the effective magnetic field due to spin-orbit coupling points into the growth direction and spins oriented along this direction do not precess. Hence spin relaxation based on the spin precession is suppressed. If, however, QWs are asymmetric, the structure inversion symmetry is broken and Rashba spin-orbit coupling causes an in-plane effective magnetic field, thus speeding-up spin dephasing. To judge the symmetry of QWs one has to rely on the growth process but there is no independent method to check the structure symmetry readily available. Here we show that the magneto-photogalvanic effect is an ideal tool to probe the symmetry of (110)-grown QWs [1]. The photocurrent is only observed for asymmetric structures but vanishes if QWs are symmetric. The asymmetry is obtained by the position of the delta-doping in respect to the GaAs QW. By using structures with doping on the one or the other side of the QW, reversing the structure asymmetry, the photocurrent sign inversion is observed. We further show via time-resolved Kerr rotation that the spin relaxation time is maximal whenever QWs are symmetric.

[1] V. Belḱov, P. Olbrich, S. Tarasenko, D. Schuh, W. Wegscheider, T. Korn, C. Schueller, D. Weiss, W. Prettl, S. Ganichev, Phys. Rev. Lett. arXiv:0712.1704 (2008)

MON 37:

Spin Injection and Spin Accumulation Conservation in Lateral (Ga,Mn)As/GaAs Esaki Diode Devices

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We demonstrate an all-semiconductor, all-electrical scheme for spin-polarized injection, transport and detection in GaAs devices with a lateral geometry. We employed the Esaki diode structure p^+-(Ga,Mn)As/n^+-GaAs as spin-aligning ferromagnetic injector and detector contacts. Spin-accumulation generated in the GaAs was then probed in a non-local configuration by a detector contact placed within a certain distance from the injector, outside the current path. Spin-related origin of the observed signal was confirmed by experiments in external magnetic field applied both perpendicular and parallel to the sample plane. In the former case a strong modulation and suppression of the measured non-local voltage was observed that could be fully explained by a Hanle effect. From those measurements we have estimated a spin diffusion length and spin relaxation time in our samples as, respectively $\sim 3\mu$m and $\sim$5 ns at T=4.2K. In the in-plane magnetic field a spin-valve-like switching behaviour could be observed. The amplitude of the switching events decays exponentially with an injector-detector separation on the length scale of a spin diffusion length. From all above measurements we have estimated the polarization of the injected current as P$\sim$30%. We discuss also the influence of the tunnelling anisotropic magnetoresistance (TAMR) and tunneling anisotropic spin polarization (TASP) of the Esaki diode contacts on observed signal.

MON 38:

A Quantum Dot Strongly Coupled to a Microcavity - A Solid State Source of Entangled Photon Pairs

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Since the first treatment by Einstein, Podolsky, and Rosen (EPR), quantum entanglement became a necessary requirement for quantum information and communication. The basic idea which has attracted the strongest attention in the last years is to use the photon pairs produced by the decay of a biexciton in a quantum dot, limited by the coupling between the exciton states with total angular momentum 1. The anisotropic electron-hole interaction splits the exciton states into two modes linearly polarized along the crystallographic axis of the crystal, which destroys entanglement. Another timely topic in modern physics is the strong coupling regime (SCR) in semiconductor microcavities. The SCR is clearly opening a new research field where the precise control of the energy levels and the nature of the eigenmodes of the systems will be possible. We show theoretically that entangled photon pairs can be produced through the biexciton decay of a quantum dot strongly coupled to the splitted and polarized modes of a photonic crystal. Each intermediate exciton state couples to the corresponding polarized mode of the resonator and split into two mixed exciton-photon (polariton) modes. The SCR allows to tune the energy of the polariton eigenmodes, and to overcome the natural splitting existing between the intermediate exciton states. This scheme has moreover the advantage of rapidly decaying intermediate states, which are therefore extremely well protected from dephasing.

MON 39:

Magnetic-field Dependence of the Exciton Spin Relaxation in InAs/GaAs Quantum Dots

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We have measured the longitudinal spin relaxation time, T_1, for excitons in InAs/GaAs quantum dots (QDs) as a function of magnetic field, B, at 1.7 K. We provide the first verification of the B^{-3} dependence of T_1, predicted by theory [1]. Our unique method combines steady-state polarized magneto luminescence with a separate measurement of the radiative lifetime. In this way, we can accurately measure T_1, even when the spin flipping is slow compared to the optical lifetime, unlike some time-resolved methods [2]. A CW laser was used to generate unpolarized spins in the QDs. Due to the energy splitting in the B-field, there is a redistribution of carriers, leading to a non-zero degree of PL polarization. A rate-equation model is used to relate the PL polarization to T_1, the Zeeman energy, and the radiative lifetime. The

extracted values for T_1 go from about 100 ns to a few ns for B fields ranging from 3 to 7 Tesla. We find that T_1 evolves according to $B^{-3.1}$. For dots exposed to electric fields, T_1 times are shorter, which we attribute to the extension of the carriers into the bulk material. The study of T_1 in QDs is of particular interest due to thier potential use in the storage and manipulation of spins, which promises to open frontiers of powerful spintronic functionality and possible quantum information devices.

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MON 40:

Circular Polarization in Asymmetric P-type Resonant Tunneling Diodes

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We investigated the spin polarization effects in an asymmetric GaAs-AlAs double-barrier diode. Our device consists of a 4.2 nm GaAs QW surrounded by two AlAs barriers (4.5 and 5.7 nm, respectively), undoped GaAs space-layers (5.1 nm) and p-doped GaAs contact layers. The I(V) current-voltage characteristics presents several peaks associated to heavy- and light-hole resonances. Under light excitation, two additional peaks are observed in the I(V) curve, which we associated, respectively, to a Gamma-X intervalley transfer and to a conventional Gamma-Gamma resonant tunneling. The spin-dependent carrier injection was investigated by measuring the left-and right-circularly polarized QW emission intensities under magnetic field as a function of the applied voltage. Under low bias, we observed a clear correlation between the I(V) curve and the PL intensity for both polarizations. In this range, the polarization degree is highly bias-sensitive and exhibits signal inversions near the resonance voltages. For high bias, the PL intensity is no longer correlated to the I(V) curve and the polarization degree tends to saturate. The strong variation of the polarization, going from up to -40% to +40% at 15 T as the bias is tuned through the sub-band resonances demonstrates a spin-dependent tunneling effect and opens the possibility of developing voltage-controlled spin filters using standard non-magnetic structures.

MON 41:

Spin-orbit Interaction in Quantum-wires: Effects on Ground State Spin-splitting and Polarization

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Up to now the Dresselhaus Spin-Orbit Interaction (SOI) effect has been partially introduced in the study of the electronic structure of nano-structures by taking the mean values of the wave vector k as done in 2D electron gas in quantum wells. Thus, such approximation considers only the k-linear term. For other types of confinements and large values of the SOI strength, the k-cubic term must be included in the total Hamiltonian. Recently, the effect of the k-cubic term has been pointed out as relevant for AlGaAs/GaAs structures. Here, we present a detailed k.p analysis of the electronic structure in quasi-one-dimensional (1D) semiconductor structures, after including *all* terms of the so called Dresselhaus contributions in the SOI Hamiltonian up to third order in k accounting for the full symmetry of the crystal. By changing the axial quantum number and the ratio between the SOI strength and the strength of quantum confinement, we are able to follow the relative influence of each BIA term on the electronic spectra. On the other hand, we show that a reduced symmetry induced by changing the cross section shape of the cylindrical quantum wires leads to different Dresselhaus contributions and important qualitative differences. This effect has been tracked for each *effective* BIA contribution term and its interplay on the spin splitting energy and the spin-polarization of the ground state. A strong dependence on the spatial confinement is obtained.

MON 42:

Coherent Dynamics of Localized Spins in An Inhomogeneous Magnetic Field

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One of the central aims in spintronics is to gain control over the spin degree of freedom in semiconductors. Since the spin is accompanied by a magnetic moment, a promising approach for local spin manipulation on a (sub-)micrometer scale is the usage of nanopatterned ferromagnets. The question however arises, which consequences of the inherent lateral field inhomogeneity of nanostructured ferromagnets on the coherent spin dynamics in an underlying semiconductor have to be tackled. Using time-resolved Kerr rotation, we studied the coherent spin precession of a strictly localized Mn

spin system in a (Zn,Cd,Mn)Se/ZnSe semiconductor quantum well exposed to a laterally inhomogeneous magnetic fringe field originating from nanoscale Co wires. We observe an ensemble response that clearly differs from a simple damped sinusoidal oscillation. Most important, the ensemble precession frequency shows a pronounced temporal variation and, in addition, the ensemble spin dephasing time is strongly reduced as compared to the reference. Model calculations demonstrate that this behavior is a direct consequence of an asymmetric Larmor frequency distribution of the individual spins which arises from the laterally inhomogeneous fringe field. We show that our findings are even of more general importance for any spin system exhibiting a spatial variation of the total magnetic field and/or the g-factor which results in an asymmetric precession frequency distribution.

MON 43:

Electrical Spin Manipulation in Semiconductors by Micro Coils

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One key topic in spintronics is the ability to locally manipulate spins in semiconductors. Here,we present an approach for achieving electrical spin manipulation in a magnetic semiconductor(MS) on a sub-microsecond time scale and a micrometer length scale.

Gold micro coils are defined on top of a CdMnTe/CdMgTe quantum well(QW). Introducing an external current, an electrically switchable magnetic field is generated, which aligns the Mn2+ ion spins in the MS. Due to the sp-d exchange interaction between the Mn2+ and the charge carriers, the effective g factor of the carriers in the MS QW is quite large (200 at 4K) and thus, their spin states can be efficiently manipulated even by small current induced magnetic fields of several 10 mT inside the coil area.

We investigated the carrier spin polarization inside the micro coil by micro magneto-luminescence spectroscopy. All the experiments are performed at 5 K. Introducing an AC current with a pulse width of 400 ns, an efficient carrier polarization of 8.5% is demonstrated. By time-resolved experiments we show that the Mn2+ spins can be switched electrically on a time scale below 100 ns and spatially resolved experiments are used to monitor the current induced spin polarization within the coil with an accuracy of 1 um. The latter one gives access not only to the local field distribution but also to the local temperature, which increases from only 10 K in the center of the coil to about 22 K in the vicinity of the metal wires.

MON 44:

Study of Magnetic Dipole Transition the of Nd^{3+} Ions in Glasses

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Abstract It employs up to the Nd3+ ion in optical devices because their physical properties, such as range of wavelength of work, both in the optical absorption and in the issue, in the region of the optical windows, heavy emissions, efficiency of pump and especially the ease of operation at room temperature. The ions of neodymium, because of some of these properties, can be used as optical amplifiers in optical fibers and active elements for solid-state lasers. In rare earth, the transitions that are allowed by magnetic dipole display intensity from 10 to 100 times smaller and less sensitive to the host of the electric dipole. Vitreous samples, the basis of oxides doped with increasing concentrations of Nd2O3, were synthesized by the method of merger. V of the absorption spectra observed is well-defined bands around 1598 nm and 685 nm transition purely magnetic dipole, 804 and 586 nm electric and magnetic dipole transitions at the same time. There was also that the area under the band corresponding to the transition dipole magnetic according to the increasing concentrations of Nd2O3 presented is linearly increasing. The index of refraction increased gradually in line with the increasing concentration of Nd2O3, given that the strength of magnetic dipole oscillator via showed up higher for the sample of greater concentration.

Acknowledgements
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MON 45:

Electric Field Control of Ferromagnetism in Iii-v Quantum Wells With Mn-delta Doping.

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Ferromagnetic semiconductors show important and potentially useful differences from their metallic counterparts [1]. If the magnetism is mediated by carriers, then changes in the carrier density could enable light- or bias-controlled ferromagnetism [2,3] not possible in conventional ferromagnetic metals. Motivated by the experimental demonstration of magnetic order in a single (Al,Ga)As quantum well with Mn delta doping [4], we study theoretically the effect of tuning the Curie temperature T_C by electric field. Within an envelope function approximation and self-consistently obtained spin-polarized eigenstates [5], we employ a Monte Carlo approach to find the T_C in this system. We explore the effects of quantum confinement on the onset of magnetic ordering and suggest experimental approaches to optimize the Curie temperature.

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MON 46:

Optical and Magnetic Properties of $Pb_{1-x}Mn_xSe$ Nanocrystals Growth in Glass Matrix

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Diluted magnetic semiconductor nanocrystal has attracted much attention in recent years due to the optical and magnetic properties displayed, leading to potential technological applications, including quantum computing, spitronics, and magneto-optics [1,2]. In diluted magnetic semiconductor (DMS) materials magnetic impurities are intentionally introduced in the crystal structure, usually replacing in a controllable way a small fraction of non-magnetic atoms by magnetic ones [2]. Mn-doped PbSe nanocrystals ($Pb_1 - xMn_xSe$) embedded in glass matrix were synthesized by means of fusion method. The magnetic and optical properties of Mn-doped PbSe nanocrystals have been investigation using electron paramagnetic resonance (EPR) and optical absorption. The six lines associated to the Mn-ion hyperfine splitting are observed in the EPR spectra. The hyperfine structures are attributed of electron spin-nuclear spin interactions of isolated Mn2+ ion at or near the surface of Pb1-xMnxSe nanocrystals. Optical absorption of the $Pb_1 - xMn_xSe$ nanocrystals shows the increase of band gap with the increase of Mn concentration. The band gap of $Pb_1 - xMn_xSe$ semiconductors finds between 3.5 eV (gap MnS bulk) and 0.28 eV (gap PbSe bulk).

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MON 47:

Spin-polarized Resonance Effects in Magnetic Metal/semiconductor Tunnel Junctions

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The integration of spintronic devices in semiconductor technology (SC) is an atractive domain in solid state physics. A key point is to control the injection and detection of polarized carriers that can be performed using a ferromagnetic metal (FM) as a polarized injector with an interfacial tunnel barrier to overcome the impedance mismatch problem. The efficiency of such systems can be evaluated by magnetotransport measurements on metal/SC/metal tunnel junctions1. I will report the growth of these structures by molecular beam epitaxy, the influence on the interfacial structure and discuss their properties. Two systems have been investigated: Fe/ZnSe/Fe and MnAs/GaAs/MnAs. The analysis of transport experiments helps to understand the electronic structure for such very thin semiconducting barriers. It results that defects strongly influence the transport properties2,3. We succeeded to show that the tunneling itself has resonant effects with defects that are tightly related with the growth mechanisms4. Alternatives for reduction of defects like the use of nanometric junctions or the tailoring of their distribution on the heterostructures will be discussed5.

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MON 48:

Effect of Charge State of Exciton on the Spin-orbit Interaction in Single Parabolic GaAs Quantum Dot

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Spin-orbit coupling provides a way for orbital degrees of freedom to influence spin states. As a result the spin dynamics is affected, making spin qubit operations more complex. Furthermore, spin-orbit coupling leads to spin decoherence and relaxation due to phonons, limiting the operation time. In this work, we have performed Unrestricted Hartree-Fock and configuration interaction calculation for neutral and charged excitons in a parabolic GaAs quantum dot (QD). We found that electron spin relaxation shows many quite different features with holes, and spin-orbit interaction is strongly dependent upon the charge state of the dot, in which the exciton possesses zero, positive and negative charge. We also found that the filling of electronic shells of QD (closed and open-shell configurations) can dramatically change the spin-orbit interaction. Hence the spin relaxation can be controlled electrically.

MON 49:

Spin-state Dynamics in Thermally Annealed ZnCdSe Semiconductor Quantum Dots

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We have been able to describe the dynamics of size and composition change of quantum dots (QDs) during post-growth rapid thermal annealing and its effects on the distribution of spin-polarized electron and holes. Multiband calculations reveal that the phenomenon is explicable considering changes in the confinement and composition of the QDs due to Zn-Cd interdiffusion, and the presence of extra charges within the structure. The anomalous degree of circular polarization response of the QDs in magnetic fields can be unambiguously related to the effective spin-occupation of holes and the complex valence band dispersion with field due to heavy and light-hole coupling. The interplay of lateral and longitudinal quantization with the tuning of band parameters leads to a valence band hybrid ground state. It is inferred that QD-size-and-composition-dependent hybridization imparts to the hole-ground state a Zeeman splitting behavior with annealing time able to be detected in the optical response of single QDs. The theoretical model has confirmed the trends of the experimental observations. Thus, controlling the microstructure of semiconductor QDs using thermal annealing provides opportunities for creating novel devices, and can be generalized to other substrates or other synthesis techniques. As a post-growth method, it becomes a controllable technique to manipulate valence-band mixing. We expect that similar effects will prove useful for other types of semiconductor alloys.

MON 50:

Impedance and Magnetic Permeability of Soft Ferromagnetic Metals

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Low frequency (RF) impedance measurements is a valuable tool to study magnetic transitions and the dynamical properties of domain walls in soft magnetic materials. A magnetic phase transition can generate intrinsic effects in both the real and imaginary parts of the impedance. One important property that may be clearly observed in these experiments is the Hopkinson effect. On the other hand, the frequency dependence of the impedance may be used to study the relaxational dynamics of domain walls. In this

work we report measurements of the complex impedance as a function of temperature and frequency of the probe AC current of the following systems: Heusler compounds Pd_2MnSn and Pd_2MnSb; re-entrant alloys Au_xFe_{1-x} and *Gadolinium* metal. Strong magnetoimpedance effects were obtained when low DC magnetic fields were applied parallel to the measuring current. From the experimental data, the complex initial magnetic permeability, $\mu = \mu' + i\mu''$, could be extracted as a function of temperature and frequency of the probe current. In the Heusler compounds, μ' diverges critically near Curie temperature. A critical behavior of μ' was also identified in Gd. Cole-Cole analyses of the frequency dependent μ' and μ'' were performed in the ferromagnetic phase of the studied systems. These results were fitted to a modified Debye formula and parameters related to the relaxational motion of domain walls could be extracted.

MON 51:

Hyperfine Interaction Between Exciton and Nuclear Spin in Lateral Quantum Dot Molecules

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Given the tunability of the total spin with magnetic field and electron numbers in a single dot, it is natural to explore the possibility of control of hyperfine interaction between exciton and nuclear spin in lateral quantum dot molecules with an electrical gate, magnetic field, interdot tunneling, and electron-hole interactions. For instance, we can manipulate the state coupling in the two dots by bringing them into and out of resonance by application of an electric field. We have described exciton confined in a quasi-two-dimensional quantum dot molecule of InGaAs/GaAs in a uniform perpendicular magnetic field by the effective mass Hamiltonian, and calculated the orbital energies and wave functions of the four lowest exciton states. We found that the hyperfine interaction can be manipulated by applied voltage due to evolution of charge states of individual quantum dot. We also show the effects of interdot tunneling and geometric asymmetry of the system on the mixing of the exciton states as well as hyperfine interaction.

MON 52:

ρ_{xx} Ringlike Structures with Tilted Magnetic Field via SDFT

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In the quantum Hall regime, the longitudinal resistivity ρ_{xx} plotted as a density and magnetic-field diagram displays ringlike structures due to the crossings of two sets of spin split Landau levels from different subbands (e.g., Ref [1-3]). Here we present a theoretical investigation of these structures using

Spin Density Functional Theory in the Kohn-Sham scheme within the Local Spin Density Approximation [4,5]. We show that at low temperatures the Landau level crossings near the Fermi level are broken due to quantum Hall ferromagnetic phase transitions [6]. For tilted magnetic fields, the ringlike structure collapses sideways as the tilt angle is increased and fully disapears near $\theta_c = 6°$ [1,2]. We find that a quantitatively description of this collapse must include (i) Hartree and exchange-correlation effects and (ii) the subband–Landau-level coupling term in the Hamiltonian for $\theta > 0$. We acknowledge support from FAPESP and CNPq.

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MON 53:

Quantum Hall Ferromagnetism in Semiconductor Heterostructures Within Density Functional Theory

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We used spin-density-functional theory to study reported hysteretic magnetoresistance spikes in Mn-based 2D electron gases [Phys. Rev. Lett. 99, 026801 (2007)]. We found hysteresis loops in our calculated Landau fan diagrams and total energies signaling quantum Hall ferromagnet phase transitions. Spin-dependent exchange-correlation effects are crucial to stabilize the relevant magnetic phases arising from distinct symmetry-broken excited- and ground-state solutions of the Kohn-Sham equations of the density functional theory (DFT). Besides hysteretic spikes in the longitudinal magnetoresistivity, we could also predict hysteretic dips in the Hall resistance. Our theory, without domain walls, satisfactorily explained the experimental data. This work was supported by FAPESP and CNPq.

MON 54:

Structutral and Optical Properties of InMnAs Quantum Dots

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The study of materials that combine both magnetic and semiconducting properties is attracting much attention nowadays. Their potentiality in applications guarantees the interest in their physical properties as a function of the growth conditions. The semiconductor heterostructures based in the ternary InMnAs alloys represent well this kind of material, associating the InAs semiconducting behavior to the magnetic properties due to the exchange interaction between Mn ions and holes. These structures are considered as potential candidates to be used in the new generation of optoelectronic devices and components whose operation is based in the spin. Raman spectroscopy plays an important role among the techniques generally used in order to analyze the semiconductor nanostructures, since it furnishes relevant information about their dynamical properties, in a non-destructive way; doping effects can also be studied from the observation of the coupled plasmon-phonon mode. InMnAs quantum dots were grown by low temperature molecular beam epitaxy on [100] GaAs substrates and with different Mn concentrations. The substitutional Mn incorporation in the InAs lattice and the conditions for obtaining coherent and non-relaxed structures are here discussed from the comparison between Raman spectroscopy and structural properties obtained by X-ray grazing incidence diffraction; magnetic properties were also analyzed.

MON 55:

Magnetic Properties of Nano-particles of Sr_2FeMoO_6 Prepared by An ICR Method

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Sr_2FeMoO_6 (SFMO) presents high magnetoresistance at room-temperature and at low values of magnetic field making it candidate for applications in spintronics. However, the magneto-electronic properties of SFMO are strongly dependent on its microstructure which is controlled by the synthesis

process. In this work, samples of Sr_2FeMoO_6 were prepared by an ionic coordination reaction method (ICR) using the biopolymer chitosan as a nanoreactor. The obtained precursor powders were calcined from 550 to 700 ^0C and sintetized at 900 and 1000 ^0C. The amount of $SrMoO_4$ and *alpha*-Fe present in the precursor powder was controlled by the calcination and sintering temperatures. The powder samples were analyzed by X-ray diffraction, electron microscopy and their magnetic properties were investigated by ac magnetic susceptibility measurements and by vibranting sample magnetometry. The formation of the SFMO phase was accompanied by employing an Rietveld refinement method. This analysis yielded an everage grain size of 174 nm for the sample calcinated and sinterized at 700 and 900 ^0C, respectively. X-ray diffractions showed that the atomic ordering of Fe/Mo is influenced by the sintering temperature. The magnetic data yielded a ferromagnetic ordering temperature of 147 ^0C and showed that the saturation magnetization is enhanced by more than 20 % in samples presenting the SrMoO4 and *alpha*-Fe phases. Work partially supporte by CNPq, FACEPE and FINEP.

MON 56:

Valence Band Structure of Coupled Diluted Magnetic Quantum Dots

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The valence band structure of vertical symmetric and asymmetric coupled InAs/GaAs diluted magnetic quantum dots (QDs) have been studied by performing multi-band k·p calculation. In our physical model, a parabolic quantum confinement potential in (x,y) plane and two coupled quantum well potential in z-direction is assumed. Several anti-crossings due to anisotropic masses, anisotropic potential, and inter-dot coupling take place in un-doped quantum dot molecules. It is strongly dependent on the energy-tuning between two quantum wells. In the weak (x,y) plane confinement regime, the anticrossing occurs between the ground anti-bounding and the first excited bounding states at a separation between the two quantum wells about 2 Å. For diluted magnetic quantum dots, because of the large value of effective g-factor, these effects are strongly enhanced.

MON 57:

Investigation of the Spin Splitting Energies and Electron g-factor in AlSb/InAs/AlSb Quantum Well

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Spin splitting energies for asymmetric AlSb/InAs/AlSb quantum wells (QW) were investigated using (1) the weak antilocalization analysis ($B \approx 0$ T, denoted as $\Delta_{0\mathrm{T}}$) and (2) the tilted field coincidence method of the Shubnikov de-Haas (SdH) oscillations ($B \approx 5.5$ T, denoted as $\Delta_{5.5\mathrm{T/tilted}}$). We obtained $\Delta_{0\mathrm{T}} = 4.11$ meV and $\Delta_{5.5\mathrm{T/tilted}} = 2.58$ meV, where the electron sheet density N_{S} is 1.80×10^{12} cm^{-2}. The value of the corrsponding spin-orbit coefficeint is $\alpha \equiv \Delta_{0\mathrm{T}}/2k_{\mathrm{F}} = 6.1 \times 10^{-12}$ eVm. Having the values of $\Delta_{0\mathrm{T}}$ and $\Delta_{5.5\mathrm{T/tilted}}$, we performed the theoretical simulation of $\Delta(\mathbf{B})$ for arbitrary values/directions of $\mathbf{B}$. We, however, show specifically the results where $\mathbf{B}$ is perpendicular to the sample surface, which may shed light on the mysterious issue of failing to observe the beating pattern in the SdH oscillations even in some high-quality AlSb/InAs/AlSb QW samples [Brosig(1999)]. Our simulation included the Rashba, Dresselhaus and Zeeman Hamiltonians as well as the effect of the vector potential responsible for $\mathbf{B}$ [Das(1990)]. We obtained $g = -6.41$ from this analysis assuimg $m^* = 0.03m_{\mathrm{e}}$. The noteworthy result in this analysis is the anti-crossing behavior of the spin-split Landau levels near $\Delta(\mathbf{B}) = n\hbar\omega_{\mathrm{C}}$ (n: integer).

MON 58:

Demonstration of Spin Interference in Rectangular Loop Arrays Using InGaAs/InAlAs Quantum Wells

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We present the first experimental demonstration of the spin interferece effect in rectangular loop arrays that were fabricated in the InAlAs/InGaAs/InAlAs quantum wells. We fabricated the rectangular loops in such a way that their sides are aligned along either ⟨110⟩ or ⟨−110⟩ crystalographic axes, where the directions of the Rashba and Dresselhaus fileds coincide, i.e. their magnitudes either add up or diminish each other. We analyze the observed spin interference pattern (the amplitude of the Alt́shuler-Aronov-Spivak oscillation at $B = 0$ T as a function of the applied gate voltage) using the extended spin interferometer model as a function of the aspect ratio of the rectangular loops. In addition, we newly introduced a phase decoherence parameter into the model which takes care of the modification of the AAS amplitude besides the pure spin interference effect, thus the agreement between the experimental results and theoretical simulations is now quantitative.

TK acknowledges Grant-in-Aid for Young Scientists (A), No.19684009, from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Support Center for Advanced Telecommunications Technology Research, Foundation for the work performed at Hokkaido University.

MON 59:

Temperature Driven Magnetization Reversal of Fe Deposited on a MnAs/GaAs(001) Magnetic Template

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We report on the magnetic behavior of Fe epitaxially grown on MnAs/GaAs(001). Recently we have recorded element selective hysteresis curves, which were obtained by resonant X-ray magnetic scattering at the Fe and Mn L_3 absorption edge at three representative temperatures: 0 °C, (MnAs in the ferromagnetic α-phase), 22 °C ($\alpha - \beta$ phase coexistence with stripe-pattern formation), and 70 °C (paramagnetic-pure β-phase). The temperature dependence of the dichroic signals suggest that the formation and disappearance of the stripes is accompanied by a reorientation from parallel to antiparallel and then back to parallel coupling of the Fe and MnAs magnetizations [1]. This was confirmed by X-ray Photo-Emission Electron Microscopy (X-PEEM), which allows imaging of the magnetic domains corresponding to the structure of the ferromagnetic Fe film on the surface and of the underlying MnAs.We found that the relative coupling between two ferromagnetic layers in direct contact can be reversed by temperature variation. The element selective X-PEEM data will be compared to SQUID measurements, which gives the magnetic response of the whole system. First results of magneto-transport measurements, in the current perpendicular to plane geometry (CPP), will also be presented.

[1] - M. Sacchiet al., Phys. Rev. B, 165317 (2008).

MON 60:

Spin-Polarized Injection Into a Non-magnetic Region

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Nowadays one of spintronic interests is to take advantage of how semiconductors are manipulated to control carrier properties modifying some parameters, such as doping materials introducing acceptors and donors, or drastically change their behavior building different semiconductor layers making them potentially light emitters, and apply these techniques to control spin carrier densities in an attempt to building polarized light emitters.

Circular polarized-photoluminescence can be obtained through direct transitions in Diluted Magnetic Heterostructure (DMH) due to spin separation promoted by these materials and the scope of this work is the study of different heterostructure systems where Arsenide Mn doped layers, DMSs materials are put between non-magnetic Arsenide alloys such InAs, GaAs and AlAs, looking for changes into polarized photoluminescence spectra. Looking for systems whose present those characteristics, we have studied several DMHs changing their parameters such as: geometric structures, magnetic ions density into the magnetic layers, acceptor donors, number of magnetic wells and different depths. These changing properties allow do inject polarized spin into a non-magnetic region.

The calculations were made with Kane kp method extended to bidimensional heterostructures where strain and exchange-correlation effect were taken into account and the magnetic effect is introduced throughout RKKY hypothesis which take account of the spin interaction with the magnetic fields.

MON 61:

Spin Effects in a Stepped n-type GaAs/AlGaAs/AlAs Resonant Tunneling Diode

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We have studied the polarization resolved photoluminesce (PL) of a *GaAs-GaAlAs-AlAs* resonant tunneling diode. Our device consists of a stepped quantum well (QW) composed of 1.7 nm of GaAs and 5.7 nm $Al_{0.1}Ga_{0.9}As$ QW surrounded by *AlAs* barriers of 5.1 nm, undoped GaAs space-layers (7.6 nm) and n-doped *GaAs* contact layers with an AlGaAs top optical window. The I-V characteristic shows one peak associated to the electron resonance. Under the magnetic field, two additional peaks are observed in the I-V curve probably related to $Gamma - X$ tunneling. We have investigated the spin polarization by measuring the left and right circularly polarized emission from the QW and *GaAs* contact as function of magnetic field and applied voltage.

We have observed a good correlation between the I-V curve and PL intensity for both polarizations. The degree of the circular polarization exhibits a bias dependence with maxima near the resonant peaks. Oscillations of the PL intensities and degree of polarization as function of the magnetic field have also been detected and may be attributed to the filling factor behavior.

MON 62:

Magnetism of Electrodeposited CeO_2 Films Doped With Mn, Fe, Co and Cu

V. Fernandes[1], J. J. Klein[1], W. H. Schreiner[2], N. Mattoso[2], J. Varalda[2], D. H. mosca[2], P. Schio[3], A. J. A. de Oliveira[3]

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We report on the magnetic, structural and electronic properties of ceria (CeO2) films doped with transition metals (TM = Mn, Fe, Co and Cu) prepared by potentiostatic electrodeposition onto Si(001) substrates. Ceria films with dilute TM ($< 1.2at.$)incorporation were prepared from aqueous chloride-based solutions at cathodic potentials of -1.2 V (V versus Ag-AgCl reference electrode). X-ray diffraction and selected area electron diffraction analyses reveal that deposits are nanocrystallines. Analyses of x-ray photoelectron spectroscopy reveal that the percentage of CeIII ions in pure ceria films is 22.7 %, indicating the presence of significant amount of oxygen vacancies. The percentage of CeIII ions depends on the dopants and doping level reaching values of 26.4% for Fe, 29% for Co, 41% for Mn, and 22.5 for Cu. Robust ferromagnetism at room temperature for deposits containing 0.5 at. % Co is observed by SQUID (superconducting quantum interference device) magnetometry. This ferromagnetic behavior with doping levels below the percolation threshold must somehow be associated with underlying exchange mechanism involving oxygen vacancies instead of incipient formation of secondary phases or dopant clustering. A connection between magnetic properties and electronic structure of deposits containing different dopants as well as potential for applications due to compatibility with silicon are discussed.

[1] Fernandes et al, Phys. Rev. B 75 (2007) 121304R

MON 63:

Annealing Effect in the Ferromagnetism of Co-doped CeO_2 Films

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We report on the magnetic properties of Co-doped CeO_2 films prepared by potentiostatic electrodeposition onto Si(001) substrates[1]. Co-doped CeO_2 films with 0.5 at.% Co were obtained from aqueous chloride-based solutions at cathodic potentials of -1.0 V (V versus Ag-AgCl reference electrode). Samples were annealed for one hour at 670 K at ambient atmosphere and pressure of 10^{-6} Torr. SQUID (superconducting quantum interference device) magnetometry measurements of Co-doped CeO_2 films confirm a robust ferromagnetic behavior at room temperature given 4.5, 2.9 and 8.7 mu_B/Co for as-deposited, air and vaccum annealed samples, respectively. Values of giant magnetic moment for Co atoms are probably connected to the interaction between Co and CeO_2 matrix. Even pure CeO_2 films with oxygen deficiency exhibit both magnetic moment and remanence similar to Co-doped CeO_2 films. This ferromagnetic behavior must somehow be associated with underlying exchange mechanism involving oxygen vacancies and localized magnetic moment in both Co and hybridized O-Ce sites, instead of Co clustering or incipient formation of secondary phases.

[1] Fernandes et al, Phys. Rev. B 75 (2007) 121304R

MON 64:

Magnetic Properties of Multiferroic Composites Based on PMn-Pt and $NiFe_2O_4$

A. J. Gualdi, F. L. Zabotto, M. Venet, J. A. Eiras, A. J. A. de Oliveira, D. Garcia

Departamento de Física - Universidade Federal de São Carlos

MMultiferroic materials with coexistence of at lest two ferroic order, as ferroeletric and ferromagnetic, have drawn increasing interest due to their potential for applications as multifunctional devices, in particular in spintronics, because it is possible the simultaneous control of magnetic and electric. In these materials, the coupling interaction between the different order parameter could produce new effects, such as magnetoeletric effect. In this ponit of view, the development of new composites is a interesting strategie for obtained materials with special characteristics, in particular composites made by combining piezoeletric and magnetic materials .

In this work we present the magnetic characterization of multiferroic composites based on $Pb(Mg_{1/3}Nb_{2/3})-PbTiO_3$ (PMN-PT), as ferroelectric matrix, and $NiFe_2O_4$, as ferromagnetic matrix. Magnetic characterization was perfomed using magnetization, M(H) and a.c. magnetic susceptibility, χ(H) as a function of applied magnetic field at room temperature. The reciprocal

value of quadrature signal (χ'') of a.c. magnetic susceptibility is proportional a.c. electrical resisitivity. Our results show that the samples exhibit high saturation magnetization (20 emu/g), when compared by other results in literature. The χ(H) results present a strong dependence with applied magnetic field possibly associated to magnetoelectric effects.

MON 65:

Spin Control in a Rashba-Aharonov-Bohm Quantum Dot Ring in the Kondo Regime

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Control of charge and spin in nanoscale systems is of great importance for the spintronics, as it opens possibilities to create new electronic devices with tailored properties. Of special interest are semiconductor quantum dots (QD) with discrete energy levels. At nanometer scales, low temperature electron (hole) propagation is highly coherent, and it provides a suitable way to achieve charge and spin control via quantum interferences. Fine control in these systems can be achieved by applying relatively small magnetic fields as in Aharonov-Bohm (AB) interferometers. In the presence of Rashba spin-orbit interactions (SOI) , AB quantum dot rings provide a fascinating alternative to control spin transport as well. Moreover, Coulomb interactions introduce new phenomena to be considered: the Kondo state appearing below a critical temperature (the Kondo temperature) results in an additional transport channel, realized through a Kondo resonance that can be affected by SOI.Recently, a system of a single QD in the Kondo regime embedded in a ring has been studied within perturbation theory [1]. However, a lack of a characteristic energy scale separation makes the Kondo effect a non-perturbative phenomenon that requires a renormalization group (RG) framework for a proper description. In this work we present a numerical RG study for the transport properties - including spin filtering in the zero-bias regime.

[1] R. J. Heary, J. E. Han, and L. Zhu, Phys. Rev. B 77 115132 (2008).

MON 66:

Magnetic Properties of Magnetic Semiconductors With Inhomogeneous Distribution of Magnetic Elements

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In diluted magnetic semiconductors, the distribution of magnetic elements in the host crystals is the key which dominates the magnetic properties. In (Zn,Cr)Te, it has been revealed that the ferromagnetism is enhanced in crystals co-doped with iodine as a donor impurity, which exhibit inhomogeneous Cr distribution[1]. The nano-scale Cr-rich regions formed in the inhomogeneous distribution act as ferromagnetic clusters, giving rise to superparamagnetic properties. Here we show the detailed magnetic behaviors of these

inhomogeneous system obtained from various magnetization measurements. In the temperature dependence of magnetization (M-T), there appear the irreversibility between magnetizations measured in the field-cooled (FC) and zero-field-cooled (ZFC) processes and a cusp in the M-T curves in the ZFC process. These behaviors, typical for superparamagnetism, originate from blocking phenomena of the respective clusters due to the magnetic anisotropy. In the magnetic field dependence of magnetization (M-H), a hysteresis loop is observed in the low temperature range in which the irreversibility appears in the M-T dependence. At higher temperatures, the magnetization is described as those of the ensemble of the respective clusters. In addition, the relaxation is observed in the temporal evolution of magnetization after turning off applied magnetic fields, suggesting a metastable state of the magnetizations in this system.

[1] S. Kuroda et al., Nat. Mater. 6, 440 (2007).

MON 67:

Spin Correlation and Kondo Effect in a Quantum Dot Structure: A Slave Boson Formalism.

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In the last decade many works have studied the Kondo effect in semiconductor nanostructures. The appearance of the Kondo phenomena in quantum dots(QDs) where by manipulating the external potential it is possible to continuously change the regime of the systems has been of great help to obtain a more profound understanding of this many-body effect. The work we propose is within this spirit. We study the interplay of the Kondo correlation and the anti-ferromagnetic spin-spin correlation between two QDs connected in series to two leads and to each other by the mediation of a large QD where, due to its low confinement the electron-electron interactions can be disregarded. The interplay of these two correlations constitutes the base of the so called quantum transition. The topology assumed is similar to the one adopted in a recent experiment were it was intended to study the coexistence of the Kondo correlation and the indirect RKKY interaction between the dots spins. The physics underlying the Kondo effect is incorporated thought the finite U slave bosons mean field approach. The conductance and spin-spin correlation are calculated as a function of the gate potential applied to the central QD. The results are expected to show how the occupation of the central part of the system and the consequence appearance of an indirect sort of RKKY spin-spin correlation can influence the occupation of the dots and the Kondo regime initially present in the system.

MON 68:

"Magnetic Breakdown" of Cyclotron Orbits in Systems With Rashba and Dresselhaus Spin-orbit Coupling

A. A. Reynoso, Gonzalo Usaj, C. A. Balseiro

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We study the effect of the interplay between the Rashba and the Dresselhauss spin-orbit couplings on the transverse electron focusing in two dimensional electron gases. Depending on their relative magnitude, the presence of both couplings can result in the splitting of the first focusing peak into two or three. This splitting has information about the relative value of spin-orbit couplings and therefore about the shape of the Fermi surface. More interesting, the presence of the third peak is directly related to the tunneling probability ("magnetic breakdown") between orbits corresponding to the different sheets of the Fermi surface. In addition, destructive interference effects between paths that involve tunneling and those that do not can be observed in the second focusing condition. Such electron paths (orbits) could be experimentally detected using current techniques for imaging the electron flow opening the possibility to directly observed and characterize the 'magnetic breakdownéffect.

This work was supported by ANPCyT Grants No 13829 and 13476 and CONICET PIP 5254. GU is a member of CONICET.

MON 69:

Spin Chirality of Andreev States in Josephson Junctions With Rashba Spin-orbit Coupling.

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It is known that in a two dimensional electron gas, a quantum point contact with spin-orbit coupling (QPCSOC) acts as a gate voltage controlled spin-polarizing device. Since spin-orbit coupling does not break time reversal symmetry this system is completely different from conventional ferromagnetic spin polarizing devices. We investigate the Andreev states and the Josephson current in Superconductor-QPCSOC-Superconductor ballistic junctions. For this multichannel long junction, our theory includes the mismatch between the Fermi velocities which introduces normal scattering at the Superconductor-Normal interfaces. Exact results are obtained numerically using a standard Green function approach. The fundamental result is that Andreev states can present spin chirality i.e.: states traveling in different directions have opposite in-plane spin projection. Anomalous Josephson currents appear in the presence of an external magnetic field. First we show the existence of Josephson current for zero phase difference between the superconducting electrodes. In addition, we observe very non-symmetric current phase relations. We analyze the dependence of these effects on the length of the junction, the spin-orbit strength and other parameters of the junction.

MON 70:

Organic Additive Effects in Electrodeposition of $Co_{70}Fe_{30}$ Alloy on Si(111)

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We investigated the influence of presence of sodium saccharin in the morphology and nucleation process of cobalt-iron alloys (70 Co and 30 Fe atomic percent) electrodeposited on n-type hydrogen-terminated (111)Si surfaces. Among several Co-Fe alloy thin films exhibiting structural phase transition close to room temperature, Co70Fe30 has body-centered cubic structure stable at room temperature independently of the thickness of the deposits. Deposits were potentiostatically electrodeposited at cathodic potential of -1340 mV (V versus Ag-AgCl reference electrode) from aqueous solutions containing CoSO4.7H2O and (NH4)Fe(SO4)2 .6H2O in the presence of saccharin sodium (0 to 3 g/L) as organic additive. Potentiostatic current transient curves suggest an instantaneous nucleation process, without influence of sodium saccharin. X-ray diffraction measurements reveal that deposits are polycrystalline with grain sizes decreasing as a function of sodium saccharin concentration. Atomic force microscopy images reveal that more dense and uniform deposits are obtained for solutions with 0.5 g/L of sodium saccharin. The rate of saccharin incorporation in the deposits appears as major parameter to obtain uniform coverage. Scanning electron microscopy were used to put in evidence the sodium saccharin influence in the morphology, revealing that in the time scale of few seconds uniform coverage of Si surface is obtained. Our results are important to hybrid metal/semiconductor spintronic studies.

MON 71:

Electron Spin Relaxation Due to Phonon Modulation of the Rashba Interaction in Quantum Dots

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[3] *Universidade Federal de São Carlos, Departamento de Física*

In this work we calculate the spin-flip transition rates, considering the phonon modulation of the spin-orbit interaction. For this purpose will use the spin-phonon interaction Hamiltonian proposed by Pavlov and Firsov. This seminal model has the advantage of being easily adaptive to the study of other interaction mechanisms with phonons. We compare the contributions of the electron-phonon deformation potential (DP) and piezoelectric coupling to the spin relaxation. We reveal the importance of an appropriate description of the electron Landè g-factor in the calculation of the rates, the variation of the g-factor from negative to positive values, from -14.4 to +0.2 for InAs, modifies in several orders of magnitude the spin-flip scattering rates. Our results demonstrate that, for narrow-gap materials, the DP interaction becomes the dominant one. This behavior is not observed in wide or intermediate gap

semiconductors, where the piezoelectric coupling, in general, governs the relaxation processes. In Fig. 1 we show the spin relaxation rates due to DP coupling for InSb quantum dots, as a function of the external magnetic field B and the lateral effective size. We can observe that with appropriate choices of magnetic field and lateral size, there are regions where the spin relaxation it is practically suppressed. These robust coherence regions remain stable for low temperatures.

MON 72:

Electrical Manipulation of the Electron Spin in Quantum Dots

Massoud Borhani, Vitaly Golovach, Daniel Loss

Department of Physics, University of Basel, Switzerland

An alternating electric field, applied to a spin 1/2 quantum dot, couples to the electron spin via the spin-orbit interaction. We analyze different types of spin-orbit couplings known in the literature and find that an electric dipole spin resonance (EDSR) scheme for spin manipulation can be realized with the up-to-date experimental setups. In particular, for the Rashba and Dresselhaus spin-orbit couplings, a fully transverse effective magnetic field arises in the presence of a Zeeman splitting in the lowest order of spin-orbit interaction. Spin manipulation and measurement of the spin decoherence time are straightforward in lateral GaAs quantum dots through the use of EDSR.

MON 73:

Spin Transistors Vs Conventional Transistors: What Are the Benefits and Remaining Challenges?

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For decades, silicon has been the dominant semiconductor among all the device types. And, the good news is that silicon may also be the preferable semiconductor in Spintronics [1]. In 2007, Appelbaum et. al showed that it is possible to perform coherent spin manipulation and transport in silicon [2].

Recently, a wide range of spintronic devices has been proposed and modelled, whatsoever the real advantages of the new class of devices in comparison to non-spintronic ones has not been distinguished [3]. Therefore, a study which develops a comprehensive picture between spintronic devices and common ones draws a lot of attention, so that one could clarify the real advantages of this new class of devices [3].

In our work, we treat silicon-based spintronic transistors, focusing our attention in comparing the performance of such class of spintronic devices with their counterparts from an engineer point of view. We consider both the spintronic bipolar transistor (SBT) and the spin-MOSFET (metal oxide semiconductor field effect transistor). We study some relevant parameters related to a transistor performance: the characteristic curves, the current gain (for SBT), the hybrid parameters and the cutoff frequency. With our results, we may briefly describe spintronic transistors as promising and challenging.

[1] I. Zutic e J. Fabian. Nature 447, 269(2007).
[2] I. Appelbaum, B. Huangl, D. J. Monsma. Nature 447, 295(2007).
[3] M. E. Flatté . IEEE Trans. on Elec. Dev. 54, 907 (2007).

MON 74:

Quasiequilibrium Nonlinearities in Faraday and Kerr Rotation From Spin-polarized Carriers in GaAs

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Semiconductor Bloch equations (SBEs), which microscopically describe optical properties in terms of the dynamics of a Coulomb interacting, spin-unpolarized electron-hole plasma, can be solved in two limits: the coherent and the quasiequilibrium regimes. Recently, Nemec et al. [1] reported circularly polarized pump-probe absorption spectra in the quasiequilibrium limit for carrier spin-polarized bulk GaAs at room temperature, which lacked a suitable microscopic theoretical understanding. We have very recently explained their results by solving the spin-SBEs in the quasiequilibrium regime (spin-Bethe-Salpeter equation) [2]. Numerical simulations based on our framework, are in agreement with the experimental spin-dependent, density-dependent, and spectral trends. In my presentation, I also discuss the extension of our theory to the microscopic calculation of optical nonlinearities in Faraday and Kerr rotation in the quasiequilibrium regime, for which there are no experimental or theoretical results available. As was earlier done for the (spin-unpolarized) semiconductor laser [3], it is desirable to solve the corresponding spin-Bethe-Salpeter equation to enable a microscopic understanding of a new type of spin optoelectronic device, the spin vertical cavity surface emitting laser (spin VCSEL).

[1] P. Nemec et al., Phys. Rev. B 72, 245202 (2005)
[2] A. Joshua and V. Venkataraman, Phys. Rev. B 77, 085202 (2008)
[3] H. Haug and S. W. Koch, Phys. Rev. A 39, 1887 (1989)

Tuesday Poster Session

17:45 - 19:15

TUE 1:

Integer Quantum Hall Effect in InGaAs/InP Superlattices

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[2] *Institute of Physics/USP, Brazil.*
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The InGaAs/InP hetero-system presents a particular interest because the large g-factor and a possibility of its engineering imply promising applications in the area of spintronics. In this work the formation of the quantized Hall phases with the even and odd filling factors was explored in InGaAs/InP superlattices as a function of the interlayer coupling t. The quantum Hall effect was measured at the temperature T = 50 mK in the InGaAs/InP superlattices with t = 1.0 and 3.5 meV controlled by the barrier thicknesses. When the cyclotron energy exceeds t the quantizing magnetic field opens up gaps between the spin-degenerated Landau levels of three-dimensional electron excitation spectrum resulting in the integer quantum Hall effect. We demonstrated that the spin degeneracy is lifted when the Zeeman splitting (Ds) exceeds the interlayer tunneling energy. In such case the quantized Hall phases with odd filling factors may be observed. The well defined quantized Hall phases at the even filling factors emerged in the superlattice with the stronger interlayer coupling. While the quantized phases with both the even and odd filling factors were found in the weakly coupled superlattice in the magnetic field providing Ds larger than t , with Ds = 2.5 meV. The quantized phases with the odd filling factors disappeared already at T = 1.6 K.

TUE 2:

Landauer-Büttiker Study of the Anomalous Hall Effect

Maria Silvia Garelli, John Schliemann

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We report on a numerical study of the anomalous Hall effect in a two-dimensional elelctron gas with spin-orbit coupling and magnetic impurities. Transport properties are evaluated within the usual Landauer-Büttiker formalism for a discretized model system. We consider different types of spin-orbit coupling and magnetic impurities, and we analyze the dependence of our results on the system size. The spin Hall conductance is also investigated in the presence of magnetic scatterers.

TUE 3:

Electric-field-induced Spin Excitation in Quantum Wells With Rashba-dresselhaus Spin-orbit Coupling

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Recent experimental and theoretical studies demonstrated long-range spin transport in (001) GaAs quantum wells with balanced Rashba and Dresselhaus spin-orbit coupling (SOC) terms ($\alpha = \beta$) as well as in Dresselhaus (110) quantum wells. By applying a constant in-plane electric field E_0, these long-lived spin-coherent excitations are converted into field-dependent eigenmodes. The resonant excitation of these modes requires an experimental set up, which provides the necessary wave vector. We consider surface acoustic waves (SAWs). The approach takes advantage of methods used in the field of space-charge waves. From basic equations for the spin-density matrix, a number of eigenmodes are identified both in the charge current density and the in-plane as well as out-of-plane spin polarization. At the resonance, the spin-induced charge current becomes a sizable fraction of the SAW driven current. In addition, the magnetization strongly changes with a slight variation of the electric field E_0. Both electric fields E_0 and E_{SAW} lead to a homogeneous out-of-plane spin polarization that exhibits a Hanle-like dependence. An experimental verification of these sizeable spin effects, especially the abrupt field-induced switching of magnetization in a (001) GaAs quantum well with balanced Rashba and Dresselhaus SOC, would facilitate future basic research and spintronic device applications.

TUE 4:

Magnetotransport Through Lateral (001)-(Ga,Mn)As Bars With Nanoconstriction

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Narrow constrictions in GaMnAs films display large magnetoresistance (MR) effects [1-6]. Previous explanations involve the formation of a tunneling barrier in the constriction due to carrier depletion [1,2]. A pronounced dependence of the resistance on the magnetization direction was ascribed to tunneling anisotropic magnetoresistance (TAMR) [2] and, more recently, to a metal-insulator transition [4,5]. On the other hand, experiments on a narrow GaMnAs channel revealed a Coulomb blockade anisotropic MR effect (CBAMR), where the angular dependence of the resistance was ascribed to chemical potential anisotropies [6]. Hence the microscopic origin of the huge MR effects observed in GaMnAs nanoconstrictions is still an open issue. Here we focus on MR measurements carried out on GaMnAs wires with one nanoconstriction. We show that the large MR jumps of up to several thousand percent that appear during a magnetic field sweep are solely connected to the magnetization alignment in the constriction. Based on measurements of the resistanceśtemperature dependence down to mK, we compare different models currently used to describe transport across GaMnAs nano¬*constrictions*.

[1] C. Ruester et al: PRL 91, 216602 (2003)
[2] A. D. Giddings et al: PRL 94, 127202 (2005)
[3] M. Schlapps et al: phys. stat. sol. (a) 203, No. 14, 3597 (2006)
[4] M. Ciorga et al: New J. Phys. 9, 351 (2007)
[5] K. Pappert et al: Nature Physics 3, 573 - 578 (2007)
[6] J. Wunderlich et al: PRL 97, 077201 (2006)

TUE 5:

Dimensionality Dependent Electron-electron Interaction in Ferromagnetic (Ga,Mn)As

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At low temperatures the conductance of metallic (Ga,Mn)As samples is affected by quantum interference phenomena. Here we focus on the investigation of electron-electron interaction effects (EEI) [1]. Below 10 K the conductance of ferromagnetic (Ga,Mn)As decreases with decreasing temperature without saturation. Preliminary experiments have shown that EEI interaction is indeed the origin of the conductance decrease [2]. The temperature dependence of the conductivity correction $\Delta\sigma(T)$ within the EEI picture depends on the dimensionality d of the system and is proportional to $\sqrt{D/T}$ in 1d, $\propto \ln(T/T_0)$ in 2d and $\sqrt{T/D}$ in 3d [1]. The dimensionality is defined by comparing the thermal length $\sqrt{\hbar D/K_B T}$ with the dimension of the

(Ga,Mn)As conductor. Here D is the diffusion constant which depends on the effective mass. Hence quantitative measurements of the quantum corrections can contribute to the question whether carrier transport in (Ga,Mn)As takes place in the valence band with an effective mass of order 0.5 m_0, with the free electron mass m_0, or in an impurity band with an effective mass > 10 m_0. We carried out measurements in arrays of wires, thin (Ga,Mn)As films and bulk layers to probe the EEI quantum correction from 1d to 3d which will be presented.

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[2] D. Neumaier *et al.*, Phys. Rev. B 77, 041306(R) (2008).

TUE 6:

Computational Nano-materials Design for Spincaloritronics in Semiconductor Nano-spintronics

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Based upon the first-principles calculation of dilute magnetic semiconductors (DMS), we show that spinodal nano-decomposition under layer-by-layer crystal growth condition (2D) leads to characteristic quasi-one dimensional nano-structures (Konbu-Phase) with highly anisotropic shape and high Tc (higher than 1000K) even for low concentrations in DMS [1-3]. We design a spin-currents-controlled 100 Tera bits/icnh2, Tera Hz switching, and non-volatile MRAM without Si-CMOS based on Konbu-Phase [4]. In addition to the conventional Peltier effect (about 5 W/cm2), we propose a colossal thermoelectric-cooling power (105 to 106 W/cm2) based on the non-equilibrium spin-entropy expansion in a Konbu-Phase (Zn,Cr)Te with very high blocking (B) temperature (TB higher than 1000 K) by spinodal nano-decomposition and by nano-column of Half-Heusler NiMnSi (Tc = 1050 K) [5]. We propose a new method for nano-scale thermal management in nano-spintronics (Spincaloritronics).

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[2] T. Fukushima et al., Jpn. J. Appl. Phys. 45 (2006) L416.
[3] H. Katayama-Yoshida et al., Phys. stat. sol. (a) 204 (2007) 15.; K. Sato et al., Jpn. J. Appl. Phys. 46 (2007) L682, and L1120.
[4] Japanese Patent: JP3571034, US Patent: US 7,164,180 B2, EU Patent: EP 1548832A1, Taiwan Patent:1262593, Korean Patent: 0557387.
[5] H. Katayama-Yoshida et al., Jpn. J. Appl. Phys. 46 (2007) L777.

TUE 7:

Spin Dynamics of Polariton Condensates

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We report theoretical results on the renormalization of the dispersion and superfluidity of spinor polariton condensates based on the spinor Gross-Pitaevskii equations. We show that for zero external magnetic field the condensate is linearly polarized. Its dispersion is sound-like in the region of small k; the system thus exhibits superfluid properties . The sound velocity and splitting between branches are strongly anisotropic, which have a remarkable impact on the real-space propagation of the polariton superfluid. In an external magnetic field the condensate is elliptically polarized. We show that below the critical field there is no gap between the branches with orthogonal spin projections: the system behaves as if the external magnetic field were completely screened by the condensate. In the opposite case the co-polarized dispersion branch remains sound-like, while the cross-polarized branch becomes parabolic. The gap opens between the co- and cross-polarized branches, corresponding to the restoration of a reduced Zeeman splitting. We also study effects caused by the finite number of polaritons in a condensate. For small numbers of polaritons, clear step-like increases in the circular polarization degree appear with increasing magnetic field. The polarization steps can be evidenced at finite temperatures in magneto-PL experiments.

[1] I.A. Shelykh et al PRL 100, 116401 (2008)
[2] I.A. Shelykh et al PRL 97, 066402 (2006)
[3] Y. Rubo et al PLA 358, 227 (2006)

TUE 8:

FMR Study of (Ga,Mn)As Fabricated on (311) GaAs by Mn Ion Implantation and Pulsed-laser Melting

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We present a ferromagnetic resonance (FMR) study of (Ga,Mn)As fabricated by Mn ion implantation (II) into (311)A or (311)B-oriented GaAs substrates, followed by pulsed-laser melting (PLM). Semi-insulating GaAs wafers were implanted at room temperature with Mn^{+} ions to a density of 1.5×10^{16}cm^2 at 80 keV and were subsequently irradiated with a single pulse from a KrF excimer laser to achieve single-crystalline, epitaxial regrowth of the implanted region. We measured the angular dependence of FMR in three geometries–$H\|(\bar{2}33)$, $H\|(0\bar{1}1)$ and $H\|(311)$–at 4K, 25K and 50K. For both (311)A and (311)B samples the angular dependence of FMR is symmetric in $H\|(\bar{2}33)$ and is asymmetric in $H\|(0\bar{1}1)$. The observed angular behavior of FMR can be understood in terms of contributions from two magnetic anisotropy fields: the cubic anisotropy field H4 parallel to the

<001> rangle axes, and a uniaxial anisotropy field H2 parallel to the [311] direction. After theoretical fitting, we find that H4 is around 500 Oe, and H2 is around 900 Oe at 4K, assuming the g=2 for both (311)A and (311)B samples. Both magnetic anisotropy fields decrease as the temperature increases. Our results show that the magnetic anisotropy in II-PLM (Ga,Mn)As is fundamentally similar to (Ga,Mn)As samples grown by MBE, which indicates that two completely different growth mechanisms can lead to materials with similar magnetic properties.

TUE 9:

Anisotropy of Spin Dynamics in Diffusive GaAs/AlGaAs Quasi-1D Wires

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We carried out a numerical and experimental study of spin dynamics in quasi-1D wires. The numerics show that even in a diffusive quasi-1D wire which is oriented along the [110] direction a strong suppression of spin dephasing can occur when the Rashba and linear Dresselhaus fields are of comparable magnitude and the width of this wire is below its spin precession length. Experimentally we perform time-resolved Kerr rotation measurements on diffusive quasi-1D wire arrays which are fabricated from a GaAs/AlGaAs heterojunction system that contains a high mobility two dimensional electron gas (2DEG). By excitation density dependent g-factor analysis we are able to separate the signal of the spin population in the 2DEG (g = -0.36) from the spin population of the GaAs bulk layer (g = -0.44). Compared to the free 2DEG case the spin dynamics in the wires reveal a distinct suppression of spin dephasing. This suppression of spin dephasing shows a strong dependence on the wire orientation with respect to the crystal lattice. The peak value of the spin dephasing time of 370 +/- 15 ps is indeed found for wires oriented along the [110] direction and the lowest spin dephasing time of 150 +/- 10 ps is found for orthogonal oriented wires. However, the clear signature based on differences in g-factors is not apparent when the dephasing anisotropy is strongest. A combined study of spin dephasing and g-factor anisotropy is in progress to unravell this ambiguity.

TUE 10:

Memory Behavior of the Planar Hall Effect in Ferromagnetic (Ga,Mn)As/GaAs Superlattices

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The planar Hall effect (PHE) has been studied in short period (Ga,Mn)As/GaAs superlattices. PHE measurements on lithographically patterned Hall bars have been carried out at low temperatures for various orientations of in-plane magnetic field. When sweeping the magnetic field the planar Hall resistance varies non-monotonously alternating its sign and displaying the appearance of a single or double hysteresis loops, depending on the orientation and sweeping range of the magnetic field. The results confirm the existence of a ferromagnetic interlayer coupling between the magnetic layers in the superlattices. The superlattices exhibit a lower Curie temperature, a larger coercivity and a greater magnitude of the PHE with respect to those of a reference single (Ga,Mn)As layer. The complex PHE behavior in the structures is explained by taking into account the magnetic anisotropy of the (Ga,Mn)As layers, which results from biaxial compressive strain in the layers epitaxially grown on GaAs. Attention is paid to the two-state behavior of the planar Hall resistance at zero magnetic field that provides its usefulness for applications in nonvolatile memory devices, in which a bit of information is written magnetically and read electrically. In addition, using an appropriate sequence of applied magnetic fields four different states of the planar Hall resistance, suitable for quaternary memory devices, can be realized owing to the formation of a stable multidomain structure in the Hall bar.

TUE 11:

Strain-controlled Variation of Magnetoresistive and Magnetic Anisotropy in (Ga,Mn)As

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Anisotropic magnetoresistance (AMR) and magnetic anisotropy MA), being characteristic features of (Ga,Mn)As, are well known to be greatly influenced by strain. Experimental studies addressing this issue, however, have so far been restricted to merely a limited number of representative samples with compressive or tensile strain. In order to investigate the impact of strain on the magnetic and magnetoresistive anisotropy in a systematic way, we have grown two sets of 40 and 180 nm thick (Ga,Mn)As layers with 5% Mn on relaxed (In,Ga)As/GaAs templates. By choosing different In contents the vertical strain ε_zz in the (Ga,Mn)As layers could be varied over a wide range from -0.46% to $+0.22\%$, i.e., from tensile to compressive, including the case of (nearly) zero strain. The AMR and the MA of the as-grown and annealed samples were analyzed at 4.2 K by means of angle-dependent magnetotransport measurements. The respective resistivity and anisotropy parameters,

determined by a fitting procedure within the framework of an advanced resistivity model, were found to linearly vary with the strain. Narrow tripes were prepared from the (Ga,Mn)As layers in order to additionally manipulate the MA by in-plane strain relaxation perpendicular to the stripes. The resulting uniaxial contribution to the free energy, not present in unstrained samples, turned out to have opposite sign in compressive- and tensile-strained layers, and increases with decreasing width of the stripes.

TUE 12:

Spin Polarized STM of a Kondo Adatom.

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We investigate the bias dependence of the tunneling conductance between a spin-polarized probe (SPP) of a scanning tunneling microscope (STM) and the surface conduction states of a normal metal with an adsorbed Kondo adatom. The Fano-Kondo mechanism of quantum interference of the tunneling paths through the probe-host metal conduction states and the localized Kondo state is considered. The probe´s polarization affects the adatom via Kondo peak splitting depending on the lateral probe-adatom distance with a spin dependent Fano ratio. We observe that the spatial polarization of the system introduces asymmetric zero-bias anomalies for the spin-polarized conductance for the probe placed above the adatom. Such anomalies appear as resonances and anti-resonances for the strong and weak limits of the Fano ratio respectively. For laterally displaced probe the Kondo peak splitting is suppressed and spin-polarized conductance is exclusively governed by the splitting of the density of states for the probe.

TUE 13:

Spin Correlation Effects on the Transport Properties of a Two-dot Quantum Ring

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We study transport properties of a quantum interferometer constituted by a parallel circuit of two quantum dots comprising a ring connected to two leads and threaded by a magnetic flux. The Aharonov-Bohm effect combined with the dot many-body charging effects determine the phases of the currents that go along each ring arm. We show that this system in the Kondo regime can hold currents circulating around the ring for some ranges of gate potential and magnetic flux for unequal ring arms. This means that current flows in the direction of an applied bias in one ring arm and in the opposite direction in the other arm, being in this last case a negative current. More surprisingly, circulating currents appear even if there is no magnetic flux threading the ring. They are due to interferences among the charges going along each ring arm. The conductance of the whole system is controlled by the value of the total two-dot spin S. The two Kondo regimes (S=1/2;S=1)possess different transport properties as a function of the external flux. The behavior of the

phase and amplitude of the electron wave functions in the ring arms as a function of the dot applied potentials is studied for different values of the magnetic flux. The many-body Green functions are obtained by the Embedded Cluster Approximation method (ECA) that consists in diagonalizing a finite cluster that includes all many-body interactions, and embedding it into the rest of the system.

TUE 14:

Ferromagnetism in Mn Implanted Ge/Si Quantum Dots Material Followed by Thermal Annealing

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Ten and twenty layers of self assembled Ge QDs with 44 and 59 nm-thick Si barrier were grown on high resistivity (100) p-type Si substrates by rapid thermal chemical vapor deposition followed by Mn ion implantation and post-annealing. A presence of ferromagnetic structure was confirmed in the insulating GeMn diluted magnetic quantum dots (DMQD) and semiconducting GeMn DMQD. The DMQD materials were found to be homogeneous, and to exhibit p-type conductivity and ferromagnetic ordering with a Curie temperature, TC = 350 and 230 K. The x-ray diffraction (XRD) data show that there is a phase separation of Mn5Ge3 from MnGe nanostructure. Temperature dependent electrical resistivity in semiconducting DMQD material indicates that manganese introduces two acceptor levels in germanium at 0.14 eV from the valence band and 0.41 eV from the conduction band implying Mn substituting Ge. Therefore, it is likely that the ferromagnetic exchange coupling of DMQD material with TC = 230 K is hole-mediated due to formation of polarons and the ferromagnetism in sample with TC ¿ 300 K is due to Mn5Ge3 phase. Funding agencies: Korea Science and Engineering Foundation through the Quantum-functional Semiconductor Research Center at Dongguk University

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TUE 15:

The Annealing Effect on (Ga,Mn)As Under the Application of Electric Field

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A ferromagnetic semiconductor (Ga,Mn)As shows hole-induced ferromagnetism, and its Curie temperature T_C, which is a function of hole concentration p, increases after low temperature annealing T_C = 150-250 °C as a result of the increase of both p and effective Mn composition. Unintentionally introduced Mn interstitials (Mn_I, double donors) diffuse out to the surface during annealing. Because Mn_I is ionized in p-type material, the diffusion process of Mn_I is expected to be controlled by the application of electric field E. In this work, we investigate the annealing effect on a (Ga,Mn)As under the application of E. 4 nm $Ga_{0.93}Mn_{0.07}As$ was grown on 4 nm GaAs/ 30 nm (Al,Ga)As/ 30 nm GaAs buffer layers from the surface side onto the semi-insulating GaAs (001) by molecular beam epitaxy. The sample was first processed into Hall bar structure. Subsequently 40 nm A_2O_3 gate-insulator was deposited. Finally 100 nm Au/ 50 nm Cr gate-electrode was evaporated and lifted-off. The device was annealed for 1000 min at 150 °C in vacuum under the application of E = +1, -1, -2 MV/cm, and the condition of the gate electrode opened (E = open). Larger (smaller) T_C and p were obtained for the samples annealed under negative (positive) E compared to them at the condition of E = open, consistent with the expected E dependent annealing effect on the Mn_I diffusion process.

TUE 16:

Magnetic Properties of Gagdn Studied by Squid and Sx-mcd

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We have first observed that the GaGdN is a room-temperature ferromagnetic substance [1], tentatively called the first ferromagnetic phase here. After our report, GaGdN became one of the most attractive dilute magnetic semiconductors at present both in fundamental science and the application, owing to the presence of unusual magnetic behaviors [2]. GaGdN layers studied here were grown on sapphire substrates by RF-MBE, where the substrate and the Gd cell temperatures were set at 700oC and 1100oC, respectively. The thickness of the grown layers is about 450 nm and the concentration of the Gd ions is estimated to be 2.6 atomic %. We examined magnetic circular dichroism in soft X-ray region (SX-MCD) to clarify the magnetic behaviors moreover. The MCD signals from MV transition peak at 1189 eV and MIV transition peak at 1222 eV are rather strongly observed even at room temperature. The temperature dependence of the intensity of MCD signals shows a

step-like form around 30 ?60 K. Curie-Weiss plots suggest the co-existence of the new magnetic phase around that temperature range. It was found that the GaGdN samples have three ferromagnetic like phases, showing the step-like temperature dependence of the magnetization at 10?20 K, 30?50 K and over room temperature. The detailed data from the SQUID measurements and the discussion will be presented in the Conference.

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[2] S.Dhar et al., Phys. Rev. Letters, 94 (2005) 037205-1

TUE 17:

Aharonov-Bohm Interferometer With An Additional Path

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Recently, there has been a growing interest associated with Aharonov-Bohm(AB) interferometers when the propagating electron experiences electronic states in a quantum dot(QD), because the interference pattern provides information on the physical properties of the QD, for example, the electron correlation inside it[1]. Fano resonance is a very interesting phenomenon and caused by the interference between the propagating path and localized orbital. In this work we have studied the electron transport of a (electric or magnetic) quantum structure embedded and connected through an additional path in an AB ring. This additional path intersects the ring and is controlled by a gate voltage. As a result the unique and abundant structures associated with tunneling resonance peaks and Fano resonance peaks are clearly observed as a function of electron(Fermi) energy. These peaks can be spin polarized when the magnetic structure is embedded and connected to an AB ring, and thus can be used as a spin filter. The magnetic structure[2] can be created by superconducting gates to produce the spatially inhomogeneous magnetic fields. The spin dependence of the transport comes from the Zeeman term.

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[2] K. C. Seo, G. Ihm, K.-H. Ahn, and S. J. Lee, J. Appl. Phys. 95, 7252 (2004); S. J. Lee, S. Souma, G. Ihm, and K. J. Chang, Phys. Reports 394, 1 (2004)

TUE 18:

Structural and Magnetic Properties of Nanocrystalline Ga(1-x)Mn(x)As Films Deposited by Sputtering

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The use of the RF magnetron sputtering as an alternative route to deposit hydrogenated and non-hydrogenated Ga(1-x)Mn(x)As films over a broad Mn content range is analyzed. A sputtering target composed of a GaAs single crystal covered by Mn metallic pieces, and Ar and Ar + H2 atmospheres were used in the film depositions. X-ray diffraction experiments show that the materials are nanocrystalline and indicate, as well as x-ray absorption fine structure, that the Mn is incorporated mainly in substitutional Ga sites for samples in the diluted range ($x < 0.1$). The ESR linewidth was found to be temperature independent for $x = 0.08$ film. The ESR spectra show a single resonance with g-value of 2.01(5) at 4.2 K, and no measurable g-shift was observed in the Mn2+ ESR as a function of temperature. In contrast to the ESR result of the $x = 0.08$ film, the Ga0.70Mn0.30As:H film shows a broadening of the linewidth at low temperature which may indicate the presence short range magnetic correlation but with no net internal field at the Mn site. The Ga(0.7)Mn(0.3)As:H film presented magnetization saturation values of 3 emu/g at 2 K and 1 emu/g at 300 K. A coercive field of about 10 kOe is obtained for this film. The ferromagnetic loops probably resulted of the precipitation of a secondary phase or clusters of MnAs due to the high Mn concentration in the film. Different reasons are proposed for the lack of ferromagnetic ordering in the diluted samples.

TUE 19:

Magnetoresistance of Electrodeposited Permalloy Clusters on Silicon Substrates

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The study of spin polarized currents in semiconductor is a subject of fundamental interest from the point of view of basic and applied research. The injection, transport and detection of spin polarized electrons in silicon substrates is a challenge that has to be overcome in order to develop spintronic devices integrated with the current microelectronic industry.

In this work, we have investigated the magnetoresistive properties of FeNi alloys, with composition close to permalloy (Py), electrodeposited on single crystal n-type Si. The electrodeposits at different stages of grown, from cluster distribution to compact layers, were characterized with experimental

techniques such as electrical and magnetoresistance measurements, scanning electron microscopy (SEM) and vibrating sample magnetometry (VSM).

The dependency of resistance and magnetoresistance as a function of the deposition time were obtained and the limit of percolation was inferred. Below the percolation limit, the magnetoresistive results are typical of systems that present giant magnetoresistive response, which indicates the existence of a spin polarized current flowing from cluster to cluster through the Si substrate, similarly to a Py/Si/Py spin valve. The measurements were performed mainly at room temperature.

TUE 20:

Raman Scattering Study of Annealed Ga(Mn)N Films

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Wide bandgap semiconductors in which magnetic elements are incorporated, undoubtedly constitute promising materials for spintronic applications; among them, Ga(Mn)N attracts much interest, thanks to its high Curie temperature (above 300K). We here present a Raman analysis of the structural modifications induced by thermal annealing of nanocrystalline $Ga_{1-x}Mn_xN$ grown with different x values. Films with $0 \leq x \leq 0.08$ were prepared by reactive magnetron sputtering using a Ga target covered by small Mn pieces (Mn cosputtering), in N_2 atmosphere. Successive thermal annealings were realized up to 700^0C in the same atmosphere. The depolarized Raman spectra taken at 9K and excited by the 514.5nm Ar^+ laser line, revealed that as the Mn concentration increases, the peaks corresponding to the TO and LO GaN modes are shifted to lower frequencies and broadened as compared to the crystalline features; these observations point to an increase of the distortion of the crystalline lattice. The same spectral bands of the samples with $x = 0.02$ and $x = 0.08$ become more intense and narrow after the annealing realized at 500 and 600^0C, as an evidence of the increasing crystallinity of the films. The Mn local vibrational mode (Mn-LVM) at 587 cm^{-1} becomes clear as the annealing temperature is increased, indicating that the proportion of Mn atoms effectively incorporated to the lattice (in substitution to Ga atoms) increases with the heat treatment procedure.

TUE 21:

Suppression of Electron Spin Relaxation in Mn-doped GaAs

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The fast spin relaxation of donor-bound electrons in p-GaAs is the result of an exchange interaction with holes bound to the acceptors, known as the Bir-Aronov-Pikus (BAP) mechanism. We found that the spin relaxation of electrons is strongly suppressed when the doping of p-GaAs results from magnetic Mn acceptors [1]. This is in stark contrast to the general believe that the incorporation of local magnetic moments should necessarily lead to an efficient spin relaxation channel. The spin relaxation time scales with the optical pumping and increases from 12 ns in the dark to 160 ns upon saturation. The latter value is by two orders of magnitude longer as compared to similarly doped p-GaAs containing nonmagnetic acceptors, and even comparable with the best results achieved in n-GaAs.

This behavior is associated with the difference in spin relaxation rates of electrons precessing in the fluctuating fields of ionized or neutral Mn acceptors, respectively. For the latter the antiferromagnetic exchange interaction between a Mn ion and a bound hole results in a partial compensation of these fluctuating fields, leading to the enhanced spin memory. These findings may open up a new route for spin memory engineering.

[1] G. V. Astakhov et al., arXiv:0710.0246

TUE 22:

Accelerating Spin Flows in Weak Magnetic Fields

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In order to control spin flows biased structures are utilized: An applied voltage induces current of electrons, which carry spins. We show that the spin outflow from the injection point can be accelerated in unbiased structures, only by application of weak magnetic fields of several tens of Gauss. Rather than changing the charge current, an external magnetic field enlarges the spin gradient. The effect exists in the strong spin pumping regime providing different spin lifetimes at the points of injection and detection.

Accelerating spin flow in weak magnetic fields is directly monitored in spin imaging experiments by means of scanning Kerr microscopy. With increasing magnetic field, first the spin flow increases by a factor of two (at 5 mT) and then decreases to zero (above 50 mT). Alternatively, the effect manifests itself in spatially resolved Hanle effect measurements. When the detection point is moved away from the injection point, the width of the Hanle curve decreases. This implies suppression of the additional spin decay channel caused by the spin outflow.

These findings demonstrate a possibility to manipulate spin flows without or in addition to electric means.

TUE 23:

Observation of the Onset of Magnetic Clustering in Superparamgnetic $Zn_{1-x}Co_xO$ Films

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The existence of room temperature ferromagnetism (RTFM) in $Zn_{1-x}Co_xO$ remains controversial. It is experimentally very challenging to distinguish between the homogeneous magnetic contribution originating from the intrinsic spin interactions and the inhomogeneous contributions from Co/CoO nanoclusters. We have shown by x-ray linear dichroism (XLD) that $Zn_{1-x}Co_xO$ films of high structural perfection behave paramagnetic [1] A series of $Zn_{1-x}Co_xO$ films were obtained by UHV-magnetron reactive sputtering. XRD and XPS were used for standard crystallographic characterization revealing good crystalline quality for the oxygen-rich conditions and indicating the presence of Co^{2+} ions without detectable metallic Co. These studies are further refined by means of XLD suggesting that Co^{2+} ions sit on substitutional Zn sites and the onset of phase separation becomes quantifiable. Interestingly, such $Zn_{1-x}Co_xO$ films display altered magnetic properties measured by SQUID and EPR, ranging from paramagnetism to the emergence of magnetic clustering revealed by superparamagnetism with increasing blocking temperature. We will discuss the transition from paramagnetic to superparamagnetic behavior in the light of our detailed structural, electronic and magnetic investigations, especially with regard to the perspective of RTFM in this transition regime.

[1] A. Ney, K. Ollefs, S. Ye, T. Kammermeier, V. Ney et al., Phys. Rev. Lett. 100, (in press 2008)

TUE 24:

Laser-induced Precession of Ferromagnetically Coupled Mn Spins in (Ga,Mn)As

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Photoexcitation of (Ga,Mn)As by strong femtosecond laser pulses can strongly disturb the equilibrium between the mobile carriers (holes), localized spins (Mn ions), and the lattice. This in turn leads to the precession of ferromagnetically coupled Mn [1, 2]. We report on the simultaneous measurements of dynamics of the transient polar Kerr rotation (KR) and of the transient reflectivity induced by laser pulses in ferromagnetic (Ga,Mn)As. It is shown that the measured KR signal consists of several different contributions, among which only the oscillatory signal is directly connected with the ferromagnetic order in (Ga,Mn)As [3, 4]. The origin of the light-induced magnetization precession is discussed and the magnetization precession damping is found to be strongly correlated with the magnetic quality of the samples. This work was supported by Ministry of Education of the Czech Republic in the framework of the research centre LC510 and the research plan MSM0021620834.

[1] A. Oiwa, H. Takechi, H. Munekata, J. Supercond. 18, 9 (2005)
[2] J. Qi, Y. Xu, N.H. Tolk, X. Liu, J.K. Furdyna, I.E. Perakis, Appl. Phys. Lett. 91, 112506 (2007)
[3] E. Rozkotova, P. Nemec, P. Horodyska, D. Sprinzl, F. Trojanek, P. Maly, V. Novak, K. Olejnik, M. Cukr, T. Jungwirth, Appl. Phys. Lett 92, 122507 (2008)
[4] E. Rozkotova, P. Nemec, D. Sprinzl, P. Horodyska, F. Trojanek, P. Maly, V. Novak, K. Olejnik, M. Cukr, T. Jungwirth, submitted, preprint http://arxiv.org/abs/0803.0320

TUE 25:

Experimental Studies of Ferromagnetism in GaN-based Systems

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It is now widely accepted that the ferromagnetic features persisting up to above room temperature observed in wide band-gap semiconductors and oxides doped with transition metals stem from self-organized magnetic ions aggregated into magnetically robust nanocrystals embedded in the host paramagnetic matrix. Despite constituting well defined isolated ferromagnetic entities, these nanocrystals collectively reveal themselves in magnetometry as a blocked superparamagnet. The tendency towards aggregation, however, is expected to be modified by the Fermi level engineering through co-doping with shallow acceptors or donors [1]. Using dedicated high precision SQUID magnetometry (complemented with TEM, XRD, ESD imaging and SIMS) we show that indeed the presence of a significant amount of Mg or Si in (Ga,Fe)N alters the process of aggregation, and consequently the ferromagnetic response in general (and the superparamagnetic signatures in particular) get significantly reduced. A similar effect takes place upon increasing the growth rate, implying that the aggregation process is limited by a kinetic barrier for surface diffusion of the Fe ions. In contrast, we observe a nearly pure diamagnetic response in our Fe-free GaN:Mg,Si samples, indicating that the recently postulated vacancy-related ferromagnetism of GaN [2] is not present in a high quality material.

[1] T. Dietl, Nature Mat. 5, 673 (2006)
[2] P. Dev, Y. Xue, P. Zhang, Phys. Rev. Lett. 100, 117204 (2008)

TUE 26:

Spin Polarization in Asymmetric N-type GaAs/AlGaAs Resonant Tunneling Diodes

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We investigated the polarization-resolved photoluminescence in an asymmetric n-type GaAs/ AlGaAs resonant tunneling diode[1]. The emission from the GaAs contact layer shows a large constant negative circular polarization. A similar result is observed for the GaAs quantum well, but only when the electrons are injected from the substrate side, while for inverted biases, the polarization tends to become positive for small voltages and large laser excitation intensities. We analyze our results considering the thermal occupation of the Zeeman-split levels at the GaAs contact layers by minority carriers. This occupation results in the large negative polarization for the bulk GaAs emission and it should also have a main role on the polarization of the QW emission, as it determines the dominant spin of the minority holes tunneling into the well. The occupation of the spin-split QW levels may also contribute to the polarization of the QW emission, even tough the QW levels should not follow an equilibrium distribution. A particular and important point concerning our structure is that this occupation can be strongly affected by the large variation of the density of electrons and holes in the QW as a function of the bias voltage, which can even invert the minority carrier character in the QW.

[1] L. F. dos Santos, Y.Galvão Gobato, V.Lopez-Richard, G.E. Marques, M.J.S.P. Brasil, M. Henini, R. Airey, Appl. Phys. Lett. 92, 143505 (2008)

TUE 27:

Spin-dependent Current Ringing and Spin-diode Effect in Quantum Dots

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Coherent spin dynamics and transport in quantum dots has attracted a lot of attention due to their relevance to a new generation of spintronic devices and to quantum computation [1]. In this work [2] we report spin-dependent quantum coherent oscillations (ringing) of the total $(I\uparrow + I\downarrow)$ and the spin $(I\uparrow - I\downarrow)$ currents flowing through a quantum dot with Zeeman split levels. We show that the ringing responses of the current and spin current are controlled via the Zeeman energy Ez and the temperature kT. In particular, we observe that with increasing temperature the ringing response tends to disappear. We also discuss a recent proposal for a spin-diode device [3]-[4]. This system is composed of a quantum dot coupled to one nonmagnetic lead and to a ferromagnetic lead. Due to the interplay between Coulomb interaction and ferromagnetic leads the current becomes polarized for forward bias while remains unpolarized for reverse bias voltages. This system thus behaves like a diode for the spin current. The authors acknowledge support from the Brazilian agencies CNPq, CAPES, FAPESP and IBEM and the FiDiPro program of the Finnish Academy.

[1] D. D. Awschalom and M. E. Flatté, Nature Phys. 3, 153 (2007)
[2] F. M. Souza, Phys. Rev. B 76, 205315 (2007)
[3] F. M. Souza, J. C. Egues, and A. P. Jauho, Phys. Rev. B 75, 165303 (2007)
[4] C. A. Merchant and N. Marković, cond-mat/0710.2297

TUE 28:

Spin Interference in Quantum Rings Controlled *Via* Lead-to-ring Point Contacts

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The Aharonov-Bohm (AB) and Aharonov-Casher (AC) effects are two typical interference phenomena that appear in semiconductor quantum rings. Although the AB effect has been observed since long time ego, its counterpart, the AC effect has been only recently observed in clever magnetoconductance oscillations experiments on HgTe/HgCdTe based quantum rings exhibiting strong Rashba SO-interaction [1]. There is also evidence of spin quantum interference due to spin precession and its control via gate voltage [2]. In this work, using the S-matrix formalism we study the role of the contacts (conjunctions) of the leads with the quantum ring on the AB and AC conductance oscillations of the device in the presence of Rashba and Dresselhaus type of SO interactions. We describe the backscattering and transparence of the conjunctions lead-to-ring through quantum point contacts (QPCs) modelled with gate-controllable saddle-point potentials. The variable transmitivity of the QPCs, adjusted in the experiment by gate voltages and/or applied magnetic field is readily incorporated in our approach. It is shown that manipulating electrostatically the confinement strength at the QPCs, may be of utility to implement a novel way to modulate spin interference effects in semiconductor quantum rings [3]. Work supported in part by DGAPA-UNAM project IN1138073.

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[2] T. Bergsten et al., PRL 97, 196803 (2006)
[3] L. Diago and F. Mireles (in preparation)

TUE 29:

Spin Photocurrents in IV-VI Semiconductor Quantum Wells

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Photocurrents with optical orientation, allowed in gyrotropic structures as QWs with Rashba split subbands, form a recent tool to investigate these structures. Pure spin currents and circular and spin photogalvanic effects have been observed in different III-V [1] and SiGe [2] QWs. A multi-valley, large and anisotropic pure Rashba splitting was predicted in IV-VI asymmetric QWs [3]; but the spin photocurrents have not been considered. Here, the circular photogalvanic effect in PbTe-like QWs is theoretically studied. From symmetry analysis, we determine the allowed lowest order invariants and the non-zero components of the second rank pseudo-tensor for spin photocurrents in both [100] and [111] lead-salt QWs. It is found that in both cases there is only one allowed invariant linear in k-parallel, which is of the Rashba type; in accord with multi-band envelope function calculations based on the Dimmock kp model. In [111] QWs, due to the break of valley degeneracy, longitudinal and oblique spin-photocurrents can be defined, both with Rashba symmetry. The anisotropy in the subbands from each oblique valley is shown to average out when contributions to the current from the three equivalent valleys are added together.

[1] K.S. Cho et al., Phys. Rev. B 75, 085327 (2007); S.D. Ganichev and W. Prettl, J. Phys. Cond. Mat. 15, R935 (2003)
[2] S.D. Ganichev et. al., Phys. Rev. B 75, 155317 (2007)
[3] M.M. Hasegawa and E.A. de Andrada e Silva, Phys. Rev. B 68, 205309 (2003)

TUE 30:

Enhancement of the Rashba Spin-orbit Interaction Due to Wave Function Engineering

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Control of the Rashba spin-orbit interaction (SOI) is one of the important technologies for realizing spin functional devices. The Rashba SOI parameter α is determined by the electric field due to *band bending* in the quantum well (QW) as well as by the interface electric field at the $heterointerface$. We have shown that the absolute value and gate voltage Vg dependence of α ($\mathrm{d}\alpha/\mathrm{d}Vg$) can be controlled by the modulation of the *field* and the $interface$ contributions in the different QW thickness due to different confinement of the electron wave function [1]. The large absolute value and the high gate sensitivity ($\mathrm{d}\alpha/\mathrm{d}Vg$) of α are desired for spintronics devices. Thus, we have designed an InP/$In_{0.53}Ga_{0.47}As$/$In_{0.7}Ga_{0.3}As$/$In_{0.53}Ga_{0.47}As$/$In_{0.52}Al_{0.48}As$ double quantum well (DQW) such that the large electron probability density is positioned at the $In_{0.7}Ga_{0.3}As$/$In_{0.53}Ga_{0.47}As$ interface in order to enhance the interface contribution. Carrier density dependence of α in the DQW is obtained from the weak antilocalization analysis and the result is compared with the InP/$In_{0.53}Ga_{0.47}As$/$In_{0.52}Al_{0.48}As$ single quantum well (SQW). The absolute value of α and $\mathrm{d}\alpha/\mathrm{d}Ns$ ($Ns \propto Vg$) in the DQW are enhanced more than twice and 1.74 times larger than that in the SQW, respectively.

[1] M. Kohda et al., Physica E 40, 1194 (2008)

TUE 31:

Spin Transport Across Depletion Region and Energy Barriers in GaAs-AlGaAs Heterostructures

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In order to realize spin-photonic devices with semiconductor heterostructures, it is indispensable to quantitatively understand to what extent carriers retain their spin polarization when they pass across the depletion region such as a p-n junction and the multi-barriers such as the Bragg reflector. We have tested efficiency of spin transport with the optical spin injection/detection scheme for various GaAs-AlGaAs heterostructures incorporating depletion layers or barriers. Illumination with circular polarized light (CPL) yields electron spins in a 3?m-thick GaAs layer, whereas light emission from a GaAs/InGaAs/GaAs QW detects electron spins P that recombine with unpolarized holes. Depletion layers or AlGaAs barriers are inserted in between the two. No emission from QW detector occurred under the forward bias less than 1V, which confirms no direct optical injection into the detector.

Control experiment without p-n junctions and AlGaAs barriers has exhibited P = 20-25 % at 4 K. Interestingly, P did not degrade upon insertion of depletion layers (p-n bi-layer) in the forward bias region in which diffusion of optically injected electrons was the dominant current component. What has been found the most sticking was that P did not degrade or rather became higher in samples having barriers with indirect band gaps (Al = 0.4 ? 0.8). Influence of applied forward bias and temperature on P apparently became weaker in the samples with indirect-gap barriers.

TUE 32:

First Principle Study of Spinodal Decomposition Thermodynamics in Half-heusler Alloys

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A systematic study on the phase transition, binodal and spinodal mechanism in various half-heusler compounds $XY_{1-x}TM_xZ$ (X = Co, Fe, Ni; Y = Ti, V, Zr; Z = Sb, Sn and TM = Mn, Fe) by first principle calculations is given. With the concentration dependence of the lattice constants assumed to follow Vegard law, the electronic structure, magnetic exchange interaction J_{ij}, chemical pair interaction V_{ij}, spin polarization P, chemical potential and mixing enthalpies H are calculated within LSDA-KKR-CPA. The phase diagrams are constructed from mixing enthalpie calculations. The pictures of nano-scale phase separations for 40, 80 and 100 steps of Monte Carlo simulations are presented.

TUE 33:

Half Metallicity and High-T_c Ferromagnetism in Si-based Half-heusler Alloys

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We present a first principle study of the ferromagnetism and half-metallicity in a class of Si-based half-heusler alloys XYSi (X = Ni, Pd, Pt; Y = Mn, Cr, V) . The structural and magnetic properties are investigated through the calculation of the electronic structure, phase stability, equilibrium lattice constant, magnetic exchange interaction J_{ij} and Curie temperature T_c. The phase stability and density of states are studied by using the ultrasoft pseudo-potential method. J_{ij} and T_c are calculated within KKR-LSDA framework. Based on the sets of parameters J_{ij}, T_c are predicted by using Monte Carlo simulation (for comparison, MFA and RPA are also employed). The magnetic configuration and lattice parameter dependence of J_{ij} and T_c are considered. All alloys can show half-metallicity and ferromagnetism at temperatures much higher than room temperature in a wide range of lattice expansion. Especially, T_c of 1050K is predicted by Monte Carlo simulation for NiMnSi[1]. Furthermore, the alloys have a wider minority band gap than the protopical alloy NiMnSb[2].

[1] V.A. Dinh, K. Sato and H. Katayama-Yoshida, J. Phys. Soc. Jpn. 77, 014705 (2008)
[2] V.A. Dinh, K. Sato and H. Katayama-Yoshida, arxiv.org/abs/0801.2222 [cond-mat.mtrl-sci] 15 Jan 2008

TUE 34:

Indication of Antiferromagnetic Interaction Between Substitutional Co Ions in $Zn_{1-x}Co_xO$

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Diluted magnetic semiconductor (DMS) $Zn_{1-x}Co_xO$ (ZnCoO) has attracted much attention since the discovery of ferromagnetism at room temperature, and is one of the most studied DMS's. Using x-ray magnetic circular dichroism (XMCD), we have reported that in ZnCoO the Co ions substituting for the Zn site is responsible for the ferromagnetism [1]. Recently, there have been many reports that defects or carriers affect the ferromagnetism. Sudaker *et al.* [2] have reported that annealing in high vacuum and in oxygen atmosphere increases and suppresses the magnetization, respectively. In the present work, we have measured magnetic-field (H) and temperature (T) dependent XMCD of ZnCoO thin films before and after high-vacuum annealing in order to obtain an understanding of the ferromagnetism. The line shapes of the Co $2p$ XAS spectra indicate that the Co ions are divalent and substitute for the Zn site. The XMCD intensities increase and decrease with H and T, respectively. Analysis of this paramagnetic behavior suggests the presence of antiferromagnetic interaction between the Co ions. Annealing in high vacuum reduces the paramagnetism and ferromagnetism. The suppression of the paramagnetic and ferromagnetic responses can be explained by thermal diffusion and aggregation of the Co ions in $Zn_{1-x}Co_xO$.

[1] M. Kobayashi et al., Phys. Rev. B 72, 201201(R) (2005)
[2] C. Sudakar et al., J. Phys. Condens. Matter 19, 026212 (2007)

TUE 35:

Polarization Multistability of Cavity Polaritons

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Cavity polaritons are elementary excitations of semiconductor microcavities with extremely small effective mass. In the low density limit they behave as weakly interacting bosons. Under resonant excitation two main mechanisms of optical nonlinearity have been identified, the polariton parametric scattering and bistability of the polariton system. They often coexist since both of them are induced by polariton-polariton interaction. An important peculiarity of polaritons is their polarization or pseudospin degree of freedom. Polaritons have two possible spin projections on the structure growth axis, corresponding to the right and left circular polarizations of the counterpart photons. We predict and analyze theoretically the new effects of polarization multistability and polarization hysteresis in a coherently driven polariton system. The polarization of the spinor polariton system under cw excitation is described by solving the polarization-dependent Gross-Pitaevskii equation. We show that for a given polarization of the pumping laser the polariton polarization can take three different values. For instance at linear pumping the resulting polariton state can be right circularly, left circularly, or linearly polarized. In realistic cases, the transitions between different states are triggered by fluctuations of the intensity and polarization of the pump. We investigate the impact of these fluctuations on the probability of transitions between different polarization states.

TUE 36:

Spin Characterization of Excited Trion in GaAs Quantum Dot

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Negative trions in semiconductor quantum dots (QDs) have attracted considerable attention in recent years as they are expected to be used as sensitive probes of single electron spin or for the manipulation of single spin coherence. To control the optical access to the spin information in a trion, we should carefully consider the spin configuration of the excited states of trions, as well as their ground states. In this study, we investigate the magneto-photoluminescence (PL) from excitons and negative trions using individual charge-controlled QDs. Our sample consists of interface fluctuation GaAs/AlGaAs QDs incorporated in an *n*-*i*-Schottky diode structure. We measured polarization-resolved PL at 6 K with a magnetic field applied in Faraday geometry. The magnetic field dependence of PL spectra provides us with a lot of information such as g factors and diamagnetic coefficients for neutral exciton and trion emissions. In addition, we found two manifolds of

PL lines, each of which shows complex magnetic field dependence. We assigned these lines to the emissions from the two types of excited trions; one consists of two electrons and a hole in *s*-, *p*-, and *s*-like shells, and another in *s*-, *p*-, and *p*-like shells in the QD, respectively. Our result infers a significant role of the spin-spin or spin-orbit interactions in the QD trion system. This work is partly supported by JSPS.

TUE 37:

Generating Electron Spin Polarization at Room Temperature in GaNAs Via Spin-dependent Recombination

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The issues of generating and maintaining carrier spin polarization in semiconductors have attracted intense research efforts, not only due to their importance for future applications in spintronics but also due to the intriguing physics underpinning spin-dependent phenomena. Entering the family of semiconductors that exhibit attractive spin-dependent properties, Ga(In)NAs was most recently found to exhibit strong spin polarization of conducting electrons at room temperature upon N incorporation with an extremely long äpparent spin lifetime. In this work we have uncovered the origin of the astonishing effect as being due to strong spin dependent recombination (SDR) via defects, by a combination of optical orientation and optically detected magnetic resonance (ODMR) studies. We were able to identify Ga self-interstitials and an As antisite complex to be the dominant defects participating in the SDR process. The involvement of these defects were unambiguously established by their unique spin-resonance signatures derived from the hyperfine interaction between the localized unpaired electron spin and nuclear spins (I=3/2) of the As and Ga atom - the core of the defects. These defects dominate in carrier capture and recombination leading to the observed strong dynamic polarization of electron spins. Further confirmation was found by the effects of growth conditions and post-growth treatments on the defect density that were closely correlated with the electron spin polarization.

TUE 38:

Co-doped TiO_2 Thin Film Grown on Glass Substrate for Transparent Spintronics

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Co-doped TiO_2 shows ferromagnetism at room temperature [1], and its anomalous Hall effect and magneto-optical effect can be controlled by doping electron carriers. This compound has a good transparency in visible light regime, thus implementation of transparent spintronics devices, e.g. on a window glass, could be possible. However, magnetic properties of Co-doped TiO_2 grown on a glass substrate have not been sufficiently investigated. Here, we report on the magnetic properties of Co-doped TiO_2 films grown on the glass substrates using a dc magnetron sputtering method. The films with weak rutile (100) orientation were grown at 600°C in a mixture of Ar and O_2 gasses. The electron density was controlled by changing an amount of partial O_2 pressure during growth, where the films with high electron density showed room temperature ferromagnetism. The saturation magnetization was as high as 3 μ_B/Co, that is nearly ideal value assuming Co^{2+} high spin state. The magnetic circular dichroism (MCD) was over 10^4 deg./cm at maximum that is larger than those of epitaxial films grown by pulsed laser deposition method. The magnetization, Hall resistivity, and MCD at 300 K represent their identical magnetic field dependence. In the presentation, we will also show further enhanced MCD in a magnetophotonic multilayer structure.

[1] Y. Matsumoto it et al. Science bf 291, 854 (2001).

TUE 39:

Electron-nuclear Spin Polarization Dynamics in InGaAs Quantum Dots

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In present work, results of the detailed experimental investigation of the dynamical nuclear polarization (DNP) in an ensemble of the InGaAs quantum dots (QDs) performed in a wide time range from tens of microseconds to fractions of a second is reported. The DNP was determined at Faraday geometry from the position of a dip in the magnetic field dependence of the resident electron spin polarization measured by means of the negative circular polarization (NCP) of the luminescence of the sample [1]. The sample was excited with a circularly polarized light which helicity was periodically

changed so that the duration of the illumination with every helicity of the polarization, tpump, was half of the period T. We measured the magnetic field dependences of the NCP in different time moments within one half-period and thus detected the dynamics of the nuclear polarization. The dependence of the DNP on the period T of the polarization modulation was measured at the end of the half-period too. The experiments performed show that, in accordance to theoretical predictions [2], the dynamics of the nuclear polarization in the InGaAs QDs is really nontrivial. The first stage of the polarization rise can be described by an exponential function. However further increase of the polarization occurs according to approximately logarithmic dependence on time.

[1] B. Pal et al., Phys. Rev. B, v.75, 125322 (2007).
[2] H. Christ, J. I. Cirac, and G. Giedke, Phys. Rev. B, V.75, 155324 (2007).

TUE 40:

Influence of Concentration of Magnetics Ions in the Sensitivity of Glasses to the Ionizing Radiation

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In this work had been synthesized the system vitreous LDA ($Li_2CO_3 - 45B_2O_3 - 5Al_2O_3$) doped with CaF_2 (60 %wt) and LiF (80 % wt), separately, through the fusing method. Each one of them was doped with different concentrations of Mn and Co, separately. The samples were divided on various aliquots and submitted to exposition of gamma radiation of Co-60 source: 1 and 10 Gy, aiming at the production of sensible glass samples to the ionizing radiation. A TL reader model Daybreak 1000 was used to obtain glow curves with a linear heating rate of 10°C/s.

TUE 41:

Controllable Spin-flip Transport Through a Quantum Antidot in the Integer Quantum Hall Regime

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In light of recent experiments demonstrating the potential of nanostructures in the integer quantum Hall (IQH) regime for the coherent manipulation of electrons through edge states, we have begun to explore the potential for spin control in such systems, in order to utilize both long spin-coherence timescales and controllable electron transport along edge states. Here we describe new measurements of spin-resolved transport through a quantum antidot (AD) in the IQH regime with potentially exciting applications for spin manipulation. Our device employs quantum point contacts to inject and detect non-equilibrium edge-state populations through an AD, thereby probing the spin structure of AD states. Surprisingly, we find that most resonances at AD filling factor $\nu = 2$ (for magnetic fields ≈ 1T) show contributions from both spin channels, rather than spin-polarized transport of alternating polarity as standard theories predict. Moreover, while in most cases the initial spin of the transported electron is conserved, we have discovered specific regimes in which a fraction of the injected current shows a spin flip during transmission through the AD. These observations imply a mixing between AD states of opposite spin in the lowest Landau level, possibly through spin-orbit effects, and a spin-flip timescale that can be tuned to be comparable to the tunneling time.

TUE 42:

A Numerov Sixth Order Numerical Scheme to Accurately Solve the 1d Poisson Equation

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We present an analytical direct method to solve the discrete one-dimensional Poisson equation with Dirichlet boundary conditions. This method is based on a Numerov three-point scheme, which is sixth order accurate and has a linear execution time on the grid dimension. Our results should improve numerical codes used mainly in self-consistent calculations in solid state physics.
We would like to aknowledge FAPESP for financial support and also to Rafael Calsaverini, Gerson J. Ferreira and J. Carlos Egues for useful discussions.

TUE 43:

Polarization-Resolved Emission from AlAs/GaAs/GaMnAs Heterostructures

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In this work, we have investigated Ga_{1-x} Mn_x As/AlAs quantum wells (QWs) with $x < 0.1\%$. The samples were grown at a relatively high temperature (450 °C) in order to reduce the concentration of As defects while allowing

the substitutional incorporation of Mn into Ga sites. The QW structure consists of a 2 nm of GaMnAs layer surrounded with 1 nm GaAs layer and 50 nm AlAs layer that act as barriers. We have studied the polarization-resolved photoluminescence as a function of the magnetic field, laser excitation and temperature. Under low excitation conditions, we have observed up to four distinct emission bands. The narrower emission is associated to excitonic recombinations in the QW. For certain samples, especially those with lower Mn concentrations, this emission is split in two narrow peaks, which is probably due to interface roughnesses of the QW. The intensity of the additional broader emission bands depend on the nominal concentration of Mn and are probably associated to the presence of shallow donors (interstitial Mn) in the QW and/or AlAs layers. The emission peaks present different degrees of circular polarization. The broader peaks present a relatively larger polarization degree. On the other hand, the peaks associated to QW excitonic recombinations present a rather small degree of polarization and its residual polarization has a sign opposite from that of the broader peaks.

TUE 44:

Growth and Characterization Optical and Magnetic of $Pb_{1-x}Co_xA$ (A = S, Se) Nanocrystals in Glass

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The magnetic ions doped IV-VI semiconductors nanocrystals are materials belong to the group of diluted magnetic semiconductors in which small quantities of the magnetic ions is incorporated into e semiconductor IV-VI substituting partially the cation of the semiconductor. The d electrons of the magnetic ion, usually Co2+, are located in the band gap region of the semiconductor, leading to exchange interactions with the s-p band electrons of the semiconductor. This sp-d exchange interaction constitutes a unique interplay between optical properties and magnetism depending on the mole fraction x. $Pb_{1-x}Co_xA$ (A = S, Se) nanocrystals embedded in glass matrix were synthesized by means of fusion method. The physics properties of Co-doped PbA (A = S, Se) nanocrystals have been investigation using electron paramagnetic resonance (EPR) and optical absorption. The eight lines associated to the Co-ion hyperfine splitting are observed in the EPR spectra. The hyperfine structures are attributed of electron spin-nuclear spin interactions of isolated Co2+ ion at or near the surface of $Pb_{1-x}Co_xA$ (A = S, Se) nanocrystals. Optical absorption spectra of the $Pb_{1-x}Co_xA$ (A = S, Se) nanocrystals shows the blue shift with the increase of ions magnetic concentration, which provides an obvious evidence of true Co doping in the PbA (A = S, Se) nanocrystals.

TUE 45:

Magnetic Anisotropy and Magnetization Processes of (Ga,Mn)As On GaAs (311)a Substrate

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Magnetization processes and magnetic anisotropy of (Ga,Mn)As thin films grown by low-temperature MBE on GaAs (311)A substrates are studied by means of SQUID magnetometry and magnetooptic magnetometry using polar Kerr effect (MOKE). The magnetization curves obtained by SQUID are explained phenomenologically using two main contributions to the magnetic anisotropy: a cubic magnetocrystaline anisotropy with easy <001> axes, and an effective uniaxial magnetic anisotropy with hard axis along [311] caused primarily by the epitaxial compressive strain from the substrate. We find the uniaxial anisotropy constant to depend linearly on M_S^2 and the cubic anisotropy constant to follow M_S^4 in wide temperature range, up to nearly T_C (here M_S is saturation magnetisation), thus confirming the validity of the single domain model used to describe magnetization rotations in this material. Our results are in an agreement with ferromagnetic resonance data for similar samples [1] and follow general expectation of the p-d Zener model of the carried mediated ferromagnetism [2]. Interestingly, mutually tilted cubic and uniaxial magnetic anisotropies in (311) (Ga,Mn)As allow us to reverse the magnetization in (001) plane by sweeping the magnetic field in the sample plane along [-233] direction, as is experimentally evidenced by MOKE studies.

[1] C. Bihler, et al., Appl. Phys. Lett. 89, 012507 (2006)
[2] T. Dietl, H. Ohno, F. Matsukura, Phys. Rev. B 63 195205 (2001).

TUE 46:

Magnetic and Optical Properties of $Cd_{1-x}Mn_xS$ and $Cd_{1-x}Co_xS$ Nanocrystals in Glasses Matrix

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The development of diluted magnetic semiconductor (DMS) at the nanosized scale has attracted considerable attention, in particular due to the possibility of using the combined properties of carrier charge and spin to modulate the response of the material driven by external applied fields [1-3]. Cd1-xMnxS and Cd1-xCoxS nanocrystals were synthesized in glasses matrix by fusion method and characterized by Electron Paramagnetic Resonance (EPR) and Optical Absorption (OA). Electron Paramagnetic Resonance spectra of $Cd_{1-x}Mn_xS$ ($Cd_{1-x}Co_xS$) shows the six (eight) hyperfine lines well defined

of Mn2+ (Co2+) ions of the samples with a low Mn (Co)-concentration, and of a broad EPR line, which manifests the onset of Mn-Mn (Co-Co) exchange interaction, in the samples with an elevated value of x. OA spectra of $Cd_{1-x}Mn_xS$ and $Cd_{1-x}Co_xS$ nanocrystals shows the blue shift with the increase of ions magnetic concentration, which provides an obvious evidence of true Mn (Co) doping in the CdS nanocrystals.

[1] H. Ohno, Science 281 (1998) 951.
[2] W. C. Kwak et al.; Applied Physics Letters 90 (2007) 173111.
[3] P.V. Radovanovic and D. R. Gamelin; Journal Americam Chemistry Society 123 (2001) 12207.

TUE 47:

Hyperfine Interaction in Single Modulation Doped Quantum Wells

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The spin of a confined electron, when oriented originally in some direction, will lose memory of that orientation after some time. Physical mechanisms leading to this relaxation of spin memory typically involve either coupling of the electron spin to its orbital motion or to nuclear spins. The proposed use of electron spin as solid-state qubits for quantum computing relies on the necessity to control the coherence time of the spin on semiconductor quantum dots. Over the years, much progress has been made for GaAs dots, but the great challenge is to control the spin decoherence comes from the hyperfine interaction with the surrounding nuclear spins. In this work, we have developed a self-consistent solver for Schrödinger and Possion equations for modulation doped quantum wells, including hyperfine interaction between electron-nuclear spins. We found that the spin decoherence due to the hyperfine interaction can be reduced by appropriate choice of geometric parameters of quantum well and concentration of doping.

TUE 48:

Resonance in the Intersubband-induced Spin-orbit Interaction in Double Quantum Wells

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Recently, we have found an additional spin-orbit (SO) interaction in quantum wells with two subbands [Phys. Rev. Lett. **99**, 076603 (2007)], which arises from the intersubband coupling between confined states of distinct parities, therefore being non-zero even in symmetric geometries. Here, within the self-consistent Hartree approximation, we calculate the strength of this new SO coupling for realistic symmetric modulation-doped wells with two subbands, where the intersubband SO coupling exhibits a resonant behavior near the symmetric configuration. This work was supported by the Swiss NSF, the NCCR Nanoscience, DARPA, ARO, ONR, JST ICORP, CNPq and FAPESP.

TUE 49:

Optical and Magnetic Properties of Crystals of K_2SO_4 Doped With Mn and Co by Watery Solution

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The research on syntheses of new materials and modifications of its physical properties is fundamental for technological applications. Then, this research aims to growth of Lithium Iodate ($LiIO_3$) and Potassium Sulphate (K_2SO_4) crystals pure and doped with ions of Mn, Co and Nd by watery solution method, for to study of optical, magnetic and its structural properties. The $LiIO_3$ and K_2SO_4 crystals obtained are transparent in the visible to near infra-red of the electromagnetic spectra, where are interesting to be modified with ions of rare earth and transition metals. Particularly, crystal of $LiIO_3$, not doped, is applied for generation of second harmonic in 1100 nm, 1300 nm and 1500 nm, that they are in the region of the optic windows of the telecommunications. Ahead of these basic properties crystals of $LiIO_3$ and K_2SO_4 crystals and of the possibility to modify them with earth rare ions and transition metals had prepared solutions to the LiOH base and Li_2CO_3 with HIO_3 for the crystal growth of $LiIO_3$. For the crystal growth of K_2SO_4 was used 1 molar of potassium sulphate solution. The crystals of $LiIO_3$ and K_2SO_4 had been doped with Mn, Co and Nd, added solutions the H_2SO_4 base contend these ions, the precursory solutions of these crystals. Its observed that the optical, magnetic and structural properties of these crystals had been modified for ions of Mn, Co and Nd.

TUE 50:

Optical and Magnetic Properties of Nanocrystals of $Zn_{1-x}A_xTe$ (A = Mn, Co) in Glasses

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Recently there is a increasing interest in the development of new methods of synthesis of semiconductor of the group II-VI doped with magnetic ions. Inside of various II-VI semiconductors the $ZnTe$ has received much attention because of their various applications in optoelectronic devices, such as blue lasers, devices for optical switching, and when doped with ions, for example, Mn and Co. This search has taken up the fusion method for the synthesis of the system vitreous PZABP without doping and doped, separately, with ions, Mn and Co. Samples vitreous doped, separately, with Mn and Co have been subjected to thermal treatment appropriate to encourage the growth of quantum dots of $ZnTe$, $Zn_{1-x}Mn_xTe$ and $Zn_{1-x}Co_xTe$ of different sizes. The samples were characterized by optical absorption (OA), Raman and electronic paramagnetic resonance (EPR), which confirms the growth of nanocrystals of $ZnTe$, $Zn_{1-x}Mn_xTe$ and $Zn_{1-x}Co_xTe$ of different sizes also confirmed by atomic force microscopy (AFM).

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TUE 51:

Manipulation of Curie Temperature in MnAs/GaAs and MnAs/GaSe/GaAs Heterostructures

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The strain and chemical compatibility are crucial parameters to promote a successful heteroepitaxial growth. Nowadays, hybrid structures mixing ferromagnetic materials with semiconductors are greatly envisaged for the development of a spin-based electronics. Even if interface chemical reactivity can be minimized by matching compatible materials, the residual strain in the heterostructures is undesired, since it can strongly modify the properties of thin films, leading to the degradation of the structures. One way to overcome these difficulties can be a mechanical pseudo-decoupling of the epilayers from the substrate. To explore this possibility, MnAs is an interesting material because its Curie temperature (Tc) is strongly dependent on the epitaxial strain. In this study, MnAs epilayers were prepared by molecular beam epitaxy on GaAs (001) and GaAs(111)B and GaSe/GaAs(111) substrates. A strong influence of the substrates has been found on the magnetic properties of the MnAs films. Remarkably, MnAs/GaAs(111)B samples exhibit TC much higher than bulk MnAs. This TC increase is correlated with the storage of the elastic energy density in the MnAs epilayers. We demonstrate that TC can be changed by inserting a GaSe lamellar interlayer in between MnAs and GaAs(111)B. The role of the residual strain due to epitaxy as well as the eventual chemical reaction between MnAs and GaSe will be discussed.

TUE 52:

Ferromagnetic Properties of Ordered InMnAs Quantum Dots

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Diluted magnetic quantum structures have become a very attractive subject because they combine semiconductor and magnetic properties and for their potential applications in spin-related electronics. Among the many diluted magnetic structures InMnAs/GaAs ferromagnetic semiconductor is one the potential candidates for spintronics because they have the properties of both InAs semiconductor quantum dots and Mn ferromagnetic compounds. The InMnAs self-assembled nanostructure are usually grown on semi-insulating GaAs(100) by Stranski-Krastanow method at low temperature Molecular Beam Epitaxy which provide a broad distribution in size for the ferromagnetic quantum dots. We developed a method that provides lateral ordering of InMnAs quantum dots with different Manganese concentration grown on a multi-stacked InGaAs/GaAs (100) QDs. The GaAs template surface after 15 layers of InGaAs/GaAs have unique properties, such as the strain minima field distribution, that allows even for low temperature epitaxy (300C), the diffusion and nucleation of the InMnAs quantum dots over the strain fields lines produced by the template. The lateral ordering provides a better distribution of the Manganese atoms inside the quantum dots, which was confirmed by x-ray diffraction under grazing incidence condition, performed using Synchrotron radiation. The ferromagnetic behavior was observed for the nanostructures and reveal an unusual anisotropy related to the strain-field created by the template.

TUE 53:

Heat Capacity Measurements in L-arginine Phosphate Monohydrate Doped With Magnetic Impurities

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L-arginine phosphate monohydrate - LAP ($C_6H_{14}N_4O_2H_3PO_4.H_2O$) was found to be a material with great potential for use in photonics. In these applications, the thermal properties of the material plays a major role since large optical powers are usually applied to make use of non-linear effects. In order to reduce thermal fluctuation it is desirable to use materials with large specific heat (c_p), for instance. Magnetic impurities on atomic level concentrations, on the other hand, with the aid of the EPR technique, are helpful in probing the local structure of complex compound. This was actually done in our samples. However, there is not yet reports describing the influence of such magnetic impurities on the heat capacity of LAP samples neither low temperature (T) data even for pure LAP. In this work, we report c_p data for pure and magnetically-doped single-crystals of LAP. Heat capacity measurements were carried out from room temperature (RT) down to 1.9 K at zero applied magnetic field in small (5.9-10.1 mg) samples of LAP prepared by an accurately controlled solvent evaporation technique (ACSET). The samples were doped with Mn(0.005%), Fe(0.025%), Ni(0.075%) and Cu(0.25%) in percent relative to the molar mass of the LAP. It was found that the RT c_p increases from 1.17 for the LAP:Mn sample to 1.26 J/g-K for the LAP:Cu one. Moreover, c_p varies for more than one order of magnitude at the low T end. Work supported by CNPq, FACEPE and FINEP.

TUE 54:

Modifying the Hole Landé Factor of InAs Self-assembled Quantum Dots

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Spintronics applications of any semiconductor device relies on the knowledge and tailoring of the carriers´Landé factors. The g factor is materials dependent and it was also shown that the quantum dots (QD) electronic g factors can be tailored by modifying the environment around the nanostructures [1]. Hole Landé factors, however, are expected to be more sensitive to the internal structure of the QDs, since valence band mixing is enhanced by the quantum confinement. In the present work we report on measurements of the Landé factors for holes in InAs QDs grown under different conditions (and

also with and without an InGaAs strain-reducing layer). We use photoluminescence (PL) as a function of magnetic field with circularly polarized light in order to measure the exciton g factor, and then by knowing the electron g from capacitance spectroscopy [1] we determine the Landé factor for the holes confined to the QDs. The presence of the strain-reducing layer leads to hole g values significantly higher than for the QDs capped with GaAs, contrary to what has been reported recently. The differences might reflect the degree of valence-band mixing due to the hole confinement potentials.

We acknowledge financial support from CNPq.

[1] G. Medeiros-Ribeiro, E. Ribeiro, and H. Westfahl Jr., Appl. Phys. A bf 77, 725 (2003)

TUE 55:

Exchange-correlation parametrizations effects in DMS: (Zn,Co)O and (Ga,Mn)As

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The idea to use the spin property of electrons in semiconductor electronic devices is considered as one of the promising trends for future electronics. It is expected that utilization of spin-related phenomena in information processing will extend the feasibility of electronics devices and allow development of new technological applications.

Recently we discussed the feasibility of Diluted Magnetic Seminconductor Heterostructures (DMH) based on (Zn,Co)O [4] and (Ga,Mn)As [5]. This is technologically sound since the characteristics of ZnO[1] such as easy growth, high solubility of transition metals ions (Co in this case) and the most important, presence of ferromagnetism at temperatures higher than 300 K turns it potentially appliable in opto-eletronical devices; and the GaAs, broadly used in atual eletronics, is a research target[2,3] because Mn substituting Ga have interesting characteristics such as be source of magnetic momentum and carriers acceptor, and news growth tecniques shows highers Curie temperatures (currently at 173 K) and in this material the ferromagnetism mediation is well defined.

As carriers concentrations the DMH are pretty high (in the order of 10^{19} - 10^{20} cm^{-3}, many-body corrections, and particularly exchange-correlation, play an important role. As there is a great number of exchange-correlation potential parameterizations, we studied their effects in the materials cited above, analysing the impact of those different parameterizations in the results. We did simulations with various Local Spin Density Approximation (LSDA) and Density Functional Theory (DFT) based exchange-correlation potential parameterizations. The results present a comparison of our previous results regarding the confinement of one-characteristic spin carriers, comparing their spin densities for all exchange-correlation parameterizations.

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TUE 56:

Magneto-transport Properties of GeMn Ferromagnetic Thin Films on GaAs

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It was shown recently, that using molecular beam epitaxy and under precise growth conditions of GeMn on Ge(001), spinodal decomposition induces the formation of self-organized, Mn rich, GeMn nanocolumns. Their diameter (3 to 10 nm) depends on the growth conditions and Mn concentration. Moreover, these layers exhibit ferromagnetism with a high Curie-temperature (M. Jamet et al., Nature Materials 5 (2006) 653), and a very strong Anomalous Hall Effect. Here we focus onto structures adapted to magneto-transport studies. Etching of pillars allowed us to study vertical transport, perpendicular to GeMn thin films grown on p-doped Ge substrates. For in-plane transport, we have grown GeMn on semi-insulating GaAs substrates. The morphology of the nanocolumns preserved in GeMn grown on GaAs strongly depends on the preparation of the GaAs surface. Disordered, non-parallel GeMn nanocolumns are obtained when initiating the growth on a rough GaAs surface obtained by thermal desorption of the oxide. The growth of a GaAs buffer layer allows us to start the growth of the GeMn layer on a flat, (2x4) reconstructed surface: then the growth characteristics dramatically improve, resulting in parallel GeMn nanocolums, well aligned along the growth direction. Magnetic properties improve accordingly and Anomalous Hall Effect is observed up to the critical temperature measured by magnetometry. The resulting changes in the magneto-transport properties will be also discussed.

TUE 57:

Modulating the Magnetic Properties of Poly(3-hexylthiophene) As A Function of Pressure

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Conducting polymers are interesting once it is possible to control their electronic properties from dielectric to metallic behavior. Indeed, at intermediate doping level they behave as semiconductor. In recent works we have study the magnetism properties poly(3-hexilthiophene),PHT. We have observed the ferromagnetic behavior in pressed PHT samples at room temperature. The magnetic moments in these polymers are associated with the formation of polarons and their magnetic interaction due to spin-spin exchange. In this work we have investigated the influence of the pressure used during the sample preparation on the magnetic properties of the PHT doped with ClO^4-. The polymer was prepared electrochemically in acetonitrile solution at E=1.60 V. After the that, the sample was partially reduced. Then, it was enclosed in a silicone die and isostatically pressed, in the form of pellets, using different pressures up to 1000 bar. Our results show that the sample prepared at 1000 bar exhibit a saturation magnetization, M_S, 10 times higher than the sample prepared in the form of powder. This behavior of M_S is possibly due to the increase in the crystalline portion and then to an enhancement of the intermolecular interaction by the pressure. These results open the viability of their application in spintronics devices once it is possible to control both the ferromagnetic properties and electronic conductivity.

TUE 58:

The Influence of the Morphology on the Magnetic Properties of Poly(3-hexylthiophene)

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Poly(3-hexylthiophene), PHT, electrical, and magnetic properties are sensible to the preparation conditions Additionally, the morphology,the chain length, and the dopant level affect the density of defects,leading to changes in the magnetic behavior. In this work, we present the changes in the magnetic properties of the PHT caused by introduction of small amount of water in the solution during the synthesis. The PHT samples were prepared electrochemically with the addition of water (0-400 ppm) in the acetonitrile solution during the synthesis. Then, the sample was partially reduced and isostatically pressed at 570 bar using a silicone die. Our results show that the saturation magnetization,M_S, at room temperature changes as the quantity of water used in the synthesis increases. The highest saturation magnetization were 0,0083 emu/g,with the addition of 200 ppm of water in the solution. After this point the M_S decreases. It well known that the for thiophene derivatives does not polymerize in aqueous solution due to the chain termination reaction. Therefore, it is expected that increasing the water content in the solution the polymer chain length decreases. After the maximum M_S observed for 200 ppm water addition, its decrease could be related to chain to

chain stereochemic array. These results open the viability of their application in spintronics devices once it is possible to modulate the ferromagnetic properties changing the preparation sample conditions.

TUE 59:

Strain Engineering of the Magnetocaloric Effect InMnAs Epilayers

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The magnetocaloric effect (MCE) is a magneto-thermodynamic process potentially interesting as an alternative to conventional refrigeration techniques, provided that materials with large MCE become available. This is the case of MnAs-based compounds such as bulk MnAs under hydrostatic pressure [1], Mn(1-x)Fe(x)As [2] and Mn(1-x)Cu(x)As [3], where cation substitution emulates a chemical pressure. In this work, we have investigated the impact of anisotropic strain on the MCE behaviour of 70-nm thick MnAs single-crystal epilayers grown on reconstructed (2x2) GaAs(111)B and c(4x4) GaAs(001) surfaces. The maximum magnetic entropy change for a field change of 5 T was 5.4 J/ kg K and 1.9 J/kg K for MnAs/GaAs(001) and MnAs/GaAs(111) epilayers, respectively. The temperature range, spread around room temperature, and the maximal MCE position are markedly different in the two epitaxial systems. These results illustrate how strain can be used to tune the MCE in materials with coupled structural and magnetic phase transition and suggest that the MCE of MnAs may find applications in microelectronic circuitry.

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TUE 60:

Magnetism in Mn-implanted CeO2 Films

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We report on the influence of Mn doping in the magnetic, structural and electronic properties of ceria (CeO2) films deposited by potentiostatic electrodeposition onto p-type Si(001) substrates. Depositions were performed at cathodic potential of -1.0 V (V versus Ag-AgCl reference electrode) from aqueous chloride-based solutions with addition of oxygen peroxyde to minimize CeIII / CeIV ion ratio. Mn-doped ceria films were obtained by ion implantation with ions of Mn implanted at 300 K with energy of 450 keV and dose 2×10^{16} Mn/cm^2. X-ray diffraction and selected area electron diffraction analyses reveal that both as-deposited and Mn-implanted films are nanocrystallines. X-ray photoelectron spectroscopy analyses reveal that the percentage of CeIII ions in as-deposited ceria films is 3.3 %, whereas Mn-implantated ceria films exhibit 22% of CeIII. These results are indicating that a non-negligible amount of oxygen vacancies are formed due to the implantation process. Mn-implanted films exhibit small remanence and coercivity at room temperature according to SQUID (superconducting quantum interference device) magnetometry. Since Mn-doping level is below the percolation threshold and Mn clustering leads to an antiferromagnetic behavior, the weak ferromagnetism is probably associated with an intrinsic exchange mechanism involving oxygen vacancies instead of incipient formation of secondary phases.

TUE 61:

Current Pumping From Spin Dynamics

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Spin Hall effect has recently been studied quite actively as a method for controlling magnetization by purely electric means combined with spin-orbit interaction. We here analyze theoretically its inverse effect, namely the inverse spin Hall effect [1-7]. We treat perturbatively both spin-orbit interaction and exchange interaction between conduction electrons and local spins. We calculate pumped currents analytically using nonequilibrium Green function, similarly to the case of a disordered two-dimensional electron gas system with Rashba spin-orbit interaction studied by Ohe *et al.* [8]. We assume general systems (three-dimensional metallic systems and semiconductors) [9], so this result can be applied to any cases. The effect we found can be useful as a novel battery mechanism due to dynamical spins without any electric voltage.

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TUE 62:

Ab Initio Study of Spin-dependent Electronic Transport Through Mn-doped Copper Nitride

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Much effort has been spent trying to characterize the transport properties of systems in order to build nanoscopic devices useful for potential applications in spintronics. Very recently, spin-dependent transport through nanomagnet has attracted a special attention. In this context the Mn doped CuN system shows great promise for this proposal. In this work, we have performed a study of electronic structure and magnetic property of the Mn atoms deposited on CuN system using the full-potential (linearized) augmented plane waves plus local orbitals (FPLAPW + lo) method within the local-density approximation (LDA) and the generalized gradient approximation (GGA). The electronic transport has also been calculated by non-equilibrium Green function. Our calculation indicates that the Mn atoms are embedded into a molecular network of polar covalently bonded Cu and N atoms within the CuN surface. The strong spin-polarized current due to large magnetic anisotropy of a single atomic spin embedded in a surface molecular network is found.

TUE 63:

Electrical Control of Single Spins in Coupled Double Quantum Dots

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The electronic [1], optical [2] and spin-dependent transport [3] properties of individual quantum dots doped with a single Mn atom has been studied. It was found that a versatile control of the number of carriers, spin, and the quantum confinement could lead to improved transport, optical and magnetic properties. In present paper, we have performed an investigation about sp-d exchange interaction between carriers and a single magnetic atom in coupled double II-IV quantum dots, using exact diagnolization method. We found

that the sp-d exchange interaction is very sensitive to the number of carriers, the dot coupling and the energy tuning between two-dots. We can open and close exchange interaction through changing the number of carriers. This operation can also be realized by changing energy tuning and/or quantum coupling. This opens a versatile way to manipulate spin states.

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TUE 64:

Effect of Dynamical Nuclear Polarization on the Transport Through Double Quantum Dots

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Recent transport experiments in double quantum dots show that Pauli exclusion principle plays an important role [1-5] in current rectification. Thus, these devices could behave as externally controllable spin-Coulomb rectifiers with potential application in spintronics as spin memories or transistors. We analyze the electronic transport through a double quantum dot in the regime where spin blockade occurs as a function of a DC magnetic field. Our model consists on rate equations for the charge occupations and nuclei spin polarizations in the quantum dots in the presence of Hyperfine interaction assisted by phonons, which are self-consistently solved. We analyze the current through a double quantum dot in a static magnetic field at different level detunings.The external field produces singlet-triplet crossings. At these crossings the current presents abrupt steps, which has been experimentally observed [2,4], due to spin electron-nucleus flip-flop mediated by Hyperfine interaction. The calculated current as a function of magnetic field, presents hysteresis which is explained in terms of the induced dynamical nuclear polarization by Hyperfine interaction.

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TUE 65:

Control of Spin in Quantum Dot Molecules

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One of the main issues in spintronics is control of spin. Here we show that applied fields, together with spin-orbit (SO) effects, allow us to control spin in quantum dot (QD) systems.The time evolution of two-electron QD molecules under strong harmonic electric fields is studied using the Floquet approach. We pay particular attention to the evolution of the spin states of the system, as the SIA (Rashba-type) and BIA (Dresselhaus-type) SO effects are known to introduce spin mixing. We determine the probability of finding one electron per QD. For a given tera-hertz electric field, spin-flips can be tuned with a perpendicular magnetic field in two coupled QD's, similarly to the single QD case [1]. These flips are quasi-periodic as well as the occupation probabilities of the dots. The conditions for their appearance are discussed by means of the quasi-energy spectra and the parameters of the fields.

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TUE 66:

Zitterwebegung in Spin-orbit Coupled Systems With Perpendicular Magnetic Field

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The *Zitterbewegung* is a purely relativistic quantum mechanics effect [1]. It manifests as an oscillatory motion of electronic wave packets and occurs due to the simultaneous existence of positive and negative energy solutions of Diracś equation. The phenomena has been also predicted to occur in semiconductor systems experiencing spin-orbit coupling effects [2], and its role on the cyclotron motion an magnetic focusing has been recently studied by Schliemann [3]. Here we investigate numerically the interplay of the Rashba and Dresselhaus spin-orbit interaction (SOI) on the *Zitterwebegung* effect in the presence of perpendicular magnetic fields. We have performed a spin-dependent extension of Goldberg et al. [4] numerical approach, used to study the time evolution of electronic wave packets in the presence scatterers, to explore the quantum dynamics of injected spin-polarized Gaussian electron wave packets into regions with competing Rashba and Dresselhaus SOI and in the presence of moderated magnetic fields. The time dependent spin-resolved electron probability distributions for the system are calculated and its connection with the *Zitterwebegung* is discussed.

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TUE 67:

Josephson Junctions With Spin Polarizing Quantum Point Contacts

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We consider a ballistic Josephson junction with a quantum point contact (QPC) in a two dimensional electron gas with Rashba spin-orbit coupling (SOC). It is known that a QPC with SOC can act as a spin filter, producing spin polarized currents when the electrodes are normal. For superconducting electrodes, the Andreev states in the normal region, are strongly modified by these 'spin-filtering' properties that preserve time reversal symmetry. In particular, the Andreev states are not longer spin degenerated while those that contribute the most to the superconducting current can have nearly the same in-plane spin projection.Here, we show how these properties manifest in the super current phase relation (CPR) when an in-plane magnetic field is applied. First, an anomalous current for zero phase difference between the superconducting electrodes appears. Second, and more remarkable, the CPR can be highly non-symmetric leading to the existence of two critical currents depending on the direction of the current flow. These junctions with large asymmetries could potentially be used as supercurrent rectifiers.

TUE 68:

Group-IV Based Diluted Magnetic Semiconductors: Spin Polarization

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Diluted magnetic semiconductors (DMS) have attracted considerable attention recently because they hold the promise of using electron spin, in addition to its charge, for creating a new class of spintronic semiconductor devices with unprecedented functionality. Recently several works point to ferromagnetism in group-IV semiconductors (Si, Ge and SiC), for which transition

metal (TM) ions have been used as spin injectors. In these systems the Curie temperature can reach high values, with some reports pointing towards values of TC = 350 K for Ge(Mn, Fe) films, and Tc > 400 K for nanocolumns of GeMn with 6 percent of manganese content. Although most of theoretical research on this problem has been directed towards understanding the origin of the ferromagnetism, there are still issues to be considered, such as the role played by the generation of p-type holes in magnetic multilayers. In this work we study the behavior of Si/(n x Si/Si:TM), Ge/(n x Ge/Ge:TM), Si/SiGe/(n x Si/Si:TM), Si/SiGe/(n x Si/SiGe:TM) and SiC/(n x SiC:TM) multiple quantum wells, where n is the number of DMS layers, with 25 percent of Si content in the SiGe alloys. We apply the k.p method, by carrying out self-consistent band-structure calculations within a multi-band 6 x 6 Luttinger Kohn model, in conjunction with the Poisson equation in order to calculate the electronic properties of these systems. We study the spin polarization in these systems as a function of the acceptor donor concentration.

TUE 69:

Electrodeposition of Vox Films on Si(111)

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In this work is reported the structural and electronic properties of vanadium oxide (VOx) thin films prepared by potentiostatic electrodeposition on Si(111) substrates. Physical properties of vanadium oxides are strongly dependent of the stoichometry. For example, V2O5 is a semiconductor with an energy bandgap around 2.4 eV, whereas VO2 is an insulator at room temperature and an oxide metallic above 68 °C. For these reasons, VOx/Si hybrid systems motivated the research towards novel optical-electronic devices. Transparent vanadium oxide thin films were obtained from aqueous solutions of vanadium oxide sulfate (VOSO4) at cathodic potential of -1.3 V (V versus Ag-AgCl reference electrode). Whereas X-ray photoelectron spectroscopy analyses indicate the presence of the V2O5 phase in the deposits, scanning electron microscopy with energy dispersive spectroscopy analyses reveal that different microstructural regions (plates and granules) having distinct V/O ratio. Since x-ray diffraction (XRD) measurements show that as-deposited films are amorphous, thermal treatments were performed. For samples annealed at a pressure of 10-6 mbar for 5 hours at 400 oC, XRD measurements reveal that amorphous films become polycrystalline. In conclusion, the preparation of vanadium oxide films directly integrated on Si(111) using electrochemical method is demonstrated.

TUE 70:

Electronic Properties of Heterostructures Based on Nitrides and Oxides Derived Compounds

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The wide band gap semiconductor materials derived from the group-III nitrides and their alloys (AlN, GaN, InN, AlInN, InGaN), and from oxides such as ZnO and ZnMgO have been widely studied, due to their technological importance in the production of electronic, optoelectronic, as well as in spintronics devices. [1,2] In this work we present a systematic investigation of undoped and doped heterostructures such as AlGaN/GaN:Si, InN/AlInN:Si, and ZnO/ZnMgO:Al quantum wells (QWs) and multiple (QWs) for different structural configurations and several doping concentrations. The calculations are performed within the effective mass approximation by solving self-consistently the Schoedinger and Poisson equations. The dependence of the electronic structure of the systems on the various different parameters utilized is discussed.

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TUE 71:

GaN:MnCo As a Possible Spin-polarized Antiferromagnetic Diluted Magnetic Semiconductor.

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Diluted magnetic semiconductor (DMS) based on GaN have attracted great attention recently because it was predicted to present room temperature ferromagnetism (RT-FM) [1]. In addition to the usual FM DMS, in 2006 Akai and Ogura [2] proposed and demonstrated that ZnS doped with two different transition metals (TM) atoms can be at the same time antiferromagnetic (AFM) and half-metallic (HM) (100 percente of spin polarization). HM-AFM could be even more useful than HM ferromagnets [3]. In this work we applied the proposal of Akai and Ogura in the case of GaN, studying the quaternary $Ga_yMn_xCo_{1-y-x}N$ DMS. We perform spin density functional theory using the VASP code [3]. Firstly, we observed that for 3 percente of Mn and 3 percente of Co in GaN, the ground state is AFM and HM. However this simple model does not consider direct interaction between pairs of the same TM and others statistical effects. In order to include these possibilities, we used a modified version of Generalized Quasi-Chemical Approach-GQCA [4], simulating a diluted alloy (no cluster formation). Our GQCA results show that the ground state of $Ga_{0.94}Co_{0.03}Mn_{0.03}N$ alloy is still AFM but now the spin polarization is decreased to about 40 percente in the usual growth temperatures.

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TUE 72:

Enhancement of Sensitivity of Detection of Kerr Rotation by Time Averaging

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Steady-state electrical spin injection in Si has been optically detected by circularly polarized photoluminescence (PL) at low temperatures up to 125 K [1]. At higher temperatures, Kerr rotation (KR) is a better probe of spin polarization than PL since KR is independent of the radiative efficiency of the carriers. However the indirect bandgap of Si, the angular momentum carried by the phonon involved in an optical transition, and steady-state conditions, act to suppress the optical spin signal compared to a conventional time-resolved measurement in a direct bandgap semiconductor. Hence, extending the sensitivity of detection of KR beyond the present 2×10^{-7} radians [2] may be needed to optically detect a room temperature spin signal from Si. Here, we describe a stabilized KR pump-probe setup whose sensitivity has been enhanced, by time averaging using the concept of Allan variance, to 10^{-8} radians. We show that our setup detects a steady-state KR at that level, due to weak optical pumping in the well-studied GaAs system, at 300 K, which agrees with calculation. The stability of our setup was aided by the double modulation of the pump diode laser (i.e. chopping in addition to polarization modulation). This resulted in the electromagnetic coupling of the photoelastic modulator directly on to the probe diode laser being rejected.

[1]. B. T. Jonker et al., Nature Phys. 3, 542 (2007)
[2]. S. A. Crooker et al., IEEE J. Sel. Top. Quantum Electron. 1, 1082 (1995)

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