Institute of Molecular Physics, Polish Academy of Sciences
Faculty of Physics, Adam Mickiewicz University

The European Conference
PHYSICS OF MAGNETISM 2014 (PM'14)

ABSTRACTS

Poznań 2014

The European Conference
PHYSICS OF MAGNETISM 2014 (PM'14)
June 23-27, 2014
Poznań, Poland
Abstracts

Edited by: B. Idzikowski, R. Micnas, P. Leśniak, A. Szajek

The abstracts are reproduced as received from authors

ISBN 83-922407-9-0

Published by: Institute of Molecular Physics
Polish Academy of Sciences
M. Smoluchowskiego 17, 60-179 Poznań
phone: +48 61 8695 100; fax: +48 61 8648 524

Technical edition using LaTeX: P. Leśniak

Printed by: Perfekt Gaul i wspólnicy sp.j., Świerzawska 1, 60-321 Poznań, Poland

The European Conference

PHYSICS OF MAGNETISM 2014

June 23-27, 2014
Poznań, Poland

CHAIRMEN

B. Idzikowski, Institute of Molecular Physics, Polish Academy of Sciences
R. Micnas, Faculty of Physics, Adam Mickiewicz University

PROGRAMME COMMITTEE

C. Back, Regensburg, Germany
J. Barnaś, Poznań, Poland
A. Barthélémy, Palaiseau, France
K.W. Becker, Dresden, Germany
H.T. Diep, Pontoise, France
T. Dietl, Warszawa, Poland
J. Furdyna, Notre Dame, USA
P. Grünberg, Jülich, Germany
P. Horsch, Stuttgart, Germany
J. Kossut, Warszawa, Poland
R.K. Kremer, Stuttgart, Germany
C. Lambert, Lancaster, U.K.
L.W. Molenkamp, Würzburg, Germany
J.A. Morkowski, Poznań, Poland
H. Ohno, Sendai, Japan
H. Puszkarski, Poznań, Poland
G.A. Sawatzky, Vancouver, Canada
D.J. Singh, Oak Ridge, USA
F. Steglich, Dresden, Germany
H. Szymczak, Warszawa, Poland
K.I. Wysokiński, Lublin, Poland

ADVISORY COMMITTEE

F. Aliev, Madrid, Spain
J. Baszyński, Poznań, Poland
B. Bułka, Poznań, Poland
R. Czajka, Poznań, Poland
O. Eriksson, Uppsala, Sweden
R. Gałązka, Warszawa, Poland
G. Gubbiotti, Perugia, Italy
A. Jezierski, Poznań, Poland
S. Jurga, Poznań, Poland
G. Kamieniarz, Poznań, Poland
L. Kowalewski, Poznań, Poland
S. Krompiewski, Poznań, Poland
J. Martinek, Poznań, Poland
M. Maśka, Katowice, Poland
A. Maziewski, Białystok, Poland
M. Przybylski, Halle, Germany
R. Puźniak, Warszawa, Poland
S. Robaszkiewicz, Poznań, Poland
K. Rogacki, Wrocław, Poland
U.K. Rößler, Dresden, Germany
I. Škorvánek, Košice, Slovakia
F. Stobiecki, Poznań, Poland
R. Świetlik, Poznań, Poland
A. Szytuła, Kraków, Poland
D.A. Tennant, Oak Ridge, USA
A. Thiaville, Orsay, France
A. Wójcik, Poznań, Poland

ORGANIZING COMMITTEE

A. Szajek (secretary), **T. Toliński** (treasurer)
M. Bąk, I. Gościańska, P. Grzybowski, A. Józefczak, D. Krychowski, P. Kuświk, P. Leśniak, M. Lewandowski, S. Lipiński, G. Musiał, M. Nogala, M. Nowak, I. Olejniczak, M. Pugaczowa-Michalska, M. Sidowski, P. Skusiewicz, P. Stefański, K. Synoradzki, M. Thomas, M. Zwierzycki

PUBLICATIONS

R.J. Wojciechowski, L. Smardz, I. Weymann

AWARDS JURY

G. Cuniberti, Dresden, Germany (chairman)
I. Bakonyi, Budapest, Hungary
S. Lipiński, Poznań, Poland
J. Ranninger, Grenoble, France
A. Ślebarski, Katowice, Poland
P. Stefański, Poznań, Poland

SPONSORS

Institute of Molecular Physics of the Polish Academy of Sciences

Faculty of Physics, Adam Mickiewicz University

Committee of Physics of the Polish Academy of Sciences

The Rector of the Adam Mickiewicz University

Wielkopolska Centre for Advanced Technologies

Polish Physical Society - Poznań Branch

NanoBioMedical Centre, Adam Mickiewicz University

Central European Exchange Program for University Studies

Bureau for academic recognition and international exchange

KOMPANIA PIWOWARSKA

Quo Vadis Polonia

European Physical Society

SCHEDULE

Monday, June 23, 2014

8^{30} - 12^{00} registration

12^{00} - 12^{30} **OPENING**
B. Idzikowski, R. Micnas

S.1 RECENT DEVELOPMENTS IN SPINTRONICS AND MAGNETIC SEMICONDUCTORS
Chairmen: R. Micnas, B. Idzikowski

12^{30} - 13^{05} **S. Maekawa** Advanced Science Research Center, Japan Atomic Energy Agency, Tokai, Japan
Power Spintronics

13^{05} - 13^{40} **M.R. Wegewijs** Forschungzentrum Jülich and RWTH Aachen University, Jülich/Aachen, Germany
Magnetic anisotropy goes spintronic

13^{40} - 14^{15} **T. Wojtowicz** Institute of Physics, Polish Academy of Sciences, Warszawa, Poland
Spintronic research with (Cd,Mn)Te-based diluted magnetic semiconductor quantum structures

14^{15} - 15^{30} lunch

15^{30} - 16^{30} **ORAL SESSION 1**
(Auditorium Max) **Strongly Correlated Electrons and High Temperature Superconductivity**
Chairman: K. Rogacki
O-1-05, O-1-01, O-1-03, O-1-04
(Auditorium A) **Nano-structure, Surfaces, and Interfaces**
Chairman: A. Jezierski
O-5-01, O-5-11, O-5-12, O-5-13
(Auditorium B) **Magnetic Structure and Dynamics**
Chairman: S. Krompiewski
O-3-03, O-3-05, O-3-09, O-3-07

16^{30} - 16^{50} coffee break

S.2 SPIN ELECTRONICS
Chairman: V. Franco

16^{50} - 17^{25} **J. Dubowik** Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland
Micromagnetic approach to exchange bias

17^{25} - 18^{00} **T. Stobiecki** Department of Electronics, AGH University of Science and Technology, Kraków, Poland
Magnetic Tunnel Junctions for spintronics applications

18^{00} - 18^{35} **J.-P. Ansermet** Laboratoire de Physique des Matériaux Nanostructurés, Lausanne, Switzerland
Magnetization dynamics under heat currents

18^{35} - 19^{00} *ca.* 20 min. passage to WCAT labs

19^{00} - 20^{00} WCAT labs tour

20^{00} - **welcome party**

Tuesday, June 24, 2014

S.3 CORRELATED ELECTRON METALS, MOLECULAR MAGNETISM AND MOLECULAR SPINTRONICS

Chairman: D. van der Marel

8^{30} - 9^{05} **K. Bedell** Department of Physics, Boston College, Chestnut Hill, USA

The Higgs amplitude mode in ferromagnetic metals

9^{05} - 9^{40} **B. Keimer** Max Planck Institute for Solid State Research, Stuttgart, Germany

Spin and charge correlations in two-dimensional correlated-electron metals

9^{40} - 10^{15} **E. Coronado** Instituto de Ciencia Molecular, Universidad de Valencia, Burjasot, Spain

From Molecular Magnetism to Molecular Spintronics

10^{15} - 10^{45} coffee break

S.4 MOSTLY TOPOLOGICAL INSULATORS AND NOVEL SUPERCONDUCTORS

Chairman: G. Cuniberti

10^{45} - 11^{20} **T. Story** Institute of Physics, Polish Academy of Sciences, Warszawa, Poland

Electron and spin properties of topological crystalline insulator $Pb_{1-x}Sn_xSe$

11^{20} - 11^{55} **A. Bansil** Physics Department, Northeastern University, Boston, USA

Recent progress in modeling electronic structure and spectroscopy of topological insulators and novel superconductors

11^{55} - 12^{30} **H. Hahn** Institute of Nanotechnology, Karlsruhe Institute of Technology, Karlsruhe, Germany

Tailoring and tuning of magnetism in nanostructures

12^{30} - 13^{05} **P. Kopčanský** Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovak Republic

How to induce high sensitivity of liquid crystal to external magnetic field?

13^{05} - 14^{20} lunch

Tuesday, June 24, 2014

14^{20} - 15^{35} **ORAL SESSION 2**

(Auditorium Max) **Strongly Correlated Electrons and High Temperature Superconductivity**

Chairman: J. Kossut

O-1-08, O-1-09, O-1-11, O-1-13, O-1-14

(Auditorium A) **Nano-structure, Surfaces, and Interfaces**

Chairman: K. Tomala

O-5-08, O-5-06, O-5-03, O-5-04, O-5-10

(Auditorium B) **Spin Electronics and Magneto-Transport; Applications**

Chairman: J.-P. Ansermet

O-4-02, O-4-04, O-7-01, O-7-02, O-7-03

15^{35} - 16^{00} coffee break

16^{00} - 17^{30} **ORAL SESSION 3**

(Auditorium Max) **Mostly Strongly Correlated Electrons and High Temperature Superconductivity**

Chairman: S. Robaszkiewicz

O-1-02, O-1-06, O-1-10, O-1-12, O-4-03, O-6-05

(Auditorium A) **Magnetic Structure and Dynamics**

Chairman: R. Puźniak

O-3-01, O-3-02, O-3-04, O-3-06, O-3-08, O-3-11

(Auditorium B) **Mostly Nano-structure, Surfaces, and Interfaces**

Chairman: M.R. Wegewijs

O-5-02, O-5-05, O-5-07, O-5-09, O-8-01, O-8-02

17^{30} - 19^{00} **POSTER SESSION I** (categories: 1, 4, 5, 8)

Chairmen: A. Sherman, M. Wójcik, D. Legut, R. Raimondi, M. Šob, M. Urbaniak, B. Dąbrowski, W. Florek

Wednesday, June 25, 2014

S.5 NEW DIRECTIONS IN STRONGLY CORRELATED MATTERS

Chairman: J. Ranninger

8^{30} - 9^{05} **A.M. Oleś** Marian Smoluchowski Institute of Physics, Jagiellonian University, Kraków, Poland

Frustration and Entanglement in Spin-Orbital Models

9^{05} - 9^{40} **P. Mendels** Laboratoire de Physique des Solides, Université Paris-Sud, Orsay, France

Quantum Kagome Spin Liquids

9^{40} - 10^{15} **M. Vojta** Theoretical Solid State Physics, Dresden University of Technology, Dresden, Germany

Dirty magnets: From fractional moments to cluster spin glasses

10^{15} - 10^{35} conference photo

10^{35} - 11^{05} coffee break

S.6 MOSTLY SPIN ELECTRONICS

Chairman: J. Barnaś

11^{05} - 11^{40} **A. Bonanni** Institute for Semiconductor and Solid State Physics, Johannes Kepler University, Linz, Austria

Physics of magnetism in GaN doped with transition metals

11^{40} - 12^{15} **B. Dlubak** Unité Mixte de Physique CNRS/Thales & Université Paris-Sud, France

Graphene: new venues for spintronics

12^{15} - 12^{50} **M. Fähnle** Max Planck Institute for Intelligent Systems, Stuttgart, Germany

Theory of ultrafast demagnetization after femtosecond laser pulses

12^{50} - 13^{25} **P. Tomczak** Faculty of Physics, Adam Mickiewicz University, Poznań, Poland

How do we measure bipartite entanglement for Heisenberg antiferromagnets?

13^{25} - 14^{40} lunch

Wednesday, June 25, 2014

14^{40} - 16^{10} **ORAL SESSION 4**

(Auditorium Max) **Spin Electronics and Magneto-Transport**
Chairman: R. Allenspach
O-4-01, O-4-05, O-4-06, O-4-07, O-4-08, O-4-09

(Auditorium A) **Quantum and Classical Spin Systems**
Chairman: G. Kamieniarz
O-2-01, O-2-02, O-2-03, O-2-04, O-2-05, O-2-06

(Auditorium B) **Mostly Soft and Hard Magnetic Materials**
Chairman: B. Bułka
O-6-01, O-6-02, O-6-03, O-6-04, O-3-10, O-1-07

16^{10} - 16^{30} coffee break

16^{30} - 17^{50} **SESSION OF SCIENTIFIC EXHIBITORS**
Chairman: P. Kuświk

17^{50} - 18^{10} transportation to the concert hall

19^{00} - **concert**

Thursday, June 26, 2014

S.7 STRONGLY CORRELATED ELECTRONS AND HIGH TEMPERATURE SUPERCONDUCTIVITY

Chairman: K. Miyake

8^{30} - 9^{05} **J. Ranninger** Néel Institute, Department Condensed Matter - Low Temperatures, CNRS, Grenoble, France

High T_c superconductivity and metastability

9^{05} - 9^{40} **J. Spałek** Marian Smoluchowski Institute of Physics, Jagiellonian University, Kraków, Poland

Real space pairing in high temperature superconductors and heavy fermions: Beyond renormalized mean-field theory and comparison to experiment

9^{40} - 10^{15} **J.F. Annett** H.H. Wills Physics Laboratory, University of Bristol, Bristol, United Kingdom

Spin-flipping with conical magnets: Superconducting Proximity effects in bi- and multilayers

10^{15} - 10^{45} coffee break

S.8 STRONGLY CORRELATED OXIDES

Chairman: J. Furdyna

10^{45} - 11^{20} **D. van der Marel** University of Geneva, DPMC, Geneva, Switzerland

Optical properties of lattice tuned $RNiO_3$

11^{20} - 11^{55} **V. Franco** Condensed Matter Physics Department, Sevilla University, Sevilla, Spain

The magnetocaloric effect: A useful tool for the characterization of phase transitions

11^{55} - 12^{30} **S. Wilkins** Brookhaven National Laboratory, Upton, USA

Electronic textures in strongly correlated oxides

12^{30} - 13^{45} lunch

13^{45} - 15^{15} **POSTER SESSION II** (categories: 2, 3, 6, 7)
Chairmen: P. Rusek, M. Zwierzycki, J. Deniszczyk, A. Hoser, P. Gębara, J. Kováč, M. Timko, P. Wiśniowski

15^{15} - 15^{30} departure to Lednica

visit to the Museum of the First Piasts

banquet with themed historical show

Friday, June 27, 2014

S.9 MAGNETIC NANOSTRUCTURES, MOLECULAR MAGNETS

Chairman: K.I. Wysokiński

8^{30} - 9^{05} **G. Cuniberti** Institute for Materials Science, Dresden University of Technology, Dresden, Germany

Spin selective transport through helical molecular systems

9^{05} - 9^{40} **R. Allenspach** IBM Research–Zurich, Rüschlikon, Switzerland

Static and dynamic properties of magnetic domain walls

9^{40} - 10^{15} **M.G. Cottam** Department of Physics and Astronomy, University of Western Ontario, London, Canada

Spin-wave instability theory for ferromagnetic nanostructures

10^{15} - 10^{50} **A. Garg** Department of Physics and Astronomy, Northwestern University, Evanston, USA

Collective Relaxational Dynamics in Molecular Nanomagnets

10^{50} - 11^{20} coffee break

S.10 SUPERCONDUCTIVITY, KONDO EFFECTS, QUANTUM CRITICALITY AND HEAVY FERMIONS

PROFESSOR BERNARD COQBLIN MEMORIAL SESSION

Chairman: J. Morkowski

11^{20} - 11^{55} **K. Miyake** Toyota Physical and Chemical Research Institute, Nagakute, Japan

Kondo Effects without Magnetic Degrees of Freedom

11^{55} - 12^{30} **A. Ślebarski** Institute of Physics, University of Silesia, Katowice, Poland

Properties near magnetic instability of heavy-electron compounds $Ce_3M_4Sn_{13}$ and $La_3M_4Sn_{13}$, with M = Co, Rh, and Ru

12^{30} - 13^{05} **D. Kaczorowski** Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland

Quantum critical superconductivity in f-electron systems

13^{05} - 14^{00} **SUMMARY and CLOSING**
B. Idzikowski, R. Micnas

14^{00} - lunch

INVITED LECTURES

Monday, June 24, 2014

Power Spintronics

Sadamichi Maekawa[1]

[1] *Advanced Science Research Center, Japan Atomic Energy Agency, Tokai 319-1195, Japan*

Spintronics is not just a new type of electronics in the 21th century [1,2] but provides a variety of possibilities for energy conversions [3,4]. The spin motive-force converts magnetic energy into electricity, and spin Seebeck effect does heat to electricity via spin current. These conversions are called "power spintronics" which is a new challenge in physics. I would like to present "power spintronics" and its future.

References:

[1] *Concepts in Spin Electronics*, ed. S. Maekawa (Oxford University Press, 2006).
[2] *Spin Current*, eds. S. Maekawa *et al.*, (Oxford University Press, 2012).
[3] S. E. Barnes and S. Maekawa: Phys. Rev. Lett. 98, 246601 (2007).
[4] S. Maekawa *et al.*, J. Phys. Soc. Jpn. 82, 102002 (1-23) (2013).

Monday, June 24, 2014

Magnetic anisotropy goes spintronic

Maarten R. Wegewijs[1,2,3]

[1] *Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany*

[2] *JARA-Fundamentals of Future Information Technology*

[3] *Institute for Theory of Statistical Physics, RWTH Aachen, 52056 Aachen, Germany*

Magnetic anisotropy of quantum spins as found in magnetic atoms and single-molecule magnets has traditionally been considered an intrinsic effect, generated locally by the combination of spin-orbit coupling and ligand field effects. In this talk I will show that magnetic anisotropy can, however, appear in a new way as a transport quantity, even in a very simple a spin-isotropic quantum dot supporting a spin-1 which is exposed to the influence of magnetic electrodes. Much like spin-polarization transport, spin-anisotropy transport has two main aspects:

First, magnetic anisotropy is shown to appear as a dissipative transport quantity which is able to "get stuck" in a system, quite similar to how spin accumulates in a spin-valve. This idea is made precise by continuity equations that relate an accumulation of the spin-quadrupole moment tensor to corresponding currents [1]. The latter new tensor-valued currents describe the flow of magnetic anisotropy, very similar to how spin-currents describe the flow of the vectorial quantity of spin-polarization. I will show how measurable charge transport in a quantum-dot spin-1 valve depends on this flow and accumulation of spin-anisotropy [2].

Second, magnetic anisotropy can also be generated by coherent transport processes, resulting in a proximity effect, much like that responsible for the well-known (dipolar) exchange field, an effective magnetic field which allows for control over spin-1/2 quantum dot spin-valves, even in the time-domain [3]. The most dramatic illustration of this kind of "quadrupolar proximity effect" is the generation "from scratch" of a magnetic anisotropy term in the effective Hamiltonian of a spin-1 quantum dot. This turns an isotropic spin-1 system into a full-blown single-molecule magnet with electrically controllable magnetic bistability [4]. The magnitude of the proximity-induced spin-reversal barrier can match that of state-of-the art single-molecule magnets.

References:

[1] M. Hell, S. Das, and M. R. Wegewijs. Transport of spin-anisotropy without spin currents, Phys. Rev. B, 88:115435, 2013.

[2] M. M. E. Baumgärtel, M. Hell, S. Das, and M. R. Wegewijs. Transport and accumulation of spin anisotropy, Phys. Rev. Lett., 107:087202, 2011.

[3] M. Hell, B. Sothmann, M. Leijnse, M.R. Wegewijs, and J. König. Spin resonance without spin splitting, arXiv:1403.4002, 2014.

[4] M. Misiorny, M. Hell, and M. R. Wegewijs. Spintronic magnetic anisotropy, Nature Phys., 9:801, 2013.

Monday, June 24, 2014

Spintronic research with (Cd,Mn)Te-based diluted magnetic semiconductor quantum structures

T. Wojtowicz

Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Modern applications of II-Mn-VI diluted magnetic semiconductors in spintronic research was limited by the unavailability of appropriate nanostructures with sufficient quality. In my talk I will review recent progress in MBE technology of (Cd,Mn)Te-based nanostructures containing two dimensional electron gas (2DEG) and will discuss already demonstrated applications of such high mobility magnetic-2DEG for: a) THz and microwave radiation induced zero-bias generation of pure spin currents and very efficient magnetic field induced conversion of them into spin polarized electric current [1]; b) clear demonstration of THz radiation from spin-waves excited in DMS via efficient Raman generation process [2]; c) experimental demonstration of working principles of a new type of spin transistor based on controlling the spin transmission via tunable Landau-Zener transitions in spatially modulated spin-split bands [3].

References:

[1] S. D. Ganichev et al., Phys. Rev. Lett. 102, 156602 (2009).
[2] R. Rungsawang et al., Phys. Rev. Lett. 110, 177203 (2013).
[3] C. Betthausen et al., Science 337, 324 (2012).

Work partially supported by NCN(Poland) grant 2012/06/A/ST3/00247 and by the EU through the Innovative Economy Grant POIG.01.01.02-00-008/08.

Monday, June 24, 2014

Magnetization dynamics under heat currents

Jean-Philippe Ansermet[1]

[1] *LPMN, Ecole Polytechnique Fédéréale de Lausanne, station 3, 1015 Lausanne-EPFL*

I will report on various studies conducted by my group, the aim of which was to characterize and understand how a heat current can affect magentization.
In a metallic spin valve, a heat current was shown to change the switching field. This effect could be accounted for quantitaively by a three current model : curents of spin up, spin down, and heat.
In an insulator, we identified on a theoretical basis the existence of a magnetic equivalent to the Seebeck effect. This effect occurs only when magnetization is out of equilibrium. We found clear evidence for it by propagating spin waves into or against temeprature gradients in YIG.
Recent results will be reported.

Monday, June 24, 2014

Micromagnetic approach to exchange bias

J. Dubowik,[1] and I. Gościańska[2]

[1] *Institute of Molecular Physics, PASci, M. Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *Faculty of Physics, A. Mickiewicz University, Umultowska 85, 61-614, Poznań, Poland*

We present a micromagnetic approach to the exchange bias (EB) in ferromagnetic (FM)/antiferromagnetic (AFM) thin film systems with a small number of irreversible interfacial magnetic spins. We express the exchange bias field H_{EB} in terms of the fundamental micromagnetic length scale – the exchange length l_{ex}. The benefit from the proposed approach is a better separation of the factor related to the FM from the factor related to the FM/AFM coupling at interfaces. The model identifies the range of H_{EB} (and interfacial exchange coupling energy J_{EB}) compatible with those observed in experiment. Using the model, we proved that the highest effective number of irreversible spins is lower than $\sim$ 30–40 %.

Monday, June 24, 2014

Magnetic Tunnel Junctions for spintronics applications

Tomasz Stobiecki[1]

[1] *AGH University of Science and Technology, Department of Electronics, al. Mickiewicza 30, 30-059 Kraków, Poland*

High density spin-polarized current passed through MTJ nanopillar can affect the local magnetization using the Spin Transfer Torque (STT) effect. This effect can induce either precession of magnetization (microwave ST-oscillator) or switch the magnetization of the free layer (STT-RAM). The STT-RAM cell is characterized by low power consumption and better thermal scalability in comparison to conventional MRAM. Crucial issues of STT in MTJs are a reduction of the critical current density that is able to switch the magnetization, which is possible for example by using interfacial perpendicular anisotropy of ferromagnetic electrodes or optimizing the thickness of MgO tunnel barrier. The application of RF current to MTJ generate DC voltage across the device, when the frequency is in resonance with resistance oscillations (spin diode effect), arising from the ST. Such spin torque ferromagnetic resonance (ST-FMR) excitation in a MTJ nanopillar, as well as an inverse effect, i.e., generation of the RF signal, provide potential application in the telecommunications technology. In addition, the dynamics of MTJs, controlled by electric field will be also discussed in this presentation.

The project is supported by grants: 2012/04/M/ST7/00799 and PSPB-045/2010.

Tuesday, June 25, 2014

The Higgs Amplitude mode in Ferromagnetic Metals

Yi Zhang,[1] Henrique B. Brentan,[2] Paulo F. Farinas,[2] and Kevin S. Bedell[1]

[1] *Department of Physics, Boston College, Chestnut Hill, Massachusetts 02467, USA*

[2] *Departamento de Física, Universidade Federal de São Carlos, 13565-905, São Carlos, SP, Brazil*

Using Ferromagnetic Fermi liquid (FFL) theory, Bedell and Blagoev derived the collective low-energy excitations of a weak ferromagnet. They obtained the well-known magnon (Nambu-Goldstone) mode and found a new gapped mode that was never studied (or seen) in weak ferromagnetic metals. Recently we have identified this mode as the Higgs boson (amplitude mode) of a ferromagnetic metal. This is identified as the Higgs amplitude mode since it can be show that it corresponds to a fluctuation of the amplitude of the order parameter and it is a propagating mode. We use the FFL theory to describe the single particle and collective excitations of the itinerant-electron ferromagnetic material MnSi. By fitting the model with the existing experimental results, we calculate the dynamical structure function and see well-defined peaks contributed from the magnon and the Higgs. Our estimates of the relative intensity of the Higgs amplitude mode suggest that it can be seen in neutron scattering experiments on MnSi. The influence an external magnetic field will have upon these results is also investigated.

Tuesday, June 25, 2014

Spin and charge correlations in two-dimensional correlated-electron metals

B. Keimer[1]

[1] *Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany*

This talk will provide an overview of spectroscopic experiments on the electronic properties copper-oxide high-temperature superconductors, focusing on recent insights into spin and charge ordering and their competition with superconductivity [1-5]. We will compare and contrast the results with related experiments on spin, charge, and orbital correlations in nickel-oxide superlattices grown by pulsed laser deposition and molecular beam epitaxy [6-9]. The talk will conclude by outlining perspectives for the control of electron correlations in two-dimensional metals.

References:

[1] G. Ghiringhelli, M. Le Tacon, M. Minola, S. Blanco-Canosa, C. Mazzoli, N. B. Brookes, G. M. De Luca, A. Frañó, D. G. Hawthorn, F. He, T. Loew, M. Moretti Sala, D. C. Peets, M. Salluzzo, E. Schierle, R. Sutarto, G. A. Sawatzky, E. Weschke, B. Keimer, L. Braicovich, Science 337, 821 (2012).

[2] S. Blanco-Canosa, A. Frano, T. Loew, Y. Lu, J. Porras, G. Ghiringhelli, M. Minola, C. Mazzoli, L. Braicovich, E. Schierle, E. Weschke, M. Le Tacon, B. Keimer. Phys. Rev. Lett. 110, 187001 (2013).

[3] M. Bakr, S. M. Souliou, S. Blanco-Canosa, I. Zegkinoglou, H. Gretarsson, J. Strempfer, T. Loew, C.T. Lin, R. Liang, D. A. Bonn, W. N. Hardy, B. Keimer, M. Le Tacon, Phys. Rev. B 88, 214517 (2013).

[4] M. Le Tacon, A. Bosak, S. M. Souliou, G. Dellea, T. Loew, R. Heid, K-P. Bohnen, G. Ghiringhelli, M. Krisch, B. Keimer, Nature Phys. 10, 52 (2014).

[5] R. Comin, A. Frano, M. M. Yee, Y. Yoshida, H. Eisaki, E. Schierle, E. Weschke, R. Sutarto, F. He, A. Soumyanarayanan, Yang He, M. Le Tacon, I. S. Elfimov, J. E. Hoffman, G. A. Sawatzky, B. Keimer, A. Damascelli, Science 343, 390 (2014).

[6] A.V. Boris A. V. Boris, Y. Matiks, E. Benckiser, A. Frañó, P. Popovich, V. Hinkov, P. Wochner, M. Castro-Colin, E. Detemple, V. K. Malik, C. Bernhard, T. Prokscha, A. Suter, Z. Salman, E. Morenzoni, G. Cristiani, H.-U. Habermeier, B. Keimer, Science 332, 937 (2011).

[7] E. Benckiser, M. W. Haverkort, S. Brück, E. Goering, S. Macke, A. Frañó, X. Yang, O. K. Andersen, G. Cristiani, H. U. Habermeier, A. V. Boris, I. Zegkinoglou, P. Wochner, H. J. Kim, V. Hinkov, B. Keimer, Nature Mater. 10, 189 (2011).

[8] M. Wu, E. Benckiser, M. W. Haverkort, A. Frano, Y. Lu, N. Nwanko, S. Brück, P. Audehm, E. Goering, S. Mache, V. Hinkov, P. Wochner, G. Christiani, S. Heinze, G. Logvenov, H.-U. Habermeier, B. Keimer, Phys. Rev. B 88, 125124 (2013).

[9] A. Frano, E. Schierle, M. W. Haverkort, Y. Lu, M. Wu, S. Blanco-Canosa, U. Nwankwo, A. V. Boris, P. Wochner, G. Cristiani, H. U. Habermeier, G. Logvenov, V. Hinkov, E. Benckiser, E. Weschke, B. Keimer, Phys. Rev. Lett. 111, 106804 (2013).

Tuesday, June 25, 2014

From Molecular Magnetism to Molecular Spintronics

Eugenio Coronado[1]

[1] *Instituto de Ciencia Molecular (ICMol). Universidad de Valencia (Spain)*

Spin-based electronics is one of the emerging branches in today's nanotechnology and the most active area within nanomagnetism. So far spintronics has been based on conventional materials like inorganic metals and semiconductors. Still, molecular electronics emerged several decades ago as a promising possibility to complement or even to replace conventional inorganic electronics when it goes nano. On the other hand, molecular magnetism has provided in recent years many examples of new magnetic molecules and multifunctional materials with tunable magnetic properties or combination of properties. In this context, molecular spintronics has recently appeared as a new field at the intersection of these two molecular fields. Its final aim is that of using molecule-based materials, or even single-molecules, as components of new spintronic systems and devices [1].

In this talk I will show with different examples taken from my own research the main advances in this new area. The first example will deal with the use of single-molecule magnets as qubits in quantum computing [2]. The second example will concern the electrical addressing of the spin in molecular nanoobjects [3]. The third example will focus on the chemical design of nanostructured layered materials exhibiting multifunctional properties, in particular magnetism and electric conductivity [4]. Finally, I will show the possibility of designing multifunctional molecular devices combining luminescence and spin-valve properties (i.e., Spin-OLEDs).

References:

[1] J. Camarero, E. Coronado, J. Mater. Chem. 19, 1678 (2009).
[2] J. M. Clemente-Juan, E. Coronado, A. Gaita-Ariño, Chem. Soc. Rev. 41, 7464 (2012).
[3] F. Prins, et al. Adv. Mater. 23, 1545 (2011).
[4] E. Coronado, et al. Nature Chem. 2, 1031 (2010).

Tuesday, June 25, 2014

Tailoring and tuning of magnetism in nanostructures

Horst Hahn[1]

[1] *Institute for Nanotechnology and Helmholtz Institute Ulm*
Karlsruhe Institute of Technology (KIT)

The mechanical, physical and chemical properties of materials are determined by their microstructure. Modern materials science uses the complex interplay of defects, such as impurities, phases, point and line defects and interfaces, to tailor properties and obtain high-performance metallic alloys and ceramics. In this approach of materials design, properties can only be changed by modifying their microstructure, for example by initiating grain growth during annealing at elevated temperatures. Such a behavior, that fixes the properties irreversibly to the microstructure, is advantageous for many applications of materials, where long-term stability of the properties is required. Metallic glasses exhibit particularly interesting properties. As an example of a new development, the concept of nanoglasses will be presented, including interesting aspects in magnetic properties.

In contrast to the concept of tailoring, tuning using external fields, i.e., electric, offers completely new opportunities for the fully reversible control of materials properties. Such tuning of physical properties will be demonstrated for several nanostructures, i.e. (epitaxial) thin films, nanoporous, nanoparticulate structures and nanowires. Tuning can be either achieved using dielectric/ferroelectric gating, well known from semiconductor physics, or by electrolyte gating using liquid or solid electrolytes. Furthermore, using electrochemical ion intercalation, fully reversible magnetic properties can be achieved.

Tuesday, June 25, 2014

How to induce high sensitivity of liquid crystal to external magnetic field?

P. Kopčanský,[1] N. Tomašovičová,[1] M. Timko,[1] and J. Jadzyn[2]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland*

Liquid crystals (LC) are very sensitive to application of an external electric field due to the large value of dielectric anisotropy while are practically insensitive to application of magnetic field. The way how to improve sensitivity of currently used LC to magnetic field is to dope them with magnetic nanoparticles. The solution is the production of so called ferronematics, ferrocholesterics, ferrosmectics etc. i.e. stable colloidal suspension of LC with small volume concentrations of magnetic nanoparticles. In the presentation will be illustrated many examples of the influence of magnetic field as well combination of magnetic and electric field on the structural transitions let say Freedericksz transition in ferromematics wirh various LC i.e. calamitic liquid crystals, banana-shaped, lyothropic as well as biological LC. The low magnetic field response in studied samples will be presented as well as the effect of magnetic particles and magnetic field on the phase transition as nematic-isotropic transition.

Suported by ME SR Agency for Structural Funds of EU project No. 26110230097

Tuesday, June 25, 2014

Electron and spin properties of topological crystalline insulator $Pb_{1-x}Sn_xSe$

T. Story[1]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

Topological crystalline insulators (TCIs) constitute a new class of quantum materials with the Dirac-like metallic surface states that cross the bulk semiconductor band gap and are topologically protected by crystalline mirror plane symmetry.The TCI materials offer new ways of controlling topological states by applying perturbations lowering crystalline symmetry. The TCI states have been experimentally observed in $Pb_{1-x}Sn_xSe$, SnTe, and $Pb_{1-x}Sn_xTe$ for both (001) and (111) surfaces. These IV-VI semiconductors undergo (at a specific tin content, temperature, and pressure) a band structure inversion driven by strong relativistic effects. The investigations of the surface electronic states by angle- and spin-resolved photoemission spectroscopy will be presented for $Pb_{1-x}Sn_xSe$ (x=0-0.37) bulk monocrystals and epitaxial layers as well as $Pb_{0.65}Sn_{0.33}Mn_{0.02}Se$ crystals with magnetic Mn^{2+} ions. In the inverted band structure regime we found the Dirac-like topological in-gap states in the vicinity of four X points of the (001) surface Brillouin zone and observe a temperature-driven topological phase transition from a trivial insulator to a TCI state below the band inversion point. In crystals with Mn ions we demonstrate the tuning of the topological transition temperature by band gap engineering. The spin-resolved ARPES experiments revealed a characteristic vortical electron spin polarization texture at the Dirac points.

References:

[1] T.H. Hsieh *et al.*, Nat. Commun. 3, 982 (2012)
[2] P. Dziawa *et al.*, Nat. Mat. 11, 1023 (2012)
[3] B.M. Wojek *et al.*, Phys. Rev. B 87, 115106 (2013)
[4] C.M. Polley *et al.*, Phys. Rev. B 89, 075317 (2014)

Work supported by NCN (Poland) research projects 2011/03/B/ST3/02659 and 2012/07/B/ST3/03607.

Tuesday, June 25, 2014

Recent Progress in Modeling Electronic Structure and Spectroscopy of Topological Insulators and Novel Superconductors

Arun Bansil[1]

[1] *Physics Department, Northeastern University, Boston, Massachusetts*

I will discuss some of our recent results aimed at understanding the electronic structure and spectroscopy of novel superconductors, topological materials, and atomically thin 2D films. [1-9] Illustrative examples include: (i) How by exploiting electronic structure techniques we have been able to predict and understand the characteristics of many new classes of binary, ternary and quaternary topologically interesting materials, inclduing topological crystalline insulators; (ii) How atomically thin 'beyond graphene' 2D materials such as silicene, germanene, stanene, and $MoSe_2$ offer exciting new possibilities for manipulating electronic structures and the associated topological phases, providing novel platforms for various applications; (iii) Asymmetry of the scanning tunneling (STM) spectrum of the cuprate high-Tc superconductors between positive and negative bias voltages and the extent to which it comes about within the conventional picture, and how strong correlation effects modify the STM spectra; (iv) The character of the doped holes in the curpate superconductor La-Sr-Cu-O as revealed by the analysis of doping dependent high-resolution Compton scattering studies.

References:

[1] Yi Zhang et al., *Nature Nanotechnology* 9, 111 (2014).
[2] Vargas et al., *ACS Nano* 8, 1222 (2014).
[3] Y. Okada et al., *Science* 341, 1496 (2013).
[4] M. R. Scholz et al., *Physical Review Letters* 110, 216801 (2013).
[5] W-F Tsai et al., *Nature Communications* 4, 1500 (2013).
[6] F.-C. Chuang et al., *Applied Physics Letters* 102, 022424 (2013).
[7] Y. Sakurai et al., *Science* 332, 698 (2011).
[8] Y. Okada et al., *Nature Materials* 12, 707 (2013).
[9] J. Nieminen et al., *Physical Review B* 85, 214504 (2012).

Work supported by Basic Energy Sciences, United States Department of Energy.

Wednesday, June 25, 2014

Real space pairing in high temperature superconductors and heavy fermions: Beyond renormalized mean-field theory and comparison to experiment

Józef Spałek[1]

[1] *Instytut Fizyki im. Mariana Smoluchowskiego, Uniwersytet Jagielloński, PL-30-059 Kraków, Poland*

[2] *Akademickie Centrum Materiałów i Nanotechnologii, AGH, PL-30-059 Kraków, Poland*

I overview our comprehensive studies of real space pairing carried out in the period 2011-2014. The paired state results from the combined effect of strong kinetic exchange interaction with a correlated motion of the electron forming the pair in real space. In the case of high-T_C superconductivity we have also corrected some of the results coming from the Renormalized Mean-Field Theory and have developed subsequently a systematic diagrammatic approach of the Gutzwiller wave function. The results are compared quantitatively with experiment. I will also address briefly the question of pairing by the Kondo interaction combined with that by the kinetic exchange, with an application to the heavy fermion systems, where coexistence with antiferromagnetism often takes place. We have also applied the method to the spin-triplet pairing. At the end, I address the question of pseudogap within a unified approach (spin-fermion model).

In cooperation with J. Kaczmarczyk, M. Zegrodnik, M. Abram, M. Wysokiński, and O. Howczak. The TEAM (FNP) and MAESTRO (NCN) projects are acknowledged.

Wednesday, June 25, 2014

Quantum Kagome Spin Liquids

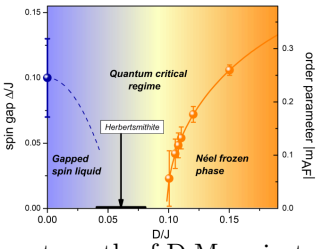
Philippe Mendels[1,2]

[1] *Laboratoire de Physique des Solides, Université Paris Sud 11, UMR CNRS 8502, F-91405 Orsay, France*

[2] *Institut Universitaire de France, 103 Boulevard Saint-Michel, F-75005 Paris, France*

The discovery of Herbertsmithite, $ZnCu_3(OH)_6Cl_2$, which features a perfect kagome geometry and has been revealed to be a leading 2D-candidate for having a quantum spin liquid ground state has triggered an intense activity on new kagome materials and related theories for the ground state of the quantum kagome Heisenberg antiferromagnet.

After introducing the basic ideas and theoretical issues, I'll illustrate some of our research thrusts in tracking down quantum spin liquid physics in Cu2+ S=1/2 materials and will discuss the experimental phase diagram which result from deviations from the pure Heisenberg case.



D = strength of D.M. anisotropy

If time permits, I'll present a new route to this physics with a novel Vanadium-based oxyfluoride kagome family.

Wednesday, June 25, 2014

Dirty magnets: From fractional moments to cluster spin glasses

M. Vojta[1]

[1] *Technische Universtität Dresden, Germany*

Quantum magnets under the influence of quenched disorder display a plethora of non-trivial phenomena. The talk will give a partial overview of the field, focussing (i) on single-impurity effects where the impurity may be used as a local probe of host properties and (ii) on effects of a finite concentration of defects which modify bulk properties. Specific examples to be discussed include fractional defect moments in frustrated magnets, the magnon spectrum of disordered magnets near quantum criticality, and the formation of cluster spin-glass phases in doped cobaltates and iridates.

Wednesday, June 25, 2014

Graphene: new venues for spintronics

B. Dlubak,[1]
M.-B. Martin,[1] R. Weatherup,[2] H. Yang,[1] M. Sprinkle,[3] C. Berger,[3] W. de Heer,[3]
S. Hoffman,[2] J. Robertson,[2] C. Deranlot,[1] R. Mattana,[1] A. Anane,[1] F. Petroff,[1]
A. Fert,[1] and P. Seneor[1]

[1] *Unité Mixte de Physique CNRS/Thales & Université Paris-Sud, France*
[2] *Department of Engineering, University of Cambridge, U.K.*
[3] *GeorgiaTech, Atlanta, USA & Institut Néel, France*

Spintronics is a paradigm focusing on spin as the information vector in fast and ultra-low-power non volatile devices such as the new STT-MRAM. Beyond its widely distributed application in data storage it aims at providing more complex architectures and a powerful beyond CMOS solution. The recent discovery of graphene has opened novel exciting opportunities in terms of functionalities and performances for spintronics devices. We will present experimental results on the impact and potential of graphene for spintronics. We will show that unprecedented highly efficient spin information transport can occur in graphene [1] leading to large spin signals and macroscopic spin diffusion lengths (∼100 microns), a key enabler for the advent of envisioned beyond-CMOS spinbased logic architectures. Furthermore, we will show that a thin graphene passivation layer can prevent the oxidation of a ferromagnet, enabling its use in novel humide/ambient low-cost processes for spintronics devices, while keeping its highly surface sensitive spin current polarizer/analyzer behavior and adding new enhanced spin filtering property [2]. These different experiments unveil promising uses of graphene for spintronics.

References:

[1] B. Dlubak et al. *Nature Physics* **8**, 557 (2012); P. Seneor et al. *MRS Bulletin* **37**, 1245 (2012).
[2] B. Dlubak et al. *ACS Nano* **6**, 10930 (2012); R. Weatherup et al. *ACS Nano* **6**, 9996 (2012).

Wednesday, June 25, 2014

Physics of magnetism in GaN doped with transition metals

Alberta Bonanni[1]

[1] *Institut für Halbleiter- und Festkörperphysik, Johannes Kepler University, Linz - Austria*

We summarise here our work aiming at elucidating the physics of magnetism in the two dilute magnetic semiconductors (Ga,Mn)N and (Ga,Fe)N and at demonstrating the unanticipated effects of the co-doping of these systems with donors (Si) and acceptors (Mg). According to our experimental and theoretical studies, the ferromagnetism of (Ga,Mn)N is driven by ferromagnetic superexchange between diluted Mn^{3+} ions [1]. Here the co-doping with Si results in Mn^{2+}, whose coupling is antiferromagnetic, whereas Mg co-doping leads to the formation of Mn-Mg_k complexes that show room temperature luminescence relevant for optoelectronic applications [2]. In contrast to Mn, the Fe cations aggregate at the growth surface, a process that can be controlled by Si and Mg co-doping, as observed experimentally and confirmed by *ab initio* studies [3]. This aggregation accounts for the formation of either ferromagnetic or antiferromagnetic Fe-rich nanocrystals, whose position can be predefined by the structure design and growth conditions [3,4].

References:

[1] A. Bonanni, M. Sawicki, T. Devillers, W. Stefanowicz, B. Faina, Tian Li, T. E. Winkler, D. Sztenkiel, A. Navarro-Quezada, M. Rovezzi, R. Jakiela, A. Meingast, G. Kothleitner, and T. Dietl, *Phys. Rev. B* **84**, 035206 (2011); S. Stefanowicz, G. Kunert, C. Simserides, J. A. Majewski, W. Stefanowicz, C. Kruse, S. Figge, Tian Li, R. Jakieła, K. N. Trohidou, A. Bonanni, D. Hommel, M. Sawicki, and T. Dietl, *Phys. Rev. B* **88**, 081201(R) (2013).

[2] T. Devillers, M. Rovezzi, N. Gonzalez Szwacki, S. Dobkowska, D. Sztenkiel, A. Grois, J. Suffczynski, A. Navarro-Quezada, B. Faina, Tian Li, P. Glatzel, F. d'Acapito, R. Jakiela, M. Sawicki, J. A. Majewski, T. Dietl and A. Bonanni, Scientific Reports 2, 722, (2012) ; T. Devillers, D. M. G. Leite, J. H. Dias da Silva, and A. Bonanni, *Appl. Phys. Lett.* **103**, 211909 (2013).

[3] A. Navarro-Quezada, N. Gonzalez Szwacki, W. Stefanowicz, Tian Li, A. Grois, T. Devillers, M. Rovezzi, R. Jakieła, B. Faina, J. A. Majewski, M. Sawicki, T. Dietl, and A. Bonanni, *Phys. Rev. B* **84**, 155321 (2011); I. A. Kowalik, A. Persson, M.A. Nino, A. Navarro-Quezada, B. Faina, A. Bonanni, T. Dietl, D. Arvanitis, *Phys. Rev. B* **85**, 184411 (2012).

[4] A. Navarro-Quezada, T. Devillers, Tian Li, and A. Bonanni, *Appl. Phys. Lett.* **101**, 081911 (2012).

Wednesday, June 25, 2014

Theory of ultrafast demagnetization after femtosecond laser pulses

M. Fähnle,[1] C. Illg,[1] M. Haag,[1] and N. Teeny[1]

[1] *Max Planck Institute for Intelligent Systems, Stuttgart, Germany*

Experimentally it has been found that a ferromagnetic metallic film is strongly demagnetized within a few hundred fs after exposure to a fs laser pulse. The talk reviews the theories of this ultrafast demagnetization, especially the scattering of the excited electrons at phonons and magnons. These calculations are performed by the ab-initio spin-density functional electron theory for Ni and Fe, and they are based on Fermi's golden rule for transition rates. The application of this rule on the fs time scale is critically discussed in view of results from quantum-kinetical density-matrix calculations. It is shown that the experimentally observed demagnetization rates cannot be explained by spin-flip scatterings of electrons exclusively at phonons [1] or exclusively at magnons [1]. A combination of individual spin-flip electron-phonon and spin-flip electron-magnon processes is shown to be a potential candidate for the explanation of ultrafast demagnetization.

References:

[1] C. Illg *et al.*, Phys. Rev. B **88**, 214404 (2013); M. Haag *et al.*, appears in Phys. Rev. B

Wednesday, June 25, 2014

How do we measure bipartite entanglement for Heisenberg antiferromagnets?

Piotr Tomczak[1]

[1] *Faculty of Physics, A. Mickiewicz University*
Umultowska 85, 61-614, Poznań, Poland

In this lecture we elucidate methods of calculating entanglement entropy in spin-1/2 Heisenberg systems. We begin by reviewing all important definitions of measures of entanglement that have been used so far: valence bond entanglement entropy, loop entanglement entropy, Renyi entropy and the most basic one — von Neumenn entropy. One can calculate easily the first two within the quantum Monte Carlo approach in over-complete and non-orthogonal valence bond basis. The clear geometrical meaning of this basis enables to define other efficiently computable quantities like *mean singlet length* (MSL) and *mean loop length* (MLL). Subsequently, we show that these *geometrical quantities* i) scale logarithmically with the subsystem size for 1D gapless quantum critical systems and linearly in gaped phase. ii) in 2D they fulfill area law (without a a multiplicative logarithmic correction) in gapless phase and valence bond (gaped) phase, i.e., they they share properties of von Neumen entropy. Finally, we examine the finite size scaling properties of MSL, MLL and their fluctuations and show that using them one can effectively calculate the quantum critical points and critical exponent related to the divergence of the correlation length.

Thursday, June 26, 2014

Frustration and Entanglement in Spin-Orbital Models

Andrzej M. Oleś[1,2]

[1] *Marian Smoluchowski Institute of Physics, Jagellonian University, Kraków, Poland*
[2] *Max Planck Institute for Solid State Research, Stuttgart, Germany*

The orbital interactions are intrinsically frustrated due to their directional character and provide novel opportunities for quantum information. Strong coupling between spins and orbitals on exchange bonds leads to spin-orbital entanglement [1] which has several consequences in the physical properties of transition metal oxides. In model systems one finds, *inter alia*, magnetic phases originating from entanglement, and a cute and surprising rigorous topological order in the SU(2)$\otimes XY$ spin-orbital ring [2]. We argue that: (i) quantum fluctuations play a crucial role in the ground states and quantum phase transitions, and (ii) effective spin exchange constants alone do not determine spin bond correlations in the spin-orbital liquid which involves entangled states. When on-site spin-orbit coupling is considered in addition, as in iridates, effective spin models arise with frustrated interactions and rich phase diagrams, Hole propagation may be then quite unusual, with either hidden quasiparticles in the zigzag magnetic phase of Na_2IrO_3, or non-Fermi liquid behavior in the Kitaev liquid [3].

References:

[1] A. M. Oleś, Journal of Physics: Condensed Matter **24**, 313201 (2012).
[2] W. Brzezicki, J. Dziarmaga, and A. M. Oleś, Phys. Rev. Lett. **112**, 117204 (2014).
[3] F. Trousselet *et al.*, Phys. Rev. Lett. **111**, 037205 (2013); arXiv:1308.3373 (2013).

Thursday, June 26, 2014

High T_c Superconductivity and metastability

Julius Ranninger[1]

[1] *Institut NEEL, CNRS and Unversite Joseph Fourier, BP 38042, Grenoble-Cedex 9, France*

The persistent superfluid (resistance-less) flow in superconductors is assured by electromagnetic gauge invariance breaking. In the low temperature BCS superconductors this arises from a normal state, which presents a highly polarizable Fermi liquid, susceptible to Bose-Einstein condense Cooper pairs into a phase correlated macroscopic quantum state. In a field theoretical approach this is expressed as spontaneous symmetry breaking of an infinitely degenerate quantum vacuum - the parent state of the superconductor, which presents a Higgs field. The elementary excitations of it are the Higgs amplitude mode and the Nambu-Goldstone phase mode of the condensate. The latter, being irrevocably coupled via gauge relations to the gauge of the electromagnetic field, thereby generates a longitudinal component of the vector field. It is that which acts as the stabilizing factor of persistent currents - solely controlled by their inertia. In high T_c superconductors the corresponding parent state is not an infinitely degenerate quantum vacuum, described by a Fermi liquid and the usual collective modes are not simply Goldstone modes. We view this state to arise from an intrinsic metastability of those materials and describe it in terms of spin-singlet pairs popping in and out of existence of a Fermi liquid background. Formulating such a scenario in terms of a generic Boson-Fermion model, the charged fermionic and bosonic excitations become effectively interchangeable. On the basis of a functional integral approach to such a scenario, analogous to a Ginzburg-Landau formulation of BCS, we highlight its salient features which emerge as a direct consequence of metastability and in particular the phase-separation driven transition between a Bose-glass, composed of localized diamagnetic pairs, and their condensed superpfluid state, monitored by a change in doping.

Thursday, June 26, 2014

Spin-flipping with conical magnets: Superconducting Proximity effects in bi- and multilayers

D. Fritsch,[1] and J.F. Annett[1]

[1] *University of Bristol, HH Wills Physics Laboratory, Bristol UK*

The long-range proximity effect through a ferromagnet or half-metal of provides a link between superconductivity and spintronics [1]. This long-range proximity effect can occur if the interface region allows for spin-flip process. One source of such a spin-flip process is provided by a conical magnet, e.g. Holmium. Here, we present results based on self-consistent solutions of the microscopic Bogoliubov-de Gennes equations in the clean limit incorporating a tight-binding model [2]. The effects of both, a general conical magnet and the special case of Holmium, on the generation of equal-spin spin-triplet pairing correlations will be shown. The effects of the conical magnet's angles on the equal-spin spin-triplet pairing will be discussed and analysed. The influence of Holmium and ferromagnetic layer thickness on the equal-spin spin-triplet correlations will be discussed in conjunction with experimental results on Holmium containing heterostructures [3].

References:

[1] M. Eschrig, Phys. Today 64, 43 (2011).
[2] D. Fritsch and J. F. Annett, arXiv:1311.3278 (2013).
[3] J. W. A. Robinson, J. D. S. Witt, and M. G. Blamire, Science 329, 59 (2010).

Supported by EPSRC grant EP/I037598/1

Thursday, June 26, 2014

Optical properties of lattice tuned $RNiO_3$

J. Ruppen,[1] J. Teyssier,[1] S. Catalano,[1] M. Gibert,[1] J.-M. Triscone,[1] and D. van der Marel[1]

Département de Physique de la Matière Condensée
Université de Genève

Rare-earth nickelates with the composition $RNiO_3$ where R is a trivalent rare earth ion, are among the few perovskite oxides showing a very sharp Metal-Insulator (MI) and a low temperature antiferromagnetic ordering. The energy scale of both MI and magnetic transitions can be tuned by the nature of the rare-earth and the strain applied through the lattice mismatch between the substrate and the film. Using spectroscopic ellipsometry in the visible range and transmission and reflectivity in the infrared, we extracted the temperature dependence of the optical conductivity of films of varying composition and strain. The spectra show strong qualitative changes on the scale of 1 eV when the material passes through the metal-insulator transition, and additional weaker changes when it passes from the paramagnetic to the magnetically ordered phase. The spectral changes reveal the effect of charge-ordering on the local electronic configuration of the nickel ions, and point toward a situation whereby the charge ordered state is characterized by two types of nickel with qualititively different electronic configurations.

References:

[1] T. Mizokawa *et al.*, PRB 61, 11263 (2000)
[2] R. Scherwitzl *et al.*, PRL 106 246403 (2011)
[3] H. Park *et al.*, PRL 109, 156402 (2012)
[4] J. Ruppen *et al.*, preprint (2014)

Thursday, June 26, 2014

Electronic textures in strongly correlated oxides

S. Wilkins[1]

[1] *Department of Condensed Matter Physics and Materials Science, Brookhaven National Laboratory, Upton, New York 11973, USA*

What is stopping the development and exploitation of the unique properties of strongly correlated systems? Strongly correlated systems display a wide range of potentially useful properties, ranging from superconductivity to colossal magnetoresistance. However, by their very nature, their strong correlations lead to many competing ground states. This in turn leads to electronic domains and inhomogeneities, over a range of real-space length scales, from nanometers to hundreds of microns. During this presentation, results from charge correlations in high Tc superconductors and antiferromagnetic domain imaging in bilayer manganites will be presented, including measurements under applied electrical current. These measurements we preformed by a new technique of soft x-ray nano-difraction and the future possibilities of this technique at NSLS-II will be presented.

Thursday, June 26, 2014

The magnetocaloric effect: A useful tool for the characterization of phase transitions

Victorino Franco,[1] and Alejandro Conde[1]

Condensed Matter Physics Department, Sevilla University, P.O. Box 1065. 41080-Sevilla, Spain

The increasing concern of modern societies about energy efficiency, together with the fact that temperature control accounts for a large portion of the energy consumption at homes and commercial buildings, has fostered research on the applicability of magnetocaloric materials for magnetic refrigeration [1]. But in addition to the studies on magnetocaloric materials for the optimization of their properties for room temperature magnetic refrigeration, in this talk we will show that MCE can be used for characterizing magnetic phase transitions [2], showing examples of how critical exponents can be determined, evidencing that the magnetocaloric response can be used to determine the order of a phase transition [3] or to infer the presence of impurity phases in the samples. Examples of the application of these kind of analyses to different kind of materials will be presented.

References:

[1] V. Franco, J. S. Blázquez, B. Ingale, and A. Conde, Annu. Rev. Mater. Res. 42, 305 (2012).
[2] V. Franco, A. Conde, Int. J. Refrig. 33, 465 (2010).
[3] C.M. Bonilla, J. Herrero-Albillos, F. Bartolomé, L.M. García, M. Parra-Borderías, V. Franco, Phys. Rev. B 81, 224424 (2010).

This work was supported by the Spanish Ministry of Science and Innovation and EU FEDER (Project MAT 2010-20537) and the PAI of the Regional Government of Andalucía (Project P10-FQM-6462).

Friday, June 27, 2014

Spin selective transport through helical molecular systems

Gianaurelio Cuniberti[1]

[1] *Institute for Materials Science, Dresden University of Technology, Dresden, Germany*

Highly spin-selective transport of electrons through a helically shaped electrostatic potential is demonstrated in the frame of a minimal model approach. The effect is significant even for weak spin-orbit coupling. Two main factors determine the selectivity: an unconventional Rashba-like spin-orbit interaction, reflecting the helical symmetry of the system, and a weakly dispersive electronic band of the helical system. The weak electronic coupling, associated with the small dispersion, leads to a low mobility of the charges in the system and allows even weak spin-orbit interactions to be effective. The results are expected to be generic for chiral molecular systems displaying low spin-orbit coupling and low conductivity.

Friday, June 27, 2014

Static and dynamic properties of magnetic domain walls

Rolf Allenspach[1]

[1] *IBM Research – Zurich, 8803 Rüschlikon, Switzerland*

Domain walls in small elements exhibit complex spin arrangements that strongly deviate from the wall types commonly encountered in magnetic thin film systems or bulk ferromagnets. They can be modified by changing the geometry of the element [1], and they can be moved by injecting electrical current pulses. We image the static properties of domain walls by spin-polarized scanning electron microscopy [2], thereby determining their internal structure with 10-nm resolution. The dynamic properties are explored by time-resolved magneto-optical Kerr microscopy, which has limited spatial yet high temporal resolution. When propagated by magnetic field, domain walls go through a sequence of entirely different behavior depending on the field strength: Steady-state motion at low fields is followed by turbulent, chaotic motion at high field, the so-called Walker breakdown. In a study combining experiment and micromagnetic simulations, we investigated vortex walls in permalloy wires with widths ranging from 300 to 900 nm. In wide wires, we find the dynamics of vortex walls to depart significantly from the current description that a domain wall is a compact entity moving along the wire [3]. Instead, the wall is composed of several substructures evolving in different dynamic regimes with very different velocities. Wire edges crucially affect this dynamics and can be influenced by a variation of growth parameters. Possibilities how to overcome the limits imposed by the Walker breakdown will be discussed. Wall motion by spin current follows different laws. We find persistent, static modifications of the wall structure upon propagation: Vortex walls transform to transverse configurations upon subsequent pulse injections [4]. This change is directly correlated with the decay of the wall velocity. Transverse walls, on the other hand, keep their transverse character. In magnetic bilayer wires, however, a new effect occurs: The direction of the spin current sets the polarity of the transverse wall [5]. Such effects become important when one tries to exploit domain walls for use in spin-based devices.

References:

[1] P.-O. Jubert, R. Allenspach, and A. Bischof, Phys. Rev. B 69, 220410(R) (2004).

[2] R. Allenspach, IBM J. Res. Develop. 44, 553 (2000).

[3] C. Zinoni, A. Vanhaverbeke, P. Eib, G. Salis, and R. Allenspach, Phys. Rev. Lett. 107, 207204 (2011).

[4] M. Kläui, P.-O. Jubert, R. Allenspach, A. Bischof, J.A.C. Bland, G. Faini, U. Rüdiger, C.A.F. Vaz, L. Vila, and C. Vouille, Phys. Rev. Lett. 95, 026601 (2005).

[5] A. Vanhaverbeke, A. Bischof, and R. Allenspach, Phys. Rev. Lett. 101, 107202 (2008).

Friday, June 27, 2014

Spin-wave instability theory for ferromagnetic nanostructures

Zahra Haghshenasfard,[1] Hoa T. Nguyen,[1] and Michael G. Cottam[1]

[1] *Department of Physics and Astronomy, University of Western Ontario, London, Ontario N6A 3K7, Canada*

A microscopic, or Hamiltonian-based, theory is outlined for studying the spin-wave instability thresholds of the parametric processes occurring in ferromagnetic nanostructures under conditions of pumping with a microwave field. Most previous work has concentrated on spheres or films with dimensions of order several microns or more, and the theoretical interpretation has been made in terms of macroscopic (continuum) methods. At smaller length scales, as in ultrathin films and nanowires with thickness or lateral dimensions less than about 100 nm, the discreteness of the quantized spin waves and their spatial distributions become modified, making it more appropriate to employ a microscopic approach to the nonlinear dynamics with a lattice of effective spins interacting through the magnetic dipole-dipole and exchange interactions. Effects of microwave pumping (in either the parallel or perpendicular configuration) are incorporated in calculations for the instability thresholds of the quantized spin-wave bands in different nanostructures and materials.

Friday, June 27, 2014

Collective Relaxational Dynamics in Molecular Nanomagnets

Anupam Garg[1]

[1] *Department of Physics & Astronomy, Northwestern University, Evanston, IL 60208, USA*

Although molecular solids based on nanomagnets such as Fe_8 and Mn_{12} display many quantum phenomena that can be understood at the level of one molecule, and are often called single-molecule-magnets for that reason, they also display other dynamical behaviours that require going beyond the single-molecule description. Examples include relaxation in zero field from a magnetized state, magnetization reversal in a swept field (the Landau-Zener-Stuckelberg protocol), and magnetization in nonzero field starting from a nonmagnetized state. Here one sees nonexponential behaviour in time, characteristic of glassy dynamics. It is found essential to consider decoherence in understanding the dynamics of one molecule, and the dipole-dipole interaction between them in understanding the dynamics of the solid as a whole. We have performed a detailed study of the decohering effects of nuclear spins and of the dipole-dipole interaction, showing how quantum mechanical tunneling between deep levels of one molecule is transformed into incoherent relaxation, and providing good justification for a classical model of relaxation for the solid as a whole [1]. In this model the relaxation probability of a given molecular spin is strongly dependent on the local field seen by that molecule, and because of the dipole-dipole interaction's long range and enormous value compared to the tunnel splitting and nuclear spin magnetic field, the relaxation of any one molecule alters the field seen by many other molecules. We have performed Monte Carlo simulations of this model, and also developed and solved rate equations and kinetic equations to compare with the simulations and the experiments [2, 3]. The agreement between simulations, kinetic equation, and experiments is very good in most respects, but not so good for ultra long times and ultra-slow phenomena. The problem of magnetization is particularly interesting, as at first sight it entails the relaxation of energy in addition to spin, whereas the as originally conceived model has no provision for energy relaxation per se. However, a modification of this model including a secondary relaxation mechanism due to phonoemissive tunneling [4] does not appear to be satisfactory. Thus, the magnetization problem remains open. Work is currently underway to see if it is possible to achieve energy relaxation from the original model without building it in at the single molecule level.

References:

[1] A. Vijayaraghavan and A. Garg, Phys. Rev. B **79**, 104423/[1–15] (2009).
[2] A. Vijayaraghavan and A. Garg, Ann. Phys. (N.Y.) **335**, 1–20 (2013).
[3] E. Lenferink, A. Vijayaraghavan and A. Garg, arxiv: 1212.5292 (2012).
[4] Y. Liu and A. Garg, arxiv: 1307.6600 (2013).

Friday, June 27, 2014

Professor Bernard Coqblin (1940 - 2012)

Robert Troć[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P. O. Box 1410, 50-950 Wrocław, Poland*

Born on Sept. 6, 1940, in *Montfort l'Amaury* near *Paris*, graduated in 1961 from the *Ecole Polytechnique*, PhD in 1967 at the *University of Orsay*, stayed at the *University of Pensylvania* (USA) (1967/68).

In 1972 became Maitre de Recherche of C.N.R.S. working at the the *University of Orsay*. Passed away on May 29, 2012 being Directeur de Recherche, emeritus at that University.

Basic scientific activity: *Theoretical study of the electronic structure and magnetism of systems with rare-earths and actinides*.

Author of the book on the *electronic structure of rare-earth metals and alloys* as well as several chapters in books on the *intermediate valence and Kondo effect in anomalous rare-earths*. He was the author or co-author of more than 200 papers, presenting 50 invited talks at international conferences. In 1998 prof. Coqblin chaired a big International Conference on the *Strongly Correlated Systems* (SCES98) in Paris. He gave invited talks in Poznań twice, on PM'08 and PM'11.

Friday, June 27, 2014

Kondo Effects without Magnetic Degrees of Freedom

K. Miyake[1]

[1] *Toyota Physical and Chemical Research Institute, Japan*

In this decade or so, Kondo phenomena without magnetic degrees of freedom have attracted much attention [1]. Of these issues, I would like to discuss the following two: (1) Multilevel Kondo effects, and (2) Charge Kondo effect related to the valence skipping phenomenon and the negative-U model.

While the effects (1) have attracted general interests following pioneering work by Kondo and Vladar and Zawadowski [1], its reality seems to have been reinforced after magnetically robust heavy fermion compound $SmOs_4Sb_{12}$, with filled-Skutterudite structure, was reported [2,3]. I discuss this problem from the viewpoint that heaviness of quasiparticles of this compound is caused by a multilevel Kondo effect [4]. It will be also discussed the multilevel Kondo effect is related intimately with a salient temperature dependence of Sm ion [5].

On the other hand, the effect (2) attracted renewed interests since superconductivity and magnetically robust $-\log T$ behavior in the resistivity was reported in $Pb_{1-x}Tl_xTe$ ($0.005<x<0.015$) [6] and interpreted by the negative-U mechanism [7], while the relevant negative-U mechanism (or valence skipping phenomenon) itself has been discussed theoretically since a quarter century ago [8,9]. Recently, we have succeeded in explaining this charge Kondo effect due to valence skipping phenomenon on the basis of a microscopic model in which the pair hopping interaction (between localized- and conduction-electrons) plays the spin-flip processes in the usual Kondo effect [10]. The importance of the pair hopping interaction relative to the usual Coulomb interaction is assured in the case of ion with high principal quantum number n in which the extension of the ns-state is considerably large. I discuss this problem from a theoretical point of view.

I am grateful to K. Hattori, Y. Hirayama, H. Matsuura, and S. Tanikawa for collaborations on which this talk is based.

References:

[1] See for example, D. Cox and A. Zawadowski, *"Exotic Kondo Effects in Metals: Magnetic Ions in a Crystalline Electric Field and Tunnelling Centres"* (Taylor & Francis, London, 2002).
[2] S. Sanada, et al., J. Phys. Soc. Jpn. **74**, 246 (2005).
[3] W. M. Yuhasz, et al., Phys. Rev. B **71**, 104402 (2005).
[4] K. Hattori, Y. Hirayama, and K. Miyake, J. Phys. Soc. Jpn. **74**, 3306 (2005).
[5] S. Tanikawa, H. Matsuura, and K. Miyake, J. Phys. Soc. Jpn. **78**, 034707 (2009).
[6] Y. Matsushita, H. Bluhm, T. H. Geballe, and I. R. Fisher, Phys. Rev. Lett. **94**, 157002 (2005).
[7] M. Dzero and J. Schmalian, Phys. Rev. Lett. **94**, 157003 (2005).
[8] C. M. Varma, Phys. Rev. Lett. **61**, 2713 (1988).
[9] A. Taraphder and P. Coleman, Phys. Rev. Lett. **66**, 2814 (1991).
[10] H. Matsuura and K. Miyake, J. Phys. Soc. Jpn. **81**, 113705(2012).

Friday, June 27, 2014

Properties near magnetic instability of heavy-electron compounds $Ce_3M_4Sn_{13}$ and $La_3M_4Sn_{13}$, with M = Co, Rh, and Ru

Andrzej Ślebarski[1]

[1] *Institute of Physics, University of Silesia, 40-007 Katowice, Poland*

In $Ce_3M_4Sn_{13}$ filled cage Kondo systems, where M = Co, Rh, or Ru, thermoelectricity can be strongly enhanced at the low temperatures as a result of sharp features in the electronic density of states at the Fermi energy and the *rattling* effects. Therefore these materials are considered as candidate for low-temperature thermoelectric cooling applications. $Ce_3M_4Sn_{13}$ and $La_3M_4Sn_{13}$ have also generated much interest due to their wide physical properties including quantum criticallity and superconductivity. $Ce_3M_4Sn_{13}$ show a cross-over from a magnetically correlated heavy fermion state to a single impurity state in applied magnetic fields. In order to study the proximity of $Ce_3M_4Sn_{13}$ to the possible magnetic quantum critical point, we investigated the system of $Ce_{3-x}La_xM_4Sn_{13}$ alloys and found a critical behaviour near $x \sim 0.6$. The low-temperature thermodynamic properties of $Ce_3Ru_4Sn_{13}$ are determined by crystal field and Kondo effects. Specific heat and resistivity data show that $La_3M_4Sn_{13}$ are typical BCS superconductors below T_c, however, $La_3Rh_4Sn_{13}$ and $La_3Ru_4Sn_{13}$ exhibit a second superconducting phase between T_c and $T_c^\star$ ($T_c < T_c^\star$), characteristic of inhomogeneous superconductors.

Friday, June 27, 2014

Quantum critical superconductivity in f-electron systems

Dariusz Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P. O. Box 1410, 50-950 Wrocław, Poland*

Since the spectacular discovery of heavy-fermion superconductivity in $CeCu_2Si_2$, reported by Steglich et al. in 1979, advanced experimental and theoretical studies on the phenomenon have continued to be at the very forefront of modern condensed matter physics. This is due to the special character of the superconducting state, which cannot be described in terms of the conventional theory, as well as due to a variety of unusual physical behavior observed in the normal state. The microscopic nature of all these anomalous phenomena usually originates from strong electronic correlations in metallic systems bearing localized magnetic moments.

In this talk, we shall briefly review the basic concepts of the physics of strongly correlated electron systems with the particular emphasis put on the formation of heavy-fermion ground states in f-electron materials, quantum critical phenomena and magnetically-driven superconductivity emerging at the verge of magnetic instability. An overview of the significant progress made in the area will include a short presentation of some results recently obtained by our research team. Eventually, an attempt will be made to identify a few most challenging open questions in the relevant field.

ORAL CONTRIBUTIONS

ABSTRACT CATEGORIES

1. Strongly Correlated Electrons and High Temperature Superconductivity

Heavy fermions and Kondo systems; Charge, orbital, and multipole orderings and excitations; Quantum phase transitions; Metal-insulator transitions; Highly correlated metals and insulators; Itinerant electron magnetism; Organic conductors; Low dimensional conductors, Correlation effects in mesoscopic systems; Multiferroics

2. Quantum and Classical Spin Systems

Low dimensional quantum magnets; Frustrated magnets and spin liquids; Quantum phase transitions; Lattice effects and spin Peierls systems; Solitons and nonlinear effects; Statistical mechanics of quantum and classical systems; Molecular magnetism; Quantum tunnelling and coherence; Quantum information; Organic and organo-metallic materials

3. Magnetic Structure and Dynamics

Crystal field and anisotropy; Magnetic structure and spin waves; Dynamic phenomena; Electronic structure; Magnetic interactions; Rare-earth and actinide magnetism; Transition metal alloys and compounds; Spin glasses; Random magnets; Magnonic crystals

4. Spin Electronics and Magneto-Transport

Magnetoresistance effects; Current induced magnetization reversal; Spin injection and accumulation; Spin Hall effect, Magnetic Semiconductors; Optical properties; Quantum computation

5. Nano-structure, Surfaces, and Interfaces

Surfaces and interfaces; Films, multilayers and superlattices; Exchange interaction and anisotropy; Spin dynamics, Patterned films; Nanoparticles; Nanowires and dots

6. Soft and Hard Magnetic Materials

Amorphous and nanocrystalline materials; Granular materials; Ferrites, garnets and microwave materials; Permanent magnets; Magnetization processes; Magneto-elastic and magnetostrictive materials; Modeling and simulations

7. Applications

Magnetic sensors; Ferromagnetic shape-memory materials; Actuators and magnetic drives; Magnetic refrigeration; Magnetic fluids; Magnetic separation and levitation

8. Other Topics

Biomagnetics; Magnetism in medicine; Measuring techniques and instruments; Magnetic recording and memories

O-1-01

Suppression of interface induced electronic phase separation in $La_{2/3}Sr_{1/3}MnO_3/SrTiO_3(110)$: ^{55}Mn NMR study

M. Wojcik,[1] E. Jedryka,[1] D. Pesquera,[2] F. Sanchez,[2] G. Herranz,[2] and J. Fontcuberta[2]

[1] *Institute of Physics, Polish Academy of Sciences, 02-668 Warszawa, Poland*
[2] *Institut de Ciència de Materials de Barcelona, Campus UAB, Bellaterra 08193, Catalonia, Spain*

Interfaces influence significantly half metallic properties of mixed valence manganite thin films. In case of double exchange mediated manganites the spin states at the interface may strongly depend on the crystallographic orientation. In this work we report ^{55}Mn NMR study of $La_{2/3}Sr_{1/3}MnO_3$ films grown on (001) and (110) $SrTiO_3$ oriented substrates, and analyse the NMR results in the context of macroscopic magnetic properties. It has been found that LSMO(110) films systematically show improved magnetic properties as compared to their (001) counterparts. In contrast to the results obtained for LSMO(001) films, the ^{55}Mn NMR spectra recorded for LSMO(110) films show only a mixed valence ($Mn^{3+/4+}$) resonance line without any contribution from localized (Mn^{4+}) charge states present in case of LSMO(001) films. These findings will be discussed in the context of a possible interface reconstruction driven by the lattice mismatch and polarity discontinuity at the LSMO/STO interface.

Work supported by NCN grant (DEC- 2011/03/B/ST3/02368)

O-1-02

Signatures of Majorana states in electron transport through a quantum dot coupled to a topological wire

P. Stefański[1]

[1] *Institute of Molecular Physics of the Polish Academy of Sciences ul. M. Smoluchowskiego 17, 60-179 Poznań, Poland*

We consider theoretically a system composed of a quantum dot coupled to a topological superconducting wire. The dot, being in Coulomb blockade (CB) regime, is additionally coupled to the leads, allowing standard transport measurements. The topological wire hosts Majorana states at its ends, which, as we show, characteristically modifies conductance through the dot. An unpaired Majorana state in the wire causes a unique temperature dependence of zero bias conductance vs. gate voltage. It decreases in-between CB peaks and on the sides of the peaks from the plateau at $\sim e^2/2h$ when temperature increases. At the same time conductance increases at the CB peak positions. It is accompanied by zero bias anomaly in differential conductance. For finite overlap of Majorana states in the wire the zero bias anomaly disappears. Instead, two characteristic Fano resonances of opposite symmetry appear, positioned mirror-symmetrically with respect to zero bias.

This work has been supported by the National Science Centre under the contract DEC-2012/05/B/ST3/03208.

O-1-03

$R\mathrm{BaCo_2O_{5.5}}$ (R = Y, Gd, and Tb) – thermal properties and phase transition

J. Wieckowski,[1] M.U. Gutowska,[1] A. Szewczyk,[1] K. Conder,[2] E. Pomjakushina,[2] V.P. Gnezdilov,[3] and S.L. Gnatchenko[3]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *Paul Scherrer Institute, Villigen, Switzerland*
[3] *B. Verkin Institute for Low Temperature Physics and Engineering, Kharkiv, Ukraine*

Layered cobaltites $R\mathrm{BaCo_2O_{5.5}}$, show numerous intriguing properties, e.g., large O_2 ionic conductivity, appearance of Co ions in different spin states, and several phase transitions of different nature. Comparative specific heat studies, aimed at explaining an influence of different rare-earth ions on thermal properties of these compounds and on the phase transitions appearing in them, were performed for the compositions with R being: Y (nonmagnetic), Gd (magnetic but not influenced by crystalline field, CEF), and Tb (magnetic and strongly influenced by CEF). The studies were performed over the temperature range 3 - 395 K, in the magnetic field up to 9 T. Lattice, magnon, and Schottky contributions to the specific heat were separated and described theoretically. The molecular field corresponding to the R–Co exchange interactions was estimated to be ~ 1 T.

The work was partly supported by the European Regional Development Fund, through the Innovative Economy Grant POIG.01.01.02-00-108/09.

O-1-04

Hyperfine field and electronic structure of magnetite

R. Řezníček,[1] V. Chlan,[1] H. Štěpánková,[1] and P. Novák[2]

[1] *Faculty of Mathematics and Physics, Charles University in Prague, V Holešovičkách 2, 180 00 Praha 8, Czech Republic*
[2] *Institute of Physics of ASCR, Cukrovarnická 10, 162 00 Prague 6, Czech Republic*

Recently, Senn et al. [1] determined precise structure of low temperature *Cc* phase of magnetite and introduced a trimeron model for the ordering of the octahedrally coordinated iron cations. The present work studies the electronic ordering and hyperfine field (HF) at the iron sites in order to verify the model. A reanalysis of published dependences of the ^{57}Fe nuclear magnetic resonance frequencies [2] on external magnetic field direction was performed to investigate HF anisotropy in *Cc* phase of magnetite. Isotropic parts and anisotropy tensors of the hyperfine interaction were extracted. Next, ab initio calculations of HF in dependence on magnetization direction yielded analogical data. Comparison of the two data sets revealed matching groups of the octahedral iron sites. Further, iron valences, minority spin valence electron density maps and populations were calculated. The results support the trimeron model.

References:

[1] M. S. Senn, J. P. Wright and J. P. Attfield, Nature **481**, 173-176 (2012).
[2] M. Mizoguchi, J. Phys. Soc. Jap. **70**, 2333 (2001).

O-1-05

Multiferroic $Sr_{1-x}Ba_xMnO_3$ Perovskite with a Huge Magnetoelectric Coupling

B. Dabrowski,[1] J. Mais,[1] O. Chmaissem,[1] S. Kolesnik,[1] E. Markiewicz,[2] V. Goian,[3] S. Kamba,[3] D.K. Pratt,[4] and J. Lynn[4]

[1] *Deptment of Physics, Northern Illinois University, DeKalb, IL, USA*
[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland*
[3] *Institute of Physics, Academy of Sciences of the Czech Republic*
[4] *NIST Center for Neutron Research, Gaithersburg, MD, USA*

We have prepared unique multiferroic $Sr^{2+}_{1-x}Ba^{2+}_{x}Mn^{4+}O_3$ perovskite ceramics (x =0.4-0.45) for which ferroelectricity (FE, $T_F \sim 400$ K) and antiferromagnetism (AF, $T_N \sim 200$ K) originate exclusively from the Mn cations. Similar to $Ba^{2+}Ti^{4+}O_3$, the classical displacive-type ferroelectric phase transition occurs for $x > 0.4$ when the Mn ions move out of the center of the MnO_6 octahedra. These materials show on cooling a sequence of transitions from the paramagnetic (PM)/paraelectric (PE) cubic phase to the PM/FE tetragonal P4mm phase and finally to AF/PE P4/mmm phase. The largest known magneto-electric coupling was observed near T_N when ferroelectricity disappears. Because of high conductivity the measurements of complex dielectric permittivity are reliable only below 40 K, where intrinsic permittivity is about 340 and does not change with magnetic field up to 9 T. We found the AF order parameter energy gap of 4.6(5) meV and the top of the magnon band at 43(1) meV.

O-1-06

DMRG study of the interorbital interaction in the periodic Anderson model

I. Hagymási,[1,2] Ö. Legeza,[1] and J. Sólyom[1]

[1] *Strongly Correlated Systems "Lendület" Research Group, Institute for Solid State Physics and Optics, MTA Wigner Research Centre for Physics, Budapest H-1525 P.O. Box 49, Hungary*
[2] *Department of Theoretical Physics, University of Szeged, Tisza Lajos krt 84-86, H-6720 Szeged, Hungary*

We investigate an extended periodic Anderson model (EPAM), where besides the standard on-site f-electron interaction ($U_f \sum_j \hat{n}^f_{j\uparrow}\hat{n}^f_{j\downarrow}$) there is an on-site interaction between the f- and conduction electrons ($U_{cf} \sum_{j,\sigma,\sigma'} \hat{n}^f_{j\sigma}\hat{n}^c_{j\sigma'}$). We apply the density matrix renormalization group algorithm (DMRG) to calculate spin-spin and density-density correlation functions in the symmetric half-filled EPAM. We show that the the antiferromagnetic spin correlations are suppressed for increasing U_{df} and the density-density correlation becomes dominant above a critical value of U_{df}. This critical point is determined by examining the block entropy. The charge and spin gaps are also calculated for a wide range of parameters and we study other band fillings as well.

O-1-07

Modified equation of motion approach for ferromagnetic systems.

J. Mizia,[1] G. Górski,[1] and K. Kucab[1]

[1] *Faculty of Mathematics and Natural Sciences, University of Rzeszów, ul. Pigonia 1, 35-310 Rzeszów, Poland*

The key problem in using the Dynamical Mean-Field Theory (DMFT) is finding the appropriate solution to the single impurity Anderson model. We use the modified equation of motion (EOM) method based on differentiation over two time variables. In such approach we obtain correct description of the Kondo effect for systems with symmetry with respect to the half-filled point. Our approach can be used also for the systems without half-filled point symmetry and in the large concentration range like e.g. the ferromagnetic systems. For the reason of these advantages we investigate in this report dependence of the system magnetics moment on carrier concentration using our modified EOM method. We also analyze influence of asymmetric densities of states on ferromagnetic alignment. The results are compared with DMFT-Quantum Monte Carlo calculations and with Hubbard I and III approximations.

O-1-08

Emergence of superconductivity in the local moment antiferromagnetic state of Ce_3PtIn_{11} at ambient pressure

M. Kratochvílová,[1] K. Uhlířová,[1] J. Prokleška,[1] M. Dušek,[2] V. Sechovský,[1] and J. Custers[1]

[1] *Faculty of Mathematics and Physics, Charles Univ. Prague, CZ*

[2] *Dept. Structure Analysis, Institute of Physics, Prague, CZ*

Similar to the iron pnictides the unconventional superconducting state in heavy Fermion (HF) compounds is ill understood. A central debate concerning the pairing mechanism is the nature of the magnetism and its relationship to superconductivity (SC). The HF family of $Ce_nT_mIn_{3n+2m}$ ($n = 1, 2$; $m = 0, 1, 2$; T = transition metal) materials are predestinated to investigate this question exhibiting both type of scenaries, that is spin density wave (weak coupling) and local moment (strong coupling) induced antiferromagnetic (AFM) ordering together with SC. Here, we report on Ce_3PtIn_{11} which is the only compound within the family showing both superconductivity and magnetic ordering at ambient pressure. In the specific heat, resistivity and ac susceptibility two magnetic transitions are observed; the compound undergoes an incommensurate AFM order below $T_N = 2.1$ K and enters a commensurate AFM state at $T_N = 2$ K. Analysis of the entropy points to local moment antiferromagnetic order. Superconductivity emerges at $T_c = 0.39$ K. Upon applying hydrostatic pressure AFM disappears and a superconducting dome forms with $T_c^{max} = 0.7$ K at 1 GPa.

O-1-09

Interplay of anisotropic superconductivity and magnetism in iron-based compounds

R. Puzniak[1]

[1] *Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, 02-668 Warszawa, Poland*

Experimentally deduced magnetic and superconducting anisotropy of various iron-based compounds is discussed. The anisotropy parameter of the superconducting state for both, iron-pnictides and iron-chalcogenides, varies for various families and strongly depends on thermodynamic parameters such as temperature and magnetic field. Interestingly, the upper critical field anisotropy is found to be much smaller than the magnetic penetration depth anisotropy, pointing towards multi-gap superconductivity. In agreement, the in-plane magnetic penetration depth, related to the superconducting carrier density, increases with increasing magnetic field due to a partial suppression of the energy gap. Besides superconductivity, various iron-based compounds exhibit coexisting magnetic order. This order can be influenced by an external magnetic field, making iron-based superconductors a fascinating template for magnetic-field tuned applications.

This work was supported by the National Science Centre of Poland based on decision No. DEC-2013/08/M/ST3/00927.

O-1-10

Spin-orbital separation in the 1D cuprates

Krzysztof Wohlfeld[1]

[1] *Stanford University and SLAC National Accelerator Laboratory*

In contrast to magnetic excitations, the dispersive orbital excitations (orbitons) are very hard to detect [1]. Nevertheless, recent advancements in resonant inelastic x-ray scattering [1] have allowed for a rather unambiguous detection of orbitons in various transition metal oxides [1,2 , 3, 4] – in particular the quasi-1D copper oxides [2, 3, 4]. Strikingly, a closer investigation of the observed 1D orbiton dispersion suggested that this dispersion could not be understood using a simple orbital wave picture [2, 5]. Instead it occurred that the orbitons are in general very strongly coupled to spin excitations. It is then only in 1D that they can decouple leading to a particularly strong dispersion which is due to a phenonemonen called spin-orbital separation: the initial orbital excitation fractionalizes into an independent orbiton and spinon excitation.

References:

[1] L. J. P. Ament *et al*; Rev. Mod. Phys. **83**, 705 (2011).
[2] J. Schlappa, K. Wohlfeld *et al.*; Nature **485**, 82 (2012).
[3] K. Wohlfeld, S. Nishimoto, M. W. Haverkort, and J. van den Brink; Phys. Rev. B **88**, 195138 (2013).
[4] V. Bisogni, K. Wohlfeld, *et al.*; arxiv: 1310.8346 (2013).
[5] K. Wohlfeld, M. Daghofer, S. Nishimoto, G. Khaliullin, and J. van den Brink; Phys. Rev. Lett. **107**, 147201 (2011).

O-1-11

Two-band superconductivity in MgB_2 controlled by charge doping and band scattering

K. Rogacki,[1,2] K. Oganisian,[2] N.D. Zhigadlo,[3] and J. Karpinski[4]

[1] *International Lab. of High Magnetic Fields and Low Temp., Wroclaw, Poland*

[2] *Institute of Low Temperature and Structure Research, Wroclaw, Poland*

[3] *Laboratory for Solid State Physics, ETH Zurich, Switzerland*

[4] *Institute of Condensed Matter Physics, EPFL, Lausanne, Switzerland*

The two-band superconductivity in MgB_2 can be controlled only if the role of doping and the intra- and inter- band scatterings is known and understood. In this work doping and the band scatterings are investigated by studying the thermopower and the in-field resistivity of MgB_2 single crystals substituted with C, Al, Li, Mn, C-Li, and Al-Li. Due to these substitutions, MgB_2 is doped with electrons (C, Al), holes (Li), electrons and holes simultaneously and is substituted isovalently with magnetic element (Mn). For these single crystals, the anisotropies of the thermopower and the upper critical field are obtained and analyzed in the frame of simple phenomenological models to better understand the observed features and explain mechanisms being important for the normal-state and superconducting properties. We believe it will help to modify in the controlled way the properties of MgB_2 and thus make this compound, which is one of the cheapest high-T_c superconductor, more suitable for small and large scale applications.

O-1-12

Evolution of a non-Fermi-liquid state in the pseudo-ternary solid solutions $URu_{1-x}Pd_xGe$

V.H. Tran,[1] and D. Gralak[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, ul. Okólna 2, 50-422 Wrocław, Poland*

X - ray diffraction, dc-magnetization M, magnetic susceptibility $\chi(T)$, specific heat $C_p(T)$, and electrical resistivity $\rho(T)$ were performed on $URu_{1-x}Pd_xGe$. The investigated solid solutions crystallize in the orthorhombic TiNiSi - type structure (space group Pnma). We found that the alloys with $x \leq 0.32$ are nonmagnetic down to 2 K, whereas these with $0.35 \leq x \leq 0.8$ are antiferromagnetic. The Néel temperature of the latter pseudo-ternaries attains its maximum value of 32 K at $x = 0.8$. The composition $x = 0.9$ manifests two magnetic phase transitions: antiferromagnetic at T_N= 20 K and ferromagnetic at $T_C = 30$ K. Remarkably, the compositions located closer to the nonmagnetic-magnetic border ($x \sim 0.3$), exhibit $\chi(T) \propto T^{0.53}$, $C_p(T) \propto \ln T$ and $\rho(T) \propto T^{1.2}$, respectively. The finding has been interpreted in terms of non-Fermi liquid properties nearby a quantum critical point. The development of magnetism in $URu_{1-x}Pd_xGe$ corresponds well to changes in the degree of $5f$ electron localization.

The work was supported by the National Science Centre (Poland) under the Grant No. 2011/01/B/ST3/04553.

O-1-13

Intrinsic mechanism of dichroism in chiral multiband superconductors

Karol Izydor Wysokiński,[1] Martin Gradhand,[2] and James F. Annett[2]
[1] *Institute of Physics, M. Curie-Sklodowska University, ul. Radziszewskiego 10, 20-031 Lublin*
[2] *H. H. Wills Physics Laboratory, University of Bristol, Tyndall Ave, BS8-1TL, UK*

We shall present an analysis of the Hall conductivity $\sigma_{xy}(\omega, T)$ in time reversal symmetry breaking states of exotic superconductors. The intrinsic Kerr signal appears in a general multiband system. This is a novel mechanism which may explain the Kerr effect observed in strontium ruthenate and possibly other multiband superconductors. The proposed mechanism does not rely on impurity scattering or a finite width of the incident photon beam.

References:

[1] K.I. Wysokinski, J.F. Annett, B.L. Gyorffy, Phys. Rev. Lett. **108** 077004 (2012).
[2] Martin Gradhand, Karol I. Wysokinski, James F. Annett, and Balazs L. Györffy Phys. Rev. B **88**, 094504 (2013).

O-1-14

Electron phase separation involving superconductivity in the extended Hubbard models with pair hopping interaction

Konrad Kapcia,[1] and Stanisław Robaszkiewicz[1]
[1] *Electron States of Solids Division, Faculty of Physics, Adam Mickiewicz University in Poznań, Umultowska 85, 61-614 Poznań, Poland*

In this work the extended Hubbard models with pair hopping interaction (at atomic limit) are investigated within the variational approach, which treats the on-site interaction term exactly and the intersite interactions within the mean-field approximation (exact in $d \to +\infty$) [1-4]. The exact results derived for $d = 1$ and approximated results for various lattices at $d < +\infty$ are also presented [1,2,4]. We analyze mutual stability of the superconducting (SS) phase and charge (CO) or magnetic (F) orderings as well as homogeneous mixed phases [3,4]. Our results show that the SS phase can coexist with the CO or F phases only in states with electron phase separation.

References:

[1] K. Kapcia, S. Robaszkiewicz, R. Micnas, J. Phys.: Condens. Matter **24**, 235601 (2012)
[2] K. Kapcia, S. Robaszkiewicz, J. Phys.: Condens. Matter **25**, 065603 (2013)
[3] K. Kapcia, J. Supercond. Nov. Magn. **26**, 2647 (2013); Acta Phys. Pol. A **121**, 733 (2012)
[4] K. Kapcia, PhD Thesis, Adam Mickiewicz University (2014)

The work has been financed by NCN as a project No. DEC-2011/01/N/ST3/00413 and as the doctoral scholarship No. DEC-2013/08/T/ST3/00012 as well as by ESF–OP Human Capital–POKL.04.01.01-00-133/09-00.

O-2-01

Topologically protected magnetic helix for energy storage

E.Y. Vedmedenko,[1] and D. Altwein[1]
[1] *University of Hamburg*

The novel generation of computers is supposed to be based on logical elements made of chains of magnetic atoms or nanomagnets. Any logical elements require energy supply, but uses the energy not all the time. A key issue for technology's competitiveness is to figure out how to store energy when it isn't used. Here, we discover that it can be stored in magnetic helices with integer number of revolutions [1]. Based on simulations and a benchmarked prototype, this finding permited to propose an energy storing element that uses spins only. To store energy one has to rotate one of the end-nanomagnets in a chain until the helix will click into place. At the later time the magnet may be released to deliver the energy on demand. The longer is a chain, the larger amount of rotations can be stored. The stable magnetic helices can be also used to transfer the information. To do so, one has to read out when a knot, created at one end of the chain will arrive at the other chain's end. The main advantage of the proposed concept is it's scalability from the macro- to the atomic scale and applicability to the great diversity of systems with different interactions like e.g. magnetic multilayers, magnetic or molecular nanoarrays and colloids.

References:

[1] E. Y. Vedmedenko and D. Altwein, Phys. Rev. Lett. 112, 017206 (2014)

O-2-02

Structure and magnetic interactions in $Ba_{3-x}Sr_xCr_2O_8$

H. Grundmann,[1] A. Schilling,[1] M. Medarde,[2] and D. Sheptyakov[3]
[1] *Physik-Institut, Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich*
[2] *Laboratory for Development and Methods, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland*
[3] *Laboratory for Neutron Scattering, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland*

We have recently reported on a non-linear tuning of the magnetic interaction constant J_0 in the spin dimer system $Ba_{3-x}Sr_xCr_2O_8$ by varying the Sr content x[1]. In the present work we show that this peculiar behavior of J_0 can be explained by changes in the crystal structure, probed with neutron powder diffraction. Performing theoretical calculations based on those structural details, we could well reproduce the change of J_0 by taking into account a structural transition due to the Jahn-Teller active Cr^{5+}-ions. This transition, lifting the magnetic frustration in the system, is heavily influenced by disorder arising from partially exchanging Ba with Sr.

References:

[1] H. Grundmann, A. Schilling, C.A. Marjerrison, H.A. Dabkowska, B.D. Gaulin, Mat. Res. Bull. 48, 3108-3111 (2013)

O-2-03

Quasi-One-Dimensional Ferromagnet $CuAs_2O_4$

K. Caslin,[1,2] R.K. Kremer,[1] F.S. Razavi,[2] A. Schulz,[1] A. Munoz,[3] F. Pertlik,[4] J. Liu,[5] M.H. Whangbo,[5] and J.M. Law[6]

[1] *Max-Planck-Institute for Solid State Research*

[2] *Brock University*

[3] *Universidad de La Laguna*

[4] *Vienna University of Technology, Institute of Mineralogy and Crystallography*

[5] *North Carolina State University*

[6] *Hochfeld-Magnetlabor Dresden, Helmholtz-Zentrum*

Many Cu^{2+} (S=1/2) linear-spin-chains systems exhibit interesting low-dimensional magnetism. Most often, these spin-chains support FM nearest-neighbor (NN) and AFM next-nearest-neighbor (NNN) interactions. Systems of this type are known to develop AFM incommensurate spin-spiral structures and sometimes multiferroic behavior. There exists a magnetic phase diagram which can predict the intra-chain behaviour of spin-chain compounds using the ratio of the NN over the NNN spin exchange constants, α=Jnn/Jnnn, with a quantum critical point exists on the boundary at α=-4. We report on $CuAs_2O_4$, mineral name Trippkeite, featuring CuO_2 ribbon chains. Trippkeite is an unusual spin-chain system because it shows long-range FM ordering and has an α ratio close to -4.

O-2-04

Transition metal ions in semiconductors: LDA, LDA+U, and experiment

T. Zakrzewski,[1] and P. Boguslawski[1]

[1] *Institute of Physics PAS, Warsaw*

The known failure of the Local Density Approximation (LDA) is the underestimation of the band gap in solids, ascribed to the oversimplified treatment of exchange-correlation effects, and particularly drastic in transition metal (TM) oxides. A considerable improvement is obtained by adding the +U correction for particular atomic orbitals. While the impact of +U terms was extensively discussed for ideal crystals, its impact on the electronic structure of defects is less understood. We analysed the impact of the +U term for Cr, Mn, Fe, and Co ions in GaN and AlN. The +U term was treated as a free parameter, and it was applied to p(N) and d(TM) orbitals. The results of LDA+U calculations were compared to available experimental data. The band gap of GaN is correct with U(N)=4 eV. The +U terms strongly affect the electronic structure of TM impurities. Surprisingly, for U(TM)=0, the energies of the gap levels induced by these centers, and of the intra-center optical transitions, agree well with experiment. In contrast, for U(N)=U(TM)=4 eV, these energies are in substantial disagreement with experimental values by about 1-2 eV.

Supported by grant NCN 2012/05/B/ST3/03095.

O-2-05

The J_1-J_2 model on the anisotropic triangular and the square lattice: similarities and differences

B. Schmidt,[1] and P. Thalmeier[1]

[1] *Max-Planck-Institut für chemische Physik fester Stoffe, Dresden, Germany*

The Heisenberg model on a triangular lattice is a prime example for a geometrically frustrated spin system. However most experimentally accessible compounds have spatially anisotropic exchange interactions. As a function of this anisotropy, ground states with different magnetic properties can be realized. On the other hand, the J_1-J_2 model on the square lattice is a well-known example for frustration induced by competing exchange. The classical phase diagrams of the two models are related in a broad range of the control parameter $\phi = \tan^{-1}(J_2/J_1)$. In both cases three different types of ground states are realized, each model having a ferromagnetic and an antiferromagnetic region in the phase diagram, and a third phase with columnar magnetic order for the square lattice and an in general incommensurate spiral structure for the triangular lattice. Quantum effects lift degeneracies in the non-FM phases and lead to additional nonmagnetic regions in the phase diagrams. The contribution of zero point fluctuations to ground state energy and wave vector, ordered moment, magnetization and susceptibility is discussed. In particular we point out that the ordered moment shows non-monotonic dependence both on the applied magnetic field H and on the control parameter ϕ in the vicinity of the disordered regions.

O-2-06

Frustration in odd-numbered AFM rings with bond defect

W. Florek,[1] M. Antkowiak,[1] P. Kozłowski,[1] and G. Kamieniarz[1]

[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

Synthesis of odd-numbered antiferromagnetic rings [1] has reopened discussion on frustration in quantum spin systems [2,3]. Definitions used in the case of the classical systems [4] cannot be applied to quantum ones. The degenerate frustration [5] describes systems with competing interactions and is restricted to models with spin degenerated ground states. Within this approach a system of three spins $s = 1$ with equal antiferromagnetic (AFM) couplings is *nonfrustrated*. We discuss an AFM system containing odd number of spins s, where one bond is 'defected', i.e. $J' = \alpha J$. Within the Ising model this system is frustrated for any $\alpha > 0$. Similarly, in the vector spin model, but one observes changes in spin configurations above $\alpha_c = 1/(n-1)$. According to the Kahn definition the quantum system is frustrated only for specific values of α. We propose and discuss a 'frustration measure', which tends to its classical version for $s \to \infty$, but preserves some features of quantum AFM systems. The relation between bipartiteness and frustration is also discussed.

References:

[1] M.L. Baker *et al.*, Proc. Nat. Acad. Sci. USA **109**, 19113 (2012)
[2] J. Schnack, Dalton Trans. **39**, 4677 (2010)
[3] S. M. Giampaolo *et al.*, Phys. Rev. Lett. **107**, 260602 (2011)
[4] H. T. Diep (ed.) *Frustrated Spin Systems*, World Sci., Singapore 2004
[5] O. Kahn, Chem. Phys. Lett. **265**, 109 (1997)

O-3-01

Superparamagnetism of individual $SrRuO_3$ nanostructures – a direct confirmation of the century-old Langevin equation

O. Sinwani,[1] J.W. Reiner,[2] and L. Klein[1]
[1] *Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel*
[2] *HGST, San Jose, California 95135, USA*

The magnetization of a magnet is only stable when the energy barrier for its reversal is large compared to the thermal energy. As the volume of a magnet is decreased, this stability is eventually lost, and the magnet enters what is known as a superparamagnetic state. This behavior limits the size of grains that can be used in magnetic data storage, but is useful, for instance, for medical imaging and treatment techniques. The fundamental equation describing the effect of an applied magnetic field on superparamagnetic particles was first proposed by Paul Langevin about a century ago. The Langevin equation has been widely used to analyze experiments performed on ensembles of magnetic nanoparticles without the ability to observe the underlying dynamics of specific nanoparticle. Here, we demonstrate for the first time the applicability of the Langevin equation to individual superparamagnetic fluctuations, by monitoring the time dependence of the magnetization of a patterned nanostructure of the itinerant ferromagnet $SrRuO_3$ [1].

References:

[1] O. Sinwani, J. W. Reiner, and L. Klein, Phys. Rev. B **89**, 020404(R) (2014).

O-3-02

Single crystal growth and magnetism of the novel U_2RhIn_8 compound

A. Bartha,[1] M. Kratochvílová,[1] V. Sechovský,[1] and J. Custers[1]
[1] *Department of Condensed Matter Physics, Charles University, Ke Karlovu 5, 121 16 Prague*

We report on the physical properties of the novel compound U_2RhIn_8. Single crystals have been prepared for the first time using In self-flux method. The compound adopts the Ho_2CoGa_8-type structure with lattice parameters a = 4.6163 Å and c = 12.0144 Å. In contrast to its nonmagnetic analog U_2RhGa_8, U_2RhIn_8 orders antiferromagnetically below T_N = 117 K with slightly enhanced Sommerfeld coefficient γ = 47 mJ.mol^{-1}.K^{-2}. The behavior of U_2RhIn_8 strongly resembles that of related $URhIn_5$ with respect to magnetization and resistivity. The susceptibility $\chi(T)$ reveals strong anisotropy with effective magnetic moment corresponding roughly the free U ion. Additionally, an unusually large Curie temperature is found, reaching almost -800 K for H || a. The weak temperature dependence of $\chi(T)$ might be attributed to the mainly itinerant nature of $5f$ electrons. Magnetic field leaves the evolution of T_N unaffected up to 14T, but T_N is enhanced upon applying hydrostatic pressure. The overall phse diagram will be discussed in the context of magnetism in $URhX_5$ and UX_3 (X = In, Ga).

O-3-03

First-Principles Study of Magnetic Properties of ε-Fe_2O_3

Daisuke Hirai,[1] Yoshihiro Gohda,[1] and Shinji Tsuneyuki[1,2]

[1] *Department of Physics, The University of Tokyo, Tokyo, Japan*

[2] *Institute for Solid State Physics, The University of Tokyo, Kashiwa, Japan*

ε-Fe_2O_3 has been attracting strong attention as a novel magnetic material because of its largest coercivity, $H_C = 2$ T, among all of the oxides [1,2]. However, the origin of high coercivity remains unclear, which is crucial not only for scientific interests, but also for materials design. Also, the magnetization is so small due to superexchange interactions via oxygen atoms: its improvement is an important key for technological applications. In this study, we performed first-principles calculations on ε-Fe_2O_3, based on density functional theory. We show that the pristine ε-Fe_2O_3 exhibits zero magnetization, which is in contrast to the finite magnetizaion in experiments at low temperature [1]. The influence of a single oxygen vacancy is also discussed, where it is introduced in the unit cell with 40 atoms. It is clarified that only the introduction to a specific oxygen site contributes to finite magnetization, whose structure is the most stable among those having a single oxygen vacancy. In the presention, we also talk about the magnetic crystalline anisotropy, which is also strongly affected.

References:

[1] S.-I. Ohkoshi and H. Tokoro, Bull. Chem. Soc. Jpn. **86**, 897 (2013).

[2] M. Yoshikiyo, K. Yamada, A. Namai, and S.-I. Ohkoshi, J. Phys. Chem. C **116**, 8688 (2012).

O-3-04

Fast vortex core switching at moderate temperatures

K.M. Lebecki,[1] and U. Nowak[2]

[1] *Nanotechnology Centre, VSB-TU Ostrava, Czech Republic*

[2] *University of Konstanz, Germany*

Ferromagnetic vortex core switching is investigated using micromagnetic simulations. For that the OOMMF program is used [1] together with a temperature extension we have developed recently [2,3]. This is a continuum micromagnetic approach where the well-known Landau-Lifshitz-Gilbert equation (valid for zero temperature) is replaced by the recently proposed Landau-Lifshitz-Bloch equation [4]. Thus, temperatures up to the Curie temperature can be modeled.

In our research we simulate switching of a ferromagnetic vortex core in a flat disk (diameter 200 nm, thickness 20 nm) with material parameters that resemble permalloy. Temperatures in the range 400 K to 700 K are considered [3]. Switching itself is caused by a very short applied oscillation magnetic pulse oscillation. Parameters used resemble conditions met in the experiment [5]: oscillation period ca. 140 ps (equal to the peak width) and amplitude 60 mT (in lower temperatures).

References:

[1] M. J. Donahue and D. G. Porter, OOMMF User's Guide, see http://math.nist.gov/oommf/.

[2] K. M. Lebecki et al ., Phys. Rev. B 86, 094409 (2012).

[3] K. M. Lebecki et al ., Phys. Rev. B 89, 014421 (2014).

[4] D. A. Garanin, Phys. Rev. B 55, 3050 (1997).

[5] M. Kammerer, Phys. Rev. B 86, 134426 (2012).

O-3-05

Role of oxygen coordination on the ultrafast demagnetization in ferrite nanoparticles

E. Terrier,[1] Y. Liu,[1] S. Bégin,[1] B. Pichon,[1] J.-Y. Bigot,[1] and V. Halté[1]

[1] *Institut de Physique et Chimie des Materiaux de Strasbourg, UMR 7504, CNRS, Universite de Strasbourg, BP 43, 23 rue du Loess, 67034 Strasbourg Cedex 02, France*

We studied the ultrafast dynamics of charges and spins in assemblies of Fe_3O_4 and $\gamma\_Fe_2O_3$ nanoparticles. These nanostructures stimulate much interest due to their potential applications in several fields. Generally, these two structural phases of iron oxide are hardly distinguishable. We demonstrate that using time-resolved magneto-optics one is able to disentangle those very similar iron oxide structures. The Fe_3O_4 nanoparticles are elaborated by hydrothermal decomposition and deposited by drop on a glass substrate. $\gamma\_Fe_2O_3$ nanoparticles assemblies have been obtained by annealing the Fe_3O_4 nanoparticles. Comparing time resolved transmission and Faraday rotation, our measurements show that in case of Fe_3O_4 the demagnetization occurs after the thermalization of the charges, as expected from previous works on ultrafast quenching of magnetization in ferromagnetic nanostructures. On the contrary, in the case of maghemite nanoparticles, an acceleration of the demagnetizing occurs, leading to a simultaneous charges and spins dynamics. We attribute this behavior to the rearrangement of vacancies and annealing of crystal defects in maghemite.

O-3-06

Coexistence of inverse and normal magnetocaloric effect in RCoGaO$_4$ (R=Lu, Yb) single crystals

I. Radelytskyi,[1] R. Szymczak,[1] T. Zayarnyuk,[1] H.A. Dabkowska,[2] P. Dłużewski,[1] J. Fink-Finowicki,[1] and H. Szymczak[1]

[1] *Institute of Physics PAS, al.Lotnikow 32/46, 02 668 Warszawa, Poland*

[2] *The Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, Canada*

The magnetic and magnetocaloric properties of RCoGaO$_4$ (R=Lu, Yb) single crystals were studied by *dc* and *ac* magnetization measurement. The results of measurements show evidences of a spin-glass-like behavior, possibly as a consequence of exchange interactions within a geometrically frustrated spin lattices. The isothermal magnetic entropy change observed for both studied crystals show a coexistence of inverse and normal magnetocaloric effect around the freezing temperature. It was evidenced that the normal magnetocaloric effect is due to paramagnetic state above the freezing temperature while the inverse effect arises due to antiferromagnetic interactions inside the studied systems.

This paper was partially supported by the European Fund for Regional Development (Contract No. UDA–POIG.01.03.01-00-058/08/00).

O-3-07

Spin waves in structured yttrium iron garnet films.

R. Gieniusz,[1] V. Bessonov,[1,2] U. Guzowska,[1] A.I. Stognii,[3] and A. Maziewski[1]
[1] *Faculty of Physics, University of Białystok, Lipowa 41, 15-424 Białystok, Poland*
[2] *Institute of Metal Physics, Ural Division of RAS, Yekaterinburg 620041, Russia*
[3] *Scientific-Practical Materials Research Center at NASB, Minsk, Belarus*

The interaction of the magnetostatic surface spin waves (SW) with a single antidot and a line of antidotes in thin garnet films is presented (see also R.Gieniusz at al. Appl. Phys. Lett. 102, 102409 (2013) and Appl.Phys.Lett. 104, 082412 (2014)). Diffraction on the single antidot as a passive point excitation source to create caustic SW beams is shown. The phenomenon of SW total non-reflection on line of antidots is observed. SW are investigated by Brillouin light scattering spectroscopy. Experimental results are well explained by the iso-frequency dependencies. The numerically modeling of both the diffraction parameters on the single antidot and total non-reflection on the line of antidotes is consistent with the experimental results.

Supported by: Team SYMPHONY project of the FNP, co-financed by the EU from ERDF, OPIE 2007–2013.

O-3-08

The influence of local atomic configuration on magnetic properties of $Ni_{50}Mn_{50-x}Z_x$ (Z=In, Sn, Sb) Heusler alloys

K. Załęski,[1] M. Ekholm,[2] B. Alling,[2] I.A. Abrikosov,[2] and J. Dubowik[3]
[1] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[2] *Department of Physics, Chemistry and Biology, Linköping University, Sweden*
[3] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

The concentration dependence of magnetic properties in the austenite phase of $Ni_{50}Mn_{50-x}Z_x$ (Z = In, Sn, Sb) Heusler alloys vary strongly with the Z component [1]. In the case of Z = In alloy the magnetic moment shows a linear dependency with decrease of concentration (x), conversely to Z = Sb case, but shows a concave curve with a minimum of about $x = 20$ in Z = Sn alloy. While the concentration dependence of the magnetic moment of Z = In(Sb) alloys is related to only (anti)ferromagnetic coupling between Mn and Mn_Z moments, the nonlinear curve observed for Z = Sn alloy is related to a change of a ratio of ferro- and antiferromagnetic coupled Mn and Mn_{Sn} moments. We propose a model of local atomic configuration of these alloys and its influence on a total magnetic moment and an exchange-bias effect. In particular, the results of *ab initio* calculations of $Ni_{50}Mn_{50-x}Z_x$ alloys and the results of magnetic measurements of $Ni_{50}Mn_{50-x}Sn_x$ ($x = 16, 20, 25$) alloy thin films are presented.

References:

[1] W. Ito, X. Xu, R.Y. Umetsu, T. Kanomata, K. Ishida, and R. Kainuma, J. Appl. Phys. **109**, 07A926 (2011)

O-3-09

Average magnetization and Fe hyperfine fields in Co_2FeSi-based Heusler alloys

L.F. Kiss,[1] G. Bortel,[1] L. Bujdosó,[1] D. Kaptás,[1] T. Kemény,[1] and I. Vincze[1]
[1] *Wigner Research Centre for Physics of the Hungarian Academy of Sciences*

Half-metallic ferromagnetic alloys are indispensable for spintronic applications. There is a controversy between experiment and theory about the half-metallic nature of the Co_2FeSi Heusler alloy. Usually a generalized Slater-Pauling type (i.e. valency-controlled) behaviour of the average magnetization (theoretically 6 μ_B/f.u.) is considered as a conclusive proof. In the present study SQUID magnetic and ^{57}Fe Mössbauer measurements were performed to clarify the situation. Bulk $Co_2FeAl_{1-x}Si_x$, $Co_{1.9}Fe_{1.1}Al_{1-x}Si_x$, $Co_2Fe_{0.9}TM_{0.1}Si$ (TM=Ti,V,Cr,Mn,Co,Ni,Cu), $Co_{2-y}Fe_{1+y}Al$ and $Co_2Fe_{1\pm y}Si_{1\mp y}$ samples were prepared by induction melting. The $Co_2FeAl_{1-x}Si_x$ shows $L2_1$ crystal structure only for $x \geq 0.4$, between $x=0$ and 0.3 it has A2 structure (Fe–Al,Si disorder). The average magnetization of these alloys does not follow the expected Slater-Pauling trend (on the Si side saturation is observed around 5.75 μ_B/f.u.) and similar deviation is observed for the replacement of Fe by TM atom. The effect of the antisite disorder (Fe-Si) on the magnetization and Fe hyperfine parameters was determined and significant decrease in the Co magnetic moment for excess Si neighbourhood is extrapolated. The formerly reported large $\approx 6\mu_B$/f.u. magnetization for Co_2FeSi was observed only in samples having Fe excess and Si deficiency.

O-3-10

First-principles calculations of Fe/Cu(001) magnetic thin films

Y. Tatetsu,[1] Y. Gohda,[1] and S. Tsuneyuki[1,2]
[1] *Department of Physics, The University of Tokyo*
[2] *Institute for Solid State Physics, The University of Tokyo*

The ground state of Fe bulk is ferromagnetic with the bcc structure, and nonmagnetic fcc structure is not stable below about 1200 K. Surprisingly, fcc or face-centered tetragonal (fct) Fe films have been grown onto Cu(001) even below room temperature. In this system, peculiar structural and magnetic properties of Fe have been reported[1, 2]. For 1-4 monolayers (ML) of Fe, the crystal structure is fct type and the magnetic structure is ferromagnetic. In the thickness between 5 and 10 ML, the crystal structure is fcc type but the magnetic structure is antiferromagnetic or spin density wave at inner layers but ferromagnetic at the top two layers. For the purpose of understanding electronic and magnetic structures of fct Fe/Cu(001) films, first-principles calculations have been performed. The structural optimisation is considered to calculate a realistic structure of this system. From our calculations, the amount of the magnetic moment in Fe films within 4ML is close to that of bulk fct Fe. On the other hand, the enhanced magnetic moment is obtained at the interlayer and surface. In this talk, more details will be presented.

References:

[1] H. Abe *et al.*, Phys. Rev. B **77**, 054409 (2008)
[2] D. Pescia *et al.*, Phys. Rev. Lett. **58**, 2126 (1987)

O-3-11

Chaos in a dynamic formation of magnetic vortex structures

Ki-Suk Lee,[1] Mi-Young Im,[2] Hee-Sung Han,[1] Sukbin Lee,[1] and Peter Fischer[2]

[1] *School of Mechanical and Advanced Materials Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan, Republic of Korea*

[2] *Center for X-ray Optics, Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA*

Owing to unique non-trivial dynamic and static properties as well as prominent applications in information technologies, magnetic vortex structures have recently been attracted much attention. To realize such systems in applications, a reliable control of vortex states is necessary and which requires a complete understanding and manipulating of the detailed dynamic formation process of vortex states. From micromagnetic simulations, it will be seen that dynamic formation process is nonlinear as well as chaotic and thus, the resultant vortex state depends sensitively on initial conditions. Moreover, by means of manipulating initial conditions, we propose an efficient method to control the vortex states.

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2012R1A1A1041922)

O-4-01

Systematic study of magnetic linear dichroism and birefringence in (Ga,Mn)As

Karel Výborný,[1] Naďa Tesařová,[2,3] and Tomáš Ostatnický[2]
[1] *Institute of Physics, ASCR, v. v. i., Cukrovarnická 10, CZ-16253 Praha 6, Czech Republic*
[2] *Faculty of Mathematics and Physics, Charles University in Prague, Praha, CZ-121 16, Czech Republic*
[3] *Department of Physics, University at Buffalo–SUNY, Buffalo, New York 14260, USA*

Magnetic linear dichroism and birefringence in (Ga,Mn)As epitaxial layers are investigated by measuring the polarization plane rotation of reflected linearly polarized light when magnetization lies in the plane of the sample. We report on the spectral dependence of the rotation angle (together with ellipticity) in the very broad energy range of $0.12 - 2.7$ eV for a sequence of optimized samples covering a wide range on Mn-dopings and Curie temperatures and find a clear blue shift of the dominant peak at energy exceeding the host material band gap. These results are discussed in the general context of the GaAs host band structure and also within the $k \cdot p$ and mean-field kinetic-exchange model of the (Ga,Mn)As band structure. We discuss the role of disorder-induced non-direct transitions on magneto-optical properties of (Ga,Mn)As.

References:

[1] N. Tesařová *et al.*, Phys. Rev. B **89**, 085203 (2014).

O-4-02

Current induced magnetization switching in magnetic tunnel junctions with perpendicular magnetic anisotropy

M. Frankowski,[1] W. Skowroński,[1] S. Ziętek,[1] M. Czapkiewicz,[1] A. Żywczak,[1] W. Powroźnik,[1] J. Wrona,[1] J. Kanak,[1] P. Wiśniowski,[1] and T. Stobiecki[1]
[1] *AGH University of Science and Technology, Department of Electronics*

Magnetic Tunnel Junctions (MTJs) with Perpendicular Magnetic Anisotropy (PMA) are of great interest for high-density non-volatile magnetic random access memory due to possible low critical current density, good thermal stability and downscalable junction size [1]. We present experimental data on MTJs with following layers structure (thicknesses in nm) 5 Ta / 20 Ru / 5 Ta / 1.0 CoFeB / 0.8-1.3 MgO / 1.5 CoFeB / 5 Ta / 5 Ru. Elliptical nanopillars with the dimensions ranging from 1 μm down to 170 nm exhibiting PMA and tunneling magnetoresistance of 90% were fabricated using e-beam lithography. Current induced magnetization switching hysteresis loops with voltage pulses of different time lenghts were measured, form which intrinsic critical current density of -0.47 MA/cm^2 for parallel to anti-parallel and 1.03 MA/cm^2 for anti-parallel to parallel switching was derived.

References:

[1] S. Ikeda et. al., Nature Materials 9, 721–724 (2010).

This projectis supported by the Diamond Grant DI2011001541 and Swiss Contribution by NANOSPIN PSPB-045/2010 grant.

O-4-03

Quantum interference in disordered ferromagnet U_2NiSi_3

Daniel Gnida,[1] Maria Szlawska,[1] and Dariusz Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences*

U_2NiSi_3 is a ferromagnet with the Curie temperature $T_C = 26$ K and the ordered magnetic moment lying within the *ab* plane of the hexagonal unit cell. The overall temperature and magnetic field dependencies of the electrical resistivity clearly reveal an interplay of the ferromagnetic ordering and quantum interference effects (QIE) resulting from crystallographic disorder. Electron-electron interaction manifests itself as a $T^{0.5}$ increase in the in-plane and out-of-plane electrical resistivity $\rho(T)$ below 4 K. This effect is weakly dependent on external magnetic field (B_{ext}) that is much smaller than internal magnetic field (B_{int}) resulting from magnetic exchange interactions. In contrast, weak localization (WL) is observed solely in the *ab*-plane resistivity as a linear-in-T contribution to $\rho(T)$, clearly seen in weak B_{ext}. In the out-of-plane $\rho(T)$, WL is suppressed already by B_{int}, which gives rise to a maximum in $\rho(T)$ near T_C. It implies that B_{int} does not break the interference of closed trajectories of electrons moving in the *ab*-plane in opposite directions, similarly to 2D disordered ferromagnets with in-plane magnetic induction. All our findings point to an important role of exchange field and magnetic anisotropy on QIE in disordered ferromagnets.

This work was supported by the National Science Center (Poland) under research Grant No.2011/03/D/ST3/02351

O-4-04

Critical Exponents of Dilute Ferromagnetic Insulator $Ga_{1-x}Mn_xN$

S. Stefanowicz,[1] G. Kunert,[2] W. Stefanowicz,[1] D. Hommel,[2] T. Dietl,[1,3,4] and M. Sawicki[1]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

[2] *Institute of Solid State Physics, University of Bremen, Germany*

[3] *Institute of Theoretical Physics, University of Warsaw, Poland*

[4] *WPI-AIMR, Tohoku University, Sendai, Japan*

Insulating ferromagnet (Ga,Mn)N brings a new paradigm into the semiconductor family. It is therefore important to comprehensively characterize its magnetic ground state. To this end we analyze the critical exponents β and γ for MBE grown layers with $0.04 < x < 0.10$ [1] and superlattice structures $Ga_{1-x}Mn_xN$/GaN:Mg. In all samples the critical behavior shows strong deviations from the magnetically clean case ($x = 1$): an apparent breakdown of the Harris criterion, a nonmonotonic crossover in the values of the γ_{eff} between the high temperature and critical regimes, and a smearing of the critical region by macroscopic inhomogeneities in the spin distribution.

References:

[1] S. Stefanowicz *et al.*, Phys. Rev. B **88**, 081201(R) (2013) and references therein

This work is supported by Polish NSC grants (DEC-2012/07/N/ST3/03146, DEC-2011/02/A/ST3/00125, DEC-2013/09/B/ST3/04175)

O-4-05

Effects of transverse magnetic anisotropy on current-induced spin switching

Maciej Misiorny,[1,2] and Józef Barnaś[2,3]

[1] *Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany*

[2] *Faculty of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland*

[3] *Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznań, Poland*

Knowledge of transport properties of individual large-spin (S> 1/2) atoms/molecules exhibiting magnetic anisotropy is of key importance for information processing technologies. Incorporating such objects as functional elements of spintronic devices, the objective is to employ spin-polarized currents to control the magnetic state of the system. In particular, for an atom/molecule with the predominant 'easy-axis' uniaxial magnetic anisotropy this allows for switching the system's spin. Yet, the uniaxial magnetic anisotropy, underlying the magnetic bistability, is often accompanied by the transverse anisotropy, whose presence manifests, e.g., as quantum tunneling of magnetization (QTM). Here, we show that not only does QTM determine an effective energy barrier for the spin switching, but also its effect on the transport reveals as an additional signal in transport characteristics. Furthermore, we propose how to experimentally investigate QTM by means of the STM inelastic transport spectroscopy.

References:

[1] M. Misiorny and J. Barnaś, Phys. Rev. Lett. **111**, 046603 (2013).

O-4-06

Microscopic Theory of the Inverse Edelstein Effect

Ka Shen,[1] G. Vignale,[1] and R. Raimondi[2]

[1] *Department of Physics and Astronomy, University of Missouri, Columbia MO 65211, USA*

[2] *Dipartimento di Matematica e Fisica, Università Roma Tre, Via della Vasca Navale 84, 00146 Rome, Italy*

The spin Hall effect and the inverse spin Hall effect are well known phenomena in current spintronics research. A third effect, deeply connected to the above two, is the the so-called Edelstein effect (EE), where a steady current J_x, driven by an electric field E_x produces a steady non-equilibrium spin polarization S^y. On the other hand, relatively little attention has been paid to the "inverse Edelstein effect" (IEE), the Onsager reciprocal of the EE, recently observed by Rojas Sánchez et al. (Nature Commun. 4, 2944 (2013)). In this presentation, we provide a precise microscopic definition of IEE, in which a non-equilibrium spin accumulation in the plane of a two-dimensional (interfacial) electron gas drives an electric current perpendicular to its own direction. The drift-diffusion equations that govern the effect, based on a $SU(2)$ gauge-theory formulation of the Rashba spin-orbit coupling in a two-dimensional disordered electron gas, are presented and applied to the interpretation of the experiments. The results here presented have partly appeared in PRL 112, 096601 (2014).

O-4-07

Cooper pair splitting as a source of entangled electrons

J. Martinek,[1] D. Tomaszewski,[1] P. Busz,[1] P. Rożek,[1] W. Kłobus,[2] A. Grudka,[2] A. Baumgartner,[3] and C. Schonenberger[3]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznan, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland*
[3] *Department of Physics, University of Basel, CH-4056 Basel, Switzerland*

We study an entangled state of spin of spatially separated electrons, in a solid state electronic system. The ground state of conventional superconductors is a singlet state of electron Cooper pairs that can provide a natural source of entangled electrons. One of the proposals to obtain the nonlocal entanglement of electrons is to use the Cooper pairs split in the Double Quantum Dot (DQD) system using the Coulomb interaction between electrons. We have analyzed an efficiency of the separation of Cooper pairs in systems. Addressing the idea of quantum communication with entangled electrons in a solid state, where ferromagnetic detectors allow for spin correlation detection, we provide, using quantum information theory, a lower bond on the spin polarization of detectors. In ferromagnetic detectors the spin information is transformed into charge information, however, any real magnetic materials feature imperfect spin polarization. We find that lower bond for the spin polarization is $p > 58\%$ for detection of entanglement using an optimal entanglement witness. It provides the minimal spin polarization of ferromagnetic materials that can be useful in quantum communication.

O-4-08

Spin Hall and Edelstein effects in metallic films: from 2D to 3D

J. Borge[1]

[1] *Dipartimento di Matematica e Fisica, Università Roma Tre, Via della Vasca Navale 84, Rome, Italy*

A normal metallic film sandwiched between two insulators may have strong spin-orbit coupling near the metal-insulator interfaces, even if spin-orbit coupling is negligible in the bulk of the film. In this paper we study two deeply interconnected effects that arise from interfacial spin-orbit coupling in metallic films. The first is the spin Hall effect, and the second is the Edelstein effect. At variance with strictly two-dimensional Rashba systems, we find that the spin Hall conductivity has a finite value even if spin-orbit interaction with impurities is neglected and "vertex corrections" are properly taken into account. Even more remarkably, such finite value becomes "universal" in a certain configuration. This is a direct consequence of the spatial dependence of spin-orbit coupling on the third dimension, perpendicular to the film plane. The non-vanishing spin Hall conductivity has a profound influence on the Edelstein effect. Our results, although derived in a specific model, should be valid rather generally, whenever a spatially dependent Rashba spin-orbit coupling is present.

References:

[1] J. Borge, C. Gorini, G. Vignale and R. Raimondi, (2014), arXiv:1403.4195.

O-4-09

Magnetooptical properties of ZnMnTe nanorods and of CdMnTe quantum dots embedded in ZnTe rods

P. Wojnar,[1] M. Szymura,[1] W. Zaleszczyk,[1] Ł. Kłopotowski,[1] J. Suffczyński,[1] and J. Kossut[1]

[1] *Institute of Physics of the Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*

We report on magnetoptical properties of ZnMnTe nanorods fabricated by vapor-liquid-solid method during molecular beam epitaxy process. We show that as-grown nanorods are relatively optically inactive, while covering them with a ZnMgTe outer shells results in appearance clear luminescence properties. The PL spetra of such core/shell nanowires show near-band edge features which are shifted to lower energies by strain exerted by the shells. Also a giant spin splitting is detected both in ensembles as well as single nanowires studied by PL and cathodoluminescence. A very specific polarization properties are detected when studying CdMnTe quantum dots embedded in ZnTe nanorods. These properties, we relate to locking of heavy hole spins to the direction of growth of the nanowires.

Supported by European Regional Development Fund through Innovative Economy grant POIG.01.01.02-00-008/08 and by National Centre of Science through the grant DEC-2013/08/A/ST3/00297.

O-5-01

Magnetic and structural study of (ZnTe)/Co core-shell nanowires grown by MBE

P.A. Misiuna,[1] T. Wojciechowski,[1] P. Dłużewski,[1] B. Kurowska,[1] M. Wiater,[1] S. Lewińska,[1] A. Ślawska-Waniewska,[1] A. Wawro,[1] E. Milińska,[1] T. Wojtowicz,[1] and L.T. Baczewski[1]

[1] *Institute of Physics Polish Academy of Sciences, Warsaw, Poland*

The aim of this work was to obtain and characterize a model object for magnetic anisotropy study – (ZnTe)/Co core-shell nanowire. Arrays of crystalline ZnTe nanowires covered with cobalt were grown by molecular beam epitaxy in the two-step growth. Firstly, vapor-liquid-solid mechanism was used to obtain nanowires of diameters from 30 to 70 nm and length around 1 μm. The second step involved covering the nanowires with Co shell of different thicknesses. Structural characterization of such structures was performed using scanning electron microscopy, transmission electron microscopy and energy dispersive X-ray spectroscopy techniques. Deposited cobalt has a polycrystalline structure. With the increment of Co deposition thickness the initial roughness of ZnTe core leads to a quasi-dendritic shape of Co shell. Vibrating sample magnetometry magnetic and force microscopy experiments revealed that magnetization easy-axis direction is perpendicular to the long axis of the nanowires, which is in agreement with theoretical predictions [1].

References:

[1] K. M. Lebecki *et. al.* Physica B: Condensed Matter (2008), 403(2-3), 360–363.

O-5-02

Pressure effect on ferromagnetism and exchange bias in Ru-doped manganites

A. Wisniewski,[1] I. Fita,[1,2] V. Markovich,[3] and R. Puzniak[1]

[1] *Institute of Physics, PAS, Aleja Lotnikow 32/46, PL-02-668 Warsaw, Poland*

[2] *Donetsk Institute for Physics and Technology, NAS, Donetsk, Ukraine*

[3] *Department of Physics, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

Pressure effect on magnetic state and exchange bias (EB) in phase-separated ferromagnetic/antiferromagnetic (FM/AFM) $CaMn_{1-x}Ru_xO_3$ ($0.06 \leq x \leq 0.15$) and $Bi_{0.4}Ca_{0.6}Mn_{1-x}Ru_xO_3$ ($x = 0.1$, 0.2) manganites was studied under a pressure up to 11 kbar. For both manganites, complex pressure and Ru-doping effects on EB and coercive fields may be explained with a model of size-variable (depending on Ru content and pressure) nanoscale FM droplets embedded in an AFM matrix. For $CaMn_{1-x}Ru_xO_3$, the observed enhancement of EB with increasing pressure is attributed to the reduction in the FM cluster size, evidenced by both pressure dependence of spontaneous FM moment and EB field dependence upon cooling field. In contrast, for $Bi_{0.4}Ca_{0.6}Mn_{1-x}Ru_xO_3$, both Ru-doping and external pressure act similarly, leading to a growth of the FM clusters and consequently to a suppression of the EB. The results show that for phase-separated FM/AFM manganites the EB effect may be smoothly controlled by pressure.

O-5-03

Electric field control of the indirect magnetic coupling through a short graphene nanoribbon

K. Szałowski[1]

[1] *Department of Solid State Physics, University of Łódź, ul. Pomorska 149/153, 90-236 Łódź*

The ability of controlling the magnetic properties of nanostructures with external fields is an important step in development of spintronics [1-3]. In the paper we study theoretically the effect of an in-plane electric field on the coupling between magnetic planes attached to the edges of a short armchair graphene nanoribbon. The tight binding model with Hubbard and electric field potential term describes the system in question. In particular we find a low-field antiferromagnetic coupling, which can be continuously changed into a ferromagnetic one by increasing the electric field. The magnitude of the effect strongly depends on the nanostructure width and geometry.

References:

[1] Y.-W. Son, M. L. Cohen, and S. G. Louie, Nature **444** (2006) 347
[2] S. Csonka, I. Weymann, and G. Zarand, Nanoscale **4** (2012) 3635
[3] K. Szałowski, J. Appl. Phys. **114** (2013) 243908

This work has been supported by Polish Ministry of Science and Higher Education on a special purpose grant to fund the research and development activities and tasks associated with them, serving the development of young scientists and doctoral students.
The computational support on Hugo cluster at Department of Theoretical Physics and Astrophysics, P. J. Šafárik University in Košice is gratefully acknowledged.

O-5-04

Effect of external contacts on edge magnetic moments in graphene nanoribbons

S. Krompiewski[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences ul. M. Smoluchowskiego 17, 60-179 Poznan*

A problem of carbon-based structures' magnetism is not free from controversies and still open to debate. Theoretically, it is well known that magnetic moments can be formed at carbon atoms with unsaturated bonds. In graphene nanostructures, typically this situation corresponds either to the zigzag-type fragments of the outer edges or the inner boundaries close to vacancies or holes. In this contribution the former case is studied within the framework of tight-binding method (for π-state electrons) and the Green function technique. The main problem of interest here is the influence of external electrodes on the edge magnetic moments. It is shown that the edge moments get reduced (and eventually disappear) when the graphene nanoribbon/electrode interface becomes more and more transparent for electrons.

O-5-05

Shape, size and internal structure influence on magnetic properties and reversal magnetization in nanodots

E. Milińska,[1] and A. Wawro[1]
[1] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warszawa*

Magnetization reversal of nanodots is fundamentally correlated with their size, shape as well as internal structure. In this work we investigate experimentally magnetic properties of monodomain magnetic dots induced by a patterned buffer in a multilayered metallic film. Experimental results are supported by micromagnetic calculations. Considered nanodots (50 – 500 nm in size) are perpendicularly magnetized. The modelled dot internal structure is uniform or composed of a core and an edge characterized by different anisotropy constants – higher or lower than that of the core. Such approach explains the differences observed in behavior of real magnetic dot fabricated by various methods. The shapes of dots assumed in calculations (round, triangular and hexagonal) are experimentally observed. Based on calculated hysteresis loops we discuss in details the magnetization reversal processes, stability of magnetic structure, and spin configurations in the dots.

This work is supported by the research funds from the National Science Centre in Poland, under the projects: DEC-2011/03/N/ST3/02662 and DEC-2012106/M/ST3/00475.

O-5-06

Coulomb edge effects in graphene nanoribbons

W. Jaskólski[1]
[1] *Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Grudziadzka 5, 87-100 Torun, Poland*

Graphene has became recently the most intensively studied material because it is expected to find applications in novel nano-electronic devices. Such applications require the usage of nanosize structures of graphene, like graphene nanoribbons (GNR), in which the properties of edges may be dominant. Graphene ribbons exhibit edge-localized electronic states with energies close to the Fermi level, which play a crucial role in transport and magnetic properties of GNRs. We investigate the influence of Coulomb effects on the edge localized states of GNRs with arbitrary shape of the edges. We work in the Hubbard model and the π-electron tight-binding approximation. We show that flat, edge-localized bands with energies at the Fermi level are especially sensitive for the electron interaction effects. Spin degeneracy of such bands is lifted when the edges are different and *non-minimal*. The strengths of the splitting depends on the edge modification and in some cases leads to spin-filter and magnetic transport properties of the ribbons.

References:

[1] W. Jaskolski, A. Ayuela, M. Pelc, H. Santos, and L. Chico, Phys. Rev. B **83**, 235424 (2011)
[2] M. Pelc, A. Ayuela, L. Chico, and W. Jaskolski, Phys. Rev. B **87**, 165427 (2013)

O-5-07

Controlling the magnetic anisotropy in Pt/Co/Pt ultrathin films by femtosecond laser pulses

J. Kisielewski,[1,2] W. Dobrogowski,[1] Z. Kurant,[1] A. Stupakiewicz,[1] M. Tekielak,[1] A. Kirilyuk,[2] A. Kimel,[2] Th. Rasing,[2] L.T. Baczewski,[3] A. Wawro,[3] K. Balin,[4] J. Szade,[4] and A. Maziewski[1]

[1] *Faculty of Physics, University of Białystok, Poland*

[2] *Institute for Molecules and Materials, Radboud University Nijmegen, The Netherlands*

[3] *Institute of Physics, Polish Academy of Sciences, Poland*

[4] *A. Chełkowski Institute of Physics, University of Silesia, Poland*

Annealing with single femtosecond laser pulses allows to alter irreversibly the magnetic anisotropy in ultrathin Pt/Co/Pt films. A preference in the magnetization alignment can be turned from an easy-plane type into an easy-axis type or vice versa, depending on the Co film thickness and the incident pulse fluence. The changes of magnetic properties were characterized using MOKE techniques, the modification of the structure was analyzed by ToF-SIMS.

References:

[1] J. Kisielewski *et al.*, J. Appl. Phys. **115**, 053906 (2014)

FNP Team Programme, European Regional Development Fund, OPIE 2007-2013; National Science Centre Poland (DEC-2012106/M/ST3/00475)

O-5-08

Spin-polarized photoemission from topological insulators thin films

L. Plucinski,[1] A. Herdt,[1] G. Bihlmayer,[1] G. Mussler,[1] M. Eschbach,[1] E. Mlynczak,[1] D. Grützmacher,[1] S. Blügel,[1] and C.M. Schneider

[1] *Peter Grünberg Institute, Forschunszentrum Jülich, Germany*

Spin polarized photoemission spectra from surfaces of Bi_2Te_3 [1] and Sb_2Te_3 [2] topological insulator (TI) thin films [3] prepared by the optimized procedure under the UHV [4] show up to 45% in-plane spin polarization in the Dirac cone near the Fermi level. We will discuss the spin-orbit entanglement mechanism behind the non-100% spin polarization in topologically protected surface states, and propose possible surface engineering solutions to secure intrinsic semiconductor properties in films grown by the MBE. Furthermore we will compare analytical band structure models with the DFT-based slab calculations. First angle-resolved photoemission results on TI heterostructures, and on bulk and surface doping of the TI thin films will also be presented and in the outlook we will provide ideas for future spectroscopic research directions on TI thin films.

References:

[1] A. Herdt *et al.*, Phys. Rev. B 87, 035127 (2013).
[2] L. Plucinski *et al.*, J. Appl. Phys. 113, 053706 (2013).
[3] J. Krumrain *et al.*, J. Cryst. Growth 324, 115 (2011).
[4] L. Plucinski *et al.*, Appl. Phys. Lett. 98, 222503 (2011).

O-5-09

Competition between the Kondo effect and electron pairing in nanoscopic systems

T. Domański,[1] J. Barański,[1] and M. Zapalska[1]

[1] *Institute of Physics, M. Curie Sklodowska University, 20-031 Lublin, Poland*

We investigate the low energy spectrum of a correlated quantum impurity embedded in a superconducting reservoir, where the proximity effect induces electron pairing manifested by the in-gap Andreev states. Recently the experiments using two-terminal and three-terminal nanoscopic heterojunctions have enabled controllabe evolution from the BCS-type to the singly occupied configurations. We study mutual dependence between the induced pairing and electron correlations using two complementary methods. In particular, we find that the spin exchange mechanism (promoting the many-body Kondo state) leads to substantial changes of the subgap Andreev conductance. We confront this result with the available experimental data.

O-5-10

Thermoelectric properties of doped zigzag silicene nanoribbons

K. Zberecki,[1] R. Swirkowicz,[1] and J. Barnaś[2,3]

[1] *Faculty of Physics, Warsaw University of Technology, ul. Koszykowa 75, 00-662 Warsaw, Poland*

[2] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

[3] *Institute of Molecular Physics, Polish Academy of Sciences, ul. Smoluchowskiego 17, 60-179 Poznań, Poland*

Electric and thermoelectric properties of silicene nanoribbons doped with either non-magnetic or magnetic impurity atoms are investigated theoretically for both antiparallel and parallel orientations of the edge magnetic moments. Inclusion of different impurities (magnetic or non-magnetic) also considerably modifies spin density distributions. Ground state of pristine nanoribbon corresponds to antiparallel spin orientation so the total magnetic moment is zero. Appropriately arranged impurities can lead to a net magnetic moment and thus also to spin thermoelectric effects.
Spin density distributions as well as transport parameters were obtained by use of the *ab-initio* numerical methods based on the density functional theory. The results of calculations show that the spin thermopower can be considerably enhanced by the impurities.

O-5-11

Effect of CoO/Ni orthogonal exchange coupling on perpendicular anisotropy of Ni films on Pd(001)

P. Kuświk,[1,2] P.L. Gastelois,[1,3] M.M. Soares,[4] H.C.N. Tolentino,[5,6] M. De Santis,[5,6] A.Y. Ramos,[5,6] A.D. Lamirand,[5,6] M. Przybylski,[7,1] and J. Kirschner[1,8]

[1] *Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

[3] *Serviço de Nanotecnologia, CDTN, Belo Horizonte, MG, Brazil*

[4] *European Synchrotron Radiation Facility, Grenoble, France*

[5] *University Grenoble Alpes, Institut Néel, Grenoble, France*

[6] *CNRS, Institut Néel, Grenoble, France*

[7] *ACMiN and Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland*

[8] *Naturwissenschaftliche Fakultät II, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany*

The effect of orthogonal exchange coupling between CoO and Ni/Pd(001) on perpendicular anisotropy of Ni films is studied. The thickness range in which Ni films are perpendicularly magnetized is extended by growing CoO on top of it, however, only at temperatures below T_{N}^{CoO}. The perpendicular orientation of Ni spins and the in-plane orientation of CoO spins are confirmed by MOKE/XMCD and XMLD, respectively.

O-5-12

Strong and weak interlayer exchange coupling in Fe-V multilayers

L. Smardz,[1] J. Skoryna,[1] and A. Marczyńska[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

The Fe (0.6 nm) - V (X nm) multilayers with constant thickness sublayers were prepared onto naturaly oxidised Si(100) substrate using UHV (5×10^{-10} mbar) DC/RF magnetron sputtering. The samples were covered with 5 nm Pd to prevent oxidation and to ensure fast hydrogen uptake and relase. The saturation and coercive fields were determined from the in-plane hysteresis loop measurements at room temperature. Results showed that the saturation field and remanece of the Fe-V multilayers oscilate with aniferromagnetic (AFM) peaks near the V spacer thickness of about 1.3, 1.7, 2.1, 2.9, and 3.6 nm. The positions of the AFM peaks were also revealed by magnetoresistance measurements. The short period of the AFM peak oscilation in the strongly coupled region could be explained by transient ferromagnetic state of V atoms near V - Fe interface due to magnetic polarisation [1].

References:

[1] M.M. Schwickert, R. Coehoorn, M.A. Tomaz, E. Mayo and D. Lederman, W.L. Obrien, Tao Lin, and G.R. Harp, Phys. Rev. B. 57 (1998) 13681.

O-5-13

Effect of segregation of sp-impurities on surface and grain boundary magnetism in nickel and cobalt

M. Všianská,[1,2,3] H. Vémolová,[3] and M. Šob[1,2,3]

[1] *Central European Institute of Technology, CEITEC MU, Masaryk University, Brno, Czech Republic*

[2] *Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic*

[3] *Masaryk University, Faculty of Science, Department of Chemistry, Brno, Czech Republic*

We present a systematic ab initio study of segregation of 12 non-magnetic sp-impurities (Al, Si, P, S, Ga, Ge, As, Se, In, Sn, Sb and Te) at $\Sigma5(210)$ grain boundary (GB) and (210) free surface (FS) in fcc ferromagnetic cobalt and nickel and analyze their effect on structure, magnetic and mechanical properties. In nickel, most of the above impurities nearly kill or substantially reduce the magnetic moments at the FS and, when segregating interstitially (i.e. Si, P, S, Ge, As, Se), also at the GB so that they provide atomically thin magnetically dead layers which may be very desirable in spintronics. Reduction of magnetic moments at the $\Sigma5(210)$ GB in fcc ferromagnetic cobalt is, in absolute values, very similar to that in nickel. However, as the magnetic moment in bulk cobalt is higher, we do not observe magnetically dead layers here. Our results may motivate experimentalists to conduct new investigations in this field.

O-6-01

Processable nanocrystalline Fe-based alloy with excellent soft magnetic properties

K. Takenaka,[1] A.D. Setyawan,[1] Y. Zhang,[1] P. Sharma,[1] N. Nishiyama,[1] and A. Makino[1]

[1] *Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan*

Nanocrystalline alloys, NANOMET [1] have attracted much attention as high performance magnetic core materials. Their properties have been investigated by using the lab.-scale ribbon of about 20 μm in thickness and 5 mm in width. For practical use, it is important to develop alloys based on the dependence of ribbon size on magnetic properties. A newly developed nanocrystalline (Fe,Co)-Si-B-P-Cu alloy ribbon (10 mm in width) with high (Fe,Co) content of 85.2 at.% has better soft magnetic properties such as high B_s of 1.84 T and low H_c of 6.5 A/m. The critical thickness (t_c) of the ribbon showing low H_c of 7 A/m is 30 μm. It is much thicker than that of the high B_s (>1.8 T) Co-free alloys, where t_c is 18 μm. In addition, the ribbon with 50 mm in width was successfully produced. The present alloy exhibits similar magnetic properties regardless of ribbon size, which is suitable for practical application. In this paper, the applicability will also be discussed on the basis of core loss evaluation.

References:

[1] A. Makino, IEEE Trans. Magn., 48 (2012) 1331.

O-6-02

Magnetic and related properties of ternary TmTX intermetallics

D. Kaczorowski,[1] and A. Szytuła[2]

[1] *W. Trzebiatowski Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P.O.Box 1410, 50-950 Wrocław, Poland*

[2] *M. Smoluchowski Institute of Physics, Jagiellonian University, Reymonta 4, 30-059 Kraków, Poland*

We reported on the magnetic, thermodynamic and eelctrical transport properties of a few TmTX compounds, where T = d-electron metal and X = p-electron element. In most of these ternaries, the tullium magnetic moments order antiferro- or ferromagnetically at low temperatures. The specific heat data confirm the magnetic ordering and reveal crystalline electric field effect. The electrical resistivity has a metallic character and exhibits distinct anomalies due to the magnetic phase transitions. Role of RKKY interactions on the emergence of magnetic order and specific to the series structure - property relationships will be discussed.

The research was supported by the Ministry of Science and Higher Education (Poland) under Grant no N N202 201 039.

O-6-03

Electronic structure and magnetic properties of $L1_0$ binary compounds

Alexander Edström,[1] Jonathan Chico,[1] Adam Jakobsson,[1] Anders Bergman,[1] and Jan Rusz[1]

[1] *Department of Physics and Astronomy, Uppsala University, Box 516, 75121 Uppsala, Sweden*

Materials exhibiting a large saturation magnetization (M_s), high Curie temperature (T_C), as well as a large magnetic anisotropy energy (MAE), are of great technological importance in a wide range of permanent magnet applications. Certain $L1_0$ ordered binary compounds reveal large MAE without containing scarce elements, such as platinum or rare-earths, making them potentially interesting from a technological perspective. In this work a combination of two different density functional theory (DFT) methods and Monte Carlo (MC) simulations is used for a thorough investigation into the electronic structure and magnetic properties of $L1_0$ structured binary compounds FeNi, CoNi, MnAl and MnGa. Large MAEs, in the order of 1 MJ/m^3 and higher, as well as high Curie temperatures, far above room temperature, are presented. Some investegation is also done into the effect of substitutional disorder and off stoichoimetric compositions. Disorder tends to decrease both MAE and T_C while going off stoichoimetry turns out to be important for the stability of a ferromagnetic phase in Mn-based compounds.

O-6-04

Tailoring the nano-structure of high Bs $Fe_{83.3}Si_4B_8P_4Cu_{0.7}$ soft magnetic alloys

Parmanand Sharma,[1] Xu Bowei,[1] Yan Zhang,[1] and Akihiro Makino[1]

[1] *Institute for Materials Research Tohoku University, Sendai, Japan*

Most popular nano-crystalline alloys are FINEMET, NANOPERM and HITPERM. Recently, a new kind of nano-crystalline alloy "NANOMET (FeSiBPCu)" is developed. Crystallization of FINEMET is independent of heating rate, whereas NANOPERM and NANOMET alloys need high heating rate (>200 C/min). Motivation of present work is to make nano-crystallization process/magnetic properties independent of heating rate. For this, amorphous ribbons of $Fe_{83.3}Si_4B_8P_4Cu_{0.7}$ were prepared by melt-spinning. The optimum annealing temperature for nanocrystallization (Hc $<$ 10 A/m and Bs $\sim$ 1.8 T) is $\sim$ 460 C. The microstructure/magnetic properties strongly depend on the heating rate. Rapid decrease in Hc with increasing heating rate was noticed and it is due to decrease in grain size. Sudden increase in crystalline volume fraction with annealing temperature is associated with the nucleation of large number of grains. By separating the nucleation and growth process, heating rate dependence in microstructure/magnetic properties was suppressed. Two step annealing process is proposed. First step is to create a large number of nuclei's whereas second step is for growth. The growth of nuclei's is shown to be independent of heating rate. Further details on structure/magnetic properties and their correlation will be presented.

O-6-05

Magnetocrystalline anisotropy calculations of $Fe_{13}Co_{19}C$ SQS

M. Werwiński,[1] J. Rusz,[1] A. Edström,[1] E.K. Delczeg-Czirjak,[1] and O. Eriksson[1]

[1] *Department of Physics and Astronomy, Uppsala University, SE-75120 Uppsala, Sweden*

In bcc Fe and Fe-Co alloys the interstitial C atoms can cause a tetragonal distortion, which may lead to increase of the magnetocrystalline anisotropy energy (MAE) of the samples. In the search for the rare earth free permanent magnets we carried out the electronic band structures calculations of bcc Fe-Co alloys doped with C located into octahedral interstitial positions [1]. Fe/Co concentration of about 40/60 is the most promising to give the highest MAE value. The 40/60 ratio is modeled within 32 atoms bcc supercell by using "mcsqs" Monte Carlo algorithm [2] to generate "special quasirandom structures" (SQS's) [3]. Generated $Fe_{13}Co_{19}$ supercell represents $Fe_{41}Co_{59}$ alloy. A single C atom is put into $Fe_{13}Co_{19}$ SQS interstitial position which indicates 3 at.% (1/33) of C. The electronic band structure is calculated using FP–LAPW method implemented in WIEN2k code [4].

References:

[1] E. K. Delczeg-Czirjak *et al.*, *Phys. Rev. B* **89** (2014) 144403.
[2] A. van de Walle *et al.*, *Calphad Journal* **42** (2013) 13.
[3] A. Zunger *et al.*, *Phys. Rev. Lett.* **65** (1990) 353.
[4] P. Blaha *et al.*, WIEN2k, 2001. ISBN 3-9501031-1-2

O-7-01

Tailored soft-magnetic properties in Fe-based amorphous alloy by nucleation and growth controlled annealing

N. Nishiyama,[1] K. Shimizu,[1] K. Takenaka,[1] Y. Zhang,[1] P. Sharma,[1] and A. Makino[1]
[1] *Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan*

NANOMET [1] exhibits high B_s of exceeding 1.8 T and low H_c of less than 10 A/m. These good soft magnetic properties are optimized by grain-size controlled annealing. Sharma has already pointed out that many nuclei formation and growth suppression by rapid heating is effective to obtain a fine grain structure, leading to extra low H_c [2]. In general, nano-crystallization of amorphous alloy by annealing can be comprehendible on the framework of classical nucleation theory. In this paper, we intend to figure out the overall feature of nano-crystallization in Fe-based amorphous alloy by use of TEM image analysis. As a result, it was clarified that the as-quenched amorphous alloy contained 10^{22} /m^3 orders of magnitude pre-existing nuclei and growth of these nuclei causes course grain structure by annealing at low heating rate. Furthermore, processable annealing for user will be quantitatively discussed.

References:

[1] A. Makino, IEEE Trans. Magn., 48 (2012) 1331.
[2] P. Sharma, X. Zhang, Y. Zhang and A. Makno, IEEE Trans. Magn., to be published.

O-7-02

Noise and magnetic field detection of tunneling magnetoresistance sensors with perpendicular anisotropy

P. Wisniowski,[1] M. Dąbek,[1] and T. Stobiecki[1]
[1] *AGH University of Science and Technology, Department of Electronics, Krakow, Poland*

Tunneling magnetoresistance sensors with perpendicular anisotropy (PA) are promising candidates for magnetic field sensing and detection because their offer high sensitivity[1] and control of sensing properties by the PA modulation [2]. The modulation can be realized by change in the sensing layer thickness and/or voltage-controlled magnetic anisotropy (VCMA) effect. We investigated the effect of PA on the noise and field detection in CoFeB/MgO/CoFeB sensors. We show that the higher the anisotropy the larger reduction of the noise in the sensors. However, the field detection improvement with the noise reduction is limited by the field sensitivity drop. Consequently, there is a compromise between noise reduction and detectivity improvement in the sensors with perpendicular anisotropy modulation.

References:

[1] P. Wiśniowski, M. Dąbek, S. Cardoso, and P.P. Freitas, Sensors Actuators Phys. 202, 64 (2013)
[2] P. Wisniowski, J. Wrona, T. Stobiecki, S. Cardoso, P.P. Freitas, IEEE Transaction on Magnetics (48) (2012) 3840

This work was supported by the National Science Centre grant N505489040. We would like to thank Singulus Technologies AG for the wafers deposition.

O-7-03

Rotating field entropy change in highly anisotropic magnets

R. Szymczak,[1] M. Berkowski,[1] R. Diduszko,[1] J. Fink-Finowicki,[1] D. Gawryluk,[1] R. Puzniak,[1] I. Radelytskyi,[1] H.A. Dabkowska,[2] and H. Szymczak[1]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

[2] *Brockhouse Institute for Materials Research, McMaster University, Hamilton, Ontario, Canada*

Recently, magnetic refrigeration based on the magnetocaloric effect has been regarded as an interesting and important alternative to gas compression-based refrigeration. The majority of studies performed until now in this field is focused on the magnetocaloric effect caused by the magnetic field changed near the phase transition points (usually near the vicinity of the Curie temperature). In this case direction of magnetic field is fixed. Alternatively, magnetic refrigeration can also be realized by a rotating magnetic field. In this case the magnetocaloric effect is based on changing the magnetic anisotropy energy in a constant magnetic field. In the present paper we report new method of magnetic entropy change in highly anisotropic magnetic materials such as Ising spin glasses (YbCoGaO4) and ferromagnets with anisotropic Curie temperature (Fe7Se8). The magnetocaloric effect is obtained here by rotating the magnetic crystal with respect to the fixed direction of magnetic field near the transition temperature from the paramagnetic state to magnetically ordered one.

O-8-01

Structure-property relation in granular $L1_0$-FePt media

S. Wicht,[1,2] V. Neu,[1] L. Schultz,[1,2] O. Mosendz,[3] V. Mehta,[3] S. Jain,[3] O. Hellwig,[3] D. Weller,[3] and B. Rellinghaus[3]

[1] *IFW Dresden, P.O. Box 260116, D-01171 Dresden, Germany*
[2] *University of Technology, D-01062 Dresden, Germany*
[3] *HGST, 3403 Yerba Buena Rd, San Jose, CA-95135, USA*

Based on their high uniaxial magneto-crystalline anisotropy of $K_U = 6.6\,MJ/m^3$ granular $L1_0$-ordered FePt-C films are seen as promising material candidates for future hard disk media. Aberration-corrected high-resolution transmission electron microscopy (HRTEM) and vibrating sample magnetometry (VSM) are used to correlate the structural and magnetic properties of these films. HRTEM images in plan view geometry reveal a bimodal distribution of the particle size ($\bar{D} = 5.9\,nm$) while cross-sectional images are used to determine the orientation of the particles' easy axes and of the underlying MgO seed crystal relative to the substrate normal. The texture spread of the [001] easy axes is roughly 3° and thus larger than the misalingment of the MgO crystals which can be ascribed to the nucleation of FePt growth at MgO step edges [1]. The magnetic analyses exhibit a high anisotropy field of $\mu_0 H_A = 9.2\,T$ and a weak dipolar coupling between the matrix-separated nanomagnets.

References:

[1] S. Wicht *et al.*, J. Appl. Phys. **114**, 063906 (2013)

O-8-02

Conductivity of strongly correlated bosons in optical lattices in an Abelian synthetic magnetic field

A. Sajna,[1] T.P. Polak,[1] and R. Micnas[1]

[1] *Solid State Theory Division, Faculty of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

Topological phase engineering of neutral bosons loaded in an optical lattice opens a new window for manipulating of transport phenomena in such systems. Exploiting the Bose-Hubbard model and using the magnetic Kubo formula proposed in this paper we show that the optical conductivity abruptly changes for different flux densities in the Mott phase. Especially, when the frequency of the applied field corresponds to the on-site boson interaction energy, we observe insulator or metallic behavior for a given Hofstadter spectrum. We also prove that for different synthetic magnetic-field configurations the critical conductivity at the tip of the lobe is nonuniversal and depends on the energy minima of the spectrum. In the case of 1/2 and 1/3 flux per plaquette, our results are in good agreement with those of the previous Monte Carlo study. Moreover, we show that for half magnetic flux through the cell the critical conductivity suddenly changes in the presence of a superlattice potential with uniaxial periodicity.

References:

[1] A. S. Sajna, T. P. Polak, and R. Micnas, Phys. Rev. A 89, 023631 (2014).

POSTER CONTRIBUTIONS

ABSTRACT CATEGORIES

1. Strongly Correlated Electrons and High Temperature Superconductivity

Heavy fermions and Kondo systems; Charge, orbital, and multipole orderings and excitations; Quantum phase transitions; Metal-insulator transitions; Highly correlated metals and insulators; Itinerant electron magnetism; Organic conductors; Low dimensional conductors, Correlation effects in mesoscopic systems; Multiferroics

2. Quantum and Classical Spin Systems

Low dimensional quantum magnets; Frustrated magnets and spin liquids; Quantum phase transitions; Lattice effects and spin Peierls systems; Solitons and nonlinear effects; Statistical mechanics of quantum and classical systems; Molecular magnetism; Quantum tunnelling and coherence; Quantum information; Organic and organo-metallic materials

3. Magnetic Structure and Dynamics

Crystal field and anisotropy; Magnetic structure and spin waves; Dynamic phenomena; Electronic structure; Magnetic interactions; Rare-earth and actinide magnetism; Transition metal alloys and compounds; Spin glasses; Random magnets; Magnonic crystals

4. Spin Electronics and Magneto-Transport

Magnetoresistance effects; Current induced magnetization reversal; Spin injection and accumulation; Spin Hall effect, Magnetic Semiconductors; Optical properties; Quantum computation

5. Nano-structure, Surfaces, and Interfaces

Surfaces and interfaces; Films, multilayers and superlattices; Exchange interaction and anisotropy; Spin dynamics, Patterned films; Nanoparticles; Nanowires and dots

6. Soft and Hard Magnetic Materials

Amorphous and nanocrystalline materials; Granular materials; Ferrites, garnets and microwave materials; Permanent magnets; Magnetization processes; Magneto-elastic and magnetostrictive materials; Modeling and simulations

7. Applications

Magnetic sensors; Ferromagnetic shape-memory materials; Actuators and magnetic drives; Magnetic refrigeration; Magnetic fluids; Magnetic separation and levitation

8. Other Topics

Biomagnetics; Magnetism in medicine; Measuring techniques and instruments; Magnetic recording and memories

P-1-01

Magnetic properties of the $CeNi_4Mn_yAl_{1-y}$ compounds

K. Synoradzki,[1] and T. Toliński[1]

[1] *Institute of Molecular Physics Polish Academy of Sciences, ul. Mariana Smoluchowskiego 17 60-179 Poznań, Poland*

The magnetic properties of the polycrystalline $CeNi_4Mn_yAl_{1-y}$ compounds have been investigated combining AC magnetic susceptibility, field-cooled and zero-field-cooled DC magnetization and magnetic relaxation measurements. The X-ray diffraction measurements show that the group $CeNi_4Mn_yAl_{1-y}$ is isostructural and crystallizes in the $CaCu_5$-type structure (P6/mmm). For 0<y<1 irreversible magnetism, long-time magnetic relaxation effect and evident upshift of the AC susceptibility peak with increasing frequency are observed at low temperatures. The spin-glass-like behavior originates from a disorder due to the statistical occupation of the 3g site.

P-1-02

The t-J model in a strong magnetic field

A. Sherman[1]

[1] *Institute of Physics, University of Tartu, Riia 142, 51014 Tartu, Estonia*

The normal-state energy spectrum of the two-dimensional t-J model in a homogeneous perpendicular magnetic field is investigated using the Mori projection operator technique. The density of states (DOS) at the Fermi level as a function of the inverse magnetic field $\frac{1}{B}$ reveals oscillations in the range of hole concentrations $0.08 \lesssim x \lesssim 0.18$. The oscillations have both high- and low-frequency components. The former components are connected with large Fermi surfaces, while the latter with van Hove singularities in the Landau subbands, which traverse the Fermi level with changing B. The singularities are related to bending the Landau subbands due to strong electron correlations. Frequencies of the low-frequency components are of the same order of magnitude as those observed in underdoped cuprates. These components become dominant if smoothing processes are accounted for. It is shown that the pseudogap affects only slightly the frequency of DOS oscillations, however it increases significantly the distance between Landau subbands.

P-1-03

Effects of Fe substitution for isoelectronic Ru on the magnetic and transport properties of $CeRu_2Al_{10}$

P. Peratheepan,[1,2] and A.M. Strydom[2]

[1] *Department of Physics, Eastern University, Chenkalady, Sri Lanka*

[2] *Physics Department, University of Johannesburg, Auckland Park, South Africa*

We have investigated the effects of magnetic Fe ion substitution in $Ce(Ru_{1-x}Fe_x)_2Al_{10}$ on the magnetic and transport properties, when the Kondo insulator $CeRu_2Al_{10}$ with anomalous antiferromagnetic order at $T_N = 27$ K [1] is fully transformed into the archetypal non-ordered Kondo insulator $CeFe_2Al_{10}$ [2]. The characteristic Kondo temperature T_K is determined from the magnetic susceptibility, and demonstrates a linear dependence on Fe concentration between 0.6 and 1. With increasing x, the positive maximum in the thermoelectric power just below T_N enhances gradually and reaches up to $\sim$80 μV/K (at $T = 40$ K) for $x = 0.8$, which is remarkably as high as $\sim$4 and $\sim$1.5 times the corresponding values in $CeRu_2Al_{10}$ and $CeFe_2Al_{10}$ respectively. The magnitude of the lattice thermal conductivity is found to be nearly independent of x, while the electronic thermal conductivity on the other hand decreases by an order of magnitude when x increases from 0 to 0.8. We discuss our results in terms of the extreme electronic sensitive nature between $CeRu_2Al_{10}$ and $CeFe_2Al_{10}$.

References:

[1] A.M. Strydom, Physica B **404** (2009) 2981.

[2] Y. Muro et. al, J. Phys. Soc. Jpn. **78** (2009) 083707.

P-1-04

Electronic properties of (Ce,La)Pd_2(Al,Ga)$_2$ Compounds

M. Klicpera,[1] and P. Javorský[1]

[1] *Charles University in Prague, Department of Condensed Matter Physics, Ke Karlovu 5, 121 16 Prague 2, Czech Republic.*

The tetragonal CeT_2X_2 compounds, where T = d-metal and X = p-metal, form a large family of intermetallics with a variety of physical properties. Heavy-fermion behavior, valence-fluctuations, non-Fermi-liquid behavior, or superconductivity are the examples of highly interesting properties of these compounds. Their properties are influenced by competition between RKKY and Kondo interaction as well as by crystal electric field. Moreover, a strong electron-phonon (e-p) interaction was observed as an additional peak in energy spectra of $CePd_2Al_2$ recently [1].

Presented study is focused on (Ce,La)$Pd_2Al_{2-x}Ga_x$ compounds investigated by means of magnetization, electrical resistivity and powder neutron diffraction measurements. The electronic and structural properties of these Ce-based compounds are discussed with respect to the strength of e-p interaction. La counterparts then undergo the superconducting transition at low temperatures. The superconductivity is not the conventional one as there are significant deviations from BCS theory predictions.

References:

[1] L.C. Chapon, E.A. Goremychkin, *et al.*, Physica B 378-380, 819 (2006).

P-1-05

Ground state, magnetization process and magnetocaloric effect of the exactly tractable spin-electron tetrahedral chain

L. Gálisová,[1] and J. Strečka[2]

[1] *Department of Applied Mathematics and Informatics, Faculty of Mechanical Engineering, Technical University, Letná 9, 042 00 Košice, Slovak Republic*

[2] *Department of Theoretical Physics and Astrophysics, Faculty of Science, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic*

A hybrid spin-electron system on one-dimensional tetrahedral chain, in which the localized Ising spin regularly alternates with the mobile electron delocalized over three lattice sites, is exactly solved using the generalized decoration-iteration transformation and the transfer-matrix technique. It is shown that the investigated system exhibits either the ferromagnetic or antiferromagnetic ground state, depending on whether the ferromagnetic or antiferromagnetic interaction between the Ising spins and mobile electrons is considered. Moreover, the enhanced magnetocaloric effect observed during the adiabatic demagnetization suggests a potential use of the studied spin-electron model for low-temperature magnetic refrigeration.

P-1-06

Structural instability in $CePd_2Al_{(2-x)}Ga_2$ compounds

P. Doležal,[1] M. Klicpera,[1] J. Prchal,[1] and P. Javorský[1]

[1] *Charles University in Prague, Faculty of Mathematics and Physics, (DCMP), Ke Karlovu 5, 121 16 Prague 2, Czech Republic*

RT_2X_2 compounds (R: rare earth element, T: d-element and X: p-element), crystallizing in tetragonal structure, revealed such physical properties as pressure-induced superconductivity, valence fluctuating phenomena or strong electron-phonon (e-p) interaction. The e-p interaction resulting in additional peak in energy spectra of $CePd_2Al_2$ attracts exceptional attention [1]. Most of RT_2X_2 compounds have stable structure, nevertheless, e.g. $CePd_2Al_2$ or $CePd_2Ga_2$ exhibit structural transition from tetragonal structure to lower symmetrical one [1, 2]. Moreover, the stability of tetragonal structure seems to be influenced by presence of strong e-p interaction in these compounds [1].

The presented study is focused on investigation of structural transition in $CePd_2Al_{(2-x)}Ga_2$ series by means of low temperature X-ray diffraction and high-pressure electrical resistivity and specific heat. Based on our recent results it seems to be probable that the pressure suppresses the e-p interaction. We will include these results in our presentation.

References:

[1] L.C. Chapon, E.A. Goremychkin, *et al.*, Physica B 378-380, 819 (2006)

[2] J. Kitagawa, M. Ishikawa, Journal of the Physical Society of Japan, 2380-2383, 68 (1999)

P-1-07

Crystal electric field and the ground state properties of heavy fermion $Ce_3Ru_4Sn_{13}$

A. Ślebarski,[1] M. Fijałkowski,[1] J. Goraus,[1] L. Kalinowski,[1] and P. Witas[1]
[1] *Institute of Physics, University of Silesia, 40-007 Katowice, Poland*

We report on the electronic structure, electric transport and basic thermodynamic properties of the skutterudite-related $Ce_3Ru_4Sn_{13}$ and $La_3Ru_4Sn_{13}$. X-ray photoelectron spectroscopy (XPS) core level spectra revealed a stable trivalent configuration of the Ce atoms in $Ce_3Ru_4Sn_{13}$, consistent with magnetic susceptibility data. Magnetic susceptibility and specific heat measurements reveal that the sixfold degenerated multiplet of Ce^{3+} ions splits into three doublets, due to the tetragonal Ce point local symmetry in the cubic $Ce_3Ru_4Sn_{13}$ system. $Ce_3Ru_4Sn_{13}$ exhibits a large increase in the specific hea, C/T, data due to Kondo effect and strong electron and short-range magnetic correlations, we also suggest significant contribution of the crystal field effect. $La_3Ru_4Sn_{13}$ is typical btained as BCS superconductor, however, specific heat and electrical resistivity data show that $La_3Ru_4Sn_{13}$ also exhibits a second superconducting phase at higher temperatures, which is characteristic of inhomogeneous superconductors.

P-1-08

Crystal structure and physical properties of $Ce_3T_2M_7$ (T = Fe, Co, Ni, Zn and M = Ge, Sn) ternary compounds

G. Chajewski,[1] and A.P. Pikul[1]
[1] *Instytut Niskich Temperatur i Badań Strukturalnych Polskiej Akademii Nauk, P Nr 1410, 50-950 Wrocław 2, Poland*

Polycrystalline samples of novel ternary compounds $Ce_3T_2M_7$ (T =Fe, Co, Ni, Zn and M = Ge, Sn) were prepared by means of conventional arc melting the stoichiometric amounts of the elements and studied by means of X-ray powder diffraction and magnetization measurements performed in wide temperature and magnetic field ranges. Rietveld refinement revealed that all the phases studied crystallize in the orthorhombic $La_3Co_2Sn_7$-type structure (space group *Cmmm*, no. 65). The magnetization data analysis showed that at high temperatures the compounds $Ce_3Co_2Ge_7$, $Ce_3Co_2Sn_7$, $Ce_3Fe_2Ge_7$, $Ce_3Ni_2Sn_7$ and $Ce_3Ni_2Ge_7$ exhibit Curie-Weiss-like paramagnetism of nearly localized cerium magnetic moments. In $Ce_3Co_2Sn_7$, $Ce_3Ni_2Sn_7$ and $Ce_3Ni_2Ge_7$ the moments order antiferromagnetically below T_N = 4.4, 4.0 and 7 K, respectively, while a ferromagnetic-like features are observed in $Ce_3Co_2Ge_7$ below 7 K and in $Ce_3Fe_2Ge_7$ at about 8 K. The preliminary magnetic properties studies will be supplemented at the conference by the results of on-going electrical resistivity and specific heat measurements.

P-1-09

The Kohn-Luttinger superconductivity in idealized doped graphene

M.Yu. Kagan,[1,2] V.V. Val'kov,[3] V.A. Mitskan,[3,4] and M.M. Korovushkin[3]

[1] *P. L. Kapitza Institute for Physical Problems, 119334 Moscow, Russia*

[2] *Moscow Institute of Electronics and Mathematics, National Research University Higher School of Economics, 109028 Moscow, Russia*

[3] *L. V. Kirensky Institute of Physics, 660036 Krasnoyarsk, Russia*

[4] *Siberian State Aerospace University, 660014 Krasnoyarsk, Russia*

The effect of the long-range Coulomb repulsion in an ensemble of Dirac fermions on the formation of the superconducting pairing in an idealized graphene monolayer is studied in the framework of the Kohn-Luttinger mechanism neglecting the van der Waals potential of a substrate and the role of the nonmagnetic impurities. The superconductive phase diagram of the system is constructed and it is shown that the Kohn-Luttinger renormalizations up to and including the second-order terms in the Coulomb interaction and the intersite Coulomb repulsion significantly affect the interplay between the superconducting phases with f-, $d+id$-, and $p+ip$-wave symmetries of the order parameter.

This work was supported by the RFBR (projects 14-02-00058 and 14-02-31237) and the Grant of President of Russia (project MK-526.2013.2).

P-1-10

Spectroscopic studies of the phase transition from the Mott insulator state to the charge ordering state of κ-$(ET)_4[M(CN)_6][N(C_2H_5)_4]\cdot 2H_2O$ ($M = Co^{III}$ and Fe^{III}) salts

A. Łapiński,[1] R. Świetlik,[1] L. Ouahab,[2] and S. Golhen[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *Organométalliques: Matériaux et Catalyse UMR 6226 CNRS-UR1 Institut des Sciences Chimiques de Rennes, Université de Rennes 1, 35042, Rennes Cedex, France*

We report detailed IR investigations of the charge ordering (CO) transition at T=150 K and charge fluctuations in κ-$(ET)_4[M(CN)_6][N(C_2H_5)_4]\cdot 2H_2O$ ($M = Co^{III}$ and Fe^{III}). As a consequence of the CO, electronic and vibrational spectra are modified. The most important proof of the CO is the appearance of the electronic band at 7000 cm^{-1} attributed to charge transfer in $(ET)_2^{2+}$ dimers and also the vibrational band at 1347 cm^{-1} being the result of coupling of C=C mode of ET with this electronic excitation. Apart from the long-range Coulomb interactions between electrons also the anions can have a significant influence on the formation of the CO state.

This work was supported by the National Science Centre (Decision No. DEC-2012/04/M/ST3/00774).

P-1-11

Magnetic, thermal and transport properties of $Y_{2-x}Bi_xRu_2O_7$ in the matallic phase

A. Zarzycki,[1] M. Rams,[2] E.A. Görlich,[2] and K. Tomala[2]

[1] *H. Niewodniczański Institute of Nuclear Physics, PAS, Kraków*

[2] *M. Smoluchowski Institute of Physics, Jagiellonian University, Kraków*

Ruthenium oxide $Y_2Ru_2O_7$ is an antiferromagnetically ordered Mott insulator with the Néel temperature of $T_N \simeq 76$ K. Dilution of the yttrium sublattice with tetravalent bismuth ions leads to the metal-insulator transition at around the critical bismuth concentration $x_{cr} \approx 0.53$. Nevertheless, some traces of the insulating phase survive at low temperatures even for systems with $x > 1$.
Two samples with bismuth concentrations of $x = 1.2$ and 1.5 were investigated above 0.4 K. Temperature dependence of the magnetic susceptibility below $T \approx 100$ K can be described by the power law $\chi \sim T^{-\lambda}$ with $\lambda = 0.50(2)$. Heat capacity can be analysed taking into account the electronic contribution in which, apart from the usual Fermi-liquid term $C/T = const$, a spin fluctuations contribution of the form $-T^3 \log(T/T_0)$ is taken into account. The electrical resistivity shows the Fermi-liquid dependence $\rho \sim T^2$ at low temperatures which changes to the anomalous behaviour $\rho \sim T^{3/2}$ above about 3 K. Application of the external magnetic field broadens the Fermi-liquid region.

P-1-12

Anomalus magnetic, thermodynamic and transport properties of the ruthenium perovskites $Ca_{1-x}Sr_xRuO_3$ in the region of high calcium concentration

A. Zarzycki,[1] M. Rams,[2] E.A. Görlich,[2] and K. Tomala[2]

[1] *H. Niewodniczański Institute of Nuclear Physics, PAS, Kraków*

[2] *M. Smoluchowski Institute of Physics, Jagiellonian University, Kraków*

$SrRuO_3$ is a metallic ferromagnet with $T_C \simeq 163$ K. In the $Ca_{1-x}Sr_xRuO_3$ system, dilution of the strontium sublattice by calcium atoms leads to decrease of the Curie temperature. The ferromagnetic order disappears at a critical concentration of strontium $x_{cr} \approx 0.27$, at the quantum phase transition between the itinerant ferromagnet and a metallic paramagnet. All materials with $x < x_{cr}$ are paramagnetic.
Investigations of the magnetic, thermodynamic and transport properties of the materials with the strontium concentration varying from $x = 0.4$ (ferromagnet with $T_C \simeq 20$ K) to $x = 0$ are reported. The ferromagnetic $Ca_{0.6}Sr_{0.4}RuO_3$ shows typical Landau Fermi-liquid behaviour with $C/T = const$ and $\rho \sim T^2$. For materials with $x < x_{cr}$ the magnetic susceptibility in the range of temperatures between about 10 K and 100 K behaves as $\chi \sim T^{1-\lambda}$. The heat capacity and the electrical resistivity demonstrate transitions from the Fermi-liquid at very low temperatures to the anomalous behaviour with $C/T \sim \log T$ and $\rho \sim T^{3/2}$ at higher temperatures. The Fermi-liquid behaviour is restored in the external magnetic field.

P-1-13

Electrically controlled spin polarization in T-shaped double quantum dots coupled to ferromagnetic leads

K.P. Wójcik,[1] and I. Weymann[1]
[1] *Adam Mickiewicz University, Faculty of Physics, Umultowska 85, 61-614 Poznań, Poland*

We analyze the spin-resolved linear transport properties of interacting double quantum dots strongly coupled to two ferromagnetic leads and forming a T-shaped configuration. The calculations are performed with the aid of the numerical renormalization group procedure [1,2] with the full density matrix of the system [3]. This method allows us to calculate the relevant spectral functions and to determine the linear conductance and spin polarization of the current. We find a range of parameters, for which the spin polarization becomes maximized, and may be continuously changed form -1 to $+1$ by adjusting the dots' energy levels. The maximum spin polarization occurs without the necessity to apply an external magnetic field and is a consequence of an exchange field, which develops due to the presence of ferromagnetic leads.

References:

[1] K. G. Wilson, Rev. Mod. Phys. **47**, 773 (1975).
[2] We use the open-access Budapest NRG code, O. Legeza, C. P. Moca, A. I. Toth, I. Weymann, G. Zarand, arXiv:0809.3143 (2008) (unpublished).
[3] A. Weichselbaum, J. von Delft, Phys. Rev. Lett. **99**, 076402 (2007).

P-1-14

Effect of Ru addition on the superconducting properties of the Eu-123 system

M. Škrátek,[1] A. Cigáň,[1] A. Dvurečenskij,[1] M. Majerová,[1] R. Bystrický,[1] P. Billik,[1] and J. Maňka[1]
[1] *Department of Magnetometry, Institute of Measurement Science Slovak Academy of Sciences, Dúbravská cesta 9, 841 04 Bratislava, Slovakia*
[2] *Department of Inorganic Chemistry, Faculty of Natural Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovakia*

Effects of an Ru addition on the structural and superconducting properties of the Eu-123 system were studied. Samples of $EuBa_2Cu_{3-x}Ru_xO_{7-\delta}$ with x ranging from 0 to 0.7 were prepared by the solid state reaction technique from Eu_2O_3, $BaCO_3$, CuO and RuO_2 precursors at the temperature of 1050 °C for 72 h in flowing oxygen and oxygen-annealed at 580 °C for 24 h. X-ray diffraction data show the presence of another Ba-Eu-Ru-O phase, for $x \geq 0.03$, in addition to the superconducting phase. AC and DC magnetization characteristics were measured by a compensation method using the second-order SQUID gradiometer at ∼77 K and the QD SQUID magnetometer MPMS XL-7 at 20 K. The superconducting properties, T_c, ΔT_c and magnetization $M(H)$, deteriorate with increasing the Ru content; e.g., T_c ranges from 92.6 K to 76 K.

P-1-15

Magnetic studies of $EuBa_2Cu_{3-x}Ru_xO_{7-\delta}$ compounds

A. Dvurečenskij,[1] A. Cigáň,[1] R. Bystrický,[1] M. Škrátek,[1] P. Billik,[1] M. Majerová,[1] and J. Maňka[1]

[1] *Department of Magnetometry, Institute of Measurement Science Slovak Academy of Sciences, Dúbravská cesta 9, 841 04 Bratislava, Slovakia*

Effects of an Ru addition on magnetic properties of $EuBa_2Cu_{3-x}Ru_xO_{7-\delta}$ compounds were studied. Samples of $EuBa_2Cu_{3-x}Ru_xO_{7-\delta}$ with x ranging from 0 to 0.7 were prepared by the solid state reaction technique from Eu_2O_3, $BaCO_3$, CuO and RuO_2 precursors. Temperature dependences of the zero-field cooled and the field cooled DC magnetic moment at low and high applied magnetic field and magnetization $M(H)$ curves at 77 K were measured at a low and high applied magnetic field by the QD SQUID magnetometer MPMS XL-7. The molar susceptibility χ of the samples was corrected to the effects of the sample holder and temperature-independent contributions and fitted by the Curie–Weiss law. The values of the Curie constant, the Weiss temperature and the effective magnetic moment of Eu and Ru-ions have been estimated for the lowest temperatures and above superconducting transition temperature.

P-1-16

Magnetism and superconductivity of S-substituted FeTe

A. Ciechan,[1] M.J. Winiarski,[2] and M. Samsel-Czekała[2]

[1] *Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warsaw, Poland*

[2] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, ul. Okólna 2, 50-422 Wrocław, Poland*

Iron chalcogenides exhibit the complex magnetic and superconducting phase diagrams. FeTe shows an antiferromagnetic order with the $(\pi, 0)$ wave vector. Superconductivity emerges under Se or S substitution into Te sites in bulk material and also under tensile stress in FeTe thin films. In turn, hydrostatic pressure induces the antiferromagnetic to ferromagnetic phase transition. The effect of hydrostatic and non-hydrostatic pressure on magnetic and electronic structure of FeTe has been investigated by us from first principle calculations [1]. In this work, we study the influence of partial substitution with sulfur. The results indicate that superconductivity is strongly related to antiferromagnetic fluctuations with the nesting (π, π) vector.

References:

[1] A. Ciechan, M.J. Winiarski, M. Samsel-Czekała, *J. Phys.: Condens. Matter* **26**, 025702 (2014).

This work was supported by the National Science Centre of Poland based on decision No. 2012/05/B/ST3/03095 and No. 2013/08/M/ST3/00927. Calculations were performed on the ICM supercomputers of Warsaw University (Grant No. G46-13).

P-1-17

The effect of dilution on the ferromagnetic ordering of CeAuGe

B.M. Sondezi,[1] and A.M. Strydom[1]
[1] *Physics Department, University of Johannesburg, P.O. Box 524, Auckland Park, 2006, South Africa*

Transport and thermodynamic properties of the well-ordered hexagonal ferromagnetic CeAuGe compound have been studied. The ferromagnetic ordering anomaly is shown in $\chi(T)$, $\rho(T)$ and $C_{\rm p}(T)$ at $T_{\rm C} = 10$ K. The location of $T_{\rm C}$ has been observed to be unstable and enhanced even in moderate applied magnetic fields. However, the dilution of magnetic species, Ce, with the non-f electron element, La, is shown in this work to achieve a continous suppression of $T_{\rm C}$ to 0 K. The integrity of the space group and the details of the unit cell occupation are retained throughout the substitution series, as is the high-temperature localized Ce-effective moment $\mu_{\rm eff} = 2.54\ \mu_{\rm B}$. Our studies of physical properties down to 50 mK show a quantum critical form of non-Fermi liquid behaviour, characterised by a logarithmic divergence in $C_{\rm p}(T)/T$ data in the very dilute Ce limit close to the putative quantum phase transition.

P-1-18

Pressure dependence of the thermodynamic critical field in francium

P.W. Pach,[1] R. Szczęśniak,[1] and A.P. Durajski[1]
[1] *Czestochowa Unversity of Technology, Ave. Armii Krajowej 19, 42-200 Częstochowa, Poland*

In the paper, the values of the thermodynamic critical field (H_C) for francium have been calculated. It has been assumed the wide range of the pressure: $p \in \langle 9, 14\rangle$ GPa. The analysis has been performed in the framework of the strong-coupling formalism. It has been predicted that the value of the ratio $H_C(0)/\sqrt{\rho(0)}$ increases with the increasing pressure from 3.81 meV to 5.84 meV, where $\rho(0)$ denotes the electron density of states at the Fermi level. The dimensionless parameter $T_C C^N(T_C)/H_C^2(0)$ is smaller than in the BCS theory and decreases with pressure from 0.147 to 0.141. The symbol T_C represents the critical temperature and C^N is the specific heat for the normal state.

P-1-19

NMR Study of Multiferroic Iron Niobate Perovskites

K. Kouřil,[1] V. Chlan,[1] H. Štěpánková,[1] R. Řezníček,[1] K. Uličná,[1] V.V. Laguta,[2] and I.P. Raevski[3]

[1] *Charles University in Prague, Faculty of Mathematics and Physics, V Holešovičkách 2, 180 00 Prague 8, Czech Republic*

[2] *Institute of Physics AS CR, Cukrovarnická 10, Prague, Czech Republic*

[3] *Institute of Physics, Southern Federal University, Rostov on Don 344090, Russia*

We present a Nuclar Magnetic Resonance (NMR) study of multiferroic iron niobate systems from series $Pb_xBa_{1-x}Fe_{0.5}Nb_{0.5}O_3$, which belong to family of relaxor perovskites exhibiting simultaneous ferroelectric and magnetic ordering. Our aim is to study phase transitions, influence of large cation species (Pb, Ba) and role of Fe/Nb local ordering.

We measured frequency swept NMR spectra and relaxation times of ^{93}Nb, ^{207}Pb and ^{135,137}Ba in the systems in magnetic field of 9.4 T at various temperatures in range $2.2 - 400$ K. Upon cooling ^{207}Pb line in $x = 1$ sample broadens severely and vanishes below 30 K. ^{93}Nb spectrum of the $x = 1$ sample consist of broad and narrow component, below 6 K it indicates additional transition. Influence of quadrupolar interaction on ^{135,137}Ba NMR was estimated from comparison of their spectra.

This work was supported by project 13-11473S of the Grant Agency of the Czech Republic.

P-1-20

Point contact spectroscopy measurements on the filled skutterudite compound $LaRu_4As_{12}$

V. Hašková,[1] P. Szabó,[1] V. Paľuchová,[1] J. Kačmarčík,[1] R. Puźniak,[2] Z. Henkie,[3] T. Cichorek,[3] and P. Samuely[1]

[1] *Centre of Low Temperature Physics, Institute of Exp. Physics, Slovak Academy of Sciences, Košice, Slovakia*

[2] *Institute of Physics, Polish Academy of Sciences, Wroclaw, Poland*

[3] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wroclaw, Poland*

Recently it was proposed that the filled skutterudite compound $LaRu_4As_{12}$ is another example of a multi-band superconductor [1]. Here we report point-contact (PC) spectroscopy measurements on the single crystal of $LaRu_4As_{12}$ with the critical temperature $T_c = 10.4$ K. The PC spectra were measured at various temperatures down to 1.5 K. From evolution of the point-contact spectra, the temperature dependence of the superconducting energy gap and the strength of the superconducting coupling were determined. Complementary experiments by *ac*-calorimetry were performed on the same $LaRu_4As_{12}$ crystal. Specific heat measurements with both temperature and magnetic field sweeps will be also discussed.

References:

[1] L. Bochenek, R. Wawryk, Z. Henkie, and T. Cichorek, PRB **86** (2012) 060511(R)

P-1-21

Magnetic and thermodynamic properties of Ce4RuAl compound

J.C. Debnath,[1] A.M. Strydom,[1] F. Tappe,[2] R. Pöttgen,[2] and B.M. Sondezi[1]
[1] *Physics Department, University of Johannesburg, South Africa*
[2] *Institut für Anorganische und Analytische Chemie, Universität Münster, Germany*

The results of magnetic susceptibility and heat capacity measurements are reported for the Ce_4RuAl compound above room temperature to low temperature range (400 K to 0.46 K) and in magnetic fields up to 7 T. The magnetic susceptibility χ(T) exhibits a distinct anomaly at 0.95 K which most probably suggests a paramagnetic to antiferromagnetic phase transition. Magnetic susceptibility obeys the Curie Weiss law and revealed an effective magnetic moment $\mu_{eff} = 2.18\ \mu_B$/Ce which is close to the value for free Ce^{3+} ($\mu_{eff} = 2.54\ \mu_B$). The paramagnetic Weiss temperature indicates net antiferromagnetic correlations. In the specific heat a peak at 1.3 K supports the bulk nature of the phase transition observed in χ(T). The Sommerfield coefficient is moderately enhanced in the paramagnetic phase, and suggests f-c correlations among the electrons prior to magnetic ordering.

P-1-22

Critical conductivity of strongly correlated bosons in optical lattices in an Abelian synthetic magnetic field

A.S. Sajna,[1] T.P. Polak,[1] and R. Micnas[1]
[1] *Faculty of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

Topological phase engineering of neutral bosons loaded in an optical lattice opens a new window for manipulating of transport phenomena in such systems. Exploiting the Bose Hubbard model (BHM) and using the magnetic Kubo formula proposed in Ref. [1] we show, that for different synthetic magnetic field configurations, the critical conductivity at the tip of the lobe is non-universal and depends on the energy minima of the spectrum. In the case of 1/2 and 1/3 flux per plaquette, our results are in good agreement with those of the previous Monte Carlo (MC) study. Moreover, we show that for half magnetic-flux through the cell the critical conductivity suddenly changes in the presence of a superlattice potential with uniaxial periodicity.

References:

[1] A.S. Sajna, T.P. Polak, R. Micnas, *Phys. Rev. A*, 89, 023631 (2014)

P-1-23

Thermal conductivity of $Ce_2Ru_3Ga_9$ compound

M. Falkowski,[1] and A.M. Strydom[1]

[1] *Physics Department, University of Johannesburg, PO Box 524, Auckland Park 2006, South Africa*

The Ce-based 2:3:9 series of compounds are known for strongly correlated electronic behaviour. The polycrystalline compound $Ce_2Ru_3Ga_9$ has been prepared by arc melting followed by annealing and checked by room temperature powder X-ray diffraction technique. The refinement method confirmed the single-phase nature of the synthesized sample which crystallizes in the orthorhombic $Y_2Co_3Ga_9$-structure with space group *Cmcm*. Here, we report for the first time a measurements of thermal conductivity $\kappa(T)$ in zero and 9T magnetic field for $Ce_2Ru_3Ga_9$ across the temperature range $2K \leqslant T \leqslant 300K$. The zero-field temperature dependence of $\kappa(T)$ exhibits a pronounced maximum, characteristic for metals with large electronic mean free path and with further increase of temperature $\kappa(T)$ starts behaves in manner usually attributed to the enhanced electron-phonon coupling. Based on Widemann-Franz law the electronic and lattice contributions to the thermal conductivity were estimated. In high temperature region a distinct step-like anomaly at $T^*=203K$ has been observed which signals a putative phase transition, probably of phononic or lattice origin. We furthermore discuss the effect of applied magnetic fields on the thermal transport in $Ce_2Ru_3Ga_9$.

P-1-24

Vibronic magnetoelectric effects in Bi-based multiferroics

P. Konsin,[1] and B. Sorkin[1]

[1] *Institute of Physics, University of Tartu, Riia 142, 51014 Tartu, Estonia*

A detailed theory of electron-lattice (vibronic) covalent hybridizations [1] between the Bi 6s lone electron pair and empty oxygen 2p states which lead to ferroelectricity is presented for Bi-based multiferroics. The vibronic interactions are the driving and stabilization forces of the phase transformations in these compounds. We derived the free energy of the Bi-based multiferroics with the ferroelectric and G-type antiferromagnetic phase transitions. At this, the Zeeman splitting of electron states in an external magnetic field and the spin-phonon couplings are very important. The energy of the magnetoelectric coupling connected with the antiferromagnetism which is determined by the difference of the magnetization vectors of the sublattice of the Fe ions contributes also to the free energy. The available experimental data are analyzed using this free energy.

References:

[1] P. Konsin and B. Sorkin, Phys. Status Solidi C 6, 2759-2761 (2009).

The research was supported by the Estonian Research Council (project IUT2-27) and by the European Union (projects 3.2.0101.11-0029 and SF0180013s07AP).

P-1-25

Structural transformations and magnetic changes in multiferroic $BiFeO_3$ under external electric field

S.V. Soloviov,[1] A.F. Popkov,[1] N.E. Kulagin,[2] and A.K. Zvezdin[3]

[1] *National Research University of Electronic Technology, Zelenograd, Moscow, Russia*

[2] *State University of Management, Moscow, Russia*

[3] *A.M. Prokhorov General Physics Institute, RAS, Moscow, Russia*

In this study we investigate an influence of the electric field on structure parameters and magnetic state in multiferroic $BiFeO_3$. Our theoretical model is based on the Landau theory of phase transitions, which takes into account a contribution of electric polarization, rotation angle of oxygen octahedra in a crystal of cubic symmetry, and a contribution of magnetic subsystem. We define the coefficients in the invariant expansion of the thermodynamic potential by the comparison of the predicted critical field of phase transitions with the results of Ref [1, 2]. Calculations are made of structural distortions in the crystal caused by the external electric field and the concomitant rearrangement of the magnetic structure in a homogeneous state and in a state with spatially modulated spin structure. *This work is supported by the Russian Foundation for Basic Research, project 13-07-12405 ofi_m2.*

References:

[1] S. Lisenkov, D. Rahmedov, and L. Bellaiche, Physical Review Letters **103**, 1025 (2009)

[2] V.B. Shirokov, Yu.I. Yuzyuk, and V.V. Lemanov, Physics of the Solid State **51**, 047204 (2009)

P-1-26

Evolution of magnetism in $UCo_{1-x}Ru_xGe$

M. Vališka,[1] J. Pospíšil,[1] G. Nénert,[2] A. Stunnault,[2] M. Diviš,[1] B. Gillon,[3] K. Prokeš,[4] and V. Sechovský[1]

[1] *Faculty of Mathematics and Physics, Charles University, DCMP, Ke Karlovu 5, 12116 Praha, Czech Republic*

[2] *Institut Laue Langevin, 6 rue Jules Horowitz, 38042 Grenoble, France*

[3] *Laboratoire Léon Brillouin, Bât. 563 CEA Saclay, France*

[4] *HZB Berlin, Hahn-Meitner Platz 1 14109 Berlin, Germany*

UCoGe is an archetype of 5f-electron ferromagnet (T_C∼3K) which becomes superconducting (T_{SC}∼0.6K) at ambient pressure. The low values of T_C and the spontaneous magnetic moment ($0.03\mu_B$/f.u.) indicate nearness of a ferromagnetic instability. We prepared a series of $UCo_{1-x}Ru_xGe$ polycrystals and studied development of magnetism. We observed that the Ru doping leads at first to a sharp increase of the T_C up to 8.5K for x=0.12 and simultaneous suppression of SC. Further doping decreases T_C towards the QCP at x≈0.3. We have grown two single crystals - $UCo_{0.88}Ru_{0.12}Ge$ and $UCo_{0.97}Ru_{0.03}Ge$. They exhibit strong magnetocrystalline anisotropy similar to UCoGe but the spontaneous magnetization is higher. These single crystals were studied by PND. In contrast to the antiparallel orientation of the Co and U moments in UCoGe we observed parallel orientation in $UCo_{0.88}Ru_{0.12}Ge$ and $UCo_{0.97}Ru_{0.03}Ge$. Our findings are confronted with theoretical calculations using CPA.

P-1-27

Existence of crystal-field states in superconducting $CeFeAsO_{1-x}F_x$

R.J. Radwanski,[1,2] D.M. Nalecz,[1,2] J. Wasowicz,[1,2] and Z. Ropka[1]
[1] *Center of Solid State Physics, S^{nt}Filip 5,31-150 Krakow, Poland*
[2] *Institute of Physics, Pedagogical University, 30-084 Krakow, Poland*

There is going on a debate about the existence and the role played by the crystal field (CEF) in compounds containing 3d/4f/5f atoms/ions both in ionic and intermetallic compounds. The uniqueness of $CeFeAsO_{1-x}F_x$ relies in a fact that in the superconducting state (T_{sc} of 41 K for x =0.16) well-defined crystal-field states have been found at 18.7 and 57 meV (Phys. Rev. Lett **101** (2008) 217002).
We have derived CEF parameters of the orthorhombic symmetry of the Ce^{3+} site and evaluated the low-energy electronic structure. We have calculated the single-ion properties of the Ce^{3+} ions and their contribution to properties of the whole compound. In particular, we have described the temperature dependence of the heat capacity with the λ-type peak at 4 K associated with the ordering of Ce ions. Very good reproduction of the temperature dependence allows for evaluation of the influence of the magnetic order within the Fe sublattice on the Ce states. Namely, the Ce ion experiences the energy splitting of the ground-state doublet by about 1 meV due to the Fe magnetism.

P-1-28

Mechanisms of Substituting Quadrivalent Ions Influence on the Properties of La-Sr Manganites

D.I. Merkulov,[1] A.G. Badelin,[1] S.Kh. Estemirova,[2] and V.K. Karpasyuk[1]
[1] *Astrakhan State University, 414056, Astrakhan, Russia*
[2] *Institute for Metallurgy UB RAS, 620016, Yekaterinburg, Russia*

Regularities of the influence of quadrivalent ions and oxygen concentrations on the phase composition, structural characteristics, saturation magnetization, Curie point, electrical conductance and magnetoresistance of ceramic manganites $La_{1-c-x}Sr_{c+x}Mn_{1-x}Me_x^{4+}O_{3+\gamma}$ (Me=Ti, Ge; $0.15 \leq c \leq 0.35$; $0.025 \leq x \leq 0.150$) were established experimentally taking into account the data of work [1]. The relation between experimental data on lattice parameters, electromagnetic properties and crystal chemistry characteristics (nonstoichiometry index, concentrations of ions residing at different charge and spin state), was determined using the modified model of effective cation-anion distances and the model of active exchange bonds in terms of double exchange.

References:

[1] A.G.Badelin, Z.R.Datskaya, I.Yu.Epifanova, S.Kh. Estemirova, V.K.Karpasyuk, A.M.Smirnov, EPJ Web of Conf., V.40, 15004 (2013)

This research was performed within the framework of the State order of the Ministry of Education and Science of Russian Federation (project 334).

P-1-29

Superconductivity in $LaPd_2(Al,Ga)_2$ Compounds

J. Pásztorová,[1] M. Klicpera,[2] and P. Javorský[2]

[1] *Pavol Jozef Šafárik University in Košice, Department of Condensed Matter Physics, Park Angelinum 9, 041 54 Košice, Slovakia*

[2] *Charles University in Prague, Department of Condensed Matter Physics, Ke Karlovu 5, 121 16 Prague 2, Czech Republic*

La-based compounds are generally used as the non-magnetic analogues for rare-earth intermetallics, but a few of them exhibit very interesting properties, especially then the superconductivity (SC) at low temperatures. Our broader study of $(Ce,La)Pd_2Al_{2-x}Ga_x$ system revealed the transition to the SC state in all La counterparts. The measured specific heat data deviates significantly from the BCS theory predictions and are discussed in context of unconventional superconductivity. The measured data do not follow weak-coupling BCS limit. Further, almost quadratic temperature dependence is observed below T_{SC} which points to an axial state with line nodes in the superconducting gap structure. The origin of observed unconventional SC in $LaPd_2Al_{2-x}Ga_x$ can be found in orthorhombic non-centrosymmetric crystal structure, which they adopt at low temperatures. The absence of inversion symmetry causes that the antisymmetric spin-orbit coupling play an important role in the electronic properties of these materials.

P-1-30

Multiferroic Properties of Orthorombic and Hexagonal $GaFeO_3$ Compound

K. Rećko,[1] U. Wykowska,[2] W. Olszewski,[1] J. Waliszewski,[1] D. Satuła,[1] B. Kalska-Szostko,[2] and K. Szymański[1]

[1] *Faculty of Physics, University of Białystok, Lipowa 41, 15-424 Białystok, Poland*

[2] *Institute of Chemistry,University of Białystok, Hurtowa 1, 15-399 Białystok, Poland*

The multifferoic nature of gallium iron oxide has been intensively studied recently for its potential applications. The physical properties especially magnetism in $GaFeO_3$, depend strongly on the method of preparation. Therefore many efforts have been expended on fabrication of gallium iron oxide by Pechini modification of the sol-gel method. The perfectly ordered gallium iron oxide crystallizes in an orthorhombic crystal structure. Then the system forms a collinear antiferromagnetic ordering along [001] direction with the calculated magnetic moment of irons equal to $\mu Fe{=}5\mu_B$. Any disorder of the cations origin leads to more complicated structures. In the light of neutron and Mössbauer measurements the very strong correlation of the magnetic ordering against the cation distribution among the sites has been proven.

P-1-31

Electronic band structure of $La_{2/3}Pb_{1/3}Mn_{2/3}(Co,Fe,Ni)_{1/3}O_3$

M. Kowalik,[1] W. Tokarz,[1] R. Zalecki,[1] and A. Kołodziejczyk[1]

[1] *AGH University of Science and Technology, Department of Solid State Physics, Kraków, 30, Mickiewicza Str, 30059 Krakow*

We present calculations of the band structure of half-metallic $La_{2/3}Pb_{1/3}Mn_{2/3}(Co,Fe,Ni)_{1/3}O_3$ colossal magnetoresistance (CMR) manganites. The calculations are based on first-principles Density Functional Theory (DFT) with General Gradient Approximation GGA+U using Wien2K package [1]. Density of states (DOS) are obtained by the modified tetrahedron method. The calculated DOS of all investigated compounds for the spin up electrons show a gap close to Fermi energy E_F. Doping of Fe and Co shifts this gap below E_F whilst Ni of above E_F. For the spin down electrons E_F lies in energy gap in all cases. The calculated magnetic moments per formula unit of 2.7, 2.3 and 2 μ_B respectively for Ni, Co and Fe doping are in good agreement with experiment [2, 3].

References:

[1] P. Blaha *et al.*, WIEN2K: An Augmented Plane Wave and Local Orbitals Program for Calculating Crystal Properties (Karlheinz Schwarz, Techn. Universität Wien, Austria), 2001. ISBN 3-9501031-1-2

[2] A. Peña *et al.*, Eur. J. Inorg. Chem. **2006**, 3227–3235

[3] A. Peña *et al.*, Eur. J. Inorg. Chem. **2006**, 2569–2576

P-1-32

Characterization of novel high-pressure close-packed superconducting phase of boron

Dominik Szczęśniak,[1] and Radosław Szczęśniak[2]

[1] *Institute of Physics, Jan Długosz University in Częstochowa, Al. Armii Krajowej 13/15, 42200 Częstochowa, Poland*

[2] *Institute of Physics, Częstochowa University of Technology, Al. Armii Krajowej 19, 42200 Częstochowa*

We report study on the thermodynamic properties of the novel high-pressure superconducting phase of boron with hexagonal $P6_3/mcm$ structure [1]. Our analysis is conducted at the pressure of $p = 400$ GPa, what is motivated by the highest value of the superconducting transition temperature (T_C) observed previously under such conditions for the $P6_3/mcm$ boron. Our investigations of the thermodynamic properties are performed within the Eliashberg formalism, due to the strong-coupling character of the considered material. In particular, we calculate the thermodynamic properties of the superconducting state which allows us to determine the values of the characteristic dimensionless parameters; the zero-temperature energy gap to the critical temperature, the ratio of the specific heats, as well as the ratio connected with the zero-temperature thermodynamic critical field.

References:

[1] D. Li, K. Bao, F. Tian, X. Jin, D. Duan, Z. He, B. Liu and Tian Cui, RSC Adv. 4, 203 (2014).

P-1-33

Disorder to ordering of spins in doped La_2CoMnO_6; Robust spontaneous exchange bias effect

A. Venimadhav,[1] and J. Krishnamurthy[1]

[1] *Cryogenic Engiineering centre, IIT Kharagpur, India*

The exchange bias(EB)is the phenomenon associated with the exchange anisotropy across the ferromagnetic and antiferromagnetic interface and it is ubiquitous to magnetic recording read heads and spintronic devices[1]. In contrast to field cooled CEB, in certain systems below the blocking temperature a spontaneous loop shift can be observed without the assistance of external magnetic field and this unusual zero-field-cooled M(H) loop shift is called spontanious EB effect. We present a giant spontaneous exchange bias effect in Sr doped La2CoMnO6 sample. Structural and magnetic transitions have been found with Sr doping in La site. A systematic magnetic study has been carried by varying Sr content observed ferromagnetic transition followed by reentrant spin glass behaviour, phase separation to spin glass and ferromagnetic phases and to canted antiferromagnetic transition below 30 K. Giant spontaneous exchange bias effect is found only below the canted antiferromagnetic transition [2]. We discuss the disorder to ordering of spin states with Sr content using structural, Raman and magnetic studies.

References:

[1] H. Meiklejohn and C. P. Bean, Phys. Rev. 102, 1413 (1956).

[2] J. Krishna Murthy and A.Venimadhav, Appl. Phys. Lett 103, 252410 (2013).

P-1-34

Band structure, magnetic and thermodynamic properties of RNi_5Sn (R=La, Ce, Nd and Pr) compounds.

A. Jezierski,[1] J. Kaczkowski,[1] and A. Szytuła[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *M. Smoluchowski Institute of Physics, Jagiellonian University, W.S. Reymonta 4, 30-059 Kraków, Poland*

The electronic structure, magnetic and thermodynamic properties of RNi_5Sn (R=La,Ce,Nd,Pr) compounds are calculated by ab-initio FPLO method within the local density approximation (LSDA and GGA). The exchange correlation potentials are assumed in the form of PW'92 and PBE'96. The effect of electron correlations is included in LDA+U approximation. These compounds crystallize in the hexagonal crystal structure (space group No.194). In this work we present the magnetic properties, band structures and the topology of the Fermi surfaces of $LaNi_5Sn$, $CeNi_5Sn$, $NdNi_5Sn$ and $PrNi_5Sn$ compounds. The thermodynamic properties (bulk modulus, Debye temperature) are calculated in the Debye-Gruneisen model using the equation of states (EOS) in the form of Birch-Murnaghan, Poirier-Tarantola and Vinet.

This work (A.J, J.K) was supported by the National Science Centre (Poland) Grant No. DEC2011/01/B/ST3/02212.

P-1-35

Multiband d-p model for the description of Sr_2RuO_4.

K. Rościszewski,[1] and A.M. Oleś[1,2]

[1] *Marian Smoluchowski Institute of Physics, Jagellonian University, Reymonta 4, PL-30-059 Kraków, Poland.*

[2] *Max-Plack Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany*

We study electronic structure of multiband d-p model (similar to that used in ref. [1]) for the description of quasi-two-dimensional RuO_4 planes such as realized in Sr_2RuO_4. The model takes into account nearest neighbor anisotropic ruthenium-oxygen and oxygen-oxygen hoppings, intraatomic Coulomb interaction and Hund's exchange on both ruthenium and oxygens and additionally spin-orbit coupling on ruthenium.
We were motivated by an earlier abinitio cluster computations which reported charges on oxygen p-orbitals close to 5 and charges on ruthenium close to 6 instead of formal 6 and 4 (ref. [2]). The ruthenium eg orbitals were also found to be occupied [2] contrary to common believes, similarly like showed earlier for CoO_2 planes [3].

References:

[1] Sugimoto T, Ootsuki D and Mizokawa T 2013 *J. Phys. Soc. Jpn.* **82** 104
[2] Kaplan I G and Soullard J 2007 *Phys. Rev.* B **76** 174505
[3] Rościszewski K and Oleś A M 2013 *J. Phys.: Condensed Matt.* **25** 345601

This investigation was supported by Polish National Science Center under project No. 2012/04/A/ST3/00331

P-1-36

Specific heat of the $Ce(Cu_{1-x}Ni_x)_4Ga$ alloys

K. Synoradzki,[1] A. Kowalczyk,[1] and T. Toliński[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences*

The heavy fermion compound $CeCu_4Ga$ is known to exhibit a huge electronic specific coefficient $\gamma = 3.3$ Jmol^{-1}K^{-2} for temperatures extrapolated to $T = 0$ K. In the present study it is shown that the γ value decreases fast with the progressive substitution of Cu with Ni. The crystallographic structure is hexagonal of the $CaCu_5$-type and is kept for all the x values in the $Ce(Cu_{1-x}Ni_x)_4Ga$ alloys, therefore the behavior of the specific heat is related strictly to the modification of the electronic structure occurring with the substitution of Cu by Ni. Moreover, the changes of the crystal electric field levels scheme are observed by extraction of the Schottky contribution to the specific heat.

P-1-37

Competition between Abelian and Zeeman magnetic field effects in two dimensional ultra-cold gas of fermions

Tomasz Polak,[1] Agnieszka Cichy,[2] and Krzysztof Cichy[1,3]
[1]*Faculty of Physics, Adam Mickiewicz University of Poznań, Umultowska 85, 61-614 Poznań, Poland*
[2]*Johann Wolfgang Goethe University, Institute of Theoretical Physics, Frankfurt am Main, Germany*
[3]*NIC, DESY, Platanenallee 6, 15738 Zeuthen, Germany*

The ground state of ultra-cold fermions in the presence of the effects of the orbital and Zeeman magnetic field is analyzed. The three different states superconducting, normal and phase separated are founded. The system, in the presence of the orbital synthetic magnetic field effects, shows non-monotonous changes of the phase boundaries when electron concentration is changed. We observe not only the reentrant phenomena but also the density dependent oscillations of the different areas of the phase diagram. The chemical potential also shows oscillatory behavior and discontinuities with respect to the changes in the number of fermions.

We thank R. Micnas and M. Mierzejewski for fruitful discussions. We also thank W. Hofstetter for carefully reading manuscript and valuable comments.

P-1-38

Ethylene groups ordering transition in the β''-(BEDT-TTF)$_4$[(H$_3$O)Fe(C$_2$O$_4$)$_3$]·Y magnetic molecular conductors

I. Olejniczak,[1] A. Frąckowiak,[1] R. Świetlik,[1] T.G. Prokhorova,[2] and E.B. Yagubskii[2]
[1]*Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*
[2]*Institute of Problems of Chemical Physics, Russian Academy of Sciences, Chernogolovka, MD, 142432, Russia*

Superconductivity in two-dimensional radical cation salts and its interplay with electron-electron correlations are continuing to attract considerable attention. The polarized infrared reflectance and Raman spectra of quasi-two-dimensional β''-(BEDT-TTF)$_4$[(H$_3$O)Fe(C$_2$O$_4$)$_3$]·Y charge-transfer salts where Y=C$_6$H$_5$Br, (C$_6$H$_5$CN)$_{0.17}$(C$_6$H$_5$Br)$_{0.83}$, (C$_6$H$_5$CN)$_{0.4}$(C$_6$H$_5$F)$_{0.6}$, have been measured as a function of temperature. Signatures of charge inhomogenity have been found in both Raman and infrared spectra. The 100 K transition to a mixed insulating/metallic state is clearly seen in the temperature dependence of the electronic spectra of superconducting β''-(BEDT-TTF)$_4$[(H$_3$O)Fe(C$_2$O$_4$)$_3$]·C$_6$H$_5$Br. We suggest that the phase transition is due to subtle change in ethylene groups ordering related with the structural phase transition in the anionic layer.

P-1-39

Mechanism of hole propagation in the orbital compass models

Wojciech Brzezicki,[1,2,3] Maria Daghofer,[2] and Andrzej M. Oleś[1,4]
[1] *M. Smoluchowski Institute of Physics, PL-30059 Kraków, Poland*
[2] *IFW Dresden, D-01171 Dresden, Germany*
[3] *SPIN-CNR, I-84084 Fisciano (Salerno), Italy*
[4] *Max-Planck-Institut FKF, D-70569 Stuttgart, Germany*

We explore the propagation of a single hole in the quantum compass model, whose nematic ground state is given by mutually decoupled antiferromagnetic (AF) chains [1]. This is the simplest model that describes orbital-like superexchange in two dimensions, which may be obtained as the strong-coupling limit of a spinless two-band Hubbard model, studied here by the mean-field theory and the variational cluster approach. Due to the symmetries of the model, the inherent disorder along one lattice direction turns out not to affect hole motion and doping a hole consequently does not lift the subextensive degeneracy of the nematic phase. We observe coherent hole motion due to both interorbital hopping perpendicular to the AF chains and three-site hopping along the chains. In the models for t_{2g} orbitals only the latter mechanism is present [2]. Finally, a generalized compass model having a fully isotropic AF ground state shows that a small admixture of interorbital hopping can trigger hole's mobility.

References:

[1] W. Brzezicki, M. Daghofer, and A. M. Oleś, Phys. Rev. B **89**, 024417 (2014).
[2] M. Daghofer, K. Wohlfeld *et al.*, Phys. Rev. Lett. **100**, 066403 (2008).

P-1-40

Electronic structure of $BiFeO_3$ in different crystal phases

J. Kaczkowski,[1] M. Pugaczowa-Michalska,[1] and A. Jezierski[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, ul. M. Smoluchowskiego 17, 60-179 Poznań, Poland*

Multiferroic $BiFeO_3$ under normal conditions crystallizes in the rhombohedral *R3c* space group. However doping can change its crystal structure to e.g. $Pn2_1a$ (with Gd [1]), *Pnma* (with Gd [1], Y [2]) or *Cm* (with Ga [3]). We present the electronic structure calculations of undoped $BiFeO_3$ in these structures within DFT+U approach. Our structural calculations are in good agreement with previous calculations [4]. Our results show that $BiFeO_3$ favors G-AFM ordering for *R3c*, $Pn2_1a$, *Pnma* structures and C-AFM ordering for *Cm* phase. In all structures $BiFeO_3$ is a semiconductor with the band gap: 2.26 eV (*R3c*), 1.91 eV (*Pnma*), 1.99 eV ($Pn2_1a$), 2.09 eV (*Cm*).

References:

[1] V.A. Khomchenko *et al.*, APL 93, 262905 (2008)
[2] Y.-J. Wu *et al.*, J. Phys.: Condens. Matter 25, 365401 (2013)
[3] J. Yan *et al.*, APL 102, 222906 (2013)
[4] O. Dieguez *et al.*, Phys. Rev. B 83, 094105 (2011)

This work was supported by the National Science Centre (Poland) through grant no. DEC-2011/01/B/ST3/02212.

P-1-41

X-ray diffraction, Mössbauer spectroscopy, and magnetoelectric effect studies of multiferroic $Bi_5Ti_3FeO_{15}$ ceramics

T. Pikula,[1] P. Guzdek,[2] J. Dzik,[3] A. Lisinska-Czekaj,[3] and E. Jartych[1]
[1] *Lublin University of Technology, Institute of Electronics and Information Technology, Lublin, Poland*
[2] *Institute of Electron Technology, Kraków, Poland*
[3] *University of Silesia, Institute of Materials Science, Sosnowiec, Poland*

In this work multiferroic $Bi_5Ti_3FeO_{15}$ Aurivillius compound was prepared by the standard ceramic route and investigated using X-ray diffraction, Mössbauer spectroscopy, and magnetoelectric effect measurements. As it was proved by XRD studies a single-phased $Bi_5Ti_3FeO_{15}$ compound was obtained. Mössbauer studies revealed paramagnetic character of the compound at room temperature. Magnetoelectric measurements were carried out using lock-in dynamic method. The sample was placed into DC magnetic field with superimposed AC field. The value of magnetoelectric coupling factor α_{ME} monotonically increases with increasing frequency of AC magnetic field and saturates above 7 kHz reaching maximal value $\alpha_{ME} = 10.7$ mV·cm^{-1}·Oe^{-1}. Additional magnetoelectric studies were carried out after initial electric polarization of the sample. The maximal value of the magnetoelectric factor $\alpha_{ME} = 20.7$ mV·cm^{-1}·Oe^{-1} was found being almost two times bigger than in the case without the initial polarization.

P-1-42

Transport through a quantum dot in presence of correlated hopping

S.B. Tooski,[1,2] A. Ramšak,[2] B.R. Bułka,[1] and R. Žitko[2]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Faculty of Mathematics and Physics, University of Ljubljana, and Jozef Stefan Institute, Ljubljana, Slovenia*

We investigate the electrical conductance and thermopower of a quantum dot coupled to external leads described by an extension of the Anderson impurity model which takes into account the assisted hopping processes, *i.e.*, the occupancy-dependence of the tunneling amplitudes. We provide analytical understanding based on scaling arguments and the Schrieffer-Wolff transformation, corroborated by detailed numerical calculations using the numerical renormalization group (NRG) method. The assisted hopping modifies the coupling to the two-particle state, which shifts the Kondo exchange coupling exponentially reduces or enhances the Kondo temperature and breaks the particle-hole symmetry. We discuss the gate-voltage and temperature dependence of the transport properties in various regimes. We show that, quite generally, the thermopower is a highly sensitive probe of assisted hopping and Kondo correlations.

P-1-43

Low-lying thermal excitations on the border of ferromagnetism in the filled skutterudite $NdOs_4As_{12}$

A. Rudenko,[1] A. Szewczyk,[2] Z. Henkie,[1] and T. Cichorek[1]
[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

Single crystals of the filled-skutterudite compound $NdOs_4As_{12}$ were grown by mineralization in a molten Cd:As flux. Features related to a ferromagnetic transition at $\simeq 1.1\,\mathrm{K}$ are observed in both transport and thermodynamic properties. Magnetic entropy considerations combined with magnetization data point at a quartet ground state of the Nd^{3+} multiplet being well separated from a first excited state. Unexpectedly, a Schottky anomaly with the maximum at $\simeq 0.93\,\mathrm{K}$ emerges on the border of the ferromagnetically ordered state. Additionally, a small magnetic field of 0.1 T shifts the Schottky peak above the Curie temperature. Thus, its origin cannot be related to the molecular-field splitting, as frequently observed for other ferromagnets. We attribute the Schottky anomaly with an energy separation $\Delta/k_\mathrm{B} \approx 2.2\,\mathrm{K}$ to a lowering of the T_h cubic point symmetry of the Nd^{3+} ions due to an unusual distortion of the Os cage, as recently proposed for $PrOs_4Sb_{12}$ and $NdOs_4Sb_{12}$ [1].

References:

[1] T. Keiber *et al.*, Phys. Rev. B **86**, 174106 (2012).

P-1-44

Coexistence of superconductivity and ferromagnetism in the *d*-band metal Y_9Co_7

Ł. Bochenek,[1] K. Rogacki,[1] A. Kołodziejczyk,[2] and T. Cichorek[1]
[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland*
[2] *Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland*

Transport and thermodynamic properties of the binary intermetallic compound Y_9Co_7 [1] have been re-investigated through precision low-temperature measurements performed on a high quality polycrystalline sample. Our results provide solid evidence for a coexistence of itinerant ferromagnetism and superconductivity in Y_9Co_7 below $T_\mathrm{sc} = 2.9\,\mathrm{K}$, as opposite to previous beliefs that superconductivity occurs in the paramagnetic phase embedded in a basically normal magnetic environment. Additionally, we demonstrate that the clean-limit condition is satisfied for a pure sample of this sole *d*-band ferromagnetic superconductor. Thus, the question whether magnetic fluctuations contribute in a formation of Cooper pairs in Y_9Co_7 remains open.

References:

[1] A. Kołodziejczyk *et al.*, J. Phys. F: Met. Phys. **10**, L333 (1980).

P-1-45

Critical temperature of a non–centrosymmetric s–wave superconductor

D. Grzybowska,[1] and G. Harań[1]

[1] *Institute of Physics, Politechnika Wrocławska*

There is an overwhelming agreement that the superconducting state of a non–centrosymmetric superconductor represents a mixture of singlet and triplet states [1], however theoretically predicted dependence of these two states on the strength of the symmetry breaking spin–orbit coupling seems to be entirely different: whereas the spin triplet states are strongly suppressed, the spin singlet states are very weakly influenced by this interaction [2]. We reexamine the issue of the non–centrosymmetric singlet superconductivity in a system with the spin–orbit coupling dependent density of states. Focussing on the s–wave superconducting state we evaluate the critical temperature in the tight–binding model and communicate a general tendency of T_c to be suppressed by the anisotropic spin–orbit coupling but for systems close to the half filling a sharp maximum in the critical temperature for weak pairing potentials is reported.

References:

[1] Lecture Notes in Physics **847**, Non–centrosymmetric Superconductors, ed. E. Bauer, M. Sigrist (Springer, 2012)

[2] P. A. Frigeri, D. F. Agterberg, A. Koga, and M. Sigrist, Phys. Rev. Lett. **92**, 097001 (2004)

P-1-46

Thermal fluctuations of bismuth based 1G tape

M. Chrobak,[1] W.M. Woch,[1] R. Zalecki,[1] and A. Kołodziejczyk[1]

[1] *Solid State Physics Department, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland*

The thermal fluctuations of bismuth based commercial 1G tape were studied near the critical temperature Tc= 110 K. The detailed analysis of the temperature dependence of resistivity measurements were made in the temperature region from the zero resistance critical temperature up to 200 K. From the results of these measurements, the thermal fluctuations of conductivity were analyzed using Aslamazov – Larkin microscopic approach and the critical exponents were calculated close to the transition temperature.

P-1-47

Polaron states in Cu-O chains and planes

Krzysztof Bieniasz,[1] and Andrzej M. Oleś[1]

[1] *Marian Smoluchowski Institute of Physics, Jagiellonian University, Reymonta 4, PL-30059 Kraków, Poland*

Ever since the discovery of high-temperature superconductivity in cuprates, the t-J model has been regarded as the prime candidate for the theoretical description of the phenomenon. This effective model arises from mapping the p-d model onto the copper $d_{x^2-y^2}$ states. Recent studies indicate, however, that oxygen p-orbital states strongly renormalize the quasiparticle energy, both for antiferromagnetic [1] and ferromagnetic [2] systems. This has led us to study the polaron dynamics in the extended t-J model which includes the oxygen states. We develop the Green's function method in the self-consistent Born approximation (SCBA) which was successfully used to study polarons in the regular t-J model. The inclusion of O($2p$) states in CuO_2 planes causes the vertex function to develop an integrable divergence at the (π, π) point in the Brillouin zone, which requires some creativity in numerical integration of the self-energy. We also obtain a toy model for CuO chains after scaling the problem down to one dimension and investigate whether the numerical integration of the aforementioned divergence may help to solve the actual 2D problem.

References:

[1] Bayo Lau, Mona Berciu, and George A. Sawatzky, Phys. Rev. Lett. **106**, 036401 (2011)

[2] Krzysztof Bieniasz and Andrzej M. Oleś, Phys. Rev. B **88**, 165102 (2013)

P-1-48

Critical Currents of Bismuth Tape

W.M. Woch,[1] R. Zalecki,[1] M. Chrobak,[1] and A. Kołodziejczyk[1]

[1] *Solid State Physics Department, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland*

The critical currents of commercial bismuth based superconducting tape were determined in the two ways. In the first one the transport critical current density was measured by the four points method using the d.c. current power supply at the liquid nitrogen temperature. In the second one the critical current densities were obtained from the absorption part of a.c. susceptibility measurements using the Bean's model near the critical temperature. The temperature dependence of the critical current densities was fitted to take advantage the Ginzburg – Landau strong-coupling limit approach. Using the fit parameters the critical current density at 77 K was calculated. The critical temperature of this tape (Tc= 110 K) was determined from the a.c. susceptibility measurements.

P-1-49

Critical currents of thallium based tape

R. Zalecki,[1] W.M. Woch,[1] W. Tokarz,[1] M. Chrobak,[1] A. Kołodziejczyk,[1] G. Gritzner,[2] and W. König[2]

[1] *Solid State Physics Department, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland*

[2] *Institute for Chemical Technology of Inorganic Materials, Johannes Kepler University Linz, Austria*

The thallium based superconducting tape was prepared by the "powder in tube" technique from the high quality of the $(Tl_{0.6}Pb_{0.24}Bi_{0.16})(Ba_{0.1}Sr_{0.9})_2Ca_2Cu_3O_y$ superconductor. The critical temperature of this tape (T_c= 118 K) was determined from the a.c. susceptibility measurements. The critical currents as a function of temperature were obtained from the absorption part of a.c. susceptibility measurements using the Bean's model. This dependence was fitted to take advantage the Ginzburg – Landau strong-coupling limit approach. Using the fit parameters, the critical current at 77 K was calculated.

P-1-50

Penetration depth of magnetic field into $YBa_2Cu_3O_x$ film on polycrystalline Ag substrate

R. Zalecki,[1] W.M. Woch,[1] M. Chrobak,[1] and A. Kołodziejczyk[1]

[1] *Solid State Physics Department, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland*

The magnetic field penetration depth into $YBa_2Cu_3O_x$ film with the critical temperature of 89 K were determined from the a.c. susceptibility measurements. The YBCO film was deposited directly on polycrystalline Ag substrate by the sedimentation process. When the sample is in the Meissner state, the disperssive component of the a.c. susceptibility as well as its temperature dependence reflects the changes of the penetration depth(s) with the temperature. In this film, the penetration depth are of the order of few micrometers.

P-1-51

Resistance and a.c. susceptibility of $YBa_2Cu_3O_x$ films on Ag substrates by DC and MF magnetron sputtering

W.M. Woch,[1] M. Chrobak,[1] R. Zalecki,[1] and A. Kołodziejczyk[1]

[1] *Solid State Physics Department, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland*

The thin films of $YBa_2Cu_3O_x$ were obtained by the DC and MF magnetron sputtering technique. The films were deposited directly on the polished polycrystalline silver substrates without any buffer layers. The polished silver used as the substrates for the YBCO films were covered by the thin films of the silver using the DC magnetron sputtering. The thickness of these films are in the order of several nanometers. The resistance and the a.c. susceptibility of the superconducting films obtained were measured and the critical temperatures and the critical currents were determined.

P-1-52

Thermodynamic and transport properties of $CeCo_{0.75}Si_{2.25}$

D. Gnida,[1] P. Swatek,[1] U. Burkhardt,[2] Yu. Grin,[2] and D. Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland*

[2] *Max Planck Institute for Chemical Physics of Solids, Dresden, Germany*

Aimed at synthesizing a ternary compound $CeCoSi_3$, a well-developed single crystal of the nonstoichiometric phase $CeCo_{0.75}Si_{2.25}$ was grown by Czochralski pulling method. Metallographic microstructure analysis by optical microscopy and electron microprobe analysis by wavelength-dispersive X-ray spectroscopy indicated homogeneous material, free of any impurity phases. Single crystal X-ray diffraction yielded an orthorhombic $CeNiSi_2$-type structure being a unit cell of $CeCo_{0.75}Si_{2.25}$, yet also provided hints at formation of so-far unsolved superstructure due to partial ordering of Co/Si atoms. The chemical composition derived from the X-ray data corroborated that obtained from the spectroscopic studies. Magnetic susceptibility measurements revealed a predominant mixed valence character of the Ce ions. Surprisingly, the compound was found to order magnetically at low temperatures, and this behavior was confirmed by the heat capacity and electrical resistivity data. The observed features may be related to complex crystal structure with a few inequivalent Ce sites characterized by both fluctuating and stable configurations of the electronic $4f$ shell.

Work supported by the National Science Center PL (grant 2011/03/D/ST3/02351).

P-1-53

Effects of on-site U interaction on the eta-pairing superconductivity and CDW ordering in the Penson-Kolb-Hubbard model with repulsive pair-hopping interaction.

W.R. Czart,[1] and S. Robaszkiewicz[1]
[1] *Institute of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

The phase diagrams and electromagnetic properties of the Hubbard model with the pair-hopping interaction J, called the Penson-Kolb-Hubbard model, are analysed for the case of repulsive J ($J < 0$). We focus on the effects of on-site U interaction on the eta-pairing superconductivity, i.e. the state with the Cooper-pair center-of-mass momentum $\mathbf{q} = \mathbf{Q}$, in this system. The phase diagrams involving magnetic, superconducting and CDW states are derived as well as the evolution of the critical fields, the coherence length, the Ginzburg ratio and the London penetration depth with particle concentration n and pairing strengths is determined at $T = 0$ for $d = 2$ (SQ lattice).

PACS: 74.20.-Z, 71.28.+D, 74.20.Mn

P-1-54

Phase diagrams and electromagnetic properties of s-wave superconductivity of the extended Hubbard model with the attractive pair-hopping interaction

W.R. Czart,[1] and S. Robaszkiewicz[1]
[1] *Institute of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

We study the ground state properties of the extended Hubbard model with the pair-hopping interaction J, i.e. the Penson-Kolb-Hubbard model, for the case of attractive J ($J > 0$). We examine the system for the case of nearest-neighbors electron hopping. For $d = 2$ (SQ) lattice we present the ground state phase diagrams involving magnetic and s-wave superconducting states and determine the evolution of electromagnetic characteristics of superconducting phase as a function of particle concentration n and interactions. The results are compared with those obtained for the repulsive J ($J < 0$) presented in a separate report on this Conference.

PACS: 74.20.-Z, 71.28.+D, 74.20.Mn

P-1-55

XMCD-Signatures of Kondo and Heavy Fermion Behaviour in the Surface Intermetallic $CePt_5$/Pt(111)

C. Praetorius,[1] M. Zinner,[1] and K. Fauth[1]

[1] *Physikalisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg*

We explore the detection of magnetic signatures of Kondo and heavy fermion physics by x-ray spectroscopy and study the anisotropic paramagnetic Ce-4f response in $CePt_5$, prepared on Pt(111). Qualitatively, the magnetic behaviour above $T \gtrsim 20$ K is readily understood in terms of interacting, considerably screened Ce-4f moments in a hexagonal crystal field (CF). A quantitative description necessitates distinct CF parameters for "inner" and "surface" atomic layers (supported by electron diffraction). Yet, treating both CF and Kondo physics at the NCA level [1] proved unsatisfactory.

The paramagnetic response displays a remarkable anomaly ($T^* \approx 18$ K), which we shall discuss as signalling the transition towards the coherent heavy fermion state. Well below T^* we find Ce-4f saturation moments much smaller than the free ion values. Their occurrence, too, can be understood to be characteristic of the coherent state and associated with a Lifshitz transition as predicted theoretically [2].

References:

[1] G. Zwicknagl, V. Zevin and P. Fulde, *Z. Phys. B* **79**, 365 (1990)
[2] K. S. D. Beach and F. F. Assaad, *Phys. Rev. B* **77**, 205123 (2005)

P-1-56

Monte Carlo study of phase separation in magnetic insulators

S. Murawski,[1] K. Kapcia,[1] G. Pawłowski,[1] and S. Robaszkiewicz[1]

[1] *Electron States of Solids Division, Faculty of Physics, Adam Mickiewicz University in Poznań, Umultowska 85, 61-614 Poznań, Poland*

Phase separation in the zero-bandwidth extended Hubbard with nearest-neighbors intersite Ising-like magnetic interaction J^z and on-site Coulomb interaction U is the focus of this study [1-4]. The system was analyzed by means of Monte Carlo simulations on two dimensional square lattice and the results in full range of chemical potential and electron concentration have been obtained. Depending on the values of interaction parameters the system could be in magnetic (F), non-ordered (NO) or phase separation state PS:F/NO [1-2]. The compressibility K is an indicator of the phase separation. Transitions between homogeneous phases (i.e. F–NO transitions) can be of first or second order. The tricritical point is also present on the diagrams.

References:

[1] W. Kłobus, K. Kapcia, S. Robaszkiewicz, Acta Phys. Pol. A **118**, 353 (2010)
[2] S. Murawski, K. Kapcia, G. Pawłowski, S. Robaszkiewicz, Acta Phys. Pol. A **121**, 1035 (2012)
[3] F. Mancini, E. Plekhanov, G. Sica, Cen. Eur. J. Phys. **10**, 609 (2012)
[4] F. Mancini, E. Plekhanov, G. Sica, Eur. Phys. J. B, **86**, 224 (2013)

The work has been financed by National Science Center as a project No. DEC-2011/01/N/ST3/00413 (K.K) and as the doctoral scholarship No. DEC-2013/08/T/ST3/00012 (K.K) as well as by ESF–OP Human Capital–POKL.04.01.01-00-133/09-00 (S.M., K.K.).

P-1-57

Transport properties of magnetic narrow-band semiconductors

S. Murawski,[1] K. Kapcia,[1] G. Pawłowski,[1] and S. Robaszkiewicz[1]

[1] *Electron States of Solids Division, Faculty of Physics, Adam Mickiewicz University in Poznań, Umultowska 85, 61-614 Poznań, Poland*

Magnetic insulators are materials in which a mixture of localized and itinerant electrons give rise to magnetic orderings [1]. This is realized in transition metal cluster compounds with formula AM_4X_8 where A-Al,Ga, M-V,Mo, X-S,Se,Te as well as in high-T_c superconductors. The extended Hubbard model with intersite magnetic interactions can be an effective model for these materials. This model was heavily investigated, especially for 1D and pseudo-1D systems [2-3]. This work presents results obtained using algorithms from the ALPS package [4] on square lattice. Ground state is shown as well as compressibility, magnetization and specific heat behaviour.

References:

[1] S. Lamba, A. K. Rastogi, and D. Kumar, Phys. Rev. B **56** (1997)
[2] G.I. Japaridze and E. Müller-Hartmann, Phys. Rev. B **61**, 9019 (2000)
[3] S. Daul, D.J. Scalapino, S.R. White PRL **84**, 18 (2000)
[4] B. Bauer *et al.* (ALPS collaboration) J. Stat. Mech. P05001 (2011)

The work has been financed by National Science Center as a project No. DEC-2011/01/N/ST3/00413 (K.K) and as the doctoral scholarship No. DEC-2013/08/T/ST3/00012 (K.K) as well as by ESF–OP Human Capital–POKL.04.01.01-00-133/09-00 (S.M., K.K.).

P-1-58

Effective mass of bound two-electron pair in extended Hubbard model on simple cubic lattice.

M. Bak[1]

[1] *Faculty of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznan, Poland*

An exact solutions of bound and resonant two-electron states in the limit of empty lattice (three dimensional, simple cubic) are found in extended Hubbard model by means of lattice Green functions. The dispersion relations, the wave functions and effective masses are calculated within symmetry channels. The results may be relevant to high temperature superconductivity.

P-1-59

Some exact results for the extended Hubbard model with intersite charge and magnetic interactions at atomic limit

Konrad Kapcia,[1] Waldemar Kłobus,[1] and Stanisław Robaszkiewicz[1]
[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Umultowska 85, 61-614 Poznań, Poland*

The extended Hubbard model in the zero-bandwidth limit is studied. The effective Hamiltonian consists of (i) the on-site interaction U, (ii) the intersite density-density interaction W and (iii) the intersite Ising-like magnetic exchange interaction J between nearest-neighbors [1,2]. We present rigorous results obtained within the transfer-matrix method for one dimensional chain in two particular cases: (a) $W = 0$ and $n = 1$ (U-J model); (b) $U \to +\infty$ and $n = 1/2$ ($W \neq 0$, $J \neq 0$). We obtain the exact formulas for the partition function and free energy what enable to calculate the thermodynamic properties such as entropy S, specific heat C and double occupancy per site D.

References:

[1] K. Kapcia, W. Kłobus, and S. Robaszkiewicz, *Acta. Phys. Pol.* A **121**, 1032 (2012).
[2] F. Mancini, E. Plekhanov, and G. Sica, J. Phys.: Conf. Series **391**, 012148 (2012).

The work has been financed by NCN as a project No. DEC-2011/01/N/ST3/00413 and as the doctoral scholarship No. DEC-2013/08/T/ST3/00012 as well as by ESF–OP Human Capital–POKL.04.01.01-00-133/09-00.

P-1-60

High temperature dielectric anomaly induced by external magnetic field on highly strained epitaxial $Bi(Fe_{0.5}Mn_{0.5})O_3$ thin films

L.E. Coy,[1,2] J. Ventura,[2] L. Rodriguez,[2] H. Glowinski,[3] K. Zaleski,[1] C. Ferrater,[2] M.C. Polo,[2] J. Dubowik,[3] and M. Varela[2]
[1] *NanoBioMedical, Adam Mickiewicz University -Poznań, Poland*
[2] *Dept. Física Aplicada i Òptica. Universitat de Barcelona - Barcelona, Spain*
[3] *Institute of Molecular Physics, Polish Academy of Sciences, - Poznan, Poland*

We report on the single phase stabilization of $Bi(Fe_{0.5}Mn_{0.5})O_3$ (BFMO) perovskite thin films deposited on $SrTiO_3$(001)-Nb(0.5%) by pulsed laser deposition. Temperature dependent impedance spectroscopy, SQUID magnetometer and VNA-FMR measurements were used to determine their dielectric and magnetic properties as a function of epitaxial strain and crystal texture. Magnetic measurements show evidence of magnetic ordering on the films with an estimated magnetic transition at ≈560K, feature not observed in bulk. The small magnetization of 0.4 μB/f.u. at room temperature exceeds the theoretical 0.2 μB/f.u. for ferrimagnetism, thus suggesting the influence of spin canting effect. Finally the magneto-electric coupling is discussed as a result of the dielectric measurements performed with and without magnetic field. A large dielectric anomaly is observed at ≈440K under a magnetic field suggesting large magneto-electric coupling well above room temperature.

P-1-61

Electronic band structure of Ru_3Sn_7

M. Sahakyan,[1] and V.H. Tran[1]

[1] *Institute for Low Temperature and Structure Research, Polish Academy of Sciences PO. Box 1410, 50-950 Wroclaw 2, Poland*

The first-principle band structure calculation of Ru_3Sn_7 was carried out using the full-potential linearized muffin tin orbital (FP-LMTO) method. The self-consistent (SC) charge density convergence was achieved using the local density approximation (LDA) for the exchange correlation potential. It was shown that the essential valence band contribution is due to the 4d electrons of Ru, while the contribution from the 5p-Sn orbitals is relatively small. Furthermore, the 4d-Ru and 5p-Sn orbitals located near the Fermi level have the non-hybridized characters, thus contributing independently to the total density of states. A high concordance was observed between the results and those obtained from the full-potential local orbital (FPLO) method. The purpose of the present work is to study in detail the electronic band structure of Ru_3Sn_7 as a reference compound, in comparison with that of the superconducting Mo_3Sb_7.

Financial support from the project 2011/01/B/ST3/04553 of the National Science Centre of Poland

P-1-62

Thermoelectric properties of the $URu_{1-x}Pd_xGe$ system

D. Gralak,[1] T. Toliński,[2] and V.H. Tran[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, ul. Okólna 2, 50-422 Wrocław, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, ul. Smoluchowskiego 17, 60-179 Poznań, Poland*

The substitution of Pd for Ru in $URu_{1-x}Pd_xGe$ causes a dramatic change in their magnetic ground properties; from non-magnetic ($x < 0.3$), non-Fermi liquid (x $\sim$ 0.3), through antiferromagnetic ($x = 0.35$ - 0.8) to complex magnetic state with two successive magnetic phase transitions in $x = 0.9$ and 1. In this contribution, we report thermoelectric power (S) and thermal conductivity (κ) measured in the temperature range 1.9 - 300 K. It is found that S of compositions $0.1 \leq x \leq 0.7$ is negative over the whole temperature range studied and shows negative minimum around 200 K. We interpret the anomaly at high temperatures as due to the Kondo effect. The low-temperature data of the non-Fermi liquid $x = 0.3$ alloy can be well described by a power law $-0.17T^{0.62}$. In contrast to nonmagnetic and antiferromagnetic alloys, the $x = 0.8$ - 0.9 exhibit positive $S(T)$ dependencies. For these compositions, we found also broad maximum nearby their magnetic phase transitions, presumably associated with the magnon drag. κ(T) of the studied solid solutions increases almost linearly with increasing temperature, expecting for dominated electronic contribution.

P-1-63

Andreev spectroscopy in three-terminal hybrid nanostructure

Grzegorz Michałek,[1] Bogdan R. Bułka,[1] Marcin Urbaniak,[1] Tadeusz Domański,[2] and Karol I. Wysokiński[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Institute of Physics, M. Curie-Skłodowska University, Lublin, Poland*

We consider a hybrid three terminal structure consisting of a quantum dot (QD) coupled to two normal (N) and one superconducting (S) lead [1]. The current flowing between one of the normal and the superconducting electrodes induces voltage in the other normal (floating) electrode. The value of the induced voltage depends on the position of the Andreev levels in the quantum dot and is a measure of the interplay between the electron transfer and the subgap anomalous reflection processes (via direct and crossed Andreev scatterings). When the crossed (i.e. non-local) Andreev reflections dominate the induced potential in the N electrode becomes negative. This situation occurs for the relatively strong coupling to the S electrode and only outside the Coulomb blockade region. Taking the S-electrode as the voltage probe one can get additional information on competition of injected carriers.

References:

[1] G. Michałek *et al.*, Phys. Rev. B **88**, 155425 (2013).

The work has been partially supported by NCN under the contracts DEC-2011/01/B/ST3/04428 and DEC-2012/05/B/ST3/03208.

P-1-64

Charge Kondo States, Superconductivity and CDW in systems of coexisting electron and local pairs

M. Sidowski[1], and S. Robaszkiewicz[1]

[1] *Institute of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

We study the phase diagrams and thermodynamic properties of a system of coexisting local pairs and itinerant electrons described by the (hard-core) boson-fermion model. The model considered takes into account both the density-density interaction V_0 as well as the intersubsystem charge exchange coupling I_0. The charge Kondo state (CKS) being an analogue of the magnetic Kondo state in the systems of the periodic Kondo lattice is characterized by a compensation of a local charge moment (isospin singlet) and it can compete with the superconducting and charge orderings. A mutual stability, within an extended mean-field approximation, of CKS, SC and CDW states are determined at $T > 0$ for various lattice structures and various particle concentrations.

P-2-01

Application of the modified Pair Approximation method for Kaya-Berker model

T. Balcerzak,[1] K. Szałowski,[1]
M. Jaščur,[2] M. Žukovič,[2] A. Bobák,[2] and M. Borovský[2]
[1]*Department of Solid State Physics, Faculty of Physics and Applied Informatics, University of Łódź, ulica Pomorska 149/153, 90-236 Łódź, Poland*
[2]*Department of Theoretical Physics and Astrophysics, Faculty of Science, P. J. Šafárik University, Park Angelinum 9, 041 54 Košice, Slovak Republic*

Up to now studies of frustrated Kaya-Berker (K-B) model [1] by means of Hard-Spin Mean-Field Theory, Effective Field Theory and Monte Carlo approach lead to some controversial results. In order to clarify the properties of that model we apply the Pair Approximation method, which has been modified for frustrated systems. In this paper, a full thermodynamic description of K-B model is obtained, based on the Gibbs free-energy analysis. The phase diagram presenting the critical (Néel) temperature is calculated and compared with other methods. In particular, we found that the ground state in K-B model is ordered for all concentrations p of magnetic atoms on one sublattice. The 1st-order phase transition at $p = 1$ and $T = 0$ is found.

References:

[1] H. Kaya, A. N. Berker, Phys. Rev E **62**, R1469 (2000)

P-2-02

Electrical detection of Rashba and Dresselhuas parameters in a quantum well layer

Hyun Cheol Koo,[1,2] Youn Ho Park,[1] Hyung-jun Kim,[1] Joonyeon Chang,[1] and Suk Hee Han[1]
[1]*Korea Institute of Science and Technology (KIST), Seoul 136-791, South Korea*
[2]*KU-KIST Graduate School of Converging Science and Technology, Korea University, Seoul 136-701, South Korea*

The absolute values of Rashba and Dresselhaus parameters are separately observed in an InAs quantum well channel via an electrical method [1]. The InAs active layer is inserted by $In_{0.52}Al_{0.48}As/In_{0.53}Ga_{0.47}As$ double cladding layers to confine the carriers. The Rashba field is always perpendicular to the wavevector direction but the Dresselhaus field depends on the crystal orientation. The vector sum of two fields is as a function of wavevector direction. Thus, the Rashba and Dresselhaus spin-orbit interaction parameters can be separately extracted by observing the Shubnikov-de Haas oscillations for the various crystal directions. The gate dependence of measurement shows that the Rashba effect is only controllable term whereas the Dresselhaus term is constant with gate electric field.

References:

[1] Y. H. Park *et al.*, Appl. Phys. Lett. 103, 252407 (2013).

P-2-03

Thermal properties of antiferromagnetic zigzag chain system β-$TeVO_4$

Yu. Savina,[1] O. Bludov,[1] V. Pashchenko,[1] S. Gnatchenko,[1] A. Szewczyk,[2] T. Zajarniuk,[2] and M.U. Gutowska[2]

[1] *B.I. Verkin Institute for Low Temperature Physics and Engineering, NASU, Kharkiv, Ukraine*

[2] *Institute of Physics of the Polish Academy of Sciences, Warsaw, Poland*

Specific heat of a β-$TeVO_4$ single crystal was measured by using a PPMS (Quantum Design) in the temperature range 0.1-300 K, in the magnetic field, H, ranging from 0 to 9 T. Both a magnetic and a non-magnetic contribution to the specific heat $C_P(T)$ of β-$TeVO_4$ were separated and analyzed. The model of 1D antiferromagnetic Heisenberg $S{=}\frac{1}{2}$ spin chains was found to describe satisfactorily the magnetic contribution. Three specific heat anomalies, appearing at $T = 2.28{\pm}0.02$, $3.28{\pm}0.02$, and $4.65{\pm}0.02$ K ($H = 0$ T), have been detected. In order to study the field dependences of these anomalies, $C_P(T)$ was measured at several fixed values of the magnetic field oriented parallel and perpendicular to the crystallographic b-axis. As the result, the magnetic H-T phase diagrams of β-$TeVO_4$, for $H||b$ and $H{\perp}b$, were constructed.
This work was partly supported by the European Regional Development Fund, through the Innovative Economy Grant POIG.01.01.02-00-108/09.

P-2-04

Exact study of strongly correlated linear chain with localized Ising spins and mobile electrons.

J. Čisárová,[1] and J. Strečka[1]

[1] *Department of Theoretical Physics and Astrophysics, Faculty of Science, P. J. Šafárik University, Park Angelinum 9, 040 01, Košice, Slovak republic*

Exact solution of a hybrid model on linear chain with localized Ising spins and mobile electrons is provided. With the use of the generalized decoration-iteration transformation the studied hybrid model is mapped onto an effective spin-1/2 Ising model on a linear chain, which is then solved exactly using the transfer-matrix method. The ground-state phase diagram is obtained as a function of chemical potential and kinetic energy of the mobile electrons. In addition, the temperature dependences of several thermodynamic properties (electronic density, compressibility and specific heat) are discussed for various values of the chemical potential. The ground state phase diagram reveals existence of five phases with different number of mobile electrons per unit cell, two of which are ferromagnetic, two are paramagnetic and one is antiferromagnetic. For the parameters from the vicinity of the ground-state boundaries the specific heat curves with up to four peaks are observed.

This work was financially supported under the grant no. APVV-0097-12.

P-2-05

Monte Carlo studies of magnetization processes in an extended Ising model on the Shastry-Sutherland lattice

H. Čenčariková,[1] and P. Farkašovský[1]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 040 01 Kosice, Slovakia*

The ground-state properties of the Ising model on the Shastry-Sutherland lattice with the first (J_1), second (J_2), third (J_3) and fourth (J_4) nearest-neighbour spin interacions are studied numerically by the classical Monte Carlo method up to clusters of $L = 120 \times 120$ sites. We have found that the switching on J_3 and J_4 interactions changes dramatically the ground-state phase diagrams as well as the picture of magnetization processes found for the conventional Ising model on the Shastry-Sutherland lattice (with only J_1 and J_2 interactions). In particular, it is shown that the combination of J_3 and J_4 interaction generates the new magnetization plateau at m/m_s=1/2 in the limit of $J_4 \leq 0$ and the following relevant magnetization plateaus at m/m_s=1/10, 1/9, 1/6, 1/5, 2/5, 4/9, 7/15, 1/2 and 5/9 for $J_4 > 0$. The ground states corresponding to these magnetization plateaus are identified by an exhaustive finite-size scaling analysis and the complete ground-state phase diagrams of the model are presented for both, negative as well as positive J_4 interaction. The relevance of these results for description of magnetization processes in rare-earth tetraborides is discussed.

P-2-06

Interplay between frustration and quantum entanglement in ring-shaped chromium-based molecular magnets

P. Kozłowski[1]

[1] *Adam Mickiewicz University in Poznań, Poland*

Magnetic frustration in quantum spin systems has been long believed to be connected to quantum entanglement. In a recent paper [1] it has been demonstrated that this relation can be quantified for some class of quantum spin models. In this contribution we investigate the interplay between frustration and quantum entanglement in the recently synthesized ring-shaped chromium-based molecular magnets [2,3] and test the relation proposed in [1]. It is showed that by using precise measures of frustration and entanglement the intuitive classification of frustration proposed in [2] can be given more solid foundation related also to quantum entanglement. Moreover, the quantities considered to be frustration signatures, like e.g. local magnetizations are showed to be in fact entanglement signatures. It is also demonstrated that the relation proposed in [1] can be used to differentiate between geometric and purely quantum frustration, though not in rings with one of the couplings larger than all the others.

References:

[1] U. Marzolino, S. M. Giampaolo, and F. Illuminati, Phys. Rev. A **88**, 020301(R) (2013)

[2] M. L. Baker, et al, P. Natl. Acad. Sci. USA **109**, 19113-19118 (2012)

[3] M. Antkowiak, P. Kozłowski, G. Kamieniarz, G. A. Timco, F. Tuna, R. E. P. Winpenny, Phys. Rev. B **87**, 184430 (2013)

P-2-07

The Matrix Product State approach versus Haldane-gap antiferromagnets

D. Woźniak,[1] A. Drzewiński,[1] and G. Kamieniarz[2]
[1] *Institute of Physics, University of Zielona Góra, ul. Prof. Z. Szafrana 4a, Zielona Góra, Poland*
[2] *A. Mickiewicz University, Faculty of Physics, ul. Umultowska 85, Poznań, Poland*

The one-dimensional quantum Heisenberg model is applied to antiferromagnetic Heisenberg spin chains with integer value of spin. The Matrix Product State formalism is applied to study the effect of alternation in the single-site anisotropy on the existence of the Haldane gap in the energy spectrum. Moreover, the time evolution of the ground-state magnetization has been performed after the sudden change in applied field.

P-2-08

Arbitrary Weak First Order Phase Transitions in the 3D standard Ashkin-Teller model by MC Computer Experiments

D. Jeziorek-Knioła,[1] G. Musiał,[1] and Z. Wojtkowiak[1]
[1] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

The phase transition line in the vicinity of the tricritical Ising point region is studied in the 3D standard Ashkin-Teller model on a cubic lattice. This model of the multicomponent order parameter is one of the most important reference points in statistical physics and it implies the interesting and rich phase diagram. The main motivation to our study are arbitrary weak first order phase transitions signalized by Arnold and Zhang [1] along this line. The large-scale Monte Carlo computer experiments using the Binder and Challa like cumulants [2] modified by Musial [3] are performed. Specific behavior of the Challa-Musial cumulants for weak first order phase transitions is discovered and its interpretation is proposed. Using the finite-size-scaling analysis applied for Challa-Musial cumulants minima values and the Musial method [3], the latent heat is calculated. The paper unambiguously confirms the arbitrary weak first order character of phase transitions studied when approaching the Ising point.

References:

[1] P. Arnold, Y. Zhang, Nucl. Phys. B **501**, 803 (1997)
[2] M.S.S. Challa, D.P. Landau, K. Binder, Phys. Rev. B **34**, 1841 (1986)
[3] G. Musiał, Phys. Rev. B **69**, 024407 (2004)

P-2-09

Moment direction and off-octahedral distortions in K_2CoF_4 and CoO

R.J. Radwanski,[1,2] D.M. Nalecz,[1,2] M. Krupska,[1,2] T. Piwowarczyk,[1,2] Z. Ropka,[1] and J. Wasowicz[1,2]

[1] *Center of Solid State Physics, S^{nt} Filip 5,31-150 Krakow, Poland*
[2] *Institute of Physics, Pedagogical University, 30-084 Krakow, Poland*

We have analyzed two cobalt compounds, K_2CoF_4 and CoO, with an aim to explain their magnetocrystalline anisotropy i.e. the origin of the given direction of the Co magnetic moment. In both these compounds Co ions are divalent. They are both antiferromagnetic below 107 and 291 K, respectively. In our atomic-like approach QUASST the *d* electrons in these compounds form the highly-correlated atomic-like system $3d^7$ realizing the high-spin state resulting from the octahedral subterm $^4T_{1g}$ (^4F). We have derived the low-energy electronic structure taking additionally into account the tetragonal distortion and the relativistic spin-orbit interaction. We have found that the tetragonal distortion determines the direction of the Co moment. The moment direction along the tetragonal axis is realized in case of the tetragonal compression explaining experimental results. We have calculated the orbital moment. These theoretical findings we treat as a large superiority of our atomistic approach over presently-in-fashion *ab initio* methods which are unable to provide e. g. low-energy (say, in the 5 meV scale) electronic structure, anisotropy and the orbital moment.

P-2-10

Magnetic characterization of binuclear nickel complex: special role of non-covalent intermolecular interactions

N. Nedelko,[1] P. Aleshkevych,[1] A. Kornowicz,[2] J. Lewiński,[2] S. Lewińska,[1] P. Demchenko,[1] M. Kuźmiński,[1] and A. Ślawska-Waniewska[1]

[1] *Institute of Physics Polish Academy of Sciences, Warsaw, Poland*
[2] *Warsaw University of Technology, Warsaw, Poland*

A new nickel(II) dimeric complex $[Ni_2(HL)_2(py)_6(ClO_4)_2]_n$ (**I**) (H_2L = 2,6-bis(hydroxyimino)cyclohexanone; py = pyridine) have been characterized by variable temperature EPR and magnetic studies. Upon cooling the magnetic structure of (**I**) changes from the paramagnetic state at room temperature through the formation of the antiferromagnetic dimers at $\sim$ 65 K to the appearance of a spontaneous long range magnetic order at T $<\sim$ 20 K. Such behaviour can be explained taking into account the crystal structure of (**I**), which is assembled into supramolecular architectures by means of intermolecular non-covalent forces. Ours studies show that the coexistence and interplay between intradimer and interdimer (propagated by the hydrogen and π-stacking bonds) magnetic interactions as well as long range dipolar interactions gives rise to the magnetically ordered state at very low temperatures.

This work was partially performed in the laboratory founded by POIG.02.02.00-00-025/09.

P-2-11

Small antferromagnetic spin systems: just beyond the rotational band mode

Wojciech Florek,[1] and Leonard A. Kaliszan[2]
[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[2] *Poznan School of Logistics, Poznań, Poland*

Investigation of molecules containing magnetic centers is one of the most important topics in contemporary physics. In the case of antifrromagnetic couplings the rotational band model, satisfying the Landé interval rule, is frequently assumed to describe the thermodynamic properties of such a system. However, the *classical* Landé rule is not fulfilled in quantum spin systems besides some special cases [1]. *E.g.*, it is satisfied for spins placed in vertices of a square or a rhombus [2]. We consider systems very close to those mentioned above: (a) 4 spins s in vertices of a isosceles trapezium and (b) a ring of 6 small spins. In both cases the total spins of sublattices, $S_{A(B)}$, are not good quantum numbers. In the first case changes in molecule geometry (or, equivalently, in exchange integrals), whereas in the second case the number of spins are responsible for this effect. In all these cases the thermodynamic properties can be easily determined, but we concentrate on eigenstates and discuss 'mixing' of states with given $S_{A(B)}$ or, in the other words, their mean values (over the quantum eigenstates).

References:

[1] L. Engelhardt, M. Luban, Phys. Rev. B **73**, 054430 (2006)
[2] W. Florek *et al.*, Physica B **405**, 3811 (2010)

P-2-12

Point group interpretation of Galois symmetry of Bethe Ansatz solutions of magnetic pentagonal ring

B. Lulek,[1] T. Lulek,[2] M. Łabuz,[3] and J. Milewski[4]
[1] *East European State Higher School, Tymona Terleckiego 6, 37-700 Przemyśl, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*
[3] *Department of Theoretical Physics, Faculty of Mathematics and Natural Sciences, University of Rzeszow, Pigonia 1, 35-310 Rzeszów, Poland*
[4] *Institute of Mathematics, Poznań University of Technology, Piotrowo 3A, 60-965 Poznań, Poland*

Exact solutions of the eigenproblem of the magnetic pentagonal ring exhibit the arithmetic symmetry expressed in terms of a Galois group of a finite extension of the prime field $\mathbb{Q}$ of rationals. We propose here a geometric interpretation of this symmetry in the interior of the Brillouin zone in terms of point groups. Explicitly, it is a subgroup of the direct product $D_4 \times C_4$. We present also the appropriate irreducible representations of the group.

P-2-13

Enhanced thermoelectric currents in graphene with impurities

M. Inglot,[1] A. Dyrdał,[2] V.K. Dugaev,[1,3] and J. Barnaś[2,4]
[1] *Department of Physics, Rzeszów University of Technology*
[2] *Faculty of Physics, Adam Mickiewicz University, Poznań*
[3] *Department of Physics and CFIF, Instituto Superior Técnico, Lisbon*
[4] *Institute of Molecular Physics, PAS, Poznań*

We consider theoretically the thermoelectric phenomena in graphene with imparities. For appropriate impurity potential one finds localized resonance states at the Fermi level (or in its close vicinity). It is shown that such impurity-induced resonant states have a significant influence on the conventional Seebeck effect and thermoelectric efficiency (figure of merit). Thermoelectrically-induced spin and charge currents in graphene with impurities that locally enhance Rashba spin-orbit coupling is also considered. We have found that such impurities strongly enhance the Seebeck and spin Seebeck coefficients in the vicinity of the spin-orbit resonance states.

P-2-14

Spin Correlations on a Frustrated Honeycomb

Dorota Gotfryd,[1] and Andrzej M. Oleś[1]
[1] *Marian Smoluchowski Institute of Physics, Jagellonian University, Reymonta 4, PL-30059 Kraków, Poland*

We present a detailed analysis of the Heisenberg and Kitaev–Heisenberg models on a single hexagon. For frustrated Heisenberg interactions with nearest neighbor (J_1) and next–nearest neighbor (J_2) antiferromagnetic couplings various types of order have been suggested which compete with disordered states: (*i*) valence-bond crystal [1], or (*ii*) plaquette resonating valence-bond state [2]. We derive the energy spectra using an exact diagonalisation of a single hexagon as well as spin–spin correlation functions for different parameter regimes. For the Heisenberg J_1-J_2 Hamiltonian we recover the lowest part of the energy spectrum for a single hexagon presented in [2]. We also investigate the evolution of the energy spectra and spin correlations between Ising and Kitaev, Ising and Heisenberg, as well as between Heisenberg and Kitaev model for a spin liquid. Finally, we consider a single hexagon within a cluster mean-field approximation introduced in [1] and demonstrate the tendency towards symmetry breaking away from the Kitaev limit.

References:

[1] A. F. Albuquerque *et al.*, Phys. Rev. B **84**, 024406 (2011).
[2] R. Ganesh, S. Nishimoto, and J. van den Brink, Phys. Rev. B **87**, 054413 (2012).

P-2-15

The spin-1 two-dimensional J_1-J_3 Heisenberg model on a triangular lattice

P. Rubin,[1] A. Sherman,[1] and M. Schreiber[2]
[1] *University of Tartu, Tartu, Estonia*
[2] *Technische Universität, Chemnitz, Germany*

Motivated by the experimental data for $NiGa_2S_4$, the spin-1 Heisenberg model on a triangular lattice with the ferromagnetic nearest- and antiferromagnetic third-nearest-neighbor exchange interactions, $J_1 = -(1-p)J$ and $J_3 = pJ, J > 0$, is studied in the range of the parameter $0 \leq p \leq 1$. Mori's projection operator technique is used as a method which retains the rotation symmetry of spin components and does not anticipate any magnetic ordering. For zero temperature several phase transitions are observed. At $p \approx 0.2$ the ground state is transformed from the ferromagnetic spin structure into a disordered state, which in its turn is changed to an antiferromagnetic long-range ordered state with the incommensurate ordering vector $Q \approx (1.16, 0)$ at $p \approx 0.31$. With growing p the ordering vector moves along the line Q-Q_1 to the commensurate point $Q_1 = (2\pi/3, 0)$ which is reached at $p = 1$. The final state with an antiferromagnetic long-range order can be conceived as four interpenetrating sublattices with the 120° spin structure on each of them. We compare these results with the exact-diagonalization data obtained by the SPINPACK code.

P-2-16

Chirality domain wall generated by Z_2 vortex in 2D frustrated Heisenberg spin system

P. Rusek[1]
[1] *Institute of Physics, Wroclaw University of Technology, Wroclaw, PL*

The state of the noncollinear spin system has additional quantum number – chirality: spin on a plaquatte rotate clock- or counter-clock-wise. The order parameter of frustrated spin system is a rotation matrix, as the rotational symmetry is completely broken there. Such order parameter allows for existance of the spin Z_2 vortices in a system ($\pi_1(SO(3)) = Z_2$). We show that in the presence of a dipole spin anisotropy the order parameter space is reduced from the $SO(3)$ group manifold to a sphere S_2. It results in the creation of a line terminating on Z_2 vortex, where the chirality of underlying spins is rapidly changed – the chirality domain wall. The structure of chirality domains and chirality of domain walls in the spiral phase of underdoped La-based cuprate is discussed.

P-2-17

Higgs modes and triviality in quantum spin dimers in the vicinity of the quantum critical point

M. Fidrysiak,[1] and P. Rusek[1]

[1] *Institute of Physics, Wroclaw University of Technology, Wroclaw, PL*

We study the longitudinal spin fluctuations (Higgs mode) in 3D quantum dimer systems in the vicinity of the quantum phase transition (QPT) quantum dimer $\rightarrow$ quantum antiferromagnet. As an example we consider $TlCuCl_3$, where this QPT is driven by pressure. The critical dynamics is described in the framework of Φ^4 model. The renormalization group analysis applied to the lattice Φ^4 model shows that the quartic coupling constant g diverges (Landau pole) at a finite momentum scale, i.e., the continuum limit of this model is free (trivial). The presence of the Landau pole generates an upper bound (triviality bound) on the mass of the Higgs mode.
We have found that in the case of $TlCuCl_3$ the Landau pole develops at the underlying lattice (reciprocal) scale, i.e., this system should be described within the strong coupling limit of Φ^4 model or, equivalently, quantum non-linear σ-model (QNLσM). Applying $1/N$ expansion method to the QNLσM the dynamical spin susceptibilities of $TlCuCl_3$ have been computed and the pressure dependence of the longitudinal magnon gap and its full width at half maximum have been extracted. The Néel temperature, staggered magnetization, and the gap in the dimerized phase have been calculated. A good agreement with experiments has been obtained.

P-2-18

Non-uniform coupling model of the Cr_8Ni ring

M. Antkowiak,[1] Ł. Kucharski,[1] and G. Kamieniarz[1]

[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

We analysed the magnetic properties of a ring of eight chromium ions doped with one nickel ion, denoted in short Cr_8Ni. By making calculations for smaller rings we have demonstrated that the chromium and nickel anisotropies can be neglected for modeling the susceptibility in the considered temperature range due to their relatively low values. Omission of anisotropy allowed us to make simulations for three models with different degrees of diversification of the exchange integrals between chromium ions, using a genetic algorithm. The models revealed better agreement with experiment than those previously known from literature. We also calculated the magnetization in a magnetic field and compared the results with experimental data, which so far have not been taken into account for modelling. We calculated the energy structure as a function of the ratio of the exchange integral between chromium and nickel ions to the remaining integrals, and have determined the energy differences for the selected transitions, which may be expected to be observed in the INS experiment.

This work was supported in part by the MNISW grant No. 579138. Numerical calculations were carried out on the platforms of the PSNC in Poznań and the TASK in Gdańsk, Poland.

P-2-19

Thin films of octacyanido-bridged molecular magnets

M. Fitta,[1] T. Korzeniak,[2] P. Czaja,[3] M. Bałanda,[1] and B. Sieklucka[2]

[1]*Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Kraków, Poland*

[2]*Faculty of Chemistry, Jagiellonian University, Ingardena 3, 30-060 Kraków, Poland*

[3]*Institute of Metallurgy and Materials Science Polish Academy of Sciences, Reymonta 25, 30-059 Kraków, Poland*

In the last few years, there has been a significant interest in the study of molecular magnets in a form of thin films, which is motivated by the possibility of applying these materials in spintronic devices. Among the group of cyanido-bridged coordination networks, the most studied compounds are thin films of hexacyanidometallates, while the reports on the preparation of thin films based on octacyanidometallates are quite rare.

This work presents synthesis and study of magnetic and structural properties of thin films based on transition metals octacyanides, in particular Mn^{II}−L−$[Nb^{IV}(CN)_8]^{4-}$ coordination networks (L−bridging ligand). The samples are obtained by electrostatic self-assembly using the dip-coating technique. Results of dynamic and static magnetic susceptibility, IR spectroscopy measurements and SEM analysis will be discussed.

P-2-20

Low temperature properties of the spin-1 Heisenberg antiferromagnet with nearest and next-nearest neighbour couplings and single ion anisotropy on the honeycomb lattice

Adam Sajna,[1] Ravindra W. Chhajlany,[2,1] Przemyslaw Grzybowski,[1] and Roman Micnas[1]

[1]*Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614, Poznan, Poland*

[2]*ICFO - Institut de Ciences Fotoniques, Av. Carl Friedrich Gauss 3, 08860 Castelldefels (Barcelona), Spain*

Possible existence of quantum spin liquid states in the spin-1 Heisenberg model with Single Ion Anisotropy (SIA) on the honeycomb lattice has motivated recent studies of its low temperature properties (Xu et al [PRL 108, 087204 (2012)], Chen et al (CHR) [PRL 109, 016402 (2012)]). Here we derive a low temperature theory of the model built over the paramagnetic phase using the the Green's function equations of motion in the Standard Basis Operator (SBO) formalism within the RPA approximation. For the 3-d case, our results are in broad agreement with those of CHR suggesting the low temperature putative spin liquid properties of the model can be explained through proximity of the system to the paramagnet-spin spiral quantum phase transition. In 2-d, however, we obtain a region of parameters where the system does not attain conventional magnetic ordering, suggesting the possibility of more exotic ordering.

P-3-01

Boson fields in ordered magnets

A. Hoser, U. Köbler[1]
[1] *Helmholtz-Zentrum Berlin, 14109 Berlin, Germany*

Universality in the critical dynamics near phase transitions means that the dynamics is independent of the interactions between spins and therefore is identical for ferromagnets and antiferromagnets. As a consequence, the magnetic ordering transition is not executed by exchange interactions. From Renormalization Group (RG) theory [1] we know that the critical dynamics is as for a continuous medium. Quite generally, the excitations of a continuous medium are bosons. Since spin dynamics is that of the boson field, field theories treat on the dynamics of the field exclusively. Typical for boson dynamics is that the critical power functions hold over a finite distance from critical temperature. Within the finite temperature range thermal energy is in the boson field. The field quanta were, however, not specified by RG theory. Realistic field theories therefore are not yet possible. We will show that the field quanta are essentially magnetic dipole radiation emitted upon precession of the magnetic moments. The field therefore has radiation character. Since Ising spins do not precess they are unable to generate magnetic dipole radiation. The boson field remains, so to say, empty. Only in Ising magnets the dynamics is defined by exchange interactions.

References:

[1] K.G. Wilson, Rev. Mod. Phys. 47, 773 (1975)

P-3-02

Magnetic field induced spin dynamics in $KEr(MoO_4)_2$

V. Tkáč,[1] A. Orendáčová,[1] R. Tarasenko,[1] M. Orendáč,[1] and A. Feher[1]
[1] *Centre of Low Temperature Physics of P. J. Šafárik University and SAS, Park Angelinum 9, 040 00 Košice, Slovak Republic*

Specific heat study identified $KEr(MoO_4)_2$ as a quasi-two-dimensional array of $S' = 1/2$ Ising chains with ferromagnetic intrachain interaction $|J_1|/k_B \approx 0.9$ K and antiferromagnetic interchain coupling $|J_2| \approx 0.2|J_1|$ [1]. A phase transition to the magnetic ordered state has been observed at $T_c = 0.95$ K [1]. Analysis of the specific heat in the fields up to 1 T applied along the easy axis suggests that a one-dimensional Ising spin cluster model is a good approximation for this system [2]. We studied magnetic field and temperature dependence of ac susceptibility in the magnetic field up to 1 T and temperatures from 1.8 to 20 K. Our experiments indicated a presence of a slow magnetic relaxation. The magnetic field dependence of the intensity of the relaxation processes is discussed.

References:

[1] D. Horváth, A. Orendáčová, M. Orendáč, M. Jaščur, B. Brutovský, A. Feher, Phys. Rev. B **60**, 1167 (1999)
[2] A. G. Anders, V. S. Bondarenko, A. Feher, A. Orendáčová, M. Orendáč, J. Magn. Magn. Mater. **187**, 125 (1998)

This work was supported by the projects APVV 0132-11, VEGA 1/0143/13 and CFNTMVEP.

P-3-03

Dimensionality in field theory and spin wave theory

U. Köbler[1]

[1] *Forschungszentrum Jülich, 52425 Jülich, Gemany*

It is illustrated on account of experimental examples that the terms universality and dimensionality have a different meaning in field theory and in spin wave theory. Universality means that the dynamics is independent of material specific atomistic details such as the exchange interactions between spins. Atomistic theories therefore are inappropriate. This reveals clearly from the fact that the observed critical power functions of type $(T_c - T)^{\beta}$ hold over a finite temperature range instead of asymptotically at T_c only. Within the finite critical range thermal energy is in a boson guiding field. The dynamics of the spins is that of the boson field. Field theories therefore need to consider the field degrees of freedom exclusively. Since the observed critical exponents and the actual value of the ordering temperature are due to the field, they should not be compared with atomistic model predictions. The dimensionalities of field and exchange interactions can be different. In the tetragonal antiferromagnet MnF_2 magnon dispersions are isotropic but the boson field is one-dimensional and aligns all moments rigidly along tetragonal axis. One therefore has to classify MnF_2 as a one-dimensional antiferromagnet in spite of isotropic magnon dispersions.

References:

[1] U. Köbler: Towards a Field Theory of Magnetism, in: Recent Developments of Bosons Research, p.1-66, Nova Science Publishers, Inc., Hauppauge, N.Y. (2013)

P-3-04

Nonlinear ferromagnetic resonance in micron and sub-micron amorphous wires

Luděk Kraus,[1] and Gabriel Ababei[2]

[1] *Institute of Physics of the ASCR, v.v.i., Prague, Czech Republic*

[2] *National Institute of Research and Development for Technical Physics, Iaşi, Romania*

Ferromagnetic resonance of glass-coated amorphous microwires FeSiB and CoFeSiB with the diameters varying from 133 nm to 25 μm and the glass thickness about 10 μm was measured at frequency of 9.5 GHz. Electric polarization of the wire can substantially amplify the microwave magnetic field on the sample surface. This allows us to achieve the threshold fields for nonlinear behavior with microwave power of only few mW. Above some critical value of incident power a distortion of central part of FMR curves is observed on FeSiB wires. For diameters less than 1.5 μm a series of sharp, nearly equidistant, peaks appears with the period δH inversely proportional to the wire diameter. The phenomenon is explained by the parametric excitation of dipole-exchange modes via the first order Suhl's spin-wave instability and the spin-wave confinement in very thin wires. In the CoFeSiB wires the nonlinear phenomena cannot be achieved even with the maximum power available (about 20 mW). It is probably because the threshold field is higher due to larger Gilbert damping constant and lower saturation magnetization of this alloy.

P-3-05

Surface magnetism of iron borate films

K. Seleznyova,[1,2] M. Tekielak,[3] A. Maziewski,[3] J. Kliava,[1] S. Yagupov,[2] and M. Strugatsky[2]

[1] *LOMA, UMR 5798 Université Bordeaux 1-CNRS, Talence, France*

[2] *Taurida National University, Simferopol, Ukraine*

[3] *Department of Physics of Magnetism, Faculty of Physics, University of Bialystok, Poland*

Iron borate, $FeBO_3$ is a two-sublattice easy-plane antiferromagnetic with a weak in-plane moment. Recently, surface magnetic anisotropy (SMA) was studied in non-basal planes of *bulk* $FeBO_3$. In the present paper we have focused on the SMA in basal plane of iron borate *thin films*. Experiments were performed with a Kerr microscope in longitudinal mode. Magnetization curves were measured for different orientations of external magnetic field. Normally, $FeBO_3$ should possess hexagonal anisotropy in the basal plane. However, mechanical stresses can significantly modify this behavior. In the simplest case an uniaxial contribution to the magnetic anisotropy is expected. Moreover, the character of magnetization of thin near-surface layer is determined largely by domain configuration in the portion examined in the visual field of the microscope. Taking into account the influence of domain structure as suitable corrections of hexagonal and uniaxial anisotropies we have obtained a satisfactory fit to the observed angular dependence of saturation field.

P-3-06

Magnetic and thermal properties of $TbAl_3(BO_3)_4$ borate down to 140 mK

T. Zajarniuk,[1] A. Szewczyk,[1] M.U. Gutowska,[1] M.I. Pashchenko,[2] V.A. Bedarev,[2] S.L. Gnatchenko,[2] L.N. Bezmaternykh,[3] and V.L. Temerov[3]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

[2] *B. Verkin Institute for Low Temperature Physics and Engineering, Kharkiv, Ukraine*

[3] *L. V. Kirensky Inst. Phys., Siberian Branch of RAS, Krasnoyarsk, Russia*

Specific heat of a trigonal $TbAl_3(BO_3)_4$ single crystal was measured between 0.14 and 300 K. At $T_C = (0.678 \pm 0.002)$K, a second order phase transition, accompanied by a λ-type anomaly, was discovered. It was interpreted as being related to the appearance of a long range magnetic (probably antiferromagnetic) order of Tb^{3+} magnetic moments. Studies of the influence of magnetic field (up to 1 T) applied along the trigonal axis on the transition and on the specific heat, aimed at determining the kind of magnetic order and explaining whether the transition has a classical or a quantum character, were performed. Lowering the transition temperature, damping the anomaly, and appearance of the Schottky anomaly (related to excitations of the Tb^{3+} ions) were observed with increase of the field.

The work was partly supported by the European Regional Development Fund, through the Innovative Economy Grant POIG.01.01.02-00-108/09.

P-3-07

Magnetism in R_2RhIn_8 compounds

P. Javorský,[1] P. Čermák,[1] M. Kratochvílová,[1] J. Zubáč,[1] Y. Skourski,[2]
A.V. Andreev,[3] B. Ouladdiaf,[4] and M. Boehm[4]

[1] *Charles University in Prague, Department of Condensed Matter Physics, Ke Karlovu 5, 121 16 Prague 2, Czech Republic*

[2] *Dresden High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden, Germany*

[3] *Institute of Physics AS CR, Na Slovance 2, 182 21 Prague 8, Czech Republic*

[4] *Institut Laue Langevin, 6 rue Jules Horowitz, BP156, 38042 Grenoble Cedex 9, France*

The R_2RhIn_8 compounds belong to a large system of structurally related ternary intermetallics in which the crystal structure can be described as a sequence of RX_3 and TX_2 layers, where R represent rare earth or actinide atom, T is a transition metal and X is In or Ga. The possibility of changing dimensionality in these materials by changing m and n ratio together with changing of T element gives scientists a big playground for tuning ground state properties of these compounds. In this work we present magnetic properties of R_2RhIn_8 (R = Nd, Tb, Dy, Tb, Er and Tm) compounds studied by bulk and microscopic experiments. All studied compounds order magnetically, showing complex magnetic properties with several magnetic phases.

P-3-08

Bonding analysis $BiFeO_3$ substituted by Gd^{3+}

M. Pugaczowa-Michalska,[1] and J. Kaczkowski[1]

[1] *Institute of Molecular Physics Polish Academy of Sciences, Poznań, Poland*

$BiFeO_3$ is very impressive due to its initial multiferroic features. Bulk $BiFeO_3$ with the space group *R3c* exhibits a *G*-type antiferromagnetic (AFM) order. Unfortunately, this AFM order in $BiFeO_3$ prevents the observation of any net magnetization and the linear magnetoelectric effect. However, some investigations show that the partial ionic substitutions of Bi by Gd^{3+} is necessary for obtaining spontaneous magnetization in $BiFeO_3$. In respect to this fact, we present results of DFT calculations for $Bi_5GdFe_6O_{18}$ in the rhombohedral *R3c* structure. Our calculations are performed using full-potential projector-augmented wave method, as implemented in the Vienna *ab initio* simulation package (VASP). Within LSDA+U approach it is found that the *G*-type AFM structure with the insulating ground state gives a minimal total energy for studied compound. The effect of Gd substitution is observed as an increase in magnetization compared to the pure $BiFeO_3$. The $Bi_5GdFe_6O_{18}$ compound has nonzero total magnetic moment, which arises from antiparallel moments on Fe sites and reduced moment on Gd. Chemical bonding of the compound is analyzed using partial density of states, electron localization function and charge density distribution.

This work was supported by the National Science Centre (Poland) through Grant nr DEC 2011/01/B/ST3/02212.

P-3-09

Special modes in spin wave spectra of two-dimensional nanodots and nanorings in the vortex state

S. Mamica,[1] and M. Krawczyk[1]

[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, ul. Umultowska 85, 61-614 Poznań, Poland*

We use a microscopic theory taking into account the nearest-neighbour exchange and dipolar interactions to study two-dimensional (2D) magnetic nanodots and nanorings. Magnetic configuration is assumed to form an in-plane vortex (circular magnetization). We examine the dependence of the frequencies and profiles of spin wave excitations on the dipolar-to-exchange interaction ratio d, the size of the dot L, and the symmetry of the 2D lattice, from which the dot is cut. Special attention is paid to some particular modes, including the lowest mode in the spectrum and the fundamental mode, the frequency of which proves almost independent of d. In the case of the lowest mode different profiles are observed: azimuthal, fundamental (quasiuniform) or highly localized, depending on d and L. We also study the hybridization of the modes, show the multi-mode hybridization and explain the selection rules.

References:

[1] S. Mamica, J. Appl. Phys. **113**, 093901 (2013).
[2] S. Mamica, J. Appl. Phys. **114**, 233906 (2013).
[3] S. Mamica, J.-C. S. Lévy, and M. Krawczyk, J. Phys. D **47**, 015003 (2014).

P-3-10

Magnetic properties of bulk and thin films after $Nd_2Fe_{14}B$ corrosion action

V. Constantin,[1] E.I. Neacşu,[1] A.M. Popescu,[1] K.I . Yanushkevich,[2] A.I. Galyas,[2] and O.F. Demidenko[2]

[1] *"Ilie Murgulescu" Institute of Physical Chemistry of the Romanian Academy, Splaiul Independentei 202, Bucharest, Romania*

[2] *Scientific-Practical Materials Research Center NAS, P.Broski Str.19, Minsk, Belarus*

The corrosion action on the bulk $Nd_2Fe_{14}B$ and based on it thin films magnets in different corrosion media was studied. The thin Nd-Fe-B layers of 100 nm $\leq$ d $\leq$ 1000 nm were obtained on glass substrate by "flash" method. The structure and microstructure of the thin Nd-Fe-B films and bulk was studied by X-ray diffraction analysis (XRD), scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). In such films the long-range structural order is destroyed. The temperature specific magnetization study before and after corrosion action in the 80 $\leq$ T $\leq$ 800 K temperature range are carried out by ponderomotive method. It is shown that the magnetization of the layer of d $\geq$ 1000 nm thickness is comparable to those for powder samples. From the hysteresis loops the values of the coercive force and magnetic saturation field are determined.

P-3-11

Magnetic properties of $Mn_{1-x}Gd_xSe$ solid solutions

S. Aplesnin,[1] A. Panasevich,[2] A. Galyas,[2] O. Demidenko,[2] G. Makovetskii,[2] and K.I. Yanushkevich[2]

[1] *Siberian State Aerospace University, 31, Krasnoyarsky Rabochy Av., 660014 Krasnoyarsk, Russia*

[2] *Scientific-Practical Materials Research Center NAS, 220072,P.Brovki Str.19, Minsk, Belarus*

The synthesis of polycrystalline $Mn_{1-x}Gd_xSe$ solid solutions is carried out by solid-state reaction method followed by quenching from the temperature of 1370 K. The X-ray diffraction studies realized at 300 K revealed that the structure of the single-phase samples in the $0 \leq x \leq 0{,}15$ concentration range is identified on base a face-centered cubic crystal cell of Fm3m space group. The heating of the solid solutions to $\sim$ 900K does not affect on the magnetic susceptibility as the dependence is identical to the measurements in the "heating-cooling" regime. Comparing the research results of magnetic properties of the $Mn_{1-x}Gd_xSe$ solid solutions with those of $Mn_{1-x}Gd_xS$ and $Mn_{1-x}Yb_xS$ [1,2] solid solutions, we can conclude that substitution of manganese ions by gadolinium in manganese selenide lead to smaller changes in the basic magnetic characteristics than in manganese sulfide.

References:

[1] Solid State Physics, 2010, Vol.52, N.4., P.687-690.

[2] Izvestia RAN, seria fizicheskaja, 2013. Vol.77, N.3. P. 2059-2062.

P-3-12

Electronic and magnetic properties of $Cr_{3-x}Co_xSi$ alloys - ab-initio study

A. Go[1]

[1] *Faculty of Physics, University of Bialystok, Lipowa 41, 15-424 Bialystok, Poland*

Cr_3Si crystallizes in A15-type structure. When Cr_3Si is doped with cobalt, anomalous magnetic properties are observed [1]. Presence of Co leads to appearance of magnetism in Cr_3Si. Total energy calculations for small Co concentrations x=0.0625 and x=0.125 indicate a tendency to clustering of Co atoms [2]. Obtained values of magnetic moments in case of small Co-Co distance are in agreement with experimental reports about ferromagnetism in this alloy, where probably dimerization occurs. The aim of the contribution is to investigate theoretically an influence of Co dopants on electronic and magnetic properties of $Cr_{3-x}Co_xSi$ alloys. Ab-initio calculations will be carried out by the Full Potential – Linearized Augmented Plane Waves with Local Orbitals method implemented in Wien2k code [3] in wide range of Co concentrations.

References:

[1] P. Zaleski, M. Biernacka, L. Dobrzyński, *et al.*, Phys. Stat. Sol. (a) 196 (1),260 (2003).

[2] A.Go, M.Pylak, L.Dobrzyński, J. Magn.Magn.Matter, in press.

[3] P.Blaha, K.Schwarz, G.K.H.Madsen, D.Kvasnicka and J.Luitz, WIEN2k, An Augumented Plane Wave + Local Orbitals Program for Calculating Crystal Properties (Karlheinz Schwarz, Techn. Universität Wien, Austria), 2001. ISBN 3-9501031-1-2

P-3-13

Thermal Properties of the (Nd,Ca)$BaCo_2O_{5.5}$ Materials

M.U. Gutowska,[1] J. Wieckowski,[1] A. Szewczyk,[1] J. Piętosa,[1] S. Kolesnik,[2] B. Dabrowski,[2] and M. Kowalczyk[3]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *Physics Department, Northern Illinois University, DeKalb, Illinois 60115, USA*
[3] *Fac. of Materials Engineering, Warsaw Univ. of Techn., Warsaw, Poland*

Layered cobaltites $R\mathrm{BaCo_2O_{5.5}}$, which are considered as potential materials for fuel cells cathodes, exhibit a rich spectrum of magnetic and electronic properties. By substituting Ca^{2+} ions (which have nearly identical ionic radius as Nd^{3+}) for Nd^{3+} in $(Nd_{1-x}Ca_x)BaCo_2O_{5.5}$, the hole doping has been realized without disturbing the crystalline structure and the ordering of oxygen vacancies. Thus, we were able to study the influence of hole doping alone on thermal and magnetic properties for compounds with $x = 0 - 0.2$. Specific heat of the synthesized samples was measured over the temperature range from 2 to 395 K in magnetic field of 0 and 7 T. The lattice and magnon contributions to the specific heat were separated and described theoretically by using the Debye and the Einstein models for the lattice contribution and by using a model of magnons in anisotropic materials for the magnon contribution.
This work was partly supported by the NCN 1662/B/H03/2011/40 research project and by the European Regional Development Fund, through the Innovative Economy Grant POIG.01.01.02-00-108/09.

P-3-14

Computer Simulations on Depinning Transition of Magnetic Domain Wall

Bin Xi,[1,2] and Xiao Hu[2]

[1] *Elements Strategy Initiative Center for Magnetic Materials (ESICMM), National Institute for Materials Science (NIMS), Tsukuba 305-0047, Japan*
[2] *International Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for Materials Science (NIMS), Tsukuba 305-0044, Japan*

Recently considerable attentions have been paid to domain-wall dynamics in magnetic materials in order to achieve high coercivity. Here we investigate the domain-wall dynamics under driving field in a thin film of permanent ferromagnet by computer simulations on the two-dimensional Ising model with dipole-dipole interactions and random fields. At zero temperature, there is a critical driving magnetic field, below which the system is pinned by random pinning potentials, whereas above which the domain wall acquires a finite velocity. This sharp depinning transition point defines the coercive force. However, at finite temperatures velocity is non-zero even below the critical field due to thermal activations. We have found a scaling relation among the velocity, temperature and driving field. Interestingly, the domain-wall motion derived from the scaling function and critical exponents is a non-Arrhenius-type one. In this way, we have formulated a systematic way for analyzing experimental results at finite temperatures.

P-3-15

Excitation of a Gaussian beam of spin waves in thin ferromagnetic plate

P. Gruszecki,[1] and M. Krawczyk[1]

[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Umultowska 85, 61-614 Poznań, Poland*

Lasers emit coherent light beam with very low divergence, what means that an intensity profile of light for a long distance from the emission point in Rayleigh range can be described using a Gaussian distribution. Such kind of beams (so-called Gaussian beams) are well mathematically described and due to its properties widely used in photonics but do not considered in magnonics, so far. Obtaining such beams of spin waves (SWs) in thin, plane, ferromagnetic layer should permit to investigate many new phenomenon in magnonics, to propose new applications and to help to better understand the properties of SW's propagation with its anisotropic dispersion relation. We present results of micromagnetic simulations where we show how to mold the amplitude's distribution of a dynamic magnetic field to obtain a SW beam with the Gaussian profile, optimized properties and capable to propagate for a long distance.

We acknowledge the financial assistance from the EU, GA. 247556 (People) - NoWaPhen and NCN of Poland: DEC-2-12/07/E/ST3/00538.

P-3-16

Goos-Hänchen effect for spin waves in thin films - micromagnetic simulations

P. Gruszecki,[1] Y.S. Dadoenkova,[2] N.N. Dadoenkova,[2] J. Romero Vivas,[1] I.L. Lyubchanskii,[2,3] and M. Krawczyk[1]

[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Poland*

[2] *Donetsk Physical and Technical Institute of the National Academy of Sciences of Ukraine, Donetsk, Ukraine*

[3] *Department of Physics and Technology, Donetsk National University, Donetsk, Ukraine*

Goos-Hänchen shift (GHS) is an effect known from optics which can occur for a reflection of light falling on the interface between two dielectric medias at the angle of incidence close or bigger than the critical angle. The appearance of the lateral shift along interface between the incident light beam spot (point of incidence) and the reflected light beam spot (point of reflection) is called as a GHS. We show that for spin waves propagating in thin ferromagnetic film the GHS can also exist at the reflection from the edge of the film and reach measurable values. We prove this using micromagnetic simulations and analyse the properties of the GHS with the theoretical model. The nonuniformity of the internal magnetic field at the ferromagnetic film edge is shown to be a key parameter for the observation of a GHS.

We acknowledge the financial assistance: FP7 NoWaPhen and NCN MAGNOWA.

P-3-17

Non-thermally induced of ultrafast magnetization precession in rare-earth Bi-doped iron garnets

Sergii Parchenko,[1] Isao Yoshimine,[2] Takuya Satoh,[2,3] Andrzej Maziewski,[1] and Andrzej Stupakiewicz[1]

[1] *Laboratory of Magnetism, Faculty of Physics, University of Bialystok, 15-424 Bialystok, Poland*

[2] *Institute of Industrial Science, The University of Tokyo, Tokyo 153-8505, Japan*

[3] *PRESTO, Japan Science and Technology Agency, Tokyo 102-0076, Japan*

Excitation of the magnetization precession by femtosecond laser pulses, via the Inverse Faraday effect, in $Gd_{4/3}Yb_{2/3}BIG$ single crystal was studied. We demonstrate dependenses on function of different parameters, including amplitude and direction of external magnetic field, temperature, wavelength of light pulses excitation and thickness of the sample. Temperature dependences of two different types of precession were observed as low-frequency magnetic field-depended mode and high-frequency field-independent mode. Obtained results have strong importance for non-thermal spins manipulation by polarized laser pulses.

This work was supported by the SYMPHONY project operated within the Foundation for Polish Science Team Programme co-financed by the EU European Regional Development Fund, OPIE 2007-2013.

P-3-18

Transition into the vortex state in dysprosium observed on ZFC and FC curves

B. David,[1] O. Schneeweiss,[1] and M. Hapla[1]

[1] *CEITEC IPM, Institute of Physics of Materials, Academy of Sciences of the Czech Republic, v.v.i., Žižkova 22, CZ-61662 Brno, Czech Republic*

The studies of the magnetic phase diagram of a single crystal of dysprosium (Dy) identified four main regions: helical antiferromagnetic phase, angular ferromagnetic phase, fan phase and collinear ferromagnetic phase [1]. Just below $T_N = 180$ K, an anomaly was identified and ascribed to the so called vortex state. The vortex state exists in the temperature range 170−180 K (at zero applied magnetic field) and disappears above 0.3 T. We have examined the region of the vortex state through the evaluating of the characteristic transition temperatures on zero field cooled curves (ZFC) and field cooled curves (FC) for applied fields up to 0.3 T. Measurements were performed on a QD PPMS ECII 9T device using the VSM option. We conclude that vortex state develops only by cooling as a kind of transition state between paramagnetic state and helical antiferromagnetic state. By heating, fully developed helical antiferromagnetic state converts directly into paramagnetic state.

References:

[1] M.T. Alkhafaji, Naushad Ali, J. Alloy. Compd. 250 (1997) 659-661.

P-3-19

Efficient calculation of low energy configurations of nanoparticle ensembles for magnetoresistive sensor devices by means of stochastic spin dynamics and Monte Carlo methods

L. Teich,[1] C. Schröder,[1] C. Müller,[1] A. Patel,[1] J. Meyer,[2] and A. Hütten[2]

[1] *University of Applied Sciences Bielefeld, Department of Engineering Sciences and Mathematics, Bielefeld, Germany*

[2] *Bielefeld University, Department of Physics, Thin Films and Nanostructures, Bielefeld, Germany*

By dispersing magnetic nanoparticles in conductive gel-like matrices, magnetoresistive sensors with promising features can be developed [1][2]. Moreover, theoretical investigations of the magnetic nanoparticle ensembles reveal sophisticated magnetic behaviour. While Monte Carlo simulations [3] show a transition between a disordered state and a paramagnetic state, a multitude of low energy configurations is revealed by stochastic spin dynamics simulations [3], both resembling dipole glass behaviour. Here, we present strategies to find these low energy configurations efficiently by simulating demagnetization protocols.

References:

[1] J. Meyer *et al.*: **Smart Mater. Struct.**, 2013, **22**, 025032

[2] C. Müller *et al.*: **Chem. Commun.**, 2013, **49**, 10163-10165

[3] L. Engelhardt and C. Schröder: *Simulating computationally complex magnetic molecules.* In R. E. P. Winpenny (Ed.), *Molecular Cluster Magnets*, 2011, World Scientific Publishers, Singapore

P-3-20

Two-step development of antiferromagnetic order in $LiNiPO_4$

S. Lewinska,[1] Yu. Kharchenko,[2] M.U. Gutowska,[1] A. Szewczyk,[1] M.F. Kharchenko,[2] and R. Puzniak[1]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

[2] *B. Verkin ILTPE, National Academy of Sciences of Ukraine, Kharkiv, Ukraine*

Among orthorhombic olivines, promising for application as cathodes in Li-ion batteries and showing a large linear magnetoelectric effect, $LiNiPO_4$ is the most intriguing compound, because an antiferromagnetic ordering develops in it in two steps. On cooling, there appear a second order transition to an incommensurate antiferromagnetic, IC, phase at 21.8 K, and next, at 20.9 K, a first order transition to a commensurate antiferromagnetic, C, phase. To elucidate nature of these transitions and their evolution in magnetic field (i) temperature dependences of specific heat at several values of magnetic field (applied along different crystallographic axes), and (ii) angular dependences of magnetic torque and magnetization for the magnetic field rotating within *a*-*c* and *b*-*c* planes (for several temperatures and magnetic field values) were measured for the $LiNiPO_4$ single crystal. A splitting of a sharp specific heat anomaly accompanying the IC-C transition was found and interpreted as indication that the appearance of the C phase is coupled to the appearance of a non-zero electric polarization.

This work was partly supported by the European Regional Development Fund (Innovative Economy Grant POIG.01.01.02-00-108/09).

P-3-21

Spin wave spectra in the Fibonacci sequence of magnetic wires in crossover of dipolar-exchange regime

J. Rychły,[1] M, Mruczkiewicz,[1] J.W. Kłos,[1] and M. Krawczyk[1]
[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Poland*

The main goal of our research was to investigate the spin wave spectra in fractal magnonic system. Thus we have investigated theoretically 1D Fibonacci sequence of Co and Py infinite long wires of the same dimensions, being in the direct contact, which ensures the exchange coupling between them. The system is saturated by the external magnetic field applied along wire axis. We have performed numerical calculations using finite element method. The results for Fibonacci sequences were compared with the magnonic spectra of respective periodic systems composed of Co and Py wires. We have found in the aperiodic system the reach magnonic spectrum with numerous magnonic band gaps being converged for sufficiently large rank of the Fibonacci sequence. Moreover, within the magnonic band gaps the isolated surface states were observed, which frequency is shown to be sensitive to the endings of the magnonic system. The conclusions are supported by the spatial distribution of a dynamical magnetization.

We acknowledge the financial assistance from Foundation of Polish Science, TEAM program no TEAM/2011-8/4.

P-3-22

Andreev reflexion spectroscopy study of spin polarization in $Co_2Cr(Fe)Al$ Heusler alloys

V. Hašková,[1] P. Szabó,[1] J. Kováč,[2] T. Ryba,[2] Z. Vargová,[3] and R. Varga[2]
[1] *Inst. Exp. Physics, SAS, Watsonova 47, 04001 Košice, Slovakia*
[2] *Inst. Phys., Fac. Sci., UPJS, Park Angelinum 9, 041 54 Košice, Slovakia*
[3] *Dep. Inorg. Chem., Fac. Sci., UPJS, Moyzesova 11, 041 54 Košice, Slovakia*

The large class of Heusler compounds offer many potential applications. One of the most promising application is in spintronics as some Heusler alloys exhibit high spin polarization. The typical example of a such Heusler half-metal is Co_2CrAl [1]. In the present contribution the influence of Fe on the spin polarization of Co_2CrAl will be studied. A recently successfully introduced new rapid quenching method have been used for the sample preparation [2]. The spin polarization parameter P of each sample has been determined from Point-contact Andreev reflexion spectra [3], measured on different microconstrictions between a superconducting Nb tip and $Co_2Cr(Fe)Al$ sample.

References:

[1] T. Graf, C. Felser, S.S.P. Parkin, Prog. Solid State Chem. **39** (2011)
[2] B.Hernando, J.LSanchez Liamazares, J.D.Santos, V.M.Prida, D.Baldomir, D.Sarentes, R.Varga, J.Gonzales, Appl. Phys. Lett. **92** (2008) 132507
[3] I.I. Mazin *et al.*, J. Appl. Phys., **89** (2001) 7576

P-3-23

Peculiarities of Optical and Magnetic Properties of Magnetoelectric $LiNiPO_4$ Crystal in Vicinity of the Neel Temperature

Yu. Kharchenko,[1] O. Miloslavskaya,[1] M. Kharchenko,[1] S. Lewinska,[2] and A. Szewczyk[2]

[1] *B.Verkin ILTPE of NASU, Kharkiv, Ukraine*

[2] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

The $LiNiPO_4$ is one of magnetoelectric antiferromagnetic(AFM) crystals of the orthorhombic olivine family. This crystal is notable for its unique properties: the pronounced pre-transition spin correlations in the paramagnetic state; the incommensurate AFM phase existing in the narrow temperature interval near Neel temperature, 20.9-21.8K; several magnetic phases, sequentially arising in increasing magnetic field applied along AFM vector, and the ultra weak ferromagnetism in commensurate AFM phase. The results of magnetization and magnetic field-induced optical birefringence measurements, performed near the AFM ordering temperature in a magnetic field applied along the main AFM vector are reported. As the result a new property of incommensurate phase, i.e. the appearance of linear magnetooptical effect (the linear in magnetic field birefringence of linearly polarized light) was revealed. This property is characteristic for magnetically ordered material that has no antiinversion symmetry. Nature of the revealed property is discussed.

P-3-24

Band gap properties in one-dimensional YIG magnonic crystals

V.D. Bessonov,[1] M. Mruczkiewicz,[2] R. Gieniusz,[1] U. Guzowska,[1] A.I. Stognij,[3] M. Krawczyk,[2] and A. Maziewski[1]

[1] *University of Białystok, Białystok, Poland*

[2] *Adam Mickiewicz University in Poznan, Poznan, Poland*

[3] *Scientific-Practical Materials Research Center at NASB, Minsk, Belarus*

We studied the properties of forbidden band gaps in the spin wave (SW) dispersion in one-dimensional 1D magnonic crystals (MCs) based on the yttrium iron garnet (YIG) film. Two MCs structures were investigated: YIG film with array of grooves or gold stripes placed a top. The Vector Network Analyzer transmission measurements were confronted with the Finite Element Method calculations [New J. Phys. 15, 113023 (2013)]. A different position and width of the gaps is observed experimentally and theoretically in structures with metal stripes, due to the existence of the exchange Bragg gaps. A two characteristic of SWs gaps are analyzed, i.e., the frequency position of the magnonic band gap and the width of the gap. Further, the width of the gap studied independence on both structures of the external magnetic field, both theoretically and experimentally.

Supported by: Team SYMPHONY project of the FNP, co-financed by the EU from ERDF, OPIE 2007–2013.

P-3-25

Magnetism in $TmCo_2$

J. Šebesta,[1] J. Prchal,[1] J. Valenta,[1] M. Kratochvílová,[1] and V. Sechovský[1]

[1] *Charles University in Prague, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Ke Karlovu 5, 121 16 Praha 2*

Magnetic properties of RCo_2 compound has been subject of studies already in the second half of last century. However, in recent years these materials are becoming interesting again because of new magnetic state - called "parimagnetism" recently discovered in RCo_2 ferrimagnets (R$\in \{Gd, \ldots, Tm\}$) in the paramagnetic range. The parimagnetism is explained like a short-range anti-parallel coupling between magnetization of Co clusters and rare-earth magnetic moments. The importance of $TmCo_2$ compound comes from its position at the end of the series of ferrimagnetic compounds. There exist discrepancies in the literature concerning a behavior of Co magnetism. As a results of a set of several experiments we obtain two characteristic temperatures. One at T_C=3,5 K corresponding to first order magnetic phase trasition and another at 35 K connected with parimagnetic configuration totaly independent on external hydrostatic pressure. We will present experimental data evidencing the exceptionality of $TmCo_2$. It is a special case among the family of RCo_2 compounds with respect to relation of the characteristic temperatures. These temperatures are moreover almost independent on the applied hydrostatic pressure.

P-3-26

Magnetic and electronic properties in series of GdT_xGa_{4-x} solid solutions (T = Ni or Cu).

P. Wiśniewski,[1] R. Gorzelniak,[1] and D. Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P.Nr. 1410, 50-950 Wrocław, Poland*

Crystallographic and magnetic data have been reported only for $GdNiGa_3$ and $GdCu_{1.25}Ga_{2.75}$ [1, 2]. Here we present results of extensive measurements of magnetic susceptibility, electrical resistance, specific heat and thermoelectric power for ranges of doping x from 0.6 to 1 for $GdNi_xGa_{4-x}$ and from 1 to 1.5 in case of $GdCu_xGa_{4-x}$. All studied phases display Curie-Weiss behaviour of magnetic susceptibility and antiferromagnetic ordering at temperatures below 25 K. Substitution of gallium with transition metal atoms has strong influence on Néel temperatures of all studied phases, shifting them by few Kelvin, depending on x. Clear metamagnetic transitions are observed for some compositions. Behavior of resistivity reveals metallic nature of all samples and their magnetic ordering is reflected in low-temperature anomalies of resistivity and thermal properties.

References:

[1] Yu.N. Grin, K. Hiebl, P. Rogl, H. Noël, J. Less-Common Met. **162**, 361 (1990).
[2] Yu.N. Grin, K. Hiebl, P. Rogl, H. Noël, J. Less-Common Met. **162**, 371 (1990).

Study supported by the National Science Centre (Poland) under Grant no. 2011/01/B/ST3/04443.

P-3-27

Dynamics of strongly correlated bosons in magnetic fields

A.S. Sajna,[1] T.P. Polak,[1] and R. Micnas[1]

[1] *Faculty of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

Neutral bosons loaded in an optical lattice open a new window for manipulating of transport phenomena in such sytems. Especially, we analytically show, that recently available synthetic magnetic field, could abruptly change optical conductivity. The role of Dirac-like physics is emphasized [1].

References:

[1] A.S. Sajna, T.P. Polak, R. Micnas, *Phys. Rev. A*, 89, 023631 (2014)

P-3-28

Magnetic and electronic properties of selected rare-earth chromium germanides compounds

A. Gil,[1] and M. Makowska-Janusik[1]

[1] *Faculty of Mathematics and Natural Science, Jan Dlugosz University in Czestochowa*

The ternary rare-earth based systems exhibit interesting physical and structural properties. Lots of them, eg. chromium germanides were experimentally studied concerning their magnetic properties [1] and up to our knowledge they were never studied theoretically explaining nature of their magnetic behaviour. In the presented work the magnetic and electronic properties of $RCrGe_2$ and $RCr_{0.3}Ge_2$ (R=Tb, Dy, Ho or Er) were investigated theoretically applying plane-wave DFT/PBE methodology. The computational investigations were performed for the crystallographic structure with the space group Cmcm. The stoichiometry of the rare-earth chromium germanides compounds has also significant effect on the electronic properties of compounds. The theoretically obtained structural parameters are in good agreement to the data contained in work of Bie et al [2]. The theoretical predictions are compared to the experimentally obtained results.

References:

[1] A. Gil, D. Kaczorowski, B. Penc, A. Hoser, A. Szytula; J. Solid State Chemistry 184 (2011) 227–235
[2] H. Bie, A. V. Tkachuk, A. Mar; J. Solid State Chemistry 182 (2009) 122–128

P-3-29

Effects of heat current on magnetization dynamics in ferromagnetic insulator

F.A. Vetrò,[1] S.D. Brechet,[1] and J-Ph. Ansermet[1]

[1] *Ecole Polytechnique Fédérale de Lausanne*

The work presented here is aimed at investigating the interplay between spin dynamics and heat currents in single-crystal Yttrium Iron Garnet (YIG).
The irreversible thermodynamics for a continuous medium [1] predicts that a thermal gradient, in the presence of magnetization waves, produces a magnetic induction field, thus a magnetic analog of the well-known Seebeck effect. Time-resolved transmission measurements of magnetizations waves propagating along the thermal gradient of a thin slab of YIG crystal provided an experimental observation of this Magnetic Seebeck effect [2].
In order to characterise further this effect, we have also conducted a study on magnetization dynamic in normally magnetized YIG disk subjected to a temperature gradient perpendicular to the plane of the disk and parallel to the applied magnetic field. For this experiment a standard FMR technique at x-band frequencies has been used.

References:

[1] S. D. Brechet and J.-P. Ansermet, "Thermodynamics of a continuous medium with electric and magnetic dipoles," Eur. Phys. J. B, vol. 86, no. 7, pp. 1–19, Jul. 2013.
[2] S. D. Brechet, F. A. Vetro, E. Papa, S. E. Barnes and J.-P. Ansermet, "Evidence for a Magnetic Seebeck effect", Physical Review Letters 111, 8, 087205 (August 22, 2013).

P-3-30

The effects of DC electric fields for electromagnetic wave transmission through an antiferromagnet plate in Voight geometry

G.G. Levchenko,[1] A.S. Savchenko,[1] A.S. Tarasenko,[1] S.V. Tarasenko,[1] and V.G. Shavrov[2]

[1] *Donetsk Institute for Physics and Engineering of the National Academy of Sciences of Ukraine, 83114, Donetsk, Ukraine*

[2] *Kotel'nikov Institute of Radio Engineering and Electronics of the Russian Academy of Sciences, 125009, Moscow, Russia*

The designing of the tunable electromagnetic metasurface on the base of magnetic materials is the one of important directions of the modern metamaterials physics. In this connection, in our report we present the results of research of the relation between the topological characteristics of a refraction surface and the characteristics of the transmission of a TM or TE bulk electromagnetic wave through a transparent half-wave antiferromagnet plate in crossed DC magnetic and electric fields. It was shown that the conditions for resonant transmission correspond to the spectrum of escaping bulk magnetic polaritons of the layer as well as the spectrum of electromagnetic waves in the plate with extreme values of the surface impedance.

P-3-31

Magnetic normal modes in ferromagnetic and antiferromagnetic state bi-component periodic systems

P. Malago`,[1] G. Gubbiotti,[2] S. Tacchi,[2] R. Zivieri,[1] L. Giovannini,[1] M. Madami,[3] and G. Carlotti[3]

[1] *Dipartimento di Fisica e Scienze della Terra, CNISM Unità di Ferrara, Università di Ferrara, Via Saragat 1, 44122 Ferrara, (Italy)*

[2] *Istituto Officina dei Materiali del Consiglio Nazionale delle Ricerche (IOM-CNR), Sede di Perugia, c/o Dipartimento di Fisica, Via A. Pascoli, I-06123 Perugia (Italy)*

[3] *Dipartimento di Fisica, CNISM- Università di Perugia, Via A. Pascoli, 06123 Perugia (Italy)*

Experimental Brillouin light scattering analysis and numerical study based on the dynamical matrix method of the thermal magnetic normal modes in periodic arrays of Py/Co elliptical dots have been performed. Dots have thickness of 25 nm, length of 1 μm and width of 225 nm. The study was done at the center of the Brillouin zone by varying H from 1500 Oe to -1500 Oe passing from the ferromagnetic state to the antiferromagnetic state. In both the ferromagnetic and antiferromagnetic states we have found six relevant collective modes belonging to Py and Co materials.

P-3-32

Defect states in the asymmetric magnonic crystal

J.W. Kłos,[1] M. Krawczyk,[1] S.L. Vysotsky,[2] Yu.V. Khivintsev,[2] Yu.A. Filimonov,[2,3] and S.A. Nikitov[3,4]

[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Poznań, Poland*

[2] *Kotelnikov Institute of Radio-Engineering and Electronics of RAS, Saratov, Russia*

[3] *Saratov State University, Saratov, Russia*

[4] *Kotelnikov Institute of Radio-Engineering and Electronics of RAS, Moscow, Russia*

We have investigated the magnonic states localized at the defect of 1D magnonic crystal (MC). In theoretical model the defect forms a cavity surrounded by two Bragg mirrors differing in the number of periods. We extended (shortened) the MC on the one (on the other) side of defect keeping the total number of periods unchanged. In the strongly asymmetric structure we have observed the shift of frequencies and the deterioration of quality of transmission peaks of the defect modes (DM's) resulting from the change in boundary conditions for exponentially decaying tails of DMs. We conducted also the measurements of spin wave transmission S_{21} in the 1D MC based on YIG film with periodic array of etched grooves. The defect was introduced by increase in distance between two selected grooves. While position of the sample with respect to antennas was changed the frequency of the DM was shifted.

This work was supported by the FP7 No 247556 (NoWaPhen) and RFFI No 13-07-00941, 14-07-00896.

P-3-33

Magnetic phases in pseudoternary system $UCo_{1-x}Ru_xAl$

Petr Opletal,[1] Jiří Pospíšil,[1] and Vladimír Sechovský[1]

[1] *Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Charles University, Ke Karlovu 5, 121 16 Prague 2, The Czech Republic*

UCoAl and URuAl, which crystallize in the hexagonal ZrNiAl-type structure, remain paramagnetic at least down to 30 mK. At He temperatures, UCoAl shows a metamagnetic transition at a magnetic field of ≈ 0.6 T applied along the c-axis [1]. Despite the paramagnetism of parent compounds a huge dome of stable ferromagnetism exists over a wide concentration range of pseudoternary $UCo_{1-x}Ru_xAl$ compounds [2]. For $x \geq 0.4$, there seems to exist two ferromagnetic phases depending on temperature [2]. We have grown three single crystals of the representative composition x = 0.56, 0.70 and 0.78, respectively, and investigated the character and temperature range of stability of the two ferromagnetic phases by measuring magnetization, electrical resistivity, heat capacity, thermal expansion and thermal transport properties. A scenario will be discussed considering different coherence of the two magnetically ordered phases.

References:

[1] V. Sechovsky and L. Havela, In: Handbook of Ferromagnetic Materials, v. 4, Eds. E.P. Wohlfarth and K.H.J. Buschow (North Holland, Amsterdam, 1988), p. 309-491, and references therein.

[2] A.V. Andreev, Philosophical Magazine B, 75, 827 (1997)

P-3-34

Reconstruction of the Exchange Integrals Map of $M(FeAl)_{12}$ Incommensurate Structure

K. Rećko,[1] J. Waliszewski,[1] and K. Szymański[1]

[1] *Faculty of Physics, University of Białystok, Lipowa 41, 15-424 Białystok, Poland*

The compounds with the general formula $M(FeAl)_{12}$ (M = Ac, U, Re) crystallize in the body centered tetragonal symmetry. They form family showing a variety of magnetic structures, and in consequence of physical properties. The studies of (U, Th)$(FeAl)_{12}$ samples showed magnetic similarity in both series of actinide's systems. In the case of $Sc(FeAl)_{12}$ compound these rules turned out to fail. The magnetic structure is described by two modulation vectors: $k_1 = \{\varepsilon_x, \varepsilon_x, 0\}$ and $k_2 = \{-\varepsilon_x, \varepsilon_x, 0\}$, where respectively ε_x=9/50 and 2/15. In order to reconstruct the exchange integrals map reproducing the observed spin ordering, the atomic magnetic moments, modulation vectors and phase transition temperature the MCMag and MCPhase programs were used. Both of them are based on Kirkpatrick's algorithm simulates cooling or heating scenario, while the configuration space is examined by random sampling in accordance with the Metropolis procedure. However, two crucial aspects differ both methods. While MCPhase allows finding the exchange integrals out by fitting and treats the spins quantum-mechanically, so far MCMag treats the spins classically and the exchange constants have to be implemented and fixed.

P-3-35

Experimental and Theoretical Study of Stripe Magnetic Domain Structure Drift in Iron Garnet Crystals

L.A. Pamyatnykh,[1] G.A. Shmatov,[1] S.E. Pamyatnykh,[1] M.S. Lysov,[1] D.S. Mehonoshin,[1] and A.V. Druzhinin[1]

[1] *Ural Federal University, Lenin Av. 51, Yekaterinburg, 620083, Russia*

The results of study of magnetic domain structure drift in oscillating magnetic field $H = H_o sin(2\pi ft)$ oriented perpendicular to iron garnet $(TbErGd)_3(FeAl)_5O_{12}$ (111) and (110) sample plates are presented. The field frequency was changed from 30 to 1000 Hz with amplitudes up to 500 Oe. Dynamic domain structure was revealed by means of magnetooptic Faraday effect and registered by high speed digital camera with speeds up to 2000 fps. Theoretical study of stripe domain structure drift was performed based on the approach developed in [1, 2]. The model includes energy of external magnetic field, magnetostatic energy and attenuation. Numerical modelling was performed for a wide frequency band including low frequencies ($f \sim 10^2$ Hz), where the drift is observed experimentally. A mechanism of domain structure drift is discussed.

References:

[1] M.M. Soloviev and B.N. Filippov, The Physics of Metals and Metallography 98, 3, pp. 12-15 (2004).
[2] L.A. Pamyatnykh, A.V. Druzhinin, M.S. Lysov, S.E. Pamyatnykh and G.A. Shmatov, Bull. Russ. Acad. Sci. Phys. 77, 10, pp. 1231–1234 (2013).

P-3-36

Really first principles calculations for CoF_3

R.J. Radwanski,[1,2] D.M. Nalecz,[1,2] M. Krupska,[1,2] T. Piwowarczyk,[1,2] and Z. Ropka[1]

[1] *Center of Solid State Physics, S^{nt} Filip 5,31-150 Krakow, Poland*
[2] *Institute of Physics, Pedagogical University, 30-084 Krakow, Poland*

We have performed calculations of the low-energy electronic structure of CoF_3 from first principles, assuming the atomistic construction of matter and the electrostatic origin of the crystal-field splitting. CoF_3 is one of compounds with the trivalent Co ions but in contrary to nonmagnetic $LaCoO_3$ (Phys. Rev. B **67** (2003) 172401) exhibits antiferromagnetism below $T_N = 460$ K. In our atomic-like approach QUASST the d electrons of the Co^{3+} ion in CoF_3 form the highly-correlated atomic-like system $3d^6$ in the high-spin state resulting from the octahedral subterm $^5T_{2g}$ (^5D term) ground state. We have derived the low-energy electronic structure taking into account the trigonal distortion and the relativistic spin-orbit interaction. With the discrete electronic structure for $3d$ electron we have described the magnetic properties (the value of the magnetic moment and its direction) and temperature dependence of the specific heat together with the λ-type peak at T_N. We evaluated the orbital moment and the strength of spin interactions responsible for the formation of the magnetic state.

P-3-37

Phase transitions in Fe–Rh alloys induced by magnetic field

V. Rodionov,[1] V. Rodionova,[1] and M. Annaorazov[1]

[1] *Immanuel Kant Baltic Federal University, Innovation park, Kaliningrad 236000, Russia*

The nearly equiatomic Fe–Rh alloys when heated without an external influences to critical temperature suffer the first-order antiferromagnetic–ferromagnetic transition. The reverse transition takes place at lower temperature. The width of thermal hysteresis can be varied by the changing of alloy's chemical content, preparation technique of the samples, heat- and mechanical treatment in wide range of temperatures [1,2]. To decrease the hysteresis - it is importante for technical applications. More over, each subsequent measurement leads to changing of the antiferromagnetic–ferromagnetic transition temperature.

This research work was aimed to find the composition of equiatomic Fe–Rh alloy with extremly narrow thermal hysteresis and repeatable results. Vibrating sample magnetometer by Lake Shore was used for measurements of magnetic moment versus temperature in range of 100-950 K.

References:

[1] M.P. Annaorazov, M. Unal, S.A. Nikitin, A.L. Tyurin, K.A. Asatryan, J. Magn. Magn. Mater. 251 (2002) 61–73

[2] M.P. Annaorazov, H.M. Guven, K. Barner, J. All. and Comp. 397 (2005) 26–30

P-3-38

Crystal-field electronic structure in $CeMg_3$, $CeNi_3$ and PrO_2

R.J. Radwanski,[1,2] D.M. Nalecz,[1,2] M. Krupska,[1,2] T. Piwowarczyk,[1,2] Z. Ropka,[2] and J. Wasowicz[1,2]

[1] *Institute of Physics, Pedagogical University, 30-084 Krakow, Poland*

[2] *Center of Solid State Physics, S^{nt} Filip 5,31-150 Krakow, Poland*

We have analyzed magnetic and electronic properties of three compounds, $CeMg_3$, $CeNi_3$ and PrO_2, with an aim to compare their low-energy discrete electronic structure and the underlying charge distribution. In all these compounds rare-earth ions have 1 f electron - due to this fact these compounds can be treated as good examples from pedagogical point of view. All of them form a cubic structure. Two cerium compounds have Γ_7 Kramers doublet ground state and excited quartet Γ_8. In PrO_2, the quartet Γ_8 is the lowest. By analysis of the strength of the octupolar interactions we would like to answer about i) the origin of the crystal-field splitting, and ii) the role played by conduction electrons. We have got consistent understanding of magnetic and electronic properties of $CeMg_3$ including the theoretical description of the λ-type peak at T_N and the value and the direction of the Ce magnetic moment. We try to determine the charge distribution in the unit cell. Our atomistic approach offers consistent theoretical description of paramagnetic and (antiferro)magnetic state of these compounds being the atomic-scale basis for heavy-fermion and/or Kondo phenomena.

P-3-39

Effect of annealing on the magnetic state in Ni-doped FeRh alloys

A. Chirkova,[1,2] A. Funk,[1] K. Nenkov,[1] N. Baranov,[2,3] L. Schultz,[1] and T.G. Woodcock[1]

[1] *IFW Dresden, PO Box 270118, 01171 Dresden, Germany*
[2] *Institute of Metal Physics, Ekaterinburg, Russia*
[3] *Ural Federal University, Ekaterinburg, Russia*

Nearly equiatomic FeRh alloys are well-known for an antiferromagnetic (AF) - ferromagnetic (FM) phase transition. The transition temperature T_t in $Fe_{49}Rh_{51}$ can be lowered by Ni-doping; applied pressure broadens the AF region raising T_t or induces an AF state in FM alloys [1]. $(Fe_{0.965}Ni_{0.035})_{49}Rh_{51}$ samples show AF or FM states depending on the heat treatment. Long term annealing and quenching produce the AF state, whereas cooling at 1 K/min results in the FM state. SEM and XRD analyses show FCC phase precipitates additionally to the main CsCl-type phase. The precipitates cause expansion of the AF region [2]. An explanation of this could be the strain on the phase boundaries due to the higher density of the FCC phase.

References:

[1] Kamenev K., Arnold Z., Kamarád J., Baranov N.V., J. Alloys Compd., 252 (1997) 1-5
[2] Takahashi M., Oshima R., Mater. Trans. JIM, 36 (1995) 735-742

We are thankful to Dr. K.-H. Müller for valuable discussions

P-3-40

Experimental verification of shielding effect in coplanar waveguide VNA-FMR experiments

Hubert Głowiński,[1] and Janusz Dubowik[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznań, Poland*

Broadband ferromagnetic resonance (VNA-FMR) based on coplanar waveguide was used to characterize double spin valves, which consist of three magnetic subsystems: a perpendicularly magnetized polarizer, an in-plane free layer and an in-plane pinned analyzer. Samples were prepared on different buffers: A - Ti/Au, B - (Ti/Au)x5 and C - (Ti/Au)x10. Despite the structures had the same magnetic properties (e.a., the same resonance fields of magnetic subsystems and the same magnetic moments) signal from samples on A buffer was 6-7 times higher than for samples on B and C buffer. These results can be regarded as an evidence of shielding of microwaves by a conducting film. To verify the effect of shielding, we prepared Co (2.5 nm) films on Au and Cu wedge buffers. Their sheet resistance decreases with thickness so that we can observe enhancement of FMR signal as a function of the buffer thickness. We observed that the amplitude of FMR absorption increases with thickness and saturates at approximately 40 nm gold buffer.

This work was supported by the Polish-Swiss Research Program NANOSPIN PSRP-045/2010.

P-3-41

Forbidden bands in magnonic crystals with nonreciprocal dispersion relation

M. Mruczkiewicz,[1] M. Krawczyk,[1] E.S. Pavlov,[2] S.L. Vysotskii,[2] Yu.A. Filimonov,[2,3] and S.A. Nikitov[3,4]

[1] *Adam Mickiewicz University in Poznan, Poznan, Poland*
[2] *Kotelnikov Institute of Radio-Engineering and Electronics of RAS, Saratov, Russia*
[3] *Saratov State University, Saratov, Russia*
[4] *Kotelnikov Institute of Radio-Engineering and Electronics of RAS, Moscow, Russia*

We have studied experimentally and theoretically the influence of a metal overlayer on the spin wave (SW) dispersion relation in magnonic crystal (MC) made of YIG film with periodically modulated thickness. The measurements of the transmitted SW signal and its phase differences were done with Vector Network Analyzer. The theoretical model was based on the Finite Element Method. The analysis of the phase difference allows for a direct comparison of the calculated and measured dispersion. The obtained results confirm that the shift of the frequency of the forbidden band in spin wave dispersion can be obtained by the presence of the metal layer atop of the MC. This metal layer leads to appearing of exchange Bragg resonances at wavenumbers different from the Brillouin zone edge of the MCs.

P-3-42

Structural relaxations in massive amorphous materials at low magnetic fields

Konrad Gruszka,[1] Marcin Nabiałek,[1] Katarzyna Błoch,[1] and Paweł Pietrusiewicz[1]

[1] *Częstochowa University of Technology, Institute of Physics*

The influence of thermal treatment on the magnetic susceptibility disaccommodation in massive amorphous materials was studied. Structural defects occurring in the material have a significant impact on the process of magnetization at low magnetic fields. Point defects (vacancies equivalents in the crystal lattice) whose dimensions are comparable with the atoms forming the material, have significant influence on magnetic properties in the Rayleigh area. Defects in the structure of amorphous alloys can be studied indirectly by measuring the so-called magnetic susceptibility disaccommodation phenomena. During the heat treatment process, a part of defects localized in the sample volume can diffuse to the surface and thus be removed. In this work, examined samples were subjected to controlled heating process, and then the dissacommodation phenomena was investigated.

P-3-43

Influence of 1% addition of Nb, W and Mo on the ralaxation process in classical Fe-based amorphous alloys

Paweł Pietrusiewicz,[1] Katarzyna Błoch,[1] and Marcin Nabiałek[1]

[1] *Czestochowa University of Technology, Faculty of Production Engineering and Materials Technology, Institute of Physics, 19 Armii Krajowej Av., 42-200 Czestochowa, Poland*

In order to compare influence of small additions of alloying elements on structure, time and thermal stability of magnetic properties, disaccommodation effect for amorphous $Fe_{61}Co_{10}Y_8Me_1B_{20}$ (where Me = Nb, W, Mo) alloys has been studied. Structure of samples has been confirmed by Mössbauer spectroscopy and X-ray diffraction. The obtained results point on strong corelation between structure and disaccommodation of studied alloys. Different configurations of atoms resulting from Mössbauer studies in amorphous alloys are leading to various potential barrier between orientation of atom pairs. For this reason, to describe the disaccommodation effect, the distribution of activation energy should be taken into account. The distribution of activation energy has been related to the distribution of relaxation times.

P-3-44

Second-Order Phase Transitions in Magnetic Crystals

H.W. Kunert,[1] P. Niyongabo,[1] and A.G.J. Machatine[1]

[1] *Department of Physics, University of Pretoria, 0002 Pretoria, South Africa*

The Landau-Lifschitz-Lubarski theory of the second-order phase transitions for non magnetic crystals of ordinary space groups and their unitary irreducible representations has been reformulated for magnetic crystals and for anti-unitary groups of irreducible corepresentations. Several magnetic crystals of structure A-15 O_h3 experience second order phase transitions. Also the ZnO doped by Mg, Mn, Co and others becomes magnetic and therefore all the physical states of this crystals suppose to be classified according to irreducible corepresentations. Here we have determined possible magnetic and non-magnetic crystals structures of ZnO:Mg, ZnO:Mn, Zn:Co, as well as alloys structure of Vi_3Si (A-15) after second order phase transitions. Our predicted symmetries of the vibrational modes which may cause transitions from the initial space group to the subgroups are in accordance with the experimental data obtained by inelastic powder neutron, Raman, and other spectroscopies. To our best knowledge the group-subgroup criterion on magnetic corepresentations have been performed for the first time.

P-3-45

Structural transitions in crystals

H.W. Kunert[1]

[1] *Department of Physics, University of Pretoria, 0002 Pretoria, South Africa*

The Landau-Lifshitz-Lyubarskii (LLL) theory of second–order phase transitions has not yet been applied to magnetic crystals. Transitions in magnetic crystals requires description in terms of magnetic groups and their corepresentations. Here we have extended and developed the theory of second-order phase transitions to magnetic crystals. Our theory has been applied to garnets of O_h^{10} (Ia3d) calcium aluminum orthosilicate $Ca_3Al_2(SiO_4)$. In addition, we also investigated transitions in rocksalt ZnO of O_h^5 symmetry. Our theoretical results are in good agreement with available experimental data such as powder neutron, x-ray diffraction and Raman spectroscopy.

P-3-46

Magnetic Anisotropy of (Ge,Mn)Te Layers

W. Knoff,[1] A. Łusakowski,[1] B. Taliashvili, A. Wołoś,[1,2] and T. Story[1]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*

[2] *Institute of Experimental Physics, University of Warsaw, Poland*

Magnetic anisotropy of (Ge,Mn)Te semiconductor layers exhibiting carrier-induced ferromagnetism was experimentally studied by ferromagnetic resonance (FMR) method. The one micron-thick monocrystalline (Ge,Mn)Te layers were grown on diamagnetic BaF_2 (111) substrate by molecular beam epitaxy technique. The analysis of the angular dependence of the FMR resonant field carried out for the external magnetic field direction varying in the (1-10) and (11-2) crystal planes revealed the usual in-plane location of the magnetization easy axis for the $Ge_{0.8}Mn_{0.2}Te$ layer with the cubic structure whereas the normal to the layer plane easy axis was found for the rhombohedral $Ge_{0.9}Mn_{0.1}Te$ layer. These experimental findings are theoretically discused employing group-theoretical methods for various crystal structures as well as density functional theory (DFT) calculations of magnetization dependent contribution to the total electronic energy of (Ge,Mn)Te supercell composed of 64 atoms with Mn substituting Ge at fcc cation sublattice sites. The DFT calculations of (Ge,Mn)Te show an order of magnitude increase of uniaxial magnetic anisotropy in the rhombohedrally distorted layer as compared to the cubic one.

Work supported by NCN (Poland) research project UMO 2011/01/B/ST3/02486.

P-3-47

Magnetic behavior of chromium ions in various molecular structures

B. Brzostowski,[1] M. Wojciechowski,[1] G. Kamieniarz,[2] J. Mroziński,[3] and A. Bieńko[3]
[1] *Institute of Physics, University of Zielona Góra, ul. Prof. Szafrana 4a, 65-516 Zielona Góra, Poland*
[2] *Faculty of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*
[3] *Faculty of Chemistry, University of Wrocław, ul. F. Joliot-Curie 14, 50-383 Wrocław, Poland*

We investigate, using density functional theory, chromium ions embedded within heteronuclear molecular ring Cr_8Cd and pentameric coordination polymer Cu_3Cr_2.
We present electronic and magnetic properties, including the magnetic moments and the spin charge density maps for various spin configurations. Furthermore, the exchange coupling parameters between transitional metals ions are extracted and the results are compared with magnetic measurements.
In the ground state, the magnetic moments are highly localized on Cr positions whereas those of Cu are rather delocalized. For the systems in question, the simulation results are qualitatively in agreement with empirical results.

The work was supported in part by the NCN grant N519 579138.

P-3-48

Mapping of the DFT spin configuration energies of chromium-based molecular rings onto the energy structure of Falicov-Kimball model

B. Brzostowski,[1] M. Wojciechowski,[1] R. Lemański,[2] and G. Kamieniarz[3]
[1] *Institute of Physics, University of Zielona Góra, ul. Prof. Szafrana 4a, 65-516 Zielona Góra, Poland*
[2] *Institute of Low Temp. and Struct. Research, Polish Academy of Sciences, ul. Okólna 2, 50-422 Wrocław, Poland*
[3] *Faculty of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

A comprehensive study of electronic and magnetic properties of a recently synthesized family of octo- and nonametalic chromium-based homo- and heteronuclear molecules is presented, using DFT and Falicov-Kimball (FK) model approach.
The magnetic moments are calculated and the spin charge density maps for various spin configurations are discussed. The exchange coupling parameters between transitional metals ions are extracted. In addition, the HOMO and LUMO orbitals are plotted and discussed. It is demonstrated that the energies of the spin configurations can be reproduced by the FK model with a given set of parameters. For all molecular rings considered, the ground state corresponds to the antiferromagnetic configuration and the ferromagnetic configuration yields the highest energy.

P-3-49

Effect of Phase Decomposition on Magnetic Structure of $Cu_{0.4}Mn_{0.3}Ni_{0.3}$

Karolina Świderska,[1] and Joanna Jankowska-Kisielińska[1]

[1] *National Centre for Nuclear Research, 05-400 Otwock-Świerk, Poland*

The purpose of present investigation was to determine the magnetic structure of the quenched $Cu_{0.4}Mn_{0.3}Ni_{0.3}$ and the effects of its ageing. The sample was examined with neutron diffraction. The results indicate that in small fraction of the quenched sample volume there are two types of antiferromagnetic order: one of them AF1 of the long range, the other one of the short range. Ageing induces spinodal decomposition which yields disappearance of AF1 long range order and increase in short range order. The evolution of magnetic ordering with the ageing time is different than that of atomic ordering.

P-3-50

Approach to ferromagnetic saturation for the bulk amorphous $(Fe_{0.61}Co_{0.10}Zr_{0.025}Hf_{0.025}Ti_{0.02}W_{0.02}B_{0.20})_{97}Y_3$ alloy

Katarzyna Błoch,[1] and Marcin Nabiałek[1]

[1] *Czestochowa University of Technology, Faculty of Materials Processing Technology and Applied Physics, Institute of Physics, Poland*

The aim of this paper were studies of magnetization in the strong magnetic fields, in the area known as the approach to ferromagnetic saturation for the bulk amorphous $(Fe_{0.61}Co_{0.10}Zr_{0.025}Hf_{0.025}Ti_{0.02}W_{0.02}B_{0.20})_{97}Y_3$ alloy. The samples were produced using the suction-casting method in the in the form of plates of dimensions $10mm \times 5mm \times 0.5mm$ and rods of length: 20 mm, and diameter 1 mm. The structure was studied using X-ray diffractometry. It was found that investigated samples were amorphous in the as-cast state. The magnetization was measured in a strong magnetic field using a vibrating sample magnetometer (VSM). On the basis of obtained results the type of structural defects having influence on magnetization in high magnetic fields for the BMGs manufactured with different cooling rates were determined.

P-3-51

Voltage control of ferromagnetic resonance in permalloy stripes on piezoelectric substrates

S. Ziętek,[1] W. Skowroński,[1] J. Kanak,[1] W. Powroźnik,[1] M. Czapkiewicz,[1] M. Frankowski,[1] A. Żywczak,[4] D. Lopez Gonzalez,[2] S. van Dijken,[2] H. Głowiński,[3] J. Dubowik,[3] F. Stobiecki,[3] and T. Stobiecki[1]

[1] *AGH University of Science and Technology, Department of Electronics*
[2] *NanoSpin, Department of Applied Physics, Aalto University*
[3] *Institute of Molecular Physics, Polish Academy of Sciences*
[4] *AGH University of Science and Technology, Academic Centre of Materials and Nanotechnology*

Voltage tuning of ferromagnetic resonance (FMR) is of interest for applications in voltage-tunable microwave devices. In this study, we report on the resonant excitation of spin waves by a radio frequency current in a 20 nm thick stripe ($40\text{x}200\mu\text{m}^2$) of $Ni_{80}Fe_{20}$ on a piezoelectric PMN-PT substrate. The FMR signal results from the spin-torque diode effect being a product of spin-transfer torque and anisotropy magnetoresistance. The application of electric field to the PMN-PT substrate shifts FMR frequency due to changes of magnetoelastic anisotropy in the permalloy film.

Supported by Polish National Science Center grant HARMONIA No.2012/04/M/ST7/00799 and AGH Dean's grant.

P-3-52

Influence of spin pumping on spin wave spectra of single and double magnetic layers

Pavel Baláž,[1,2] and Józef Barnaś[1,2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*
[2] *A. Mickiewicz University, Faculty of Physics, Umultowska 85, 61-614 Poznań, Poland*

Recent experimental studies have shown that spin current can exert a torque not only on magnetic moments in metals, but also on interfacial moments of ferromagnetic insulators like yttrium iron garnet (YIG) [1]. Here, we present results of our analysis of the influence of spin pumping on spin waves in a single and double magnetic layers of YIG. The magnetization dynamics has been modeled with the Landau-Lifshitz-Gilbert equation [2], and effect of interface perpendicular magnetic anisotropy has been included. Generally, spin pumping contributes to the intrinsic Gilbert damping. In case of two magnetic layers separated by a nonmagnetic metallic spacer, the spin current pumped into the spacer leads to an additional dynamic coupling between the layers. Numerical results on spin wave spectra will be presented and discussed.

References:

[1] Y. Kajiwara *et al.*, Nature 464, 262 – 266 (2010)
[2] M. Vohl, J. Barnaś, P. Grünberg, Phys. Rev. B **39**, 12003 (1989); J. Barnaś, P. Grünberg, J. Magn. Magn. Materials **82**, 186 (1989)

P-3-53

Crystal Structure and Magnetic Microstructure of Yb0.82Sr0.18Mn1-xFexO3

I.I. Nigmatullina,[1] V.V. Parfenov,[1] A.V. Pyataev,[1] and R.M. Eremina[2]
[1] *Kazan (Volga region) Federal University*
[2] *Kazan Physical-Technical Institute*

The structural and magnetic properties of YbMnO3, Yb0.82Sr0.18MnO3 and solid solutions Yb0.82Sr0.18Mn1-xFexO3 (x = 0.1-0.2) are investigated by X-ray analysis, magnetic resonance, Mössbauer spectroscopy. Samples were prepared using standard ceramic processing.XRA of ferromanganites showed that all samples have the ilmenite (FeTiO3) lattice. The lattice parameters are in good agreement with literature data. The Mössbauer spectra of ytterbium ferromanganites at room temperature have not magnetic hyperfine structure. Spectra are well described by a superposition of two quadrupole doublets with different quadrupole splitting relevant distorted octahedral and hexahedral environment of the Fe3+ cation [2]. Magnetic phase separation in the Mössbauer spectra observed at 80 K, when the spectrum is a superposition of doublet and sextet. Measurements of EPR spectra Yb0.82Sr0.18Mn1-xFexO3 were carried out in X-band at temperatures from 100 to 320K. At low temperatures Yb0.82Sr0.18Mn1-xFexO3 spectra consist of two lines with different temperature behavior, i.e. there is a magnetic two-phase state. When the temperature rises, the second line disappears and samples Yb0.82Sr0.18Mn1-xFexO3 become a paramagnetic.

P-3-54

Discrete diffraction of surface magnetostatic wave in laterally coupled YIG waveguides array

A.V. Sadovnikov,[1] E.G. Beginin,[1] Yu.P. Sharaevsky,[1] and S.A. Nikitov[1,2]
[1] *Saratov State University, 410012, Saratov, Russia,*
[2] *Kotel'nikov Institute of Radio Engineering and Electronics of Russian Academy of Science, 125009, Moscow, Russia*

The phenomena of discrete diffraction was studied in optics both theoretically and experimentally by scanning tunneling optical microscopy in arrays of equally spaced identical waveguide elements [1]. Coupled Yttrium iron garnet (YIG) structures are of great interest at the present time due to extremely small spin-wave loss in this material and the possibility of spin-wave wave propagation control. This report shows the results of investigation of the spatio-temporal dynamics of magnetization in the laterally coupled planar YIG waveguide array by Brillouin light scattering (BLS) spectroscopy [2]. It was shown that the degree of system discreteness could be regulated by changing the external bias magnetic field angle. The dependence of coupling between the waveguide channels on the parameters of spin wave (wavenumber, frequency, power) make s the continuous regulation of spin wave path possible.

References:

[1] Lederer F., Stegeman G.I., Christodoulides D.N. *et al.* // Phys. Rep. 2008. 463, 1 26.
[2] S.O. Demokritov, B. Hillebrands, and A. N. Slavin // Phys. Rep. 2001. 348, 441–489.

P-3-55

Influence heat treatment on the irreversible structural relaxation in bulk amorphous $Fe_{61}Co_{10}Ti_3Y_6B_{20}$ alloy

Marcin Nabiałek,[1] Katarzyna Błoch,[1] and Michał Szota[2]

[1] *Czestochowa University of Technology, Faculty of Materials Processing Technology and Applied Physics, Institute of Physics*

[2] *Czestochowa University of Technology, Faculty of Materials Processing Technology and Applied Physics, Materials Engineering*

In the amorphous materials are present a structural defects, which play a decisive role in the magnetization process in the area known as the approach to ferromagnetic saturation. The paper presents the results of magnetization studies in a strong magnetic fields of the bulk $Fe_{61}Co_{10}Ti_3Y_6B_{20}$ alloy obtained in the form of a rod 1mm in diameter, in the as-quenched state and after isothermal annealing process at a temperature below the crystallization temperature. It was observed that the heat treatment carried out below temperature T_x leads to a irreversible structural relaxations, namely remodeling in atoms configuration in a volume of the amorphous structure.

P-3-56

Modeling the hysteresis loop using hyperbolic T(x) model in nanocomposite material

Marcin Dośpiał[1]

[1] *Czestochowa University of Technology, Faculty of Production Engineering and Materials Technology, Institute of Physics, 19 Armii Krajowej Av., 42 200 Czestochowa, Poland*

In the paper are presented possibilities of hysteresis loop decomposition of (Nd, Tb)-Fe-B alloy, onto the reversible and irreversible magnetization components. Both types of components are describing processes, which are influencing reversal magnetization in studied permanent magnets. Further, these components are used for model the recoil curves and series of minor hysteresis loops using modified hyperbolic T(x) model.

P-3-57

Multiple magnetic phase transitions in single-crystalline $EuRhGe_3$ and $EuCoGe_3$

O. Bednarchuk,[1] and D. Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P. O. Box 1410, 50-950 Wrocław, Poland*

Since a few years, europium-based intermetallics have been attracting more and more attention due to their intriguing physical properties with anomalous behaviors in magnetically ordered states. Here, we report on the formation and the bulk physical properties of two tetragonal compounds $EuRhGe_3$ and $EuCoGe_3$, studied on high-quality single-crystalline specimens in wide ranges of temperature and external magnetic field. In both materials, the Eu ions are in their divalent state, which gives rise to an antiferromagnetic ordering below $T_N = 11.3$ K and $T_N = 15.4$ K, respectively. In addition, $EuCoGe_3$ exhibits a successive antiferromagnetic phase transition at $T_2 = 13.4$ K. Based on some characteristic features in the temperature variations of the magnetic susceptibility, specific heat and electrical resistivity, we suggest that in both germanides an amplitude modulated magnetic structure develops below the respective T_N, with the Eu magnetic moments directed along the crystallographic [001] axis in $EuCoGe_3$ and perpendicular to this direction in $EuRhGe_3$. The $H - T$ phase diagrams of the two ternaries were found fairly complex, comprising several magnetic phases of basically antiferromagnetic nature.

P-3-58

Electric polarization of $LiCoPO_4$ in pulsed magnetic field

V. Khrustalyov,[1] V. Savitsky,[1] M. Kharchenko,[1] and J.-P. Rivera[2]

[1] *B. Verkin Institute for Low Temperature Physics and Engineering NAS of Ukraine, Kharkiv, Ukraine*

[2] *Department of Inorganic, Analytical and Applied Chemistry, University of Geneva, Switzerland*

Lithium cobalt orthophosphate is well known Ising-like magnetoelectric antiferromagnet. Actually, it is a very weak ferromagnet below $T_N = 21.7$K. In a strong magnetic field it exhibits complex multistep phase transformation from antiferromagnetic state to a saturated paramagnetic one. To obtain additional information about the symmetry of the magnetic structures forming during field-induced spin reorientations the electric polarization, along the crystallographic $a||x$ axis, was measured in pulsed magnetic field with magnitude up to 280 kOe at $T = 4.2$K. The magnetic field was applied along the crystallographic $b||y$ axis. The magnetically induced electric polarization disappeared at the first transition field $H_1 = 121$ kOe and reappeared in the vicinity of the second one ($H_2 = 226$ kOe). The polarization finally disappeared at the phase transition to the saturated paramagnetic state ($H_3 \approx 276$ kOe). These results are in rather good agreement with the polarization measurements in DC magnetic field below 10 kOe. The possible magnetic structures formed in magnetic field during the spin reorientation and their symmetries will be discussed.

P-3-59

Magnetic properties and ordering in $Tm_5Ni_2In_4$

A. Szytuła,[1] S. Baran,[1] D. Kaczorowski,[2] and W. Sikora[3]

[1] *Institute of Physics, Jagiellonian University, Reymonta 4, 30-059 Kraków, Poland*

[2] *Institute of Low Temperature and Structural Research PAS, P.O.Box 1410, 50-950 Wrocław, Poland*

[3] *Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Mickiewicza 30, 30-059 Kraków, Poland*

Physical properties of $Tm_5Ni_2In_4$ have been investigated by means of magnetometric, calorimetric as well as neutron diffraction measurements. The compound crystallizes in the orthorhombic $Lu_5Ni_2In_4$-type structure (space group Pbam, No. 55) with Tm^{3+} ions occupying three crystal positions within crystallographic unit cell: one 2a site and two 4g sites. Experimental data indicate that the sample orders antiferromagnetically below $T_N = 4.2$ K. Magnetic structure, derived from neutron diffraction data, is a commensurate one (propagation vector $\boldsymbol{k} = [0, \frac{1}{2}, \frac{1}{2}]$) with thulium magnetic moments lying in the a-b plane. The determined magnetic structure has been verified by group theory symmetry analysis.

P-3-60

Micromagnetic Structures Near a Second Order Phase Transition In Monocrystalline Iron Garnet Plates

L.A. Pamyatnykh,[1] I.E. Belskii,[1] and G.A. Shmatov[1]

[1] *Ural Federal University, Lenin Av. 51, Yekaterinburg, 620083, Russia*

The main parameters of micromagnetic structure (MMS) formation in a vicinity of a second order phase transition were determined experimentally and theoretically. The theoretical study was performed using micromagnetic approach. External magnetic field H_c of appearance of MMS and MMS period L_c were determined for (001)-oriented plate with uniaxial K_u and cubic K_1 magnetic anisotropy. The plate was saturated by the field applied in its plane. In the model we assumed that magnetization vector undergoes small deviations from equilibrium if magnetic field is slightly reduced. These deviations are periodic in nature: MMS has the form of a plane wave. Dependencies of H_c and L_c on an azimuthal angle of external magnetic field and on anisotropy constants K_u and K_1 were derived analytically in this work. Experimental studies of MMS near the second order phase transition were conducted on $(EuEr)_3(FeGa)_5O_{12}$ (001)-oriented 50 μm thick ferrite-garnet plate with $K_u = 5700$ erg/cm^3 and $K_1 = -3700$ erg/cm^3. MMS was revealed by means of magnetooptic Faraday effect. The in-plane field was increased up to 2000 Oe. Experimentally determined values of H_c and L_c were compared with theoretical estimates.

P-3-61

Effect of alloying on magnetism and electronic structure of $Gd(In_{1-x}Sn_x)_3$ system – *ab initio* study

J. Deniszczyk,[1] A. Bajorek,[2] G. Chełkowska,[2] and E. Zipper[2]
[1] *Institute of Materials Science, University of Silesia, 41-500 Chorzów, Poland*
[2] *Institute of Physics, University of Silesia, 40-007 Katowice, Poland*

The magnetic properties and electronic structure of $Gd(In_{1-x}Sn_x)_3$ alloys were measured recently by means of different methods. The measurements showed several intriguing properties of the alloys including multiple magnetic phase transtions and oscilatory variation of magnetic parameters (e.g. Néel temperature, effective magnetic moment, paramagnetic Curie temperature) upon the succesive In/Sn substitution. The XPS valence band measurements indicated the correlation between the magnetic properties of the alloys and their electronic structure near the Fermi level.
In the contribution we present an *ab initio* study of electronic and magnetic properties of $Gd(In_{1-x}Sn_x)_3$ alloys curried out with the use of FP-LAPW method. Our *ab initio* calculations revealed that the ground state magnetic structure of the alloys is antiferromagnetic and upon the In/Sn substitution the magnetic structure undergo transition, changing the type of antiferromagnetic ordering from the AFM-I ($\langle 001 \rangle$) for the $GdSn_3$ compound to AFM-III ($\langle 111 \rangle$) for the $GdIn_3$ one, in agreement with the Mössbauer measurements. Moreover, calculations gave an explanation of the oscilatory variation of density of states near Fermi level, showed by XPS measurements.

P-3-62

The role of demagnetizing field in the formation of spin-wave spectrum in finite-width magnonic structures

N.Yu. Grigoryeva,[1] D.A. Popov,[1] and B.A. Kalinikos[1]
[1] *St.-Petersburg Electrotechnical University (LETI), Prof. Popov str. 5, 197376 St.-Petersburg, Russia*

In the last few years a set of reports about experimental study of spin-wave propagation in confined ferromagnetic structures were published [1,2]. Authors pointed out that some observed effects and dependences cannot be described in the frames of commonly used analytical approach. In this work, with the help of recently elaborated theory [3], we explain several experimental cases appeared in literature which concerned with the different finite-width structures: regular magnonic waveguide, waveguide with variable width, waveguide with periodically modulated width. We show the evidence of localized states appeared in spin-wave spectrum of the confined structures and describe their frequency dependence on the external magnetic field and the parameters of the structure.

References:

[1] V. E. Demidov, J. Jersch, S. O. Demokritov, K. Rott, P. Krzysteczko, G. Reiss, Phys. Rev. B 79, 054417 (2009)
[2] T. Sebastian, T. Bracher, P. Pirro, A. A. Serga, B. Hillebrands, T. Kubota, H. Naganuma, M. Oogane, Y. Ando, Phys. Rev. Lett. 110, 067201 (2013)
[3] N. Grigoryeva, D. Popov, B. Kalinikos, EPJ Web of Conf. 40, 12004 (2013)

P-3-63

Magnetic structure and properties of a Sr_3CuIrO_6 spin chain

C. Schaeffler,[1] A. Bauer,[2] C. Castleton,[1] G. Hix,[1] A. Senyshyn,[3] and R. Eccleston[4]
[1] *Nottingham Trent University,School of Science and Technology, Nottingham, UK*
[2] *Technische Universität München, Physik-Department, Garching, Germany*
[3] *Technische Universität München, Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM-II),Garching, Germany*
[4] *Sheffield Hallam University, Faculty of Arts, Computing, Engineering and Sciences, Sheffield, UK*

We have studied the magnetic structure and properties of Sr_3CuIrO_6 as a function of temperature and field, using susceptibility (χ_{ac}), magnetisation (M), and neutron powder diffraction. Three characteristic temperatures T_2=17 K and T_1=5.5 K and T_f $\sim$ 5 K were observed in the χ_{ac} data. T_1 is only detectable in the presence of an applied field perpendicular to $\langle 101 \rangle$. T_2 and T_f are present both with and without applied field but are field dependent. T_f shows strong frequency dependence indicating spin glass behavior, which is supported by magnetization data, in both $M(T)$ and $M(H)$. T_2 data also shows evidence of frequency-dependence indicating a glassy phase. We believe the phases above and below T_f are distinct and of different origin. No evidence of long range magnetic order was found using neutron powder diffraction.

P-3-64

Magnetic Properties and Magnetocaloric Effect in $A_{1.4}Ba_{1.6}Mn_2O_7$ (A=La, Pr,Nd) Layered Perovskite Manganites

Hasan Satilmis,[1] Bayram Yildiz,[1] Yunus Emre Tanis,[1] C. Gökhan Ünlü,[2] Gülbanu Koyundereli Çilgi,[1] and Yilmaz Özmen[2]
[1] *Faculty of Technology, Department of Material Science and Eng., Pamukkale University, Denizli, TURKEY*
[2] *Faculty of Technology, Department of Biomedical Engineering, Pamukkale University, Denizli, TURKEY*

In this study, production and characterization of $A_{1.4}Ba_{1.6}Mn_2O_7$ (A=La, Pr, Nd) layered perovskite manganites are investigated. $A_{1.4}Ba_{1.6}Mn_2O_7$ manganites are synthesized by solid state reaction technique. XRD, SEM, EDX, TEM techniques performed to determine mineralogical, chemical and micro-structural properties of samples. Furthermore RT, MT and MH measurement methods applied to characterize magnetic characteristics and Magnetocaloric Effect (MCE) of $A_{1.4}Ba_{1.6}Mn_2O_7$ perovskite manganites are calculated.

P-3-65

Scientific importance of the discrete electronic structure of f- and d-electron systems

R.J. Radwanski,[1,2] D.M. Nalecz,[1,2] M. Krupska,[1,2] T. Piwowarczyk,[1,2] Z. Ropka,[2] and J. Wasowicz[1,2]

[1] *Institute of Physics, Pedagogical University, 30-084 Krakow, Poland*
[2] *Center of Solid State Physics, S^{nt}Filip 5,31-150 Krakow, Poland*

We will point out the scientific importance of the increasing evidence for the existence of the discrete energetical states in compounds containing atoms with incomplete $4f$, $5f$ and $3d$ shells. As the existence of such states has been rather accepted in conventional rare-earth compounds, both ionic and intermetallic, there is growing evidence for their existence also in heavy-fermion compounds and $3d$ oxides. As far as the heavy-fermion compounds are concerned we will concentrate on analysis of the low-energy electronic structure, below 1 meV, of such hall-mark heavy-fermion compounds like $YbRh_2Si_2$ and UPd_2Al_3 establishing the valency, the charge distribution and the width of the discrete states. For the $3d$ compounds we recall the experimental evidence for the discrete electronic structure of $FeBr_2$ and $LaCoO_3$ with analysis of their macroscopic properties. Finally we would like to point out that the present *ab initio* calculations offer the description of the electronic structure of $3d$ compounds in the eV energy scale only, i. e. with 1000 times less accuracy than our theoretical atomistic-based approach.

P-3-66

XPS valence band studies of $LaNi_{5-x}M_x$ (M = Al, Co) alloy thin films

J. Skoryna,[1] A. Marczyńska,[1] S. Pacanowski,[1] A. Szajek,[1] and L. Smardz[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

$LaNi_{5-x}M_x$ (M = Al, Co) alloy thin films were prepared onto oxidised Si(100) substrates in the temperature range 285–700K using UHV magnetron co-sputtering. The surface chemical composition and valence bands of all the alloy thin films were measured in-situ, immediately after deposition, transferring the samples to an UHV analysis chamber equipped with XPS. Structural studies showed that the samples deposited at 295K are nanocrystalline with average grain size D∼15-20 nm. Thin films deposited at about 700K are polycrystalline with D∼200 nm. XPS results showed that the shape of the valence bands measured for the polycrystalline samples is practically the same compared to those obtained theoretically from ab-initio band structure calculations. On the other hand, the XPS valence bands of the nanocrystalline $LaNi_{5-x}M_x$ thin films are considerably broader compared to those measured for the polycrystalline samples. This is probably due to a strong deformation of the nanocrystals. Therefore, the different microstructure observed in polycrystalline and nanocrystalline alloy thin films leads to significant modifications of their electronic structure.

P-3-67

Magnetic properties of the molecular-based magnet $Na[FeO_6(C_{10}H_6N)_3]$

E. Aksimentyeva,[1] E. Zubov,[2] K. Dyakonov,[3] and V. Dyakonov[2,4]
[1] *Lviv Ivan Franko National University, Lviv, Ukraine*
[2] *A.A. Galkin Donetsk Physico-Technical Institute, Donetsk, Ukraine*
[3] *Ioffe Physico-Technical Institute, St. Petersburg, Russia*
[4] *Institute of Physics of PAS, Warszawa, Poland*

The static and dynamic aspects of magnetic behaviour of the complex $Na[FeO_6(C_{10}H_6N)_3]$ as a function of temperature, frequency and magnetic field have been analyzed. The *ac* susceptibility and *dc* magnetization were measured at temperatures of 1.5-200 K in magnetic field up to 90 kOe and at frequencies of 95-2000 Hz. The experimental data indicate an absence of magnetic long range order in this complex. The magnetization does not reach a saturation in field of 90 kOe at 1.5 K. At low temperatures the following peculiarities of magnetic properties of complex were found: cusp-like anomalies in the *ac* susceptibility and *ZFC* magnetization at $T_{cusp} =$ 17 K; frequency dependence of the T_{cusp} temperature; remanence and time-dependent relaxation of *ZFC* magnetization. Comparison of characteristic peculiarities of magnetic behavior of the spin-glasses and superparamagnets was performed. Although superparamagnetic behavior should not be completely ruled out, the analysis of results strongly suggests that the spin-glass-like behavior is a more consistent explanation.

P-3-68

EPR study of quasi-two dimensional ferromagnetism in CrTe crystals

Mariusz Bester,[1] Ireneusz Stefaniuk,[1] and Marian Kuzma[1]
[1] *University of Rzeszow, Faculty of Mathematics and Natural Sciences, ul. Pigonia 1, 35-959 Rzeszow, Poland*

The crystal structure of CrTe suggests two-dimensional magnetism in the plane perpendicular to c axis. It is consistent with the temperature dependence of the g factor and the EPR lines width observed. In present paper we investigate the CrTe alloy which has been prepared by melting of the powdered Cr_2Te_3 in evacuated quartz ampoule at the temperature 1600 K. The ESR spectra were recorded using X-band (9.4 GHz) spectrometer provided with gas nitrogen cryostat. The shape of the EPR line depends strongly on the temperature. In the vicinity of the room temperature the lines become very wide and weak or disappear completely. At lower temperatures the shape of the lines approaches the Lorentz function. The asymmetry of the lines is attributed to the strong exchange interactions as well as to the semimetal electrical conductivity. Above the room temperature the shape of the spectra is characteristic for the paramagnetic phase. The results were addressed based on model of critical spin fluctuations in two-dimensional Heisenberg magnet proposed by Eremin et al.[1].

References:

[1] Eremin, I. *et al.*, Phys. Rev. B 64, 064425 (2001)

P-3-69

Magnetic properties of 1-nm thick $Fe_3O_4(111)$ films on Pt(111) and Ru(0001)

M. Lewandowski,[1,2] N. Michalak,[1] Z. Miłosz,[1] R. Ranecki,[1] Ł. Kościński,[1] M. Błaszyk,[1] T. Luciński,[1] and S. Jurga[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

Iron oxide films grown on metal single crystals may exhibit magnetic properties different from the corresponding bulk oxides [1]. The properties of thin films are often rendered by their thickness and the structure and properties of the substrate. 1-nm thick magnetite islands grown on Ru(0001) were shown to exhibit magnetic domain structure, which confirms the presence of magnetic order in these low-dimensional islands at room temperature [2]. We studied 1-nm thick $Fe_3O_4(111)$ films on Pt(111) and Ru(0001), trying to determine their magnetic properties.

References:

[1] N. Spiridis *et al.*, Phys. Rev. B 85 (2012), 075436.

[2] M. Monti *et al.*, Phys. Rev. B 85 (2012), 020404(R).

This work was financially supported by the Polish MNiSW (2012-2015; IP2011 030071 – Ru(0001) part), the NCN (2013-2016; 2012/05/D/ST3/02855 – Pt(111) part) and the NCBiR (2012-2015; PBS1/A9/13/2012).

P-3-70

Electronic properties of in-situ prepared nanocrystalline $Fe_xNi_{1-x}Ti$ alloy thin films

S. Pacanowski,[1] J. Skoryna,[1] A. Marczyńska,[1] D. Skoryna,[1] and L. Smardz[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

In this contribution, we study experimentally the electronic properties of polycrystalline and nanocrystalline $Fe_xNi_{1-x}Ti$ ($0 \leq x \leq 1$) alloy thin films using X-ray photoelectron spectroscopy (XPS). The structure of the samples has been studied by X-ray diffraction (XRD). The $Fe_xNi_{1-x}Ti$ thin films were prepared onto naturally oxidised Si(100) substrates using UHV RF/DC magnetron co-sputtering. The surface chemical composition and the cleanness of all samples were checked in-situ, immediately after deposition, transferring the samples to an UHV analysis chamber equipped with XPS. XRD studies revealed the formation of nanocrystalline $Fe_xNi_{1-x}Ti$ alloy thin films during the deposition process at a substrate temperature of about 293K. In-situ XPS studies showed that the valence bands of nanocrystalline samples are broader compared to those measured for the polycrystalline bulk alloys. Such modifications of the valence bands of the nanocrystalline thin alloy films could influence on their hydrogenation properties [1].

References:

[1] L. Smardz, M. Nowak, M. Jurczyk, Int. J. of Hydrogen Energy 37 (2012) 3659

P-3-71

Electronic Structure Investigations of Several Orthovanadates

W.L. Malinowski,[1] P. Leśniak,[1] M. Werwiński,[1,2] A. Szczeszak,[3] S. Lis[3], and A. Szajek[1]

[1] *Inst. of Mol. Physics, PAS, Smoluchowskiego 17, 60-179 Poznań, Poland*
[2] *Dept. of Physics and Astronomy, Uppsala Univ., Uppsala, Sweden*
[3] *A. Mickiewicz University, Faculty of Chemistry, Department of Rare Earths, Umultowska 89b, 61-614 Poznań, Poland*

Orthovanadates (AVO_4, where A is a trivalent element) have recently emerged as promising optical materials for birefringent solid-state laser applications [1, 2]. They can be also employed in a number of applications including their use as cathodoluminescent materials, thermophosphors, and scintillators [3]. We considered several systems with A= Sc, Y, La, Eu, Gd, and Lu. To give insight into electronic structures of the systems we employed the full potential local orbital (FPLO) method [4]. We will present the band structure, local and total densities of electronic states. For the Eu and Gd systems the magnetic moments will be presented. The calculations showed that the band gap in electronic spectrum depends on A element and varies from 0 to 3.28 eV. **References:**

[1] W. Ryba-Romanowski, Cryst. Res. Technol. **38**, (2003) 225.
[2] S. Miyazawa, Opto-Electron. Rev. **11**, (2003) 77.
[3] D. F. Mullica *et al.*, Inorg. Chim. Acta **248** (1996) 85.
[4] K. Köpernik, H. Eschrig, Phys. Rev. B 59 (1999) 1743

Work supported by the National Science Centre grant: DEC-2011/01/B/ST3/02212

P-3-72

Electronic and Magnetic Properties of $GdPO_4$ -*Ab-initio* Calculations

P. Leśniak,[1] W.L. Malinowski,[1] M. Werwiński,[1,2] A. Szczeszak,[3] T. Grzyb,[3] S. Lis[3], B. Idzikowski,[1] and A. Szajek[1]

[1] *Inst. of Mol. Physics, PAS, Smoluchowskiego 17, 60-179 Poznań, Poland*
[2] *Dept. of Physics and Astronomy, Uppsala Univ., Uppsala, Sweden*
[3] *A. Mickiewicz University, Faculty of Chemistry, Department of Rare Earths, Umultowska 89b, 61-614 Poznań, Poland*

Among the multifunctional nanomaterials, those suitable for both optical and magnetic resonance imaging are of special interest (see [1] and the references therein). Rare earth (RE) orthophosphates crystallize in several crystal systems depending on the RE ion forming the compound as well as on synthesis conditions. $GdPO_4$ orders antiferromagnetically with T_N=0.77 K [2]. To give insight into electronic and magnetic structures of the considered orthophosphate system we employed the full potential local orbital (FPLO) method [3]. We will present the band structure, local and total densities of electronic states as well as, after spin polarized calculations, the spin and orbital magnetic moments.

References:

[1] Sonia Rodriguez-Liviano et al., Inorg. Chem., **52** (2013) 647.
[2] M. Evangelisti et al., Phys. Rev. B **84** (2011) 094408.
[3] K. Köpernik, H. Eschrig, Phys. Rev. B **59** (1999) 1743.

Work supported by the National Science Centre grant: DEC-2011/01/B/ST3/02212

P-3-73

Electronic and Magnetic Properties of the Low and High Temperature Phases of Gadolinium Orthoborate $GdBO_3$

A. Szajek,[1] M. Werwiński,[1,2] A. Szczeszak,[3] and S. Lis[3]

[1] *Inst. of Mol. Physics, PAS, Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *Dept. of Physics and Astronomy, Uppsala Univ., Uppsala, Sweden*

[3] *A. Mickiewicz University, Faculty of Chemistry, Department of Rare Earths, Umultowska 89b, 61-614 Poznań, Poland*

Much attention has been recently paid to rare earths orthoborate phosphors ($REBO_3$, RE = Y, La, Gd) due to their high visible light yield as well as chemical and thermal stability (see, e.g., [1-2]). The main aim of the paper is to study electronic and magnetic properties of $GdBO_3$ system crystallizing in the newly discovered phase having triclinic symmetry [3]. Also the high temperature phase having a calcite related structure [4] was investigated. We present results of $ab-initio$ fully relativistic band structure calculations based on the full potential local orbital (FPLO) method [5]. We will present the band structures, local and total densities of electronic states as well as after spin polarized calcualtions the spin and orbitals magnetic moments.

References:

[1] H. Giesber et al., J. Appl. Phys. **93** (2003) 8987.

[2] A. Szczeszak, S. Lis, V. Nagrinyi, J. Rare Earths **29** (2011) 1142.

[3] A. Szczeszak et al., Inorg. Chem., **52** (2013) 4934.

[4] M. Ren et al., Chem. Mater., **11** (1999) 1576.

[5] K. Köpernik, H. Eschrig, Phys. Rev. B **59** (1999) 1743.

Work supported by the National Science Centre grant: DEC-2011/01/B/ST3/02212

P-4-01

Investigation of Exchange Bias Effect for Pt_xCo_{1-x}/CoO Bilayer Thin Films by Pt Concentration

M.E. Aköz,[1] E. Demirci,[1] U. Parlak,[1] M. Öztürk,[1] N. Akdoğan,[1] O. Öztürk,[1] and M. Erkovan[2]

[1] *Gebze Institute of Technology, Dept of Physics*
[2] *Sakarya University, Dept of Metallurgical and Materials Engineering*

Exchange Bias (EB) effect is interactions between ferromagnetic and antiferromagnetic layers. Although its origin is not clear, it has wide usage area in technological applications; read heads, MRAMs and spin valves. In this study, our goal was that EB effect between having different chemical ratio of Pt_xCo_{1-x} which have large magnetocrystalline anisotropy constant (x changes from 50 to 90 by 10% steps). Bilayer samples were grown at UHV conditions by magnetron sputtering deposition technique. We used XPS for the chemical composition for PtCo and CoO. Before investigating the EB of samples, we used MOKE technique to determine easy-axis of samples and values of anisotropy. The EB effect of all samples were investigated by using VSM. We observed two different results; the blocking temperatures, and effect of decreasing Pt concentration at PtCo. According to results, the manipulation of common interface between PtCo and CoO layers gives us the possibility of tune exchange bias with Pt concentration and temperature.

P-4-02

Doublet blockade and spin dynamics in three quantum dot system

J. Łuczak,[1] and B.R. Bułka[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, ul. M. Smoluchowskiego 17, 60-179 Poznań, Poland*

We present theoretical studies on an artificial molecule constructed from three coherently coupled quantum dots in triangular geometry (TQD) which is connected to the electrodes. The symmetry of the TQD can be change by applying a local gate potential to each dot. We will analyzed the TQD with three spins in a doublet subspace (with total spin S=1/2). In calculation we use the Heisenberg Hamiltonian and the Master equation in Lindblad form. For specific configuration of the potentials one can observe the effect of blockade of the current flowing through TQD. The blockade occurs in the doublet subspace and is related with asymmetry of tunnel rates from source and drain electrodes to the TQD. We also investigate the dynamics of spins in TQD, taking into account relaxation and decoherence processes as well as leakage from the doublet subspace. Our studies are motivated to use TQD as a single qubit in the quantum computation [1].

References:

[1] D. P. DiVincenzo, D. Bacon, J. Kempe, G. Burkard, and K. B. Whaley, Nature (London) **408**, 339 (2000).

This work has been supported by the National Science Center under the contract DEC-2012/05/B/ST3/03208

P-4-03

Spin-dependent transport through triangular quantum dots in the sequential and cotunneling regimes

K. Wrześniewski,[1] and I. Weymann[1]
[1] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

Transport properties of triangular coherent quantum dots weakly coupled to external ferromagnetic leads is studied by means of the real-time diagrammatic technique. The calculations are performed for the sequential and cotunneling processes, the former ones dominating the current out of the Coulomb blockade regime and the latter ones determining the current in the blockade regime. We analyze the bias and gate voltage dependence of the current and differential conductance in the parallel and antiparallel magnetic configurations of the device as well as the resulting tunnel magnetoresistance. We show that the spin-resolved transport characteristics depend greatly on various parameters of the model and on the specific configuration of electrodes, to which the transport voltage is applied.

P-4-04

Large magnetoresistance effect in cylindrical semiconductor nanowires with constriction

M. Wołoszyn,[1] B.J. Spisak,[1] P. Wójcik,[1] and J. Adamowski[1]
[1] *AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, al. A. Mickiewicza 30 30-059 Kraków Poland*

Magnetotransport properties of the three-dimensional semiconductor nanowires with a single constriction have been studied within the Landauer-Büttkier formalism in combination with the adiabatic approximation in the presence of the magnetic field aligned along the growth axis of the nanosystems. Performed calculations prove the occurrence of the large magnetoresistance effect in the examined nanosystems at low temperatures and at relatively high magnetic fields up to 12 T.
This effect is explained in terms of the Stark resonant states found in the quantum well in front of the constriction [1]. The magnetoresistance calculated as a function of the applied voltage exhibits rapid changes due to the influence of the transmission via the Stark resonances, and the modification of the current-voltage characteristics slope resulting from the applied magnetic field.

References:

[1] M. Wołoszyn, J. Adamowski, P. Wójcik, and B. J. Spisak, J. Appl. Phys. 114, 164301 (2013)

Supported by National Science Centre, Poland, grant DEC-2011/03/B/ST3/00240.

P-4-05

Spin-dependent magnetotransport in semiconductor nanowires

B.J. Spisak,[1] M. Wołoszyn,[1] J. Adamowski,[1] and P. Wójcik[1]
[1] *AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, al. A. Mickiewicza 30 30-059 Kraków Poland*

The spin-dependent electron transport in semiconductor nanowires is considered in the presence of the external magnetic field directed along the symmetry axis of the nanowires. For this purpose calculations of the spin-dependent magnetotransport characteristics for the nanosystems have been performed within the adiabatic approximation by applying the Landauer-Büttkier formalism. The effect of the geometric inhomogeneity of the nanowire in the presence of the magnetic field on the spin-dependent current-voltage characteristics is considered. The spin current polarization is discussed as a function of the source-drain voltage and the magnetic field applied to the nanosystem.

Supported by National Science Centre, Poland, grant DEC-2011/03/B/ST3/00240.

P-4-06

Magnetic field sensor based on magnetic tunnel junction with voltage tunable magnetic anisotropy

W. Skowroński,[1] P. Wiśniowski,[1] T. Stobiecki,[1] G. Reiss,[2] and S. van Dijken[3]
[1] *AGH University of Science and Technology, Department of Electronics*
[2] *Thin Films and Physics of Nanostructures, Bielefeld University*
[3] *NanoSpin, Department of Applied Physics, Aalto University*

Measurement of ultra low magnetic fields is an important issue in many medical and technical applications. Specially designed magnetic tunnel junction (MTJ) is very promising candidate for low magnetic field sensor. We show experimental data on CoFeB(1.35 nm)/MgO(2 nm)/CoFeB(2.5 nm) MTJ with an elliptical shape of 120 x 230 nm. Taking advantage of perpendicular interface magnetic anisotropy (PMA), we tuned the thicknesses of both layers to achieve orthogonal magnetization alignement between perpendicular free layer (FL) and in-plane reference layer. Next, by reversing the bias voltage applied to the MTJ we influence the PMA of the FL and, therefore, affect the sensitivity curve [W. Skowroński et al. APL 101, 192401 (2012)]. The change of the linear operating range from 10 to 60 Oe and the sensitivity from 0.49%/Oe to 0.056%/Oe was measured.

We acknowledge the Polish National Science Center grant HARMONIA No. 2012/04/M/ST7/00799 and AGH Dean's grant.

P-4-07

Gate-Controlled Spin-Orbit Interaction in InAs Quantum Well Structures Epitaxially Transferred onto Si Substrates

Kyung-Ho Kim,[1] Doo-Seung Um,[2] Hochan Lee,[2] Seongdong Lim,[2]
Joonyeon Chang,[1] Hyun Cheol Koo,[1] Hyunhyub Ko,[2] and Hyung-jun Kim[1]
[1] *Spin Convergence Research Center, Korea Institute of Science and Technology (KIST), Seoul 136-791, South Korea*
[2] *School of Energy and Chemical Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan 689-798, South Korea*

Gate-controlled spin-orbit interaction (SOI) in InAs quantum well (QW) structures has been investigated after the epitaxial transfer onto Si substrates.[1] Successful epitaxial transfer of the QW structure after separation from an original InP substrate ensures that the InAs QW maintains a strong bonding interface and good crystalline quality with a high electron mobility. Furthermore, Shubnikov-de Haas (SdH) oscillation analysis reveals that a Rashba SOI parameter can be manipulated using a gate electric field for the purpose of spin field-effect transistor operation.

References:

[1] Kyung-Ho Kim *et al.*, ACS Nano 7, 9106 (2013)

P-4-08

Influence of substrate on inelastic electron transport through adsorbed magnetic structures

V. Val'kov,[1] S. Aksenov,[1,2] and E. Ulanov
[1] *Kirensky Institute of Physics, 660036 Krasnoyarsk, Russia*
[2] *Siberian Aerospace University, 660014 Krasnoyarsk, Russia*

Scanning tunneling microscopy and tunnel contact investigations of magnetic atomic structures demonstrate both the importance of inelastic many-particle effects and the influence of substrate which manifest themselves in the transport characteristics [1]. We studied transport properties of a single magnetic adatom and two exchange-coupled adatoms within the framework of the nonequilibrium Green functions. An expression for electron current was received with the multiple scattering processes taken into account in all orders of perturbation theory for coupling between the structure and contacts by using Keldysh diagram technique and atomic representation. It's shown that negative differential conductance regions appear in the current-voltage characteristic of a single adatom in a different crystalline environment. This effect is caused by nonequilibrium excitation of the structure and can be increased if the coupling between the structure and contacts is asymmetric.

References:

[1] A.F. Otte, M. Ternes, K. von Bergmann, *et al.*, Nature Physics 4, 847 (2008).

P-4-09

Magnetization switching and microwave oscillations in magnetic heterostructures with spin-orbit Rashba effect induced by in-plane current injection

G. Demin,[1] A. Popkov,[1] N. Kulagin,[2] and V. Korneev[1]

[1]*National Research University of Electronic Technology «MIET», 124498, Moscow, Zelenograd, Russia*

[2]*Moscow State Aviation Technological University «MATI», 121552, Moscow, Russia*

In this work we make analysis of the influence of non-equilibrium spin accumulation induced by the in-plane current due to the Rashba effect on the stability of the magnetization of the ferromagnetic ultra-thin film in a heavy metal/ferromagnetic heterostructure and find both components of the current-induced spin-orbit torque acting on it [1]. We calculate the state diagrams of ferromagnetic layer for the effective Rashba field oriented parallel or perpendicular to the easy magnetization axis. It is shown that in addition to hysteresis effects of spin state switching the conditions needed for continuous generation of microwave oscillations also can be predicted.

References:

[1] I. M. Miron, G. Gaudin, S. Auffret, B. Rodmacq, A. Schuhl *et al.*, Nature Materials **9**, Current-driven spin-torque induced by the Rashba effect in a ferromagnetic metal layer (2010)

This work is supported by the Russian Foundation for Basic Research (project No. 13-07-12405).

P-4-10

X-Ray Magnetic Linear Dichroism and T-MOKE in Reflection of crystalline Fe at the 3p Edges – Theory and Experiment

Dominik Legut,[1] Marc Tesch,[2] Peter M. Oppeneer,[3]
Hans-Christoph Mertins,[2] Christine Jansing,[2] Markus Gilbert,[2]
Andreas Gaupp,[4,2] Daniel Bürgler,[5] and Claus Schneider[5,6]

[1]*Nanotechnology Centre, VSB-TU Ostrava, Ostrava, Czech Republic*

[2]*Münster University of Applied Sciences, Steinfurt, Germany*

[3]*Department of Physics, Uppsala University, Uppsala, Sweden*

[4]*HZB, Berlin. Germany*

[5]*Forschungszentrum Jülich GmbH, Jülich, Germany*

[6]*Fakultät f. Physik and CeNIDE, Uni Duisburg-Essen, Duisburg, Germany*

We present combined first-principle calculations and experimental results of X-ray magnetic linear dichroism (XMLD-R) and T-MOKE in reflection for crystalline Fe thin films across the 3*p* edges using linearly polarized synchrotron radiation. We show that XMLD is a perfect technique to detect magneto-crystalline anisotropy since it is a quadratic effect in magnetization. In contrast T-MOKE which is linear in the magnetization depends weakly on the orientation of the crystalline axes with respect to the electric and magnetic fields.[1]

References:

[1] M. F. Tesch, D. Legut et. al, Phys. Rev. B **89**, 140404(R) (2014).

P-4-11

The enhancement of the magneto-optical effects by Bi in $(Rh/Ir)_2MnAl$ – first-principle study

Dominik Legut,[1] and Eithiraj R. Dashinamoorthy[1]

[1] *Nanotechnology Centre, VSB-TU Ostrava, Ostrava, Czech Republic*

We have performed first-principle calculations to investigate structural, electronic and optical properties of $(Rh/Ir)_2MnAl$ and $(Rh/Ir)_2MnBi$ Heusler alloys using density functional theory [1]. Three spin orderings, i.e. ferromagnetic and antiferromagnetic along [001] and [111] crystal axis were considered. In contrast to the experimental study [2], where the antiferromagnetic ordering was detected with high Neel temperature, our calculations show that the Rh_2MnAl possesses the lowest total energy with ferromagnetic ordering. Therefore, considering the ferromagnetic ordering we investigate the enahcement of the Kerr rotation and elipticity by the substitution of Al by Bi within 0-10 eV energy range.

References:

[1] P. Hohenberg and W. Kohn, Phys. Rev. 136, B864 (1964).

[2] H. Masumoto and K. Watanabe, J. Phys. Soc. Jpn., 32, 281-281 (1972).

P-4-12

Rashba effect in wurtzite n-GaN:Si layer on semi-insulating GaN:Mn

W. Stefanowicz,[1] R. Adhikari,[2] T. Andrearczyk,[1] B. Faina,[2] M. Sawicki,[1] J.A. Majewski,[3] T. Dietl,[1,3,4] and A. Bonanni[2]

[1] *Institute of Physics, Polish Academy of Sciences, Warszawa, Poland*

[2] *Institut für Halbleiter-und-Festkörperphysik, Johannes Kepler University, Linz, Austria*

[3] *Faculty of Physics, University of Warsaw, Warszawa, Poland*

[4] *WPI-AIMR, Tohoku University, Sendai, Japan*

Spin-orbit effects attract a renewed attention in the context of novel effects expected in hybrid structures involving semiconductors, metals, ferromagnets, and superconductors. Owing to broken inversion symmetry, the spin-orbit interaction gives rise to the Rashba term in wurtzite semiconductors. We have determined the magnitude of this term from millikelvin magnetotransport studies on GaN:Si deposited onto semi-insulating GaN:Mn, and compared it with results of relativistic ab initio studies [1].

References:

[1] W. Stefanowicz et al, arXiv:1402.6843.

This work was supported by ERC Grant No. 227690, FWF(P20065, P22477, P24471), NSC Grant No. 2011/03/B/ST3/02457.

P-4-13

Thermodynamical anomalous Hall effect in spin-polarized electron system

E.A. Pamyatnykh,[1] V.I. Okulov,[2] A.T. Lonchakov,[2] and Yu.V. Zabaznov[1]
[1] *Ural Federal University, Ekaterinburg, Russia*
[2] *Institute for Metal Physics, Ekaterinburg, Russia*

Theoretical description of new thermodynamic mechanism of anomalous Hall effect is presented. Consideration is based on separation of magnetization current, resulting from the magnetization M_0 of the system and not contributing to the Hall voltage. The Hall voltage is contributed by the remaining part of locally equilibrium nondissipative current — conduction current j_c, determined by the equality of the force acting in a conductor with current by the magnetic field and the pressure force. As a result, for $\Omega\tau << 1$ (Ω — cyclotron frequency, τ — mean free time of electrons) we obtain the following formula for the Hall resistance: $\rho_H = \rho(\rho\sigma_m + \Omega\tau)$, where ρ — resistivity, $\sigma_m = ec(\partial M_0/\partial\zeta)$ — "conductivity of the magnetization" which does not depend of the magnetic field (ζ — electrochemical potential). This expression contains a linear term on the magnetic field ($\rho\Omega\tau$) and independent of magnetic field anomalous contribution ($\rho^2\sigma_m$). This expression describes experimental dependencies [1].

References:

[1] Lonchakov A.T., Okulov V.I., Govorkova T.E., Andrichuk M.D., Paranchich L.D. — JETP Letters, 96, 444 (2012).

P-4-14

$Cu(H_2O)_2(en)SO_4$ optical spectra comparison: experiment *vs* theory

R. Sýkora,[1] K. Postava,[1] and D. Legut[1]
[1] *Nanotechnology Centre, Technical University of Ostrava, Ostrava, Czech Republic*

$Cu(H_2O)_2(en)SO_4$ was recently identified as a quasi-one-dimensional $S = 1/2$ antiferromagnetic insulator [1]. The structure possesses a monoclinic symmetry with the angle β of 105.5 °. We measured the system's optical functions in the range from 190 to 1700 nm and here compare these with results obtained from DFT-based (GGA+U) *ab-initio* calculations.

References:

[1] J. Appl. Phys. **115**, 17B305 (2014)

P-4-15

Magnetostatic coupling in stripes of $[Co/Au/NiFe/Au]_{10}$ films investigated with resistance measurements

M. Urbaniak,[1] M. Matczak,[1,2] P. Kuświk,[1] Ł. Majchrzycki,[3] B. Szymański,[1] and F. Stobiecki[1,2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[3] *Poznań University of Technology, Poznań, Poland*

This work is concerned with the influence of a patterning of sputtered $[Co(t_{Co})/Au(2\,nm)/NiFe(2\,nm)/Au(2\,nm)]_{10}$ multilayers on their giant magnetoresistance (GMR). Magnetostatic cupling between Co and NiFe layers is reflected in a resistance versus magnetic field dependence [1]. We show that the character of the dependence and of the coupling is preserved if the films are patterned, using electron lithography, into stripes of several micrometers width. The amplitude of GMR decreases by roughly 25 % when the structure is patterned into 10 μm wide stripes and the domain structure changes only slightly for the width of the stripes down to 2 μm.

References:

[1] M. Urbaniak, F. Stobiecki, B. Szymański, A. Ehresmann, A. Maziewski, M. Tekielak, J. Appl. Phys. **101**, 013905 (2007)

Supported by a NSC Poland under HARMONIA funding scheme - project No. 2013/08/M/ST3/00960.

P-4-16

Spin and charge transport in metal-semiconductor heterostructures with double Schottky barriers

S. Wolski,[1] C. Jasiukiewicz,[1] V.K. Dugaev,[1,2] J. Barnaś,[3] and T. Slobodskyy[4]

[1] *Department of Physics, Rzeszów University of Technology*
[2] *Department of Physics, Instituto Superior Técnico, Lisbon*
[3] *Faculty of Physics, Adam Mickiewicz University, Poznań*
[4] *Institute for Applied Physics, University of Hamburg*

One of the most important problems in modern electronics and spintronics is direct ferromagnet-semiconductor spin injection.

Basing on the analysis of previously obtained experimental results, we model the electrical properties of the interfaces. The interfaces can be considered as Fe/n^+-GaAs/nGaAs/n^+-GaAs/Fe heterostructure, which works as double Schottky barrier.

We develop the methods of numerical simulation of nonequilibrium processes in metal-semiconductor nanostructures with multiple layers. We have proposed an algorithm for the simultaneous determination of carrier concentration and the potential from the Poisson equation over the entire length of the sample.

As result of our investigation we find current-voltage characteristics and spin polarized current profiles calculated for various concentrations and shapes of dopants.

This work was done in frame of EU project Era.Net.Rus "SpinBarrier"

P-4-17

Influence of K-doping on the optical properties of ZnO by first principle studies

D.E. Aimouch,[2] R. Hayn,[1] and A. Boukortt[1,2]

[1] *Institut Matériaux Microélectronique Nanosciences de Provence, Aix-Marseille Univ. Faculté St Jérôme, case 142, F-13397 Marseille Cedex 20, France*

[2] *Laboratoire d'Elaboration et Caractérisation Physico Mécanique et Métallurgique des Matériaux (ECP3M),Département de Génie Electrique, Faculté des Sciences et de la Technologie, Université Abdelhamid Ibn Badis de Mostaganem, Algérie.*

Abstract

Optical properties of K-doped ZnO were studied using the density functional method within the local spin-density approximation LSDA. In this work, we present the influence of the potassium (K) on optical properties using the wurtzite structure and a supercell of 32 atoms, by calculating the dielectric function to understand the optical interband transitions in diverse configurations with the substitution of Zn by one and two transition metal (TM) atoms into ZnO. We show that the band gap of K-doped ZnO decrease with the rise in doping level, the intensity of K-doped ZnO is blue emission. The latter is going to be analyzed in details.

P-4-18

Coupled current-induced magnetic dynamics of ferro- and antiferromagnetic layers

O. Gomonay,[1] and V. Loktev[1]

[1] *National Technical University of Ukraine "KPI"*

Present-day spintronics uses electric field to manipulate with magnetic moments of ferromagnetic (FM) layers. However, utilization of antiferromagnets (AFM) as active parts of spintronic units promises transition to ultra-high-speed and low-energy devices. Recent experiments demonstrated sensitivity of AFM layers to spin-polarized current [1] and their ability to change the state of adjacent FM layer [2]. In the present paper we study magnetic dynamics of FM and AFM layers separated with thin nonmagentic layer (NM) in the presenence of electric and/or spin current.

The model includes standard dynamic equations for FM and AFM moments supplemented with the balance equation for nonequilibrium spin density carried by free electrons. We show that spin pumping from AFM layer increases damping of the whole structure and analyse back-action of AFM on the state of FM layer in the presence of electric current.

References:

[1] A.H. MacDonald and M. Tsoi, *Phil. Trans. A*, **369**, 3098 (2011)

[2] K. J. Lee, T.H.Y. Nguyen, and K.-Ho Shin, *J. Magn. Magn. Mater.*, **304**, 102 (2006)

P-4-19

Perpendicular Exchange Bias Properties of Ni/Pt/CoO Films

U. Parlak,[1] E. Demirci,[1] M.E. Aköz,[1] M. Öztürk,[1] N. Akdoğan,[1] O. Öztürk,[1] S. Öztürk,[1] and M. Erkovan[2]

[1] *Gebze Institute of Technology, Dept of Physics*

[2] *Sakarya University, Dept of Metallurgical and Materials Engineering*

Exchange bias effect plays a critical role in spin-dependent scattering mechanisms, such as spin valve structures, due to its unidirectional character. It manifests itself as a certain shift in magnetic hysteresis loop because of exchange interactions at the FM/AFM interface. Exchange biased systems with perpendicular magnetization have been reported starting from nearly a decade ago. Perpendicular exchange bias (PEB) systems also gained importance both scientifically and technologically, and commonly considered as a breakthrough for high density storage media. In this study, we have investigated the thickness dependency of magnetron sputtered thin films which were prepared as a series of (tÅ)Ni/Pt(5Å)/(20Å)CoO while t ranges from 12 to 30Å. Platinum was deposited between Ni and CoO layers to prevent ultra-thin nickel films from oxidization Exchange bias measurements have been measured by using vibrating sample magnetometer (VSM). Exchange bias field and blocking temperatures with respect to FM layer thicknesses will be presented as a result. This study is supported by TUBITAK through the project number 114F004.

P-4-20

Phonon-affected thermoelectric effects in a double quantum dot system attached to magnetic leads

P. Trocha[1]

[1] *Faculty of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland*

Thermoelectric effects in a double quantum dot system coupled to phonon bath and attached to external magnetic leads are investigated theoretically by means of nonequilibrium Green's function approach. The basic thermoelectric transport characteristics, like thermopower, electronic contribution to heat conductance, and the corresponding figure of merit, have been calculated in the Hartree-Fock approximation for Coulomb interactions. An enhancement of the thermal efficiency (figure of merit ZT) due to Coulomb blockade has been found. The magnitude of ZT is further modified by electron-phonon interactions. The influence of spin-dependent transport and spin bias on the thermoelectric effects (like Seebeck and spin Seebeck effects [1]) is also analyzed.

References:

[1] K. Uchida, S. Takahashi, K. Harii, J. Ieda, W. Koshibae, K. Ando, S. Maekawa, and E. Saitoh, Nature (London) **455**, 778 (2008).

This work was supported by the National Science Center in Poland as the Project No. DEC-2012/04/A/ST3/00372.

P-4-21

Current-induced spin phenomena in systems with spin-orbit interaction

A. Dyrdał,[1] and J. Barnaś[1,2]

[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

Electric field and/or temperature gradient in systems with spin-orbit interaction can generate various spin-related phenomena. In general, the spin-orbit coupling in two-dimensional systems has not only a uniform component, but also spatially fluctuating term, eg. due to random distribution of dopant ions or imperfections of quantum-well interfaces. We consider theoretically the spin Hall effect and current driven spin polarization in two-dimensional semiconducting heterostructures [1,2]. We consider two different forms of Dresselhaus spin-orbit coupling, which appears in $\langle 001 \rangle$ and $\langle 110 \rangle$ quantum wells, respectively, in the presence of constant and random Rashba terms. To determine the spin conductivity and spin polarization we use the Green function technique and diagrammatic representation of the Kubo formula.

References:

[1] A. Dyrdał, J. Barnaś, Acta Phys. Pol A **122**, 1016,(2012).

[2] A. Dyrdał, M. Inglot, V.K. Dugaev, J. Barnaś, Phys. Rev. B **87**, 245309,(2013)

P-4-22

Structure and GMR of electrodeposited Co/Cu multilayers prepared by two-pulse and three-pulse plating

N. Rajasekaran,[1] L. Pogány,[1] Á. Révész,[1] B.G. Tóth,[1] S. Mohan,[1] L. Péter,[1] and I. Bakonyi[1]

[1] *Wigner Research Centre for Physics, Hung. Acad. Sci., Budapest*

In order to better understand the formation of individual layers and their influence on giant magnetoresistance (GMR), Co/Cu multilayers (MLs) produced by two different deposition strategies were compared. The first series of Co(2nm)/Cu(t_{Cu}) MLs with t_{Cu} = 0.5 to 6 nm was prepared with galvanostatic/potentiostatic (G/P) two-pulse plating at optimized Cu-deposition potential. In the second series, first a Co(2nm)/Cu(6nm) bilayer was deposited after which another G pulse was applied with a small anodic current to dissolve part of the Cu layer to reach the same t_{Cu} values as in the first series. The G/P/G pulse combination yields MLs for which GMR can be obtained even at such low Cu layer thicknesses where G/P MLs already exhibit bulk-like MR only. The different structural quality of the two series were shown by the absence or presence of ML satellite reflections in the XRD patterns. In the G/P/G MLs with small t_{Cu} values, superparamagnetic regions were also identified resulting from an increased Cu content of the magnetic layer caused by Co segregations. Coercive force and remanence measurements gave further support for the above interpretation of the GMR data.

P-4-23

Spin-dependent sequential transport through an S=1 molecule attached to a carbon nanotube quantum dot

Ania Płomińska,[1] and Ireneusz Weymann[1]
[1] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

Transport properties of an S=1 molecule attached to a single-wall carbon nanotube quantum dot, which is coupled to two external ferromagnetic leads, are analyzed in the sequential tunneling regime. The magnetizations of the leads are assumed to form either a parallel or an antiparallel magnetic configuration. The carbon nanotube is modeled by a two-level Anderson model and is exchange-coupled to a molecule of spin S=1 exhibiting uniaxial magnetic anisotropy. The calculations are performed by using the master equation method with tunneling rates given by the Fermi golden rule. It is shown that the presence of the molecule strongly affects the gate and bias voltage dependence of the current and differential conductance in both magnetic configurations, as well as the resulting tunnel magnetoresistance. Various excited spin states of the system are revealed in the voltage dependence of both the conductance and the tunnel magnetoresistance.

P-4-24

Spin thermoelectric effects in transport through strongly correlated double quantum dot systems

Ł. Karwacki[1]
[1] *Faculty of Physics, Adam Mickiewicz University, Umultowska 85, Poznań*

Thermoelectric effects in spin-polarized transport through two capacitevely connected quantum dots strongly coupled to two ferromagnetic reservoirs are investigated theoretically by means of finite-U slave boson technique.
We consider behaviour of such basic thermoelectric coefficients as heat conductance κ, thermopower S and thermoelectric figure of merit ZT, with particular emphasis on the spin related effects due to ferromagnetism of the leads. Especially, when spin accumulation in the external leads becomes relevant, a spin thermoelectric effect arises that can be described by introducting spin counterparts to the thermoelectric parameters mentioned above, such as spin thermopower S_s and spin figure of merit Z_sT. We show the influence of the geometry of the system and the exchange field resulting from the ferromagnetic electrodes on the effectiveness of thermally-driven spin current generation.

P-4-25

Quantum-limited shot noise and quantum interference in graphene based Corbino disk

Grzegorz Rut[1]

[1] *Marian Smoluchowski Institute of Physics, Jagiellonian University*

A theoretical study of finite voltage effects on the conductance of graphene-based Corbino disk in the presence of external magnetic fields is presented [1]. Additionally, the shot noise power and the third charge-transfer cumulant are analysed. For relatively small source-drain voltages, periodic magnetoconductance oscillations, predicted in Refs. [2,3], become invisible as the current decays rapidly with the magnetic field. Quantum interference still governs the behavior of higher charge-transfer cumulants. These effects are robust against the influence of local charged impurities.

References:

[1] G. Rut and A. Rycerz, arXiv:1401.7247.

P-4-26

Cooper pair splitting efficiency in double quantum dot in cotunneling regime.

Damian Tomaszewski,[1] R. Zitko,[2] R. Lopez,[3] M. Lee,[4] and J. Martinek[1]

[1] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*

[2] *Jozef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia*

[3] *Departament de Física, Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain*

[4] *Department of Physics, Kyung Hee University, Yongin 446-701, Korea*

Quantum communication is one of the most intensively developing areas of science. The important step is to get entangled state of electrons in solid state device. One of the solutions is the use of Cooper pairs as a source of entangled electrons and separating them in Double Quantum Dot (DQD) system. Operation of Cooper pair splitting device is based on Coulomb interactions between electrons. We considered two systems: DQD connected to two superconducting leads and DQD connected to superconducting and normal leads. In both systems we studied a flow of electrons in a cotunneling regime (simultaneous tunneling of Cooper pairs through the whole system). We calculated Cooper pair splitting (CPS) efficiency for different ground states of quantum dots. We were able to show several kinds of tunneling processes that are possible in these systems. Calculations were made with use of the 4-th order perturbation theory.

P-4-27

Quantum spin torque in quantum dot coupled to ferromagnetic leads.

D. Tomaszewski,[1] A.-D. Crisan,[2] S. Datta,[2] J.J. Viennot,[2] M.R. Delbecq,[2] C. Feuillet-Palma,[3] A. Thiaville,[4] A. Cottet,[2] T. Kontos,[2] and J. Martinek[1]

[1] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*

[2] *Laboratoire Pierre Aigrain, E.N.S., 24 rue Lhomond, Paris, France*

[3] *Laboratoire de Physique et d'Etude des Materiaux, ESPCI, Paris, France*

[4] *Lab. Physique des Solides, CNRS - Univ. Paris-Sud, Orsay, France*

Spin manipulation requires applying a torque. This can be done with use of magnetic fields. We use, for this purpose, a single wall carbon nanotube (SWCN) quantum dot connected to leads (PdNi) with non-collinear magnetizations. We have studied an electron transport through this device, which acts like a spin-valve with a finite tunnelling magnetoresistance effect. Depending on system parameters a non-equilibrium spin accumulation on the quantum dot can be generated. We predicted that the interplay of spin-dependent tunnelling and Coulomb interactions in quantum-dot spin valves gives rise to an interaction driven spin precession, describable in terms of an internal exchange and external magnetic field in the limit of weak dot-lead coupling. This opens the potential of a controlled manipulation of the quantum dot spin, detectable in transport.

P-4-28

Transmission through graphene junctions with Rashba spin-orbit coupling

M. Rataj,[1] and Józef Barnaś[1,2]

[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

In this work we investigate electronic transport in a class of junctions based on graphene. The junctions consist of two parts: the first part is made of pristine graphene on a usual substrate (e.g. SiO2), while in the second part a strong Rashba spin-orbit coupling is additionally induced (e.g. by placing this part on a different substrate). Our main goal is to analyze the probabilities of transmission from the part with the Rashba spin-orbit coupling to the pristine one. We are especially interested in the spin polarization of the transmitted charge carriers. We find that the transmission through the junctions is spin-dependent. Therefore, an electric current flowing through the junction should be spin-polarized. This effect is robust against moderate changes in the parameters of the system.

References:

[1] M. Rataj, J. Barnaś, Phys. Status Solidi RRL 7, No. 11, 997–1000 (2013)

[2] M. Rataj, J. Barnaś, Appl. Phys. Lett. 99, 162107 (2011)

P-4-29

Thermoelectric effect in photon-assisted, spin-polarized tunnelling through a quantum dot.

K. Bocian,[1] and W. Rudziński[1]
[1] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

Features of electric and thermal conductance, Seebeck coefficient as well as proper figure of merit in tunnelling through a single level quantum dot connected to external ferromagnetic leads are investigated theoretically using the equation of motion method within the nonequilibrium Green function technique. The influence of the harmonic ac field on the transport characteristics for the considered system is discussed in detail. In particular it is shown that the photonic field strongly modulates the Seebeck coefficient resulting in multi-peaks structure of figure of merit. Different mechanisms leading to enhancement of the thermal conductance for the case of spin-polarized transmission are explained. Thermoelectric phenomenon in a hybrid junction modified by attaching to the dot also the third, superconducting lead, is also discussed.

P-4-30

Kondo-Fano effect in double quantum dot side attached to a pair of wires

D. Krychowski,[1] and S. Lipiński[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, Poznań 60-179, Poland*

Electron tunneling through a double quantum dot side coupled to a pair of leads is examined in finite-U slave boson mean field approach. Both the two-impurity Kondo regime at half filling and one- and three-electron Kondo effects are analyzed. With the increase of interdot tunneling at half filling, an antiferromagnetic coupling develops between the spins localized in each dot, and when the Kondo state is suppressed the full transparency of the wires is recovered. Special attention is paid to the case when one of the dots is coupled to ferromagnetic leads and another to nonmagnetic. Depending on the gate voltage, the same or opposite sign of spin polarizations of conductance of magnetic and nonmagnetic leads is observed.

P-4-31

Local and non-local effects in charge and spin transport through graphene-based junctions

R.J. Wojciechowski,[1] L. Kowalewski,[1] and M. Nogala[1]
[1] *A. Mickiewicz University, Faculty of Physics, ul. Umultowska 85, 61-614 Poznań, Poland*

We investigate the local and nonlocal charge and spin transport through graphene-based junctions in which two ferromagnet regions are connected with a conventional singlet superconductor region. Spin polarization and superconductivity in a graphene sheet are assumed to be created by proximity effects induced by a superconducting electrode and ferromagnetic electrodes placed on the top of the graphene. In order to investigate all the possible reflection processes, we include the potential barriers which separate the ferromagnetic and superconducting regions. The system is described by the Dirac-Bogoliubov-de-Gennes equation. Adopting the Blonder-Tinkham-Klapwijk formalism we solve the equation and obtain transport coefficients, by imposing the continuity conditions for the wave functions at the interfaces. The coefficients describe processes consisting of quasiparticle cotunneling, and normal reflection as well as local and crossed Andreev reflections. We discuss how the chiral nature of low-energy excitations influences these transport processes. In particular, we calculate and discuss tunneling conductance and magnetoresistance as functions of bias voltage, incident angle and the model parameters.

P-4-32

Entanglement detection with use of current measurements in double quantum dot system.

Piotr Busz,[1] Piotr Rożek,[1,2] Damian Tomaszewski,[1] and Jan Martinek[1]
[1] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*
[2] *Institute of Physics, Poznan University of Technology, 60-965 Poznan, Poland*

The development of quantum computing requires highly efficient and continuous solid-state source of spatially separated spin-entangled electrons. One of the approaches is a use of double quantum dot system connected to superconducting lead (source of naturally entangled electrons). Apart from the source, an useful tool for detection of quantum entanglement is needed. We present entanglement detection by the ferromagnetic detectors using entanglement witness operator method. Detection of entanglement is connected with a direct measurement of spin polarized current in the system. We introduce what requirements must be fulfilled by ferromagnetic detectors.

References:

[1] J. Eldridge, M. G. Pala, M. Governale, and J. König., Phys. Rev. B **82**, 184507 (2010).
[2] W. Kłobus, A. Grudka, A. Baumgartner, D. Tomaszewski, C. Schönenberger, J. Martinek, Phys. Rev. B **89**, 125404 (2014).
[3] P. Rożek, D. Tomaszewski, P. Busz, and Jan Martinek (in preparation).

P-4-33

Entanglement detection with non-ideal ferromagnetic detectors

P. Rożek,[1] P. Busz,[1] W. Kłobus,[2] D. Tomaszewski,[1] A. Grudka,[2] A. Baumgartner,[3] C. Schoenenberger,[3] and J. Martinek[1]

[1] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, 61-614 Poznan, Poland*
[3] *Department of Physics, University of Basel, CH-4056 Basel, Switzerland*

Entangled states are essential in basics quantum communication protocols and quantum cryptography. Ferromagnetic contacts which work as an electron spin detectors, give possibility of converting spin information of electrons to the electric charge, and therefore, detection of entangled states with electric current measurements. Using the entanglement witness (EW) technique [1] we find the minimal spin polarization of ferromagnetic detectors that allows for detecting entanglement. Required spin polarization for entanglement detection by the EW is lower than that for the Bell CHSH inequalities test [2], providing the EW approach more efficient in the entanglement detection.

References:

[1] M. Horodecki *et al.*, Physics Letters A 223, 1 (1996)
[2] W. Kłobus, *et al.*, Phys. Rev. B 89, 125404 (2014).

P-4-34

Carrier mobility and weak localization in rippled graphene

Maciej Zwierzycki[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

Graphene, a two-dimensional honeycomb lattice of carbon atoms, is often depicted as ideally flat plane. In reality both graphene on substrate and suspended samples typically exhibit ripples. The out-of-plane deviation is usually in the range of few Ångströms and lateral wavelengths range between tens and few hundreds nanometers. Scattering on ripples may be one of the factors limiting the mobility of the charge carriers and also lead to the suppression of the weak localization seen in some of the samples. In the paper, the transport properties of rippled graphene are studied using using single-band tight-binding model. Both the bond-length variation, and fluctuating scalar potential are included in the formalism. The samples are modeled as self-similar surfaces characterized by the roughness exponent with values ranging from typical for graphene on SiO_2 to those seen in suspended samples. The range of calculated resistivities and mobilities overlaps with experiment [1]. Additionally, the magnetoconductance is calculated for samples featuring both ripples and resonant impurities, modeled as vacancies. The results demonstrate the suppression of weak localization already for very small out-of-plane amplitudes of the ripples.

References:

[1] M. Zwierzycki, J. Phys.: Condens. Matter **26** (2014)

P-5-01

Normal and inverse magnetocaloric effect in magnetic multilayers with antiferromagnetic interlayer coupling

K. Szałowski,[1] and T. Balcerzak[1]

[1] *Department of Solid State Physics, University of Łódź, ul. Pomorska 149/153, 90-236 Łódź*

Layered and dilute magnets with antiferromagnetic coupling between ferromagnetically ordered planes exhibit interesting phenomena like magnetic compensation [1]. In the paper we characterize such spin-1/2 multilayer structure in external magnetic field within Pair Approximation [2-4], focusing on its magnetocaloric properties. We study extensively the isothermal entropy change for the system vs. interaction parameters, dilution and field. We show the existence of both direct and inverse magnetocaloric effect (MCE), depending on temperature range and external field amplitude. This MCE is highly sensitive to inter- and intralayer couplings and its temperature dependence falls within two categories corresponding to the presence or absence of compensation.

References:

[1] T. Balcerzak, K. Szałowski, Physica A **395**, 183 (2014)

[2] K. Szałowski, T. Balcerzak, A. Bobák, J. Magn. Magn. Mater. **323**, 2095 (2011)

[3] K. Szałowski, T. Balcerzak, Physica A **391**, 2197 (2012)

[4] K. Szałowski, T. Balcerzak, Thin Solid Films **534**, 546 (2013)

This work has been supported by Polish Ministry of Science and Higher Education on a special purpose grant to fund the research and development activities and tasks associated with them, serving the development of young scientists and doctoral students.

P-5-02

Contribution of the antiferromagnetic bulk to exchange bias in Ni/FeF_2 bilayer systems

H. Huckfeldt,[1] A.C. Basaran,[2,3] T. Saerbeck,[3] J. de la Venta,[3] I.K. Schuller,[3] and A. Ehresmann[1]

[1] *Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany*

[2] *Materials Science and Engineering,University of California San Diego, La Jolla, CA 92093 USA*

[3] *Department of Physics and Center for Advanced Nanoscience, University of California San Diego, La Jolla, CA 92093 USA*

Most theoretical models neglect the antiferromagnetic bulk when describing the exchange bias effect. We present a series of experiments highlighting the antiferromagnetic bulk in a Ni/FeF_2 bilayer system. By bombardment with 9 keV He^+ ions and changing penetration depths defects were created influencing the exchange bias effect. The results were confirmed by numerical simulations of the ion range and damage. Quantitative magnetic and structural characterizations were performed probing the effects of ion bombardment. It is shown that the antiferromagnetic bulk can not be neglected for a quantitative description of the exchange bias effect.

Supported by DOE #FG03-87ER-45332

P-5-03

Au/Co/Au Heterostructures Studied by ^{59}Co NMR Technique

P. Nawrocki,[1] L. Gładczuk,[1] and M. Wójcik[1]

[1] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warszawa, Poland*

Thin films of hexagonal Co with perpendicular magnetic anisotropy are interesting for spintronic applications, since they can be used as a source of highly polarized spin current. In this work we report the results of Co NMR studies on Au(111)/Co/Au heterostructures where Co layer thickness d is varied from 15Å to 100Å. The aim of this study was to examine structural changes of the Co layer as a function of thickness and to investigate interface effects due to strain induced by the lattice mismatch, which may influence the magnetic anisotropy. It was found that Co layers with d<30Å make atomically sharp interface to Au(111) substrate in major part of the contact area. Co atoms located inside a bulk of the layer reveal a higher resonance frequency than that reported for a bulk sample with magnetization in the hexagonal plane. It reveals strained Co layer with hexagonal lattice strongly clamped to the lattice of the Au(111) substrate. For thicker layers with d≥30Å a structural transition to a relaxed hexagonal structure with an increased amount of grain boundaries takes place in the entire volume of the Co film. The strain at the interface to Au substrate is released by incorporation of Au atoms into the first atomic plane of Co film.

P-5-05

Martensitic and austenitic transformations in smart nanoparticles with size effects and hysteresis splitting

R. Erdem,[1] O. Yalçın,[2] and S. Özüm[3]

[1] *Department of Physics, Akdeniz University, 07058 Antalya, Turkey*

[2] *Department of Physics, Niğde University, 51240 Niğde, Turkey*

[3] *Institute of Sciences, Niğde University, 51240 Niğde, Turkey*

We use the Blume-Emery-Griffiths (BEG) model [1] to investigate the magnetic properties of core-surface smart nanoparticles (NPs). We firstly propose a relationship between bond variables (P_{ij}) in pair approximation [2] and the number of spins so that core and surface contributions to total magnetization can be identified for the nanostructured particles [3]. Based on the numerical solutions of P_{ij}, magnetization and hysteresis curves are obtained. Besides the first- and second-order phase transitions, martensitic and austenitic phase regions are observed in the phase diagrams of homogeneous and composite NPs and the origin of martensitic transitions (MT)-austenitic transitions (AT) is investigated. It is found that MT-AT occurred for a nonzero biquadratic exchange parameter. On the other hand, nonzero single-ion anisotropy caused the hysteretic splitting in core-surface type nanoparticles.

References:

[1] M. Blume, V. J. Emery, R. B. Griffiths, Phys. Rev. A 4 (1971) 1071.

[2] M. Keskin, A. Erdinç, J. Magn. Magn. Mater. 283 (2004) 392.

[3] L. G. Rego, W. Figueiredo, Phys. Rev. B 64, (2001) 144424.

P-5-06

Low temperature properties of inhomogeneous magnetic multilayers

A. Urbaniak-Kucharczyk[1]

[1] *Chair of Solid State Physics, Faculty of Physics and Applied Informatics, University of Łódź, Pomorska 149/153, 90-236 Łódź, Poland*

In the last years the problem of magnetic excitations in multilayers has been considered in many papers. Theoretical and experimental approaches dedicated to such systems showed that it is necessary to take into account the anisotropic factors. We calculate spin wave resonance spectrum characteristics for multilayered system with spatial distribution of anisotropy across magnetic layers. Temperature dependence of anisotropy parameters is also taken into account. We assume the system in which the spin wave resonance modes are induced entirely by exchange interactions and therefore they strongly depend on magnetic inhomogeneities. Parameters of spin wave spectrum are calculated using the transfer matrix method. We take also into account the effects of damping by means of the relaxation equation. As a result the parameters describing spin wave spectrum have been obtained for several magnetic systems deposited on substrate characterised by parameters corresponding to GaAs. Moreover, the temperature dependence of magnetization of a multilayered system was calculated and the spin wave parameter B in the Bloch's law $T^{3/2}$ was found and presented in dependence of parameters characterizing the system considered.

P-5-07

Magnetic properties of laser-irradiated FePdCu thin alloy films

M. Perzanowski,[1] M. Krupinski,[1] A. Zarzycki,[1] Y. Zabila,[1] and M. Marszalek[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Krakow, Poland*

The laser annealing is a promising, and fast method for modification of thin films. The set of $[Cu/Fe/Pd]_x$ multilayers was prepared by thermal evaporation. Samples were irradiated using Nd:YAG laser operating at 1064 nm with pulse time of 10 ns and repetition frequency of 10 Hz. Samples were irradiated with 1, 10, 100, and 1000 pulses with energy of 235 mJ/cm^2 in the atmosphere of flowing nitrogen.
XRD measurements showed that even at low number of pulses the multilayer structure was destroyed and $L1_0$-ordered nanograins were formed. Magnetic measurements showed that the irradiated material is magnetically soft and the easy axis of magnetization is parallel to the surface. With increasing number of pulses the value of saturation magnetization increased, which could be related to the ordering process. It was also found that application of increasing number of pulses led to increase of the Curie temperature, which is another evidence for ordering. The magnetic imaging experiments showed, that the magnetic domains have the average size of about a few microns.

P-5-08

Model for the Surface Anisotropy Field Observed in Thin *(Ga,Mn)As* Film Spin-Wave Resonance

Henryk Puszkarski,[1] and Piotr Tomczak[2]

[1] *Surface Physics Division, Faculty of Physics, A. Mickiewicz University*

[2] *Quantum Physics Division, Faculty of Physics, A. Mickiewicz University*

The source of Spin-Wave Resonance (SWR) in thin films of the ferromagnetic semiconductor $(Ga, Mn)As$ is still under debate: does SWR stem from the surface anisotropy (in which case the surface inhomogeneity (SI) model would apply), or does it originate in the bulk inhomogeneity of the magnetic structure of the sample (and thus requires the use of the volume inhomogeneity (VI) model)? We will outline the ground on which this controversy arose and will show why in different configurations of the static magnetic field $\boldsymbol{H}$ with respect to the surface (with the angle θ_H between the surface normal and the external field) a resonance sample may meet the assumptions of either the SI or the VI model. The border between respective domains of applicability of both the VI and SI models in $(Ga, Mn)As$ thin films is related to the so-called critical angle θ_C, the particular configuration at which the multi-peak SWR spectrum reduces to a single-peak one. We anticipate that SWR fulfills the assumptions of the SI model in configurations $\theta_H > \theta_C$, whereas the VI model applies to $\theta_H < \theta_C$ - under the stipulation that both models to be modified in their touchiest point: the boundary conditions adopted (and expressed by the Surface Anisotropy Field).

P-5-09

Horizontal shift of the hysteresis loop for ultrathin Fe film on MgO(001) substrate

B. Matlak,[1] A. Kozioł-Rachwał,[1] K. Matlak,[1] J. Przewoźnik,[1] T. Ślęzak,[1] and J. Korecki[1,2]

[1] *Faculty of Physics and Applied Computer Science, AGH-UST, Kraków, Poland*

[2] *Jerzy Haber Institute of Catalysis and Surface Chemistry, PAS, Krakow, Poland*

Recently, Fan et al. [1] reported on a new exchange bias phenomenon that is manifested only in the Fe/MgO interface spins, and not in the bulk. In the present contribution we show that when the thickness of the epitaxial Fe film on MgO(001) is reduced to about 1 nm, the VSM hysteresis loop shows at low temperature a shift that is typical for the exchange bias systems composed of a ferromagnet and antiferromagnet. Narrow hysteresis loops at the room temperature were gradually broadened with lowering temperature and eventually, below 15 K, became shifted, even when cooled *without* external magnetic field. The maximum bias field of more than 100 Oe was observed at the film thickness of 0.9 nm. Our preliminary interpretation is that the interface Fe layer is antiferromagnetically coupled to the film interior due to existence of Fe-O-Fe bonds.

References:

[1] Y. Fan, *et al.*, Nature Nanotechnology 8, 438 (2013).

P-5-10

Local Magnetic Properties of $Mn_5Ge_3C_x$: ^{55}Mn NMR Study

R. Kalvig,[1] E. Jędryka,[1] M. Wójcik,[1] and L. Michez[2]
[1] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warszawa, Poland*
[2] *CINaM – CNRS UPR 3118, Campus de Luminy, Case 913, 13288 Marseille Cedex 9, France*

Hexagonal Mn_5Ge_3 compound, with Mn in two nonequivalent positions: 4d (Mn_I) and 6g (Mn_{II}), is a prospective spintronic material due to high spin polarization and high Curie temperature (up to 450 K in case of samples doped with carbon). To investigate the magnetic properties of this system, an extensive ^{55}Mn NMR study was carried out on a series of epitaxial films of $Mn_5Ge_3C_x$ for $0<x<0.85$. The NMR spectrum recorded from the pristine Mn_5Ge_3 thin film reveals NMR lines at 210 MHz and 430 MHz, readily attributed to Mn_I and Mn_{II} sites, respectively. Upon the inclusion of carbon, Mn_{II} sites are first to be affected, with a new NMR line quickly developing around 355 MHz, indicating a number of Mn_{II} atoms with altered magnetic moments. This new value of Mn magnetic moment results from the strong bonding the carbon atoms make with Mn_{II} as the nearest neighbors. The effect of carbon is much smaller on Mn_I sites where it plays the role of a more distant neighbor, and is visible only after reaching a much higher C concentration, close to x=0.5.

P-5-11

Properties of RE-TM nanoparticles prepared by inert gas condensation

F. Schmidt,[1,2] D. Pohl,[1] L. Schultz,[1] and B. Rellinghaus[1]
[1] *IFW Dresden, Helmholtzstr. 20, D-01069 Dresden, Germany.*
[2] *TU Dresden, IFWW, D-01062 Dresden, Germany.*

Rare earth (RE) magnets are already multiply used in our modern society. Magnetic nanoparticles of these materials provide additional promising properties for many applications, such as magnetic data storage, medical applications, magnetic mechanical actuators, sensors, or hybrid-catalysis. There are different methods to synthesize rare earth-transition metal (RE-TM) nanoparticles, such as, e.g., chemical preparation routes or surfactant-assisted ball milling. The purpose of this study is to investigate free, RE-TM nanoparticles prepared by inert gas condensation and to study how different thermodynamic conditions affect them. At nanoscopic sizes, the surface energy contributes significantly to the total energy of the particle, and as a consequence, the surface of a nanoparticle largely determines its properties. It is thus essential to investigate various types of surface modifying processes, for instance optical in-flight annealing. Transmission electron microscopy was used in combination with magnetic measurements to determine the atomic structure, chemical composition and magnetic behavior of the particles. It is found that surface modifications cause large differences in the crystallinity and saturation magnetization of these RE-TM nanoparticles.

P-5-12

Second-harmonic generation studies of inhomogeneous magnetization distributions in thin garnet film

A. Bonda,[1] S. Uba,[1] and L. Uba[1]

[1] *Institute of Computer Science, University of Bialystok, Lipowa 41, PL-15-424 Bialystok, Poland*

In the paper [1] we have demonstrated on the example of thin garnet film that magnetization processes can be effectively studied using magnetization-induced second harmonic generation effect (MSHG). The aim of the current work is the investigation of inhomogeneous magnetization distributions induced in the surface area of the garnet film by ion implantation. The studies were performed on magnetic garnet film of (111) symmetry, implanted with H_2^+ ions of 1.5×10^{16} cm^{-2} dose and 60 keV energy. The measurements of MSHG effect were performed as a function of the sample-normal rotation angle and the amplitude of external magnetic field. The observed MSHG intensity hystereses were subjected to a decomposition procedure into contributions having different magnetic field dependences. The contributions originating from the implanted and unimplanted parts of the film volume of different magnetic ordering were analyzed and discussed.

References:

[1] A. Bonda, S. Uba, and L. Uba, Phys. Rev. B 87, 024426 (2013).

P-5-13

Nuclear magnetic resonance in hexaferrite/maghemite composite nanoparticles

O. Hondlík,[1] P. Křišťan,[2] H. Štěpánková,[2] V. Chlan,[2] K. Kouřil,[2] R. Řezníček,[2] E. Pollert,[3] and P. Veverka[3]

[1] *Faculty of Biomedical Engineering, Czech Technical University in Prague, Sítná sq. 3105, 27201 Kladno, Czech Republic*

[2] *Charles University in Prague, Faculty of Mathematics and Physics, V Holesovičkách 2, 18000 Prague 8, Czech Republic*

[3] *Institute of Physics, ASCR, Cukrovarnická 10, 16253 Prague 6, Czech Republic*

Due to their bio-compatibility and non-toxicity, iron oxides are suitable for magnetic drug delivery or as materials for hyperthermia. Compounds of spinel structure (magnetite/maghemite) are most frequently used, however, the desired magnetic properties can be reached by combining more phases (e.g., maghemite and hexaferrite) into a composite material. We employed NMR to investigate strongly inhomogeneous nanoparticle composites. Frequency-swept ^{57}Fe NMR spectra of nanoparticle samples containing maghemite, hematite and M-phase of strontium hexaferrite were measured in zero external magnetic field at 4.2 K. Utilizing differences in optimal excitation field strengths and in relaxation times, we were able to resolve NMR signal assigned to hexagonal phase from signal which showed features attributed to maghemite.

P-5-14

Effect of iron loading on magnetooptic properties of magnetoferritin

M. Koralewski,[1] Z. Mitroova,[2] M. Pochylski,[1] L. Melnikova,[2] and P. Kopcansky[2]
[1]*Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*
[2]*Institute of Experimental Physics, SAS, Watsonova 47, 040 01 Kosice, Slovakia*

Magnetoferritin is relatively new synthetic biocompatible nanomaterial with continuously increasing interest in many fields of science. Unlike in physiological ferritin protein, the magnetoferritin's cage is loaded with different magnetic materials using chemical synthesis procedures. In this paper we present experimental studies of magnetic and structural properties of magnetoferritin prepared by controlled chemical synthesis with different iron loading factor (LF=the number of iron atoms inside the cage) ranging from 300 to 3200 Fe ions per ferritin molecule. Magnetically induced optical birefringence (MB) was measured for magnetoferritin aqueous suspensions. MB was described in the frame of Langevin formalism taking into account the log-normal distribution of the particle size. The established average magnetic dipol moment and core diameter increases with increasing the LF.

The work was supported by the project in the frame of SF EU No. 26110230097.

P-5-15

FIB nano-fabrication of the Pt/Co/Pt magnonic crystals

M. Jakubowski,[1] Z. Kurant,[2] N. Tachir,[2] P. Mazalski,[2] I. Sveklo,[2]
T. Wojciechowski,[1] L.T. Baczewski,[1] A. Maziewski,[2] and A. Wawro[1]
[1]*Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2]*Faculty of Physics, University of Białystok, Białystok, Poland*

We present our approach aiming to explore nano-structuring potential of focused ion beam (FIB) lithography in fabrication of magnonic crystals. Magnetic ultrathin Pt/Co/Pt film with naturally in-plane magnetisation and periodically modulated out-of-plane magnetisation induced by ion irradiation is expected to modify substantially spin wave propagation. Spin reorientation transition (SRT) in such a system is a result of an interplay between interface degradation and nano-alloying process which forms ordered intermetallic compounds with strong perpendicular anisotropy (PMA).

Our recent results show negligible surface damage effects during modulated spin waveguides fabrication by low-dose Ga^+ FIB technique. Experimental results are supported by computational modelling of the ion beam interaction with ultrathin film multilayers material (in-depth chemical profiles and ion erosion depth).

This work is done under SYMPHONY project operated within the Foundation for Polish Science Team Program co-financed by the EU European Regional Development Fund, No. OPIE 2007-2013.

P-5-16

Linear and non-linear magneto-optical response of magneto-plasmonic Au/YIG crystals

S. Parchenko,[1] I. Razdolski,[2] A. Stupakiewicz,[1] A. Stognij,[3] A. Kirilyuk,[2] Th. Rasing,[2] and A. Maziewski[1]

[1] *Laboratory of Magnetism, Faculty of Physics, University of Bialystok, Lipowa 41, Bialystok, Poland*

[2] *Radboud University Nijmegen, Institute for Molecules and Materials, Heyendaalseweg 135, Nijmegen, The Netherlands*

[3] *Scientific-Practical Materials Research Centre of the NASB, P. Brovki 19, Minsk, Belarus*

We report about our linear and non-linear magneto-optical studies of the plasma resonances in a 1D Au/YIG magneto-plasmonic crystal. Excitation of the resonances was studied as function of the applied magnetic field and angle of incidence of the fundamental light. An interplay between different surface plasma resonances was shown to play an important role in the magneto-plasmonic effect observed in both experimental configurations. Obtained resonance branches are in good agreement with theoretical calculations. This work was supported by the SYMPHONY project operated within the Foundation for Polish Science Team Programme co-financed by the EU European Regional Development Fund, OPIE 2007-2013.

P-5-17

Influence of temperature on magnetic properties of $Fe_{20}Ni_{80}/Co/Tb_{26}Co_{74}$ films with exchange bias

K.G. Balymov,[1] O.A. Adanakova,[1] N.A. Kulesh,[1] A.V. Svalov,[1] E.A. Stepanova,[1] and V.O. Vas'kovskiy[1]

[1] *Ural Federal University, 620002 Ekaterinburg, Russia*

Temperature dependencies of hysteresis properties of $Fe_{20}Ni_{80}$(50 nm)/Co(L)/$Tb_{26}Co_{74}$(110 nm) films with various thicknesses L have been investigated. Hysteresis properties were measured at temperatures varied from 5 to 350 K at two different ranges of magnetic field. All samples exhibited unidirectional anisotropy, which manifested itself as a shift of the hysteresis loop of the soft magnetic layer along the magnetic field axis. For samples with different thicknesses of Co spacer, temperature dependencies of coercivity (H_c) and exchange bias field (H_e) of $Fe_{20}Ni_{80}$ layer were determined. Values of H_c and H_e measured for samples with $0<L<0.8$ nm increased with temperature decreasing. The experimental results were interpreted in terms of magnetic interface delocalization.

This work was supported by The Ministry of Education and Science of the Russian Federation (contract 02.G36.31.0004), RFBR and Government of the Sverdlovsk region (grant 13-02-96027), UrFU under the Framework Program of development of UrFU through the «Young scientists UrFU» competition.

P-5-18

Magnetic resonance in $GdMnO_3/SrTiO_3$

T.P. Gavrilova,[1] R.M. Eremina,[1,2] D.V. Mamedov,[2] I.I. Fazlizhanov,[1]
I.V. Yatsyk,[1,2] V.I. Chichkov,[3] Z. Seidov,[4] H.-A. Krug von Nidda,[4] and A. Loidl[4]
[1] *Zavoisky Physical -Technical Institute RAS, Kazan, Russia*
[2] *Kazan (Volga Region) Federal University, Kazan, Russia*
[3] *National University of Science and Technology MISiS, Moscow, Russia*
[4] *EP V, Center of ECM, Augsburg University, Augsburg, Germany*

Rare-earth manganites with orthorhombically distorted perovskite structure have been subject to intensive studies since the multiferroic phases, in which magnetism and ferroelectricity simultaneously emerge, were found in some of these materials, for example in $GdMnO_3$.
The thin film of the multiferroic $GdMnO_3$ of thickness about 100 nm was deposited onto ferroelectric material $SrTiO_3$ ($GdMnO_3/SrTiO_3$) and investigated using electron spin resonance (ESR) in the wide temperature range. The most interesting results was observed in the temperature range from 40 K to 100 K where except the exchange-narrowed line from $GdMnO_3$ we observed the group of lines of the spin wave resonance. The intensity of the group of lines of spin wave resonance increases with increasing the external magnetic field or with decreasing the temperature.

The reported study was partially supported by RFBR, research project No. 13-02-97120.

P-5-19

Annealing and partial oxidation of exchange-biased FeNi / FeMn structures.

P.A. Savin,[1] A.V. Svalov,[1,2] V.N. Lepalovskij,[1] and V.O. Vas'kovskiy[1]
[1] *Department of Magnetism and Magnetic Nanomaterials, Ural Federal University, 620002 Ekaterinburg, Russia*
[2] *Departamento de Electricidad y Electrónica, Universidad del País Vasco (UPV/EHU), 48080 Bilbao, Spain*

Multilayered structures combined ferromagnetic and antiferromagnetic layers has been widely used in many magnetoresistive devices. Heating is due standard techniques demand or carried out to achieve certain properties. The ability of manganese to oxidize before the iron, can lead to formation ferromagnetic layer inside of FeMn-layer. This effect creates additional opportunities for the formation of practical properties. In this work we have carried out studies of the samples containing layers Fe20Ni80/Fe50Ni50 obtained by magnetron sputtering technology. Annealing was carried out at temperatures from 100 to 400 C in a vacuum or in a mixture of N_2 and 0.5% O_2. For as-deposited FeNi/FeMn layers the strong peaks on the X-ray diffraction patterns at about 43.6 and 44.4 grad demonstrate a high degree of fcc FeMn(111) and FeNi(111) orientation respectively. The peak intensity of FeMn(111) decreases with the increase of the annealing temperature. Moreover, for the samples annealed in gas mixture the peaks arising from the formation of α-Fe(Mn) phase and MnO started to appear.

P-5-20

Influence of the FM/AFM interface roughness on the exchange bias phenomenon

M. Pankratova,[1] and A. Kovalev[1,2]

[1] *B.Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine, 47 Lenin Ave., 61103 Kharkov, Ukraine*

[2] *V.N. Karazin Kharkiv National University, 4 Svobodi sq., 61107 Kharkov, Ukraine*

The exchange bias phenomenon in the layered ferromagnetic (FM) and the antiferromagnetic (AFM) system with a rough interface is theoretically studied. We assume that the FM and the AFM subsystems interact through randomly distributed magnetic point contacts (MPC). The shift and the asymmetry of the hysteresis curve for the magnetization dependence on the field have been associated with the domain walls, that are oriented perpendicular to the FM/AFM interface. We show that even a small density of the MPC leads to a shift of the hysteresis loop and to the transformation of its shape. These dependencies are in accordance with the experimental data. The results obtained for the rough interface were compared with the hysteresis loops for the perfect FM/AFM interface. It was shown that the qualitative shape of the hysteresis curve for the rough and perfect interfaces may be similar. We propose a method to distinguish the cases with different character of FM/AFM interface.

P-5-21

Three-Dimensional Micromagnetic Simulation of Spatial Distribution of Magnetization in Thick Cobalt Layers

M. Kisielewski,[1] A. Maziewski,[1] and V. Zablotskii[2]

[1] *Faculty of Physics, University of Białystok, 41 Lipowa street, 15-424 Białystok, Poland*

[2] *Institute of Physics ASCR, Na Slovance 2, 18221 Prague, Czech Republic*

Spatial magnetization distribution of cobalt layer is studied by means of three-dimensional micromagnetic simulations in the range of cobalt thickness d from 10 to 200 nm. In this range a spin-reorientation phase transition occurs, while the cobalt thickness increases, from a state with in-plane-oriented magnetization, to a state with out-of-plane-oriented components of magnetization [1, 2]. An infinite cobalt layer is modeled by the 750nmx750nmx$d$ structure consisting of simulation cells of sizes of 3nmx3nmx3nm and the periodic boundary conditions. For larger thicknesses, a labirynth, partially closed, stripe structure has been found.

References:

[1] M. Kisielewski, A. Maziewski, V. Zablotskii, J. Magn. Magn. Mater. 316 (2007) 277–280

[2] A. Maziewski, *et al.*, Phys. Status Solidi A, 1–14 (2014) / DOI 10.1002/pssa.201300750

This work was supported by the Foundation for Polish Science Team Programme co-financed by the EU European Regional Development Fund, OPIE 2007-2013. This research was supported in part by PL-Grid Infrastructure.

P-5-22

g-factor of exciton-polaritons

S. Richter,[1] C. Sturm,[1] H. Franke,[1] R. Schmidt-Grund,[1] and M. Grundmann[1]
[1] *Universität Leipzig, Faculty of Physics and Earth Sciences, Institute for Experimental Physics II, Linnéstr. 5, 04103 Leipzig, Germany*

Exciton-polaritons, formed by strong coupling between excitons and photons in microcavities, are fascinating quasi-particles since they can form a (dynamic) Bose-Einstein condensate. Magnetic fields can strongly influence the properties of these particles, e.g. a reduction of the condensation threshold[1]. These fields acting in the polarization space do not need to have external sources, they can also occur as effective fields, e.g. caused by the TE-TM linear polarization splitting of a cavity-photon mode. Here we discuss different kinds of effective magnetic fields and their impact on the entire coupled system as well as the excitonic and photonic components of the polaritons. An important quantity is the polaritonic g-factor which connects external fields to the polarization space, and which is not explored so far in detail. We deduce the shape of the g-factor tensor and its composition, which both depend on the detuning between the exciton and photon and the momentum orientation of the polaritons.

References:

[1] V.P. Kochereshko *et al.*, arXiv:1309.6983 (2013)

P-5-23

Influence of the interface quality on magnetic properties of $Fe_{20}Ni_{80}$/Tb-Co films with unidirectional anisotropy

N.A. Kulesh,[1] K.G. Balymov,[1] M.O. Korotnev,[1] and V.O. Vas'kovskiy[1]
[1] *Ural Federal University, 620002 Yekaterinburg, Russia*

Mechanism of the exchange coupling between adjacent magnetic layers often remains obscure because of complexity of the magnetic frustrations and compositional gradients in the interface region. In this study we considered effect of annealing on magnetic properties of $Fe_{20}Ni_{80}$/Tb-Co and $Fe_{20}Ni_{80}$/Ti/Tb-Co films with unidirectional anisotropy. Changes in the interface region were evaluated by means of grazing incidence x-ray fluorescent (GIXRF) analysis. This method allowed us to compare interlayer diffusion and interface roughness at different stages of cumulative annealing. In case of $Fe_{20}Ni_{80}$/Tb-Co sample, annealing at 100 C initiated the interdiffusion process, whereas for $Fe_{20}Ni_{80}$/Ti/Tb-Co film even ultrathin (0.7 nm) Ti spacer was enough to prevent active mixing of the layers for temperatures up to 300 C. Hysteresis properties of $Fe_{20}Ni_{80}$ layer demonstrated good correlation with the changes observed in GIXRF experiment.

This work was supported by The Ministry of Education and Science of the Russian Federation (contract No 02.G36.31.0004), RFBR and Government of the Sverdlovsk region (grant No 13-02-96027)

P-5-24

Study of high-field magnetization process in amorphous RE-Co films (RE=La,Gd,Tb)

V.O. Vas'kovskiy,[1] O.A. Adanakova,[1] K.G. Balymov,[1] A.S. Bolyachkin,[1] N.A. Kulesh,[1] A.V. Svalov,[1] and E.A. Stepanova[1]

[1] *Ural Federal University, 620002 Yekaterinburg, Russia*

Experimental study and numerical modeling of magnetization process in thin amorphous films of Co alloy with Gd,Tb and La have been performed. Magnetization curves were measured at temperatures varied from 5 to 300 K in the field range of 70 kOe. Analysis of the results revealed relatively large magnetic susceptibility for Gd_xCo_{1-x} (x<0.4) and Tb_xCo_{1-x} (x<0.25) films, which remained the same for different x and demonstrated little change with temperature. Magnetic saturation of La-Co films was observed in low-field region. Magnetization curves were interpreted by numerical modeling in terms of sperimagnetic ordering and magnetization ripple. For Tb_xCo_{1-x} (0.25<x<0.4) samples in low-field region (below 10 kOe) nonlinear growth of the magnetization was observed. The last tendency can be explained in terms of stochastic magnetic structure, which was confirmed by magnetic force microscopy.

This work was supported by The Ministry of Education and Science of the Russian Federation (contract No 02.G36.31.0004), RFBR and Government of the Sverdlovsk region (grant No 13-02-96027)

P-5-25

Electromagnetic waves absorption by graphene - magnetic semiconductor - graphene nano-structure in external magnetic field: Voight geometry

Dmitry A. Kuzmin,[1] Igor V. Bychkov,[1] and Vladimir G. Shavrov[2]

[1] *Chelyabinsk State University, Chelyabinsk, Russia*

[2] *Kotelnikov Institute of Radio-engineering and Electronics of RAS, Moscow, Russia*

Nowadays graphene attract researchers' attention with their special properties including electrodynamical ones. Despite the large number of studies, the authors are usually limited by investigation of a non-magnetic dielectric medium, where graphene is placed. It is very interesting to study the electrodynamics of graphene-based structures with more complex materials. A magnetic semiconductor could be an example of such material. Plasma waves can excite in the semiconductor structures. In its turn, the magnetic semiconductors may have a large magnetoresistance, magnetooptical properties, etc. Thus, the electrodynamics of graphene-magnetic semiconductor-based structures can be quite interesting.

This paper is devoted to investigation of the absorption of electromagnetic waves by graphene - magnetic semiconductor - graphene nano-structure placed in an external magnetic field, directed parallel to the structure surface (Voigt geometry). Investigation shows that absorptance of electromagnetic waves by such a structure can be efficiently controlled by both value and direction of an external magnetic field.

P-5-26

Magnetic properties of magnetoplasmonic crystals based on commercial digital discs

V. Belyaev,[1] V. Rodionova,[1] K. Chichay,[1] A. Grunin,[2] and A. Fedianin[2]
[1] *Immanuel Kant Baltic Federal University, A. Nevsky 14, Kaliningrad, Russia*
[2] *Lomonosov Moscow State University, Leninskie Gory 1, Moscow, Russia*

Several topics of photonic are targeted on the enhancement of magneto-optical response in nanostructures. One of such approaches is creating magnetoplasmonic crystals (MPC) based on digital discs with ferromagnetic film. It is necessary to investigate in-plane anisotropy of MPCs and influence of ferromagnetic layer to improve the quality factor of plasmons. MPCs based on Fe and Ni were investigated using VSM by LakeShore and a step-like behavior of hysteresis loops in case of transverse plasmon propagation way was observed. Measurements along the plasmon propagation way showed near-rectangular hysteresis loops typical for Ni-based thin films. In-plane anisotropy was found in Ni thin films on Si/SiO_2 substrate, too. All Fe structures had isotropic in-plane magnetic properties.
In-plane anisotropy for Ni on Si/SiO_2 can be explained by magnetostriction properties of Ni. For MPCs it can be explained as a result of interaction between different factions of Ni that partly covered sides of the substrate battlements.

P-5-27

Fabrication, structure and magnetic properties of Co/Pd and Fe/Pd multilayered nanorods and antidots arrays on anodic aluminium oxide templates

A. Maximenko,[1,2] A. Zarzycki,[1] Y. Zabila,[1] M. Perzanowski,[1] M. Krupiński,[1] M. Kąc,[1] M. Marszałek,[1] and J. Fedotova[2]
[1] *The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, 31-342 Cracow, Poland*
[2] *National Centre for Particle and High Energy Physics of BSU, 220030 Minsk, Republic of Belarus*

A fabrication method of multilayered (ML) Co/Pd and Fe/Pd magnetic nanorods and antidots arrays with carefully engineered pinning on the top of nanoporous anodized aluminum oxide (AAO) templates (pore diameters 30, 40 and 180 *nm*) is presented. The surface morphology and crystallographic structure of the systems were investigated by SEM and X-ray diffractometry, respectively. TEM cross-sectional confirmed ML structure of nanosized arrays. SQUID-magnetometry indicates enhanced perpendicular anisotropy and more than twofold increase of coercivity of nano-sized arrays in comparising to flat films. Magnetization reversal mechanisms in the systems were investigated by analysing the angular dependence of the remanent coercivity.
Presented method of magnetic nano-arrays fabrication can be used as low-cost nanopatterning technique.

P-5-28

Exchange-bias effect in core-shell nanoparticles with non-spherical shape and imperfect shell

V. Dimitriadis,[1] D. Kechrakos,[1] N. Moutis,[1] and E. Sideris[1]

[1] *Department of Education, School of Pedagogical and Technological Education (ASPETE), 14121 Athens, Greece*

The isothermal magnetic hysteresis of composite nanoparticles with FM core - AF shell morphology and various sizes and shapes is studied, in order to elucidate the sensitivity of the exchange bias effect on the shape of the particles and the structural imperfections of the interface and the shell. We use classical Heisenberg Hamiltonian with different local anisotropy terms for the core, the shell and the surface. The field-cooled process and the isothermal hysteresis loop are simulated implementing the Metropolis Monte Carlo algorithm. The coercive and exchange bias fields for spherical and cubical nanoparticles with similar nominal sizes are compared. We find that interface roughness smears out the differences between spherical and cubical particles, while incomplete shells lead to degradation of the exchange bias effect.

Research co-financed by the European Social Fund and Greek national funds through the Research Funding Program "ARCHIMEDES III".

P-5-29

Dependence of exchange bias field on thickness of antiferromagnetic layer in Co(or NiFe)/IrMn structures

V. Rodionova,[1] I. Dzhun,[2] K. Chichay,[1] and N. Chechenin[2]

[1] *Immanuel Kant Baltic Federal University, Innovation park, Kaliningrad 236000, Russia*

[2] *Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow 119991, Russia*

Magnetic properties of ferromagnetic/antiferromagnetic thin-films structures for spin-valve applications have been studied. Multilayer structures of Ta/Co/IrMn/Ta and Ta/FeNi/IrMn/Ta were deposited on Si substrate at room temperature by DC magnetron sputtering. Thickness of the antiferromagnetic layer changed from 2 to 60 nm. Uniform forming magnetic field of 420 Oe was applied parallel to the sample's plane during the deposition. The magnetic properties of these structures were obtained from ferromagnetic resonance and vibrating sample magnetometry measurements. Both the coercive force and the exchange bias field were found to be non-monotonic functions of the antiferromagnetic layer thickness. To achieve the maximum effect of the exchange bias the optimal thicknesses were found for each system. More over, it was found the alternative sequence of the deposition (antiferromagnetic layer on the top or below the ferromagnetic layer) leads to dramatic changes of the magnetic properties of bilayer structures.

P-5-30

Magnetic nanoparticles and electromagnetic waves impact on red blood cells

Claudia Nadejde,[1] Cristina Plamadeala,[1] and Dorina Creanga[1]
[1] *Univ. "Al. I. Cuza" Faculty of Physics, Iasi, Romania*

Biocompatible magnetic nanoparticles were prepared by co-precipitation technique from iron ferrous and ferric salts being further stabilized with organic molecules in aqueous suspensions to ensure their specific properties preservation for the optimal interaction with cells and tissue. Microwaves of low power density were supplied from specialized laboratory source. Total human blood samples of 8 ml volume were treated with equal concentrations of magnetic nanoparticle suspension of 120 microliter per liter to investigate possible magnetic contamination from environmental sources. Haemolysis extent assessed by spectral assay was found increased especially for longer exposure time of samples loaded also with magnetic nanoparticles suggesting red blood cell membranes disorganization. Possible side effects of magnetic nanoparticles utilization in biomedicine appeared to be a research issue to be further approached through our project.

P-5-31

Magnetic resonance in Sr-doped $Yb_{0.82}Sr_{0.18}Mn_{1-x}Fe_xO_3$

I.I. Nig'matullina,[1] V.V. Parfenov,[1] R.M. Eremina,[1,2] and I.V. Yatsyk[1,2]
[1] *Kazan (Volga Region) Federal University, Kazan, Russia*
[2] *Zavoisky Physical -Technical Institute RAS, Kazan, Russia*

Electron spin resonance (ESR) measurements were performed in $YbMnO_3$, $Yb_{0.82}Sr_{0.18}Mn_{1-x}Fe_xO_3$ (x=0; 0,1-0,2) in a wide temperature range from 100 to 300 K. The ESR spectrum in ceramics $YbMnO_3$ consists of one exchange-narrowed line with the g-factor about 2.11 and the linewidth about 800 Oe in the entire temperature range. This value of the linewidth in ceramics $YbMnO_3$ is about 2.3 times less than in $LaMnO_3$. Probably, this experimental fact is related with a change in the symmetry of the crystal structure from hexagonal $P6_3cm$ ($YbMnO_3$) to orthorhombic Pbnm ($LaMnO_3$) and thus with the change of the crystal field parameters.
ESR spectrum of Sr-doped $Yb_{0.82}Sr_{0.18}Mn_{1-x}Fe_xO_3$ consists of two lines in the temperature range from 100 to 260 K due to the phase separation in the sample. At the temperature above 260 K phase transition was observed into single-phase state in ceramics $Yb_{0.82}Sr_{0.18}Mn_{1-x}Fe_xO_3$. In spectrum we observed only one line. The antiferromagnetic ordering is observed in the Fe-doped samples $Yb_{0.82}Sr_{0.18}Mn_{1-x}Fe_xO_3$ (x=0,1-0,2) at the temperature below 130 K, thus the spectrum of magnetic resonance are not observed.

The reported study was partially supported by RFBR, research project No. 13-02-97120.

P-5-32

Magnetic properties of Heusler nanoparticles encapsulated inside carbon nanotubes

M. Gellesch,[1] M. Dimitrakopoulou,[1] M. Scholz,[1] C.G.F. Blum,[1] S. Hampel,[1] S. Wurmehl,[1,2] and B. Büchner[1,2]

[1] *IFW Dresden, 01069 Dresden, Germany*

[2] *Institute for Solid State Physics, TU Dresden, 01062 Dresden, Germany*

Magnetic properties of nanoscale systems may differ largely from the magnetism in the respective bulk phase and can lead to the emergence of interesting physical properties. Furthermore, Heusler compounds constitute a family of materials with a broad range of physical properties - among them different types of magnetism and materials with high spin polarisation [1]. Here we present results of investigations of thermomagnetic properties of Heusler nanoparticles prepared inside multi-walled carbon nanotubes via a wet-chemical approach [2]. Our study shows, that the coercive field of the Heusler nanocrystals is greatly enhanced and depends on the mean diameter of the Heusler nanocrystals, while the saturation magnetic moment known from the bulk phase is preserved.

References:

[1] T. Graf *et al.*, Prog. Solid State Ch., 2011, 39 (1), pp 1-50

[2] M. Gellesch *et al.*, Cryst. Growth Des., 2013, 13 (7), pp 2707–2710

P-5-33

Determination of exchange and rotational anisotropies in Co_2FeSi/IrMn exchange coupled structures using broadband ferromagnetic resonance

H. Głowiński,[1] I. Gościańska,[2] A. Krysztofik,[2] and J. Dubowik[1]

[1] *Institute of Molecular Physics, PASci, M. Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *Faculty of Physics, A. Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

In ferromagnetic (FM)/antiferromagnetic (AFM) bilayer systems the exchange bias (EB) is the most spectacular phenomenon resulting in a shift of a hysteresis of the exchange anisotropy field H_{EB}. However, another phenomenon related to EB—rotational anisotropy—has been far less recognized. The rotatable anisotropy field H_{RA} is a field that follows the macroscopic motion of the magnetization, decreasing the resonance field in all directions. In this contribution, we present broadband VNA-FMR measurements of both H_{EB} and H_{RA} in $[Co_2FeSi/IrMn]_3$ structures comprising three bilayers with distinct H_{EB} of $\sim 20 - 70 - 220$ Oe, respectively. The aim of the study is to find correlation between H_{EB} and H_{RA}. It appears that H_{RA} scales $\propto H_{EB}$, contrary to our expectations.

P-5-34

Micro-Raman spectroscopy of natural and synthetic ferritins and their mimetics

M. Szybowicz,[1] M. Koralewski,[2] and J. Karoń[3]

[1] *Faculty of Technical Physics, Poznań University of Technology, Nieszawska 13A, 60-965 Poznań*

[2] *Faculty of Physics, A. Mickiewicz University, Umultowska 85, 61-614 Poznań, PL; e-mail-koral@amu.edu.pl*

[3] *Clinic of General Surgery, Poznań University of Medical Sciences, Szwajcarska 3, 61-285 Poznań*

Micro-Raman spectroscopy (μ-RS) is known to be powerful tool in investigation of biological tissues. Of particular intrest is the search for methods allowing detection of different form of iron inside ferritin protein both *in vitro* and *in vivo*. In this study we propose to use μ-RS as potential tool to distinguish between the forms of iron present in human organs especially in brain tissues. Using a inVia Renishaw micro-Raman spectrometer systematic studies of biogenic ferritin (horse spleen), synthetic ferritin with magnetic core (magnetoferritin) and their mimetics were performed. As model ferrihydrite-like mineral and nanoscale magnetite parenteral iron formulation Venofer and Endorem were used respectively. The ability of μ-RS to discrimination between ferritin and magnetoferritin was demonstrated. The results are promising for further studies of brain tissues among other typical magnetic techniques used currently.

P-5-35

Superferromagnetic Sensors

V.N. Kondratyev,[1,2] Yu.V. Korovina,[3] and Ph. Blanchard[2]

[1] *Physics Department, Taras Shevchenko National University, Kiev, Ukraine*

[2] *Faculty of Physics, Bielefeld University, D-33501 Bielefeld, Germany*

[3] *Department of Technology, Moscow Institute of Open Education, Russia*

Superferromagnets (SFMs), e.g., magnetic nano-crystal self-assemblies and/or arrays, represent promising candidates for Lab on a Chip systems including many laboratory tasks. Such soft magnetic systems provide an opportunity to develop new materials with characteristics far beyond traditional solids. The randomly jumping interacting moments (RJIM) model, see [1] and refs. therein, gives useful framewok for studies of SFMs. In particular, it provides a basis for developing analytical tools employed in order to specify, quantify and analyse respective magnetic structures. Such tools explore correlations of magnetic noise amplitudes and allow for quantitative definition, description and study the SFM origin, as well as self-organized criticality in the response properties. In this contribution we briefly overview some results for a sensor mode of SFM reactivity associated with spatially local external fields, i.e., a detection of magnetic particles. Favorable designs of superferromagnetic systems for sensor implications are revealed.

References:

[1] V.N. Kondratyev. J. Phys.: CS, 248, 012027 (2010)

P-5-36

Magnetic structure of artificial spin ice

M. Matczak,[1,2] F. Lisiecki,[3] P. Kuświk,[1] D. Wilgocka-Ślęzak,[4] M. Ślęzak,[5,6] T. Giela,[4] J. Raabe,[6] N. Pilet,[6] P. Mazalski,[7] J. Korecki,[4,5] A. Maziewski,[7] J. Dubowik,[1] and F. Stobiecki[1,2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[3] *Faculty of Technical Physics, Poznań University of Technology, Poznań, Poland*
[4] *Jerzy Haber Institute of Catalysis and Surface Science, Polish Academy of Sciences, Kraków, Poland*
[5] *Faculty of Physics and Applied Computer Science, AGH University of Technology, Kraków, Poland*
[6] *Swiss Light Source, Paul Scherrer Institut, Switzerland*
[7] *Faculty of Physics, University of Białystok, Białystok, Poland*

Arrays of dipolar coupled ferromagnetic nanostructres (artificial kagome spin ice) were produced using lift-off electron beam lithography and ultrahigh vacuum magnetron sputtering of permalloy ($Ni_{80}Fe_{20}$) films. The topologies of the structures were examined by: scanning electron microscopy, photoelectron microscopy (PEEM), and atomic force microscopy. Magnetic structures were observed with PEEM employing the XMCD effect and with magnetic force microscopy. The specific features of magnetic structure characteristic for artificial spin ice were recorded with both methods.

P-5-37

FMR evidence of stable ferromagnetic correlations at zigzag edge states in graphene

M.A. Augustyniak-Jabłokow,[1] M. Maćkowiak,[1] K Tadyszak,[2] and R. Strzelczyk[1,2]

[1] *Institute of Molecular Physics of PAS, Smoluchowskiego Str. 17, 60-179 Poznan, Poland*
[2] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska Str. 8, 61-614 Poznan, Poland*

According to theoretical predictions spins on the zig-zag edge of a graphene ribbons and flakes should interact ferromagnetically. But the edge magnetism is hardly observed. We have studied this problem experimentally, searching for the ferromagnetic resonance (FMR) signal associated with the correlated edge spins. We found such signal in the sample of a single layer graphene in a high vacuum. It showed very unusual temperature dependence of intensity. Very strong FMR signal, found in the freshly prepared samples of multilayer graphene and nanographite in vacuum, disappeared in several hours, presumably due to weak antiferromagnetic coupling between graphene layers. Recently we have found that for composite of paraffin and graphene flakes the FMR signal is stable in time and its temperature dependences of the intensity and positions is similar to that observed for the pristine graphene and can be interpreted in the frame of 1D-ferromagnetism.

P-5-38

Structural, spectroscopic and magnetic properties of the Eu^{3+}-doped $GdVO_4$ nanocrystals synthesized by hydrothermal method

A. Szczeszak,[1,2] T. Grzyb,[1] Z. Śniadecki,[2] N. Andrzejewska,[1] S. Lis,[1] M. Matczak,[2,3] G. Nowaczyk,[3] S. Jurga,[3] and B. Idzikowski[2]

[1] *Adam Mickiewicz University, Faculty of Chemistry, Department of Rare Earths, Grunwaldzka 6, 60-780 Poznań, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznań, Poland*

[3] *Nanobiomedical Centre at Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

The structural, spectroscopic and magnetic studies on the $Gd_{1-x}Eu_xVO_4$ (x = 0, 0.05 and 0.2) nanophosphors, synthesized using hydrothermal route, are presented and discussed. New aspects of the luminescent and magnetic properties of products obtained as well as the method of their synthesis are performed. Detailed analysis of the emission properties, *e.g.* asymmetry ratio R and luminescence lifetimes depended on the excitation wavelength was done. Moreover, for the first time in this group of nanomaterials, the explanation is not based on the giant spin model and the existence of thermally occupied low-lying excited states of Eu^{3+} ions.

P-5-39

Structure and magnetic properties of magnetic tunnel junctions with Ta/CuN/Ta and Ta/Ru/Ta buffer layers

J. Kanak,[1] M. Banasik,[1] A. Żywczak,[1,2] S. Ziętek,[1] M. Czapkiewicz,[1] W. Skowroński,[1] W. Powroźnik,[1] J. Wrona,[1,3] M. Frankowski,[1] and T. Stobiecki[1]

[1] *AGH University of Science and Technology, Department of Electronics, Krakow, Poland*

[2] *AGH University of Science and Technology, Academic Centre of Materials and Nanotechnology, Krakow, Poland*

[3] *Singulus Technologies AG, Hanauer Landstrasse 103, 63796 Kahl am Main, Germany*

Multilayer structures, designed for magnetic tunnel junctions fabrication, were prepared with two different buffer layers: 5 Ta / 50 CuN / 3 Ta / 50 CuN / 3 Ta and 5 Ta / 20 Ru / 3 Ta (thicknesses in nm) and investigated in order to analyze the structural and the magnetic properties. The structure of the samples was as follows: buffer / 16 PtMn / 2.0 $Co_{70}Fe_{30}$ / 0.9 Ru / 2.5 $Co_{40}Fe_{40}B_{20}$ / 0.6 - 1.1 wedge MgO / 2.5 $Co_{40}Fe_{40}B_{20}$ / 5 Ru. We present strong influence of buffer structure on crystallization of PtMn antiferromagnetic layer, roughness of magnetic layers and interlayer coupling energy.

This project is supported by the Polish National Science Center Grant 2012/05/E/ST7/00240 and Swiss Contribution by NANOSPIN PSPB-045/2010.

P-5-40

A DFT study of adsorption of copper-dioxolene complex at a gold surface

T. Ślusarski,[1] and T. Kostyrko[1]
[1] *Institute of Physics, A. Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

A problem of a modification of the electronic and magnetic structure of a metaloorganic complex by the process of chemisorption at a metallic surface is studied.[1] A model of a Cu-dioxolene complex is proposed and analyzed with the help of the density functional theory (DFT). Various conformations of both neutral and positively charged model complex are considered.[2] Next the molecule is connected to the Au(111) surface with alkanethiol linkers. A study of the dependence of the electronic and spatial structure on the linker length is performed. The conclusion is that properties of molecule are well preserved during the adsorption process and that the charge transfer from the molecule to the metallic substrate is sligthly affected by the length of the linking chain.

References:

[1] J. V. Barth, Surface Sci. **603**, 1533 (2009).
[2] P. Verma, J. Weir, L. Mirica, and T. D. P. Stack, Inorg. Chem. **50**, 9816 (2011).

This work has been supported by the National Science Centre under the contract DEC-2012/05/B/ST3/03208, DEC-2012/07/B/ST3/03412 and the grant No. NN202 480039. Most of our computations were performed at the PCSS (Poznań).

P-5-41

Atomic Structure, Magnetic Anisotropy and Magnetization Reversal in Fe films on Pt(997)

R. Fradczyk,[1] H. Bardenhagen,[1] K.-M. Wolf,[1] S. Rutsch,[1] and K. Fauth[1]
[1] *Physikalisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany*

Vicinal surfaces may serve as templates for the growth of films with nanoscale structural and strain modulation. In magnetic materials this gives rise to various contributions to the magnetic anisotropy energy density.

In our present work we revisit [1] the growth of Fe on Pt(997) and the resulting magnetic properties. Using electron diffraction (LEED, LEED-IV) we observe notable structural differences to previous reports under optimized growth conditions. The magnetic easy axis is rotated by 90° as a result. Our results suggest that the atomic structure established at the step edges provides the dominant contribution to the magnetocrystalline anisotropy energy density, even above the spin reorientation thickness.

We present and analyze in detail saturation magnetization, anisotropy field(s) and magnetization reversal at a Fe film thickness of five atomic layers.

References:

[1] D. Repetto *et al.*, Phys. Rev. B 74, 054408 (2006)

P-5-42

Properties of Cu/chromium-nickel steel multilayers made by PVD methods

B. Kucharska,[1] J. Kanak,[2] E. Olejnik,[1] A. Zywczak,[2] M. Hasiak,[3] and T. Stobiecki[2]
[1] *Czestochowa University of Technology, Czestochowa, Poland*
[2] *AGH University of Science and Technology, Krakow, Poland*
[3] *Wroclaw University of Technology, Wroclaw, Poland*

The magnetic properties of multilayers Cu/Ni are known because of their giant magnetoresistance effect. Under conditions of elevated temperature and diffusion between the components of multilayers their magnetic properties, such as magnetoresistance, decrease. In this work the chrome-nickel steel (AISI310S) was used as the ferromagnetic material in the multilayers. Austenitic chromium-nickel steel after the magnetron sputtering and depositon i onto Si-substrate has structure of ferrite. Ferritic structure is stable up to about 500degC. It can be assumed that due to the complex chemical composition of the steel components the mutual diffusion at the boundary interfaces could be slower than in Cu/Ni multilayers, and thus the multilayer retain their magnetoresistance in a wider temperature range. The AFM, X-ray and VSM investigation of Cu/CrNi steel multilayers with 50-150 bilayers were presented in the paper.

P-5-43

Oxidation kinetics of thin and ultra-thin Fe films

A. Marczyńska,[1] J. Skoryna,[1] M. Lewandowski,[1,2] and L. Smardz[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*
[2] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

We have studied oxidation kinetics of Fe thin films under atmospheric conditions using the fact that metallic iron is a ferromagnet but ultra-thin natural iron oxides are practically nonmagnetic at room temperature. As a consequence, oxidation is associated with a loss in ferromagnetism. Fe thin films were deposited onto 1.5 nm V buffer layer using UHV magnetron sputtering. As a substrate we have used Si(100) wafers with an oxidised surface. The chemical composition and the cleanness of all layers was checked in-situ, immediately after deposition, transferring the samples to an UHV analysis chamber equipped with XPS. Results show that all samples with an initial Fe thickness greater than 6 nm oxidize practically instantaneously, whereby a constant amount of 2.5 nm of metal is transformed into oxides. For Fe thickness lower than 6 nm the time constant for oxidation increases considerably and follows an approximately linear dependence with decreasing film thickness.

This work was financially supported by the MNiSW grant No. IP2011 030071 and NCN grant No. 2012/05/D/ST3/02855.

P-5-44

Magnetic centers in functionalized graphene

Ł. Majchrzycki,[1,2] M.A. Augustyniak-Jabłokow,[3] R. Strzelczyk,[3,4] and M. Maćkowiak[3]

[1] *Institute of Physics, Poznan University of Technology, Nieszawska 13a, 60-965 Poznan; Poland*

[2] *Wielkopolska Centre of Advanced Technology, Adam Mickiewicz University, Grunwaldzka Str. 6, 60-780 Poznan, Poland*

[3] *Institute of Molecular Physics of PAS, Smoluchowskiego Str. 17, 60-179 Poznan, Poland*

[4] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska Str. 8, 61-614 Poznan, Poland*

We study magnetic properties of variously functionalized graphene. The attached functional groups or adatoms can be treated as defects perturbing the periodicity of the crystal field potential and introducing sp^3 hybridization. Paramagnetic centers appearing in such materials can be due to functional groups or local instabilities of the electronic structure of graphene. In this report we analyze ESR and FMR signals observed in graphene oxide (GO), hydrazine reduced GO, GO reduced thermally in air and in paraffin and lithium doped reduced graphene oxide. For an explanation of the origin of these signals we analyze the temperature dependence of parameters characterizing the investigated spectrum and take into account the specific nature of functionalization of each material.

P-5-45

Growth and structural characterisation of Fe/V multilayers

B. Szymański,[1] J. Skoryna,[1] A. Marczyńska,[1] and L. Smardz[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland*

The Fe/V multilayers (MLs) were prepared at room temperature using UHV magnetron sputtering. A capping layer of 5 nm Pd was used to prevent oxidation. As a substrate we have used Si(100) wafers with an oxidised surface. The surface chemical composition and the cleanness of all layers was checked in-situ, immediately after deposition, transferring the samples to an UHV analysis chamber equipped with X-ray photoelectron spectroscopy (XPS). The structure of the MLs has been studied ex-situ by X-ray reflectivity (XRR) and diffraction (XRD) using copper radiation. The modulation wavelength was determined from the spacing between satellite peaks in the low-angle XRD patterns. Results were consistent with the values obtained from total thickness divided by the number of repetitions. The thicknesses of individual Fe and V sublayers were also determined using X-ray fluorescence analysis. Growth of the Fe (V) on 1.5 nm – V (Fe) underlayer was studied by succesive deposition and XPS measurments starting from 0.2 nm of Fe (V) layer, respectively. From the exponential variation of the XPS Fe-2p and V-2p integral intensities with increasing layer thickness we conclude that the Fe and V sublayers grow homogeneously.

P-5-46

Some aspects of the inelastic photon scattering on magnons in YIG

A. Lehmann-Szweykowska,[1] R.J. Wojciechowski,[1] and A. Walczak[1]
[1] *A. Mickiewicz University Faculty of Physics, ul. Umultowska 85, 61-614 Poznan, Poland*

We propose and discuss a very simple model of the inelastic photon scattering on magnons in thin films of YIG [1]. Among other questions, we touch the one what influence surface nanostructures can have on the spectrum of the magnons and the latters' interactions with the light photons. The nanostructures can be either natural or artificially manufuctured. Our analysis is inspired by a renewed interest in different puzzling properties of the YIG magnons such as the Bose-Einstein condensation of the magnon gas in YIG at room temperature [2] or using garnets as magnonic materials [3].

References:

[1] W Wettling, M G Cottamand and J Sandercock, J.Phys.C: Solid State Phys.8, 211 (1975)
[2] S.M. Rezende, Phys.Rev.B79,174411(2009)
[3] A A Serga, A V Chumak and B Hillebrand, J.Phys.D: Appl.Phys.43, 264002 (2010)

P-5-47

Study of the angular dependence of ferromagnetic resonance in nanorods

Maciej Kasperski,[1] and Henryk Puszkarski[1]
[1] *Surface Physics Division, Faculty of Physics, Adam Mickiewicz University*

We have developed a theory describing the magnetization dynamics in nanorods under an external magnetic field oriented arbitrarily with respect to the symmetry axis of the nanorod. First we determine the non-collinear ground state by Monte Carlo simulation. In the next step we calculate numerically the spin-wave spectrum by solving the system of coupled Landau-Lifshitz equations of motion. A single FMR peak is observed at a certain (critical) angle between the external field vector and the symmetry axis of the nanorod; the singlet splits into a multi-peak spectrum as the field is tilted from this critical orientation. We attempt to elucidate the physical grounds of this numerically disclosed resonance effect in magnetic nanorods. This study is a part of a project financed by Narodowe Centrum Nauki (National Science Center of Poland), Grant no. DEC-2013/08/M/ST3/00967.

P-5-48

Nonlinear effects in thermal transport: quantum dot connected with three leads

Marcin Urbaniak,[1] Grzegorz Michałek,[1] and Bogdan R. Bułka[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

We consider thermal transport of electrons through a single-level quantum dot coherently coupled with three electrodes, where one of them is floating. Calculations of charge and heat current are performed by means of non-equilibrium Green functions. We show that flowing currents induce a voltage and temperature in the floating electrode with strongly nonlinear characteristics in the isothermal, isopotential and adiabatic regime. Detailed calculations and analytical expressions of transport coefficients up to the second order are presented. Crossover between the low temperature limit, obtained using Sommerfeld expansion, and high temperature is analyzed. Additionally we present the entropy production in the isothermal, isopotential and adiabatic case. Our studies are motivated by investigations of efficient energy conversion devices in nanoscale.

The work has been supported by NCN under the contract DEC-2011/01/B/ST3/04428 and DEC-2012/05/B/ST3/03208.

P-5-49

Influence of the Schottky barrier on conductance of metal-semiconductor nanocontacts

M. Wawrzyniak,[1] D. Tomaszewski,[2] P. Busz,[2] and J. Martinek[2]

[1] *Faculty of Electronics and Telecommunications, Poznan University of Technology, 60-965 Poznan, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*

The break-junction technique is widely used to create atomic-scale nanocontacts. We use this technique to create nanocontacts at the metal-semiconductor interface and demonstrate that step-like conductance traces resulting from quantum conductance effects are possible to observe in the presence of the Schottky barrier. In our investigations the temporary histogram is applied to detection the barrier. We have developed the experimental setup that allows to measure the I-V characteristic for the last stable configuration of atoms in the nanocontact just before breaking. The I-V characteristics have been determined for several metals. This characteristics have nonlinear character, which demonstrate the influence of the Schottky barrier on the nanocontacts conductance.

References:

[1] Makk P., Tomaszewski D., Martinek J., Balogh Z., Csonka S., Wawrzyniak M., Frei M., Venkataraman L., Halbritter A., ACS Nano **6**, 34111 (2012).

[2] Wawrzyniak M., Maćkowski M., Śniadecki Z., Idzikowski B., Martinek J., Acta Physica Polonica A **118**, 375 (2010).

P-5-50

Unusual temperature and pressure dependencies of FMR signal observed for Ni/C in the polymer matrix.

A. Krupska,[1] M.A. Augustyniak-Jabłokow,[1] J. Typek,[2] and N. Guskos[2,3]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, ul. M. Smoluchowskiego 17, 60-179 Poznań, Poland*

[2] *Institute of Physics, West Pomeranian University of Technology, Al. Piastow 48, 70-311 Szczecin, Poland*

[3] *Solid State Section, Department of Physics, University of Athens, Panepistimiopolis, 15 784, Greece*

FMR study of carbon coated nickel nanoparticles in the PBT-block-PTMO polymer show unusual temperature and pressure dependencies of signal parameters. A decrease of the resonance field with temperature is accompanied by increase of the line width. Hydrostatic pressure causes increase of resonance field and narrowing of the line width. These phenomena can be understood on the assumption that the nickel nanoparticles, with the average diameter of 10-20 nm have some degree of freedom in the polymer matrix. As a result, part of them can perform a small turn to the direction of the external magnetic field. This influences the effective resonance field of nanoparticles in composite and increases the effective anisotropy, which effects the line width. Hydrostatic pressure acts mainly on the matrix, which compression forces return of nanoparticles to the initial arrangement.

P-6-01

Anhysteretic Functions for the Jiles-Atherton Model

Edmund Kokornaczyk,[2] and Marek W. Gutowski[1]
[1] *Institute of Physics, Polish Academy of Sciences, 02-668 Warszawa, Poland*
[2] *no current affiliation*

The Jiles-Atherton (JA) model of ferromagnetic hysteresis usually bases on the Langevin function as its anhysteretic part. This leads to a problem, since for some known materials the anhysteretic curve may not be modeled in view of fact, that the coupling parameter α, as determined from their major hysteresis loop, is too large, i.e. greater than the value permissible for the Langevin function. Therefore a new function is required in order to omit this mathematical dilemma. Here we present a set of simple functions, with their knees depending on one parameter only. Also a more complicated function, with knee location depending on two parameters is analyzed – however the Brillouin function again does not solve the difficulty with α. Therefore, within the frame of JA model, a new function is proposed, making possible to have the initial differential susceptibility arbitrarily small. Moreover the strenghtening of the effective field is taken into account and the permissible values of the second coupling parameter β, in respect to the Brillouin and Langevin functions, are presented. Finally, our new function is successfully used to model the measured anhysteretic curve.

P-6-02

Fragmentation of Co-Fe-Ta-B soft magnetic amorphous alloy

J. Miškuf,[1] K. Csach,[1] A. Juríková,[1] M. Huráková,[1] and E.D. Tabachnikova[2]
[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*
[2] *B. Verkin Institute for Low-temperature Physics and Engineering UAS, Kharkov, Ukraine*

The main limitation of high-strength Co-based bulk metallic glasses for their application as structural materials is the large brittleness. Spontaneously emerging cracks in the alloy degrade the magnetic properties. We analyzed the failure characteristics of $Co_{43}Fe_{20}Ta_{5,5}B_{31,5}$ bulk soft magnetic metallic glass deformed in a compression at the room temperature and a low strain rate. Under loading the amorphous structure store high elastic energy. During the failure this energy is released and the alloy breaks into small particles or powder exhibiting a fragmentation mode.

This work was supported by the Project of SF EU No. 26110230097

P-6-03

Core Loss of Compacted NiFeMo Powder

Denisa Olekšáková,[1] Peter Kollár,[2] and Ján Füzer[2]

[1] *Department of Applied Mathematics and Informatics, Faculty of Mechanical Engineering, Technical University in Košice, Košice, Slovakia*

[2] *Institute of Physics, Faculty of Science, P. J. Šafárik University, Košice, Slovakia*

Supermalloy is a soft magnetic material with extremely high initial and maximum permeability and low coercivity. Supermalloy (usually $Ni_{79}Fe_{16}Mo_5$) is fabricated in the form of thin sheet, in the form which is not convenient for some applications; therefore it is logical to attempt to prepare such material in more bulk form.
The aim of this work was to investigate dc (magnetization curves, initial and maximum permeability) and ac magnetic properties of bulk soft magnetic materials in the form of a ring prepared by the compaction of $Ni_{79}Fe_{16}Mo_5$ powder obtained by milling of small swarfs for 1 or 100 hours in planetary ball mill.
From the frequency dependences of the core loss (dc to 50 Hz) were calculated the components of the loss: dc loss, classical loss and domain wall eddy current loss.

P-6-04

Magnetic properties of a novel $CeCo_{0.715}Si_{2.285}$ compound

J. Moudřík,[1] J. Prokleška,[1] I. Císařová,[2] J. Pospíšil,[1] and V. Sechovský[1]

[1] *Charles Univ, Fac Math and Phys, Department of Condensed Matter Physics, Ke Karlovu 5, 121 16 Prague 2, Czech Republic*

[2] *Charles Univ, Fac Sci, Department of Inorganic Chemistry, Hlavova 2030/8, 128 43 Prague 2, Czech Republic*

We report on the basic physical properties of a novel $CeCo_{0.715}Si_{2.285}$ compound, mainly its rich magnetic phase diagram. Using the Czochralski method (single) crystals have been grown for the first time. The compound crystallizes in the *I-42m* space group structure with extremely prolongated unit cell ($a = 4.12$ Å, $c = 32.84$ Å). In a zero magnetic field it orders antiferromagnetically at $T_N = 10.5$ K with another order-to-order transition at 9.5 K. Under application of a magnetic field along the c-axis it manifests numerous magnetic phases in small fields ($B < 500$ mT), similar to the so-called "devil's staircase" systems, however, having the high field state stable with respect to field removal. Above 1 T the magnetization is almost unchanged up to 14 T (maximum magnetic field applied within our study) and quite reduced (0.3 μ_B/Ce) with respect to the free Ce^{3+} ion. The compound also exhibits strong hysteresis of magnetization in temperature and magnetic field. For fields applied along the a-axis a typical behavior for the antiferromagnetic hard axis is observed.

P-6-05

Structural stability of amorphous alloy of modified Finemet type

M. Hurakova,[1] K. Csach,[1] A. Jurikova,[1] J. Miskuf,[1] M. Rajnak,[1] and T. Kvackaj[2]
[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*
[2] *Department of Metals Forming, Faculty of Metallurgy, Technical University of Košice, Košice, Slovakia*

The Finemet type amorphous alloys are well known as high frequency soft magnetic materials. Because of the lack of crystalline anisotropy, they have good soft magnetic properties characterized by low coercive force and high permeability. The structural stability of Finemet type amorphous alloy modified by Mn, Al and Cr was studied using calorimetric measurements of the Curie temperature. With increasing the crystalline portion in the samples, the Curie transition is shifted to the higher temperatures.

The work was supported by the project in the frame of SF EU No. 26110230097.

P-6-06

The crystal and magnetic properties of some Fe-Nb-B-Ni bulk alloys

M. Kądziołka-Gaweł,[1] and A. Chrobak[1]
[1] *Institute of Physics, University of Silesia, Katowice, Poland*

The crystal and magnetic properties of $(Fe_{80}Nb_6B_{14})_{1-x}Ni_x$ (x=0.1, 0.2 and 0.4) bulk alloys prepared by making use of mould casting technique [1] has been studied by X-ray diffraction, magnetostatic and Mössbauer effect methods. Structural and magnetic properties of investigated bulk alloys were compared with polycrystalline $Fe_{1-x}Ni_x$ (x= 0.1, 0.2 and 0.4) alloys. The measurements showed that the crystal and magnetic nonhomogeneity for bulk alloys are higher than in polycrystalline compounds what confirms many magnetic transformations above temperature 500 K and wide magnetic hyperfine field distribution from 0T to 36T. The mean diameters of crystallites for $(Fe_{80}Nb_6B_{14})_{1-x}Ni_x$ alloys was calculated from X-ray line broadening and were bigger then 10 nm. The mean magnetic moment of alloys and average magnetic hyperfine fields decreases with increasing of nickel concentration in investigated compounds.

References:

[1] A.Chrobak, M.Karolus, G.Haneczok, Sol. St. Phen., 163 (2010) 233-238.

P-6-07

Atom force microscopy and magnetic force microscopy investigations of the thin films Finemet-type alloy

E. Mikhalitsyna,[1] V. Kataev,[1] P. Geydt,[2] and V. Lepalovsky[1]

[1] *Ural Federal University named after the first President of Russia B.N. Yeltsin*

[2] *Lappeenranta University of Technology*

Research is devoted to the investigation of the thin films Finemet-type alloy with a thickness of 10, 45, 440, 796 nm. The samples were prepared by RF (radio frequency) sputtering technic of $Fe_{72,5}Cu_{1,1}Nb_{1,9}Mo_{1,5}Si_{14,2}B_{8,7}$ targets. Sputtering was held in Ar atmosphere under pressure 1-2$\times 10^{-6}$ Torr. Thin films have been investigated in amorphous state and after annealing at temperatures 450 ^{o}C and 540 ^{o}C. Topography, magnetic pattern and mechanical properties were measured on the AFM Multimode 8 using Si probes Co-Cr coated probes. Two main results have been obtained. Firstly, topography shows formation of the nanocrystalline state for annealed samples. In amorphous state hills were not observed. Diameter of hills and their amount for annealed samples is rises with increasing of annealing temperature. Secondly, from magnetic patterns relationship between topography and magnetic structure of samples were not detected. Samples have inhomogeneous magnetic structure that can be described in frame of Random Anisotropy Model and by using fractal analysis.

References:

[1] J. Balcerski, R. Brzozowski, M. Wasiak, K. Polanski, M. Moneta, Vacuum 83, 5182-5185 (2009).

P-6-08

Determination of Critical Exponents and Order of Phase Transition in the $LaFe_{11.14}Co_{0.66}Si_{1.2}$ Alloy

P. Gębara,[1] P. Pawlik,[1] I. Skorvanek,[2] J. Marcin,[2] and J.J. Wysłocki[1]

[1] *Institute of Physics, Czestochowa University of Technology, Al. Armii Krajowej 19, 42 – 200 Czestochowa*

[2] *Institute of Experimental Physics, SAS Watsonowa 47 043 33 KOSICE SLOVAKIA*

Critical exponents (β, γ, δ) and magnetic phase transition of the $LaFe_{11.14}Co_{0.66}Si_{1.2}$ alloy were investigated. The ingot sample was obtained by arc – melting under the low pressure Ar atmosphere. Subsequently the alloy was annealed at 1323K for 15 days. Magnetic measurements at various temperatures allowed to study critical exponents by Kouvel-Fisher method. Additionally, magnetic investigations allowed to determine the order of phase transition from ferro- to paramagnetic state based on the Landau theory.

Work supported by the research project No. NN 507 233 040 in years 2011 – 2014 financed by National Science Centre. Ivan Škorvánek and Jozef Marcin acknowledge the support of APVV-0492-11, VEGA 2/0192/13 and Cex CFNT-MVEP.

P-6-09

The influence of Nb atoms on the crystallization process of Fe-B-Nb amorphous alloys

R. Babilas,[1] and M. Kądziołka-Gaweł[2]

[1] *Institute of Engineering Materials and Biomaterials, Silesian University of Technology, Konarskiego 18a, 44-100 Gliwice, Poland*

[2] *Institute of Physics, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

The ferromagnetic Fe-based amorphous alloys have been studied due to the attractive properties for soft magnetic applications. Depending on different Nb concentration, we studied the formation of crystalline phases in annealed samples of amorphous metallic alloys for $Fe_{80-x}B_{20}Nb_x$ (x = 0, 4, 10). The nature of the crystallization products as well as the phase structure was determined using Mössbauer Spectroscopy combined with XRD and DSC results. Substitution of Fe atoms by Nb lead to significant changes in hyperfine magnetic field (B_{hf}) distributions in as-quenched amorphous alloys $Fe_{80-x}B_{20}Nb_x$, for x = 10 the minimal value of B_{hf} is observed. Addition of this element causes shift of crystallization process towards higher temperatures and induces formation of phase complex including the α-Fe, Fe_2B and Fe_3B. Combination of X-ray diffraction and Mössbauer Spectroscopy is very useful method in studying the structural environment of Fe atoms on a nearest-neighbor length scale.

P-6-10

A Henkel plots computer modeling of an exchange coupled isotropic single-domain ensemble

A. Bolyachkin,[1] and A. Volegov[1]

[1] *Ural Federal University named after First President of Russia B.N. Yeltsin, Yekaterinburg, Russia*

A Henkel plot technique is widely used for an analysis of single-domain isotropic magnetic ensembles from the point of view of interactions between its elements. It based on a comparison of relations between normalized isothermal remanent magnetization $m_r(H)$ and dc demagnetization remanence $m_d(H)$, which characterized by δM, for investigated objects and Stoner-Wohlfarth ensemble of small noninteracting particles [1]. In a compliance with recent works [2] a positive contribution to the δM is considered as a result of exchange interaction. Nevertheless any quantitative analysis of Henkel technique have not been done reliably yet. In presented work dependence of Henkel plots maximums and intergrain exchange interaction in uniform ensemble of grains is studied using computer modelling methods. A functional dependence of δM maximum value on the intergrain exchange interaction constant is proposed. In aims of experimental verification material parameters (J_s, exchange constant A_{IEI} and magnetocrystalline anisotropy K) for $Nd_2Fe_{14}B$ are used.

References:

[1] P.E. Kelly, K.O'Grady *et al.*, IEEE Trans. Magn. 25, 3881 (1989)

[2] H. Zhang, C. Rong *et al.*,Appl. Phys. Lett. 82, 4098 (2003)

P-6-11

Measurements of magnetocaloric effect in $LaFe_{11.14}Co_{0.66}Si_{1.2-x}Al_x$ (x=0.1, 0.2, 0.3) alloys

P. Gębara,[1] P. Pawlik,[1] B. Michalski,[2] and J.J. Wysłocki[1]
[1] *Institute of Physics, Częstochowa University of Technology, Al. Armii Krajowej 19, 42 – 200 Częstochowa*
[2] *Faculty of Materials Engineering, Warsaw University of Technology, ul. Wołoska 141, 02 – 507 Warszawa*

In present work, phase constitution and termomagnetic properties of $LaFe_{11.14}Co_{0.66}Si_{1.2-x}Al_x$ (where x= 0.1, 0.2, 0.3) alloys were investigated. Ingot samples were obtained by arc – melting under the low pressure Ar atmosphere. Subsequently samples were annealed at 1323K for 15 days. X-ray diffraction of all samples revealed coexistence of two crystalline phases dominant $La(Fe,Si)_{13}$ – type and minor bcc α-Fe. Furthermore, the magnetic measurements at various temperatures allowed to study Curie temperature, magnetic entropy changes and cooling capacity. Additionally, magnetic investigations allowed to determine the order of phase transition from ferro- to paramagnetic state.

Work supported by the research project No. NN 507 233 040 in years 2011 – 2014 financed by National Science Centre.

P-6-12

Magnetization Reversal Processes in Nanocrystalline (Pr,Dy)-(Fe,Co)-B Bulk Alloys

A. Przybył,[1] P. Gębara,[1] P. Pawlik,[1] K. Pawlik,[1] and J.J. Wysłocki[1]
[1] *Institute of Physics, Czestochowa University of Technology, Armii Krajowej 19, 42-200 Czestochowa*

The aim of this paper was to study the phase constitution, magnetic properties and magnetization reversal processes in the rapidly solidified bulk (Pr, Dy)-(Fe, Co)-B alloys doped with Zr, Ti, Mn and Ni. The 3 mm outer diameter tubes samples of the $Pr_8Dy_1Fe_{60}Co_7Ni_{(6-x)}Mn_xB_{14}Zr_1Ti_3$ (where x = 0, 3, 6) alloys were produced by suction-casting technique. The admixture of Zr was introduced in order to improve their glass forming abilities while Dy was substituted to enhance the magnetocrystalline anisotropy of hard magnetic phase. The effect of Ni and Mn addition on the phase constitution and magnetic properties was studied in the presented work. The phase constitution was investigated by X-ray diffractometry. The XRD analysis revealed that the tube samples were crystalline in as-cast state. The magnetic parameters were determined from hysteresis loops measured in the external magnetic field up to 2T at room temperature. Furthermore, rates of irreversible magnetization changes upon the change of external magnetic field H, were studied to determine magnetization reversal processes. In order to characterize interactions between grains of crystalline phases the δM plots were also constructed from recoil curves.

P-6-13

Magneto-optical and Optical Investigation of the Surface Region of Ion implanted Garnet Films.

L. Kalandadze[1]

[1] *Dept. of Physics, Batumi State University*

In the present work we have shown the efficiency of complex investigation of the ion implanted garnet surface region by magneto-optical and optical methods [1]. With the aid of the odd-magnetization equatorial Kerr effect it has been found that implantation leads to a significant inhibition of the growth of anisotropy. The latter is expressed in the decrease of the amount of saturation fields in- plane films. It has shown that ion implantation influences significantly the magneto-optical properties of the garnet films and practically does not change its optical characteristics. We have also determined the spectral dependences of the component of the tensor of dielectric permittivity for the surface of ion implanted ferrite-garnet films before and after implantation process. These calculations let us evaluate the influence of implantation on an electronic energy structure of the surface layer for the sample.

References:

[1] L. Kalandadze: Influence of Implantation on the Magneto-Optical Properties of garnet surface. IEEE Trans. on Magnetics, vol. 44, No. 11, (2008), 3293-3295

P-6-14

Fabrication of Soft Magnetic Fe-based Nanocrystalline Wide-Ribbons towards Industrial Application

A.D. Setyawan,[1] K. Takenaka,[1] M. Yokoyama,[1] N. Nishiyama,[1] and A. Makino[1]

[1] *Inst. for Materials Research, Tohoku University, Sendai 980-8577, Japan*

Success in development of nanocrystalline Fe-Si-B-P-Cu soft-magnetic alloys, NANOMET[1], has urged the materials to be used in industrial application. Fabrication of wide ribbons or atomized powder is, therefore, crucial for making prototype products, such as cores for transformers or motors. This paper reports the fabrication of wide ribbons having widths of 50 mm and 80 mm and a length of 70 m of a new NANOMET alloy by single-roll melt spinning technique. The as-quenched ribbons (25-μm thick) have amorphous structure and good outside appearance. The nanocrystalline ribbons, resulting from the optimum annealing, exhibit excellent soft-magnetic properties, i.e. low coercivity (Hc) of 7 A/m and high saturation magnetostriction (Bs) of 1.8 T. Low core-loss (W at 50 Hz) of 0.4-0.5 W/kg under maximum flux density of 1.5 T, which is much smaller than that of the commercially-used oriented/non-oriented Si-steels, regards the applicability of the alloys as magnetic core materials for electric power devices.

References:

[1] A. Makino, IEEE Trans. Magn., 48 (2012) 1331

P-6-15

Structural Analyses for $Fe_{85.2}Si_1B_9P_4Cu_{0.8}$ Nanocrystalline Soft Magnetic Alloy by XAFS and TEM

M. Nishijima,[1] M. Matsuura,[1] K. Takenaka,[1] and A. Makino[1]

[1] *Institute for Materials Research, Tohoku University, Sendai, Miyagi, 980, Japan*

New soft magnetic alloys $Fe_{85-86}Si_{1-2}B_8P_4Cu_1$ (NANOMET) developed by Makino *et al*[1] exhibit low *Hc*∼5.8 A/m and low magnetic core loss (*W*) as well as high *Bs*∼1.8 T. Because their soft magnetic properties depend significantly on the grain refining of α-Fe precipitates, it is quite important to understand the nanocrystallization kinetics of NANOMET. In this work, the structural change during the nanocrystallization of $Fe_{85.2}Si_1B_9P_4Cu_{0.8}$ alloy is investigated by means of X-ray absorption fine structure (XAFS) and transmission electron microscope (TEM). The transformation from amorphous structure starts below the 1st crystallization temperature and a primary crystalline phase α-Fe crystallites begin heterogeneously nearby fcc Cu-clusters. A short range order of a bcc structure develops before the formation of the long range bcc structure and transforms entirely into bcc structure at optimum heating condition. Close relationships between the local structure change around Cu and progress of bcc-Fe precipitation are confirmed by XAFS and TEM observatn.

References:

[1] A. Makino, IEEE Trans. Magn., vol. 48, pp. 1331-1335, Apr. 2012.

P-6-16

Order-disorder transition in 2D conserved spin system with cooperative dynamics

K. Halagan,[1] and P. Polanowski[1]

[1] *Department of Molecular Physics, Lodz University of Technology, 116 Zeromskiego Street, 90-924 Lodz, Poland*

Order-disorder phase transition in classic Ising system has been intensively investigated for many years. Less attention was put on a case with conserved spin number (called conserved order parameter model). In our work we propose the use of Dynamic Lattice Liquid (DLL) model to investigate the dynamics of phase separation phenomenon in spin conserved system with all lattice sites occupied. DLL model enables non-locally correlated relaxation dynamics and allows to simulate dense systems in absence of vacancies and parallel treatment of all spins. DLL algorithm was successfully used for diffusion limited aggregation problem, polymer dynamics and reaction front evolution investigation. In our studies interactions were defined by standard Ising Hamiltonian for simple magnetic system $E = -(J/k_B T)\sum_{<i,j>} \sigma_i\sigma_j$, $i, j = -1, 1$. This approach can be regarded as a mixture of spin liquids with repulsive nearest neighbor interactions undergoing spinodal decomposition process. Simulations were performed on two dimensional triangular lattice. The special emphasis was put on thermodynamic quantities, temporal evolution of domain morphology and diffusion.

P-6-17

Magnetic properties of cold rolled Gd in high fields

S. Taskaev,[1] M. Ulyanov,[1] D. Bataev,[1] V. Buchelnikov,[1] K. Skokov,[2] A. Pellenen,[3] and V. Khovaylo[4]

[1] *Chelyabinsk State University, Chelyabinsk, Russia*
[2] *TU Darmshtadt, Darmshtadt, Germany*
[3] *National Research South Ural State University, Chelyabinsk, Russia*
[4] *National University of Science and Technology "MISIS", Moscow, Russia*

This work reports the magnetic properties of thin Gd ribbons obtained with the help of severe plastic deformation (SPD) technique. SPD are very interesting for designing novel functional materials. Depending on the degree of deformation, magnetic, structural or thermodynamic properties could be varied in severely deformed materials, especially in thin ribbons of SPD-treated materials. The reason of such behavior is in a giant magnetic anisotropy induced by SPD. This unexpected phenomena drives to a new thermodynamic and magnetic properties of severely deformed Gd ribbons (1) which are inapplicable for magnetocaloric applications without additional heat treatment procedure. In this work we continue our previous investigations of the SPD on the magnetic properties of 4-f elements, with special accent on magnetic anisotropy.

References:

[1] S.V.Taskaev, M.D.Kuz'min, K.P.Skokov, D.Yu.Karpenkov, A.P.Pellenen, V.D.Buchelnikov and O.Gutfleisch, JMMM 331, 33 (2013)

Authors appreciate RFBR grant 12-07-00676-a for financing this work

P-6-18

Magnetic Properties and Phase Constitution of the Nanocrystalline $(Nd_{10}Fe_{67}B_{23})_{100-x}Nb_x$ (where x=1,2,3,4) Alloy Ribbons

M. Szwaja,[1] K. Pawlik,[1] P. Pawlik,[1] P. Gębara,[1] A. Przybył,[1] and J.J. Wysłocki[1]

[1] *Institute of Physics, Częstochowa University of Technology, Armii Krajowej 19, 42-200 Częstochowa, Poland*

In the present work the magnetic properties and phase constitution of $(Nd_{10}Fe_{67}B_{23})_{100-x}Nb_x$ (where x=1,2,3,4) alloys in a form of ribbons were studied. The base alloys were prepared by arc-melting under an Ar atmosphere of the high purity elements with pre-alloyed Fe-B. The ribbon samples were obtained by controlled atmosphere melt-spinning technique. In order to generate the nanocrystalline microstructure, ribbons were annealed at various temperatures (from 923K to 1023K) for 5 minutes. The aim of present work was to determine the influence of Nb addition and annealing conditions on the phase constitution and magnetic properties.

Work supported by the research project No NN507 240840 in years 2011-2014 financed by Polish National Science Centre.

P-6-19

Mössbauer spectroscopy investigation of YFe_xCo_{2-x} (x = 0.03 and 1) compounds

Z. Śniadecki,[1,2] M. Kopcewicz,[3] N. Pierunek,[1] R. Puźniak,[4] A. Wiśniewski,[4] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*
[2] *INT, KIT, Eggenstein-Leopoldshafen, Germany*
[3] *Institute of Electronic Materials Technology, Warszawa, Poland*
[4] *Institute of Physics, PAS, Warszawa, Poland*

YCo_2 compound is an exchange-enhanced Pauli paramagnet on the verge of being magnetic. Ferromagnetic long-range ordering can be induced by topological or chemical disorder [1]. The influence of Fe substitution and quenched-in topological disorder on the magnetic properties of $YFe_{0.03}Co_{1.97}$ and YFeCo is studied by means of x-ray diffraction, vibrating sample magnetometry, Mössbauer spectroscopy and AC magnetic susceptibility measurements. All samples crystallize in cubic $MgCu_2$-type phase with lattice constant changing from 7.223 Å for YCo_2 to 7.313 Å for YFeCo. Fe atoms are responsible for stabilization of magnetic moments on Co and mictomagnetism is observed in $YFe_{0.03}Co_{1.97}$ sample. The Mössbauer spectra permitted distinction between two magnetically inequivalent Fe sites, as reported earlier for YFe_2 [2].

References:

[1] Z. Śniadecki et al., J. Appl. Phys. 115 (2014) 17E129
[2] Y. Nishihara et al., J. Phys. Soc. Jpn. 51 (1982) 2487-2492

P-6-20

Electromagnetic waves generation in $Ni_{2,14}Mn_{0,81}GaFe_{0,05}$ Heusler alloy at structural phase transitions

I.V. Bychkov,[1] D.A. Kuzmin,[1] A.P. Kamantsev,[2] V.V. Koledov,[2] D.V. Kalenov,[2] D.S. Kuchin,[2] and V.G. Shavrov[2]

[1] *Chelyabinsk State University, Chelyabinsk, Russia*
[2] *Kotelnikov Institute of Radio-engineering and Electronics of RAS, Moscow, Russia*

In recent years both theoreticians and experimentalists have heightened interest in new effects of electromagnetic waves generation under nonequilibrium processes in condensed media. Phase transitions (PT) of 1st and 2nd orders are progressing at significant deviation from equilibrium state, and in this case the medium is active, i.e. it is capable to emit energy as electromagnetic and acoustic waves. So, there is a jump of magnetization ΔM or polarization ΔP of a sample at PT in the magnetic or electrodipole subsystem respectively, which lead to generation of electromagnetic and acoustic fields pulses. Structural phase transitions of 1st order have a more complex nature of the radiation. Structural PT goes during a certain time when nuclei of a new phase, phase boundaries, various defects, dislocations and fractures may form in the sample, what lead to the generation of electromagnetic and acoustic pulses. In this work we investigate both experimentally and theoretically the electromagnetic response and the ability to electromagnetic wave self-radiation at a free surface of the sample Heusler alloy $Ni_{2,14}Mn_{0,81}GaFe_{0,05}$.

P-6-21

Study of biphase microwires magnetic properties in temperature range from 295 to 1200 K

I. Iglesias,[1] R. El Kammouni,[2] K. Chichay,[1] N. Perov,[3] V. Rodionova,[1] and M. Vazquez[2]

[1] *Immanuel Kant Baltic Federal University, 236041 Kaliningrad, Russia*
[2] *Materials Science Institute of Madrid, CSIC, 28049 Madrid, Spain*
[3] *Faculty of Physics, Lomonosov Moscow State University, 119991 Moscow, Russia*

To operate with objects of micro and nanosizes it is necessary to have small "instruments". For this purpose we can use a microactuator, made of a partially covered magnetically biphase microwire, which can be controlled by means of a magnetic field. In this work we have studied, analyzed and compared the magnetic properties of two series of fully covered magnetically biphase microwires with different thickness of the hard or soft shell, in order to understand the magnetostatic interaction between the shell ($CoNi$- or $FeNi$- based) and the core (Fe- or $FeCo$-based glass-coated microwires). The magnetic properties were analyzed as a function of temperature in the range from 295 K to 1200 K using a Vibrating Sample Magnetometer (Lake Shore). The magnetic properties of samples varied with the thickness of the shell. Analysis of the magnetization process of each phases with measuring temperature has been performed.

P-6-22

Hyperfine fields in Ba and Sr hexaferrites changed by lattice deformations

V. Chlan,[1] K. Kouřil,[1] and H. Štěpánková[1]

[1] *Faculty of Mathematics and Physics, Charles University in Prague, V Holesovičkách 2, 180 00 Prague 8, Czech Republic*

M-type hexagonal ferrites are well established magnetic materials providing a broad range of applications and displaying many interesting phenomena. Recently our ^{57}Fe nuclear magnetic resonance (NMR) experiments on thin films of barium and strontium hexaferrites revealed a slight anomaly in spectral line shifts. NMR spectroscopy is capable of distinguishing the effect of global fields, e.g., due to demagnetization field, from the effect of local fields corresponding to particular crystal sites. Our measurements indicate that an additional mechanism other than macroscopic field contributes to the resulting spectrum. In order to investigate whether the deformation of structure is connected with the changes to the local fields, we perform a structural study by means of electronic structure calculations. Barium and strontium hexaferrites with various volumes and c/a ratios are calculated, and subsequently the hyperfine fields on iron nuclei are extracted using our semi-empirical method based on the calculated magnetic moments.

P-6-23

Magnetization processes of nanoparticles embedded into ferromagnetic matrix

G. Ziółkowski,[1] and A. Chrobak[1]

[1] *Institute of Physics, Uniwersytecka 4, 40-007 Katowice, Poland*

In the field of hard magnetics, interactions between the phases are important and can lead to an appearing of new and unique properties. Especially interesting is an influence of interacting surroundings on magnetization presses of magnetic nanoparticles and a comparison with the Stoner-Wohlfarth model describing magnetic response of single ferromagnetic particle. Magnetic objects can be characterized by the so-called blocking energy E_B and overall magnetic moment μ. The main problem is some obvious indistinguishability - at a given temperature T and field H - let say an object α and β behave similarly (can be activated with the same probability) when $E_B^{\alpha} - \mu_0 \mu^{\alpha} H = E_B^{\beta} - \mu_0 \mu^{\beta} H$. In a non-interacting system one may omit the indistinguishability by performing magnetic measurements in two different temperatures. The main question is how the possible interactions between particle and its surroundings can influence the indistinguishability effect. In the present work we performed some simulated annealing plus Monte Carlo studies concerning spherical particles embedded into ferromagnetic matrix. Magnetization process of such system depends on exchange interactions of particle, matrix and interface between them. Moreover, the influence of different kind of anisotropy (volume and surface) is also widely discussed.

P-6-24

The influence of Fe on the magnetic properties and electronic structure in the $Tb(Ni_{1-x}Fe_x)_3$ intermetallic compounds

K. Ociepka,[1] A. Bajorek,[1] A. Chrobak,[1] G. Chełkowska,[1] and M. Kądziołka - Gaweł[1]

[1] *Institute of Physics, Uniwersytecka 4, 40-007 Katowice, Poland*

We present and discuss magnetic properties and electronic structure of $Tb(Ni_{1-x}Fe_x)_3$ crystalline compounds. The magnetic properties have been investigated in the broad temperature range 2K – 1100K by using the SQUID magnetometer as well as the Faraday type magnetic balance and ^{57}Fe Mössbauer spectra have been collected at 300K. Partial substitution of Ni by Fe atoms is reflected in the increase of the Curie temperature (T_C) up to 851K (x=0.4) and subsequent decrease of T_C value to 655K with further iron doping up to x=1.0. Simultaneously in the same range of x concentration the value of the saturation magnetic moment (M_S) exhibits the gradual decrease from 7.60 $\mu_B/f.u$ (x = 0.0) to 3.42 $\mu_B/f.u$ (x = 1.0). The maximum values of the magnetic entropy change (ΔS_m) indicates a significant decrease from 1.56 J/kgK (x=0.0) to 0.24 J/kgK (x=0.2). The mean hyperfine magnetic field increases with increase of the Fe concentration. The XPS spectra have been measured at the room temperature. The valence band spectra as well as the core level lines have been analyzed as the influence of Ni//Fe substitution on the electronic structure.

P-6-25

Effect of temperature and time annealing under applied stresses on magnetic properties of amorphous microwires

K. Chichay,[1] V. Rodionova,[1] M. Ipatov,[2] V. Zhukova,[2] and A. Zhukov[2]
[1] *Immanuel Kant Baltic Federal University, 236041 Kaliningrad, Russia*
[2] *Dpto. Fisica de Materiales, UPV/EHU, 20018 San Sebastian, Spain*

Amorphous ferromagnetic glass coated microwires (MWs) are one of the most perspective materials for coding system and memory applications [1]. For successful implementation of these devices it is necessary to control MWs magnetic properties and domain wall dynamics. In this work we investigated the effect of annealing under tensile applied stress on magnetic properties of amorphous MWs with compositions of $Co_{68,6}B_{14,8}Si_{10}Mn_{6,6}$, $Co_{68,7}Fe_4Ni_1B_{13}Si_{11}Mo_{2,3}$ and $Fe_{3,85}Co_{67,05}Ni_{1,44}B_{11,53}Si_{14,47}Mo_{1,66}$. Samples of MWs were annealed at temperatures of 300-400 ° C during different times up to 90 min with different applied stresses up to 300 Pa. We observed changing of the magnetic properties depending on all parameters of annealing. Some conditions of annealing lead to appear of bistability and possibility to observe the domain wall movement with high velocity. Besides, it was shown that MWs with acquired bistability can be more useful for applications than originally bistable.

References:

[1] Zhukov A., Encyclopedia of Nanoscience and Nanotechnology, V.X.– P.23., (2004)

P-6-26

Temperature dependent magnetic and structural properties of Ni-Mn-Ga Heusler alloy glass-coated microwires

S. Shevyrtalov,[1] V. Rodionova,[1] K. Chichay,[1] V. Zhukova,[2] and A. Zhukov[2]
[1] *Immanuel Kant Baltic Federal University, Kaliningrad, Russia*
[2] *Dpto. Fisica de Materiales, Fac. Quimicas, sUPV/EHU, 20009 San Sebastian, Spain*

In last years, Ni-Mn-X Heusler alloys have attracted significant attention because of number of their functional properties. Ni-Mn-Ga glass-coated microwires (MWs) have a good prospects for new generation technical applications [1]. We investigated magnetic and structural properties of the Ni-Mn-Ga MWs fabricated by Tailor-Ulitovsky method. MWs with total diameter of 54.6 and 24.7 μm and the diameter of metallic core of 26.7 and 8.3 μm, respectively, were obtained. Energy dispersive spectrometer (Oxford Instr. X-Act) was used to detect composition of the metallic core of as-cast and annealed MWs. Magnetic moment versus temperature (-196-77° C) measurements and hysteresis loops were obtained by VSM (Lakeshore 7400 system). X-Ray diffraction (using Bruker D8 Discover in temperature range of -100-350 ° C) and magnetic temperature measurements reveal martensitic transition in the samples near the room temperature.

References:

[1] A. Zhukov, Journal of Alloys and Compounds 575, 73-79 (2013)

P-6-27

Radiofrequency characteristics of the soft magnetic nanoceramic Fe:BN

K. Oganisian,[1] P. Gluchowski,[1] K. Orzechowski,[2] A. Vogt,[2] and W. Strek[1]

[1] *Institute of Low Temperature and Structure Research, PAS, Okolna 2, 50-422 Wroclaw, Poland*

[2] *Faculty of Chemistry, Wroclaw University, F. Joliot-Curie 14, 50-383 Wroclaw, Poland*

Structural and radiofrequency characteristics of the soft magnetic composite Fe:BN are reported. The sample of 95:5 % wt ratio was obtained by application of the hot isostatic pressing method at 8 GPa pressure and T=1450 C. Scanning electron microscope studies revealed ceramic-like structure of iron grains separated by thin layer of hexagonal boron nitride. Such a structure significantly increases many important parameters such as electric resistivity and corrosion resistance etc. The frequency dependence of permeability was investigated at room temperature in the range 1 MHz-1 GHz. It was found that magnetic permeability is frequency independent up to 20 MHz with value of about 22 with low loss factor ($tg\delta<1$) up to 200 MHz. Taking into account very high value of the saturation of magnetic induction of about 2 T it could be concluded that Fe:BN nanoceramic is very promising for radiofrequency applications.

P-6-28

Magnetocaloric Effect in Amorphous and Partially Crystallized Fe-Zr-Nb-Cu-B Alloy

J. Gondro,[1] K. Błoch,[1] and M. Nabiałek[1]

[1] *Czestochowa University of Technology, Faculty of Materials Processing Technology and Applied Physics, Institute of Physics*

This paper presents the results of an investigation into the: microstructure, magnetic properties and influence of annealing temperature on the magnetocaloric effect of $Fe_{82}Zr_7Nb_2Cu_1B_8$ alloy in the as-quenched and partially crystalline state. The microstructure was investigated using a Mössbauer spectroscopy. The magnetocaloric effect was observed as a change in the magnetic entropy, which was calculated from isothermal magnetization curves. Additional from these curves measured for as-quenched state and partially crystalline alloy Arrott plots were constructed.

P-6-29

Magnetocaloric Properties of $Fe_{75}Mo_8Cu_1B_{16}$ and $Fe_{81}Mo_8Cu_1B_{10}$ Metallic Glasses

M. Hasiak,[1] M. Miglierini,[2,3] J. Kaleta,[1] and M. Bujdos[4]

[1] *Wrocław University of Technology, 50 370 Wrocław, Poland*

[2] *Slovak University of Technology, 812 19 Bratislava, Slovakia*

[3] *RCATM, Palacky University, 771 46 Olomouc, Czech Republic*

[4] *Comenius University, 842 15 Bratislava, Slovakia*

Magnetocaloric materials, intensively studied for over 20 years, are very interesting because of possible refrigeration applications. In this paper we investigate the microstructure and magnetic properties of $Fe_{75}Mo_8Cu_1B_{16}$ and $Fe_{81}Mo_8Cu_1B_{10}$ metallic glasses in as quenched state and after annealing. The microstructure of the investigated alloys was examined by Mössbauer spectroscopy using surface sensitive technique (CEMS). The magnetic properties were recorded in a temperature range 50 – 400 K. The magnetocaloric effect was calculated from the Maxwell thermodynamic equation. The obtained results will be discussed both from the point of view of microstructure and magnetic properties.

This work was supported by the research projects VEGA 1/0286/12, SK-PL-0032-12, CZ.1.05/2.1.00/03.0058, and CZ.1.07/2.3.00/20.0155.

P-6-30

Microstructure and Magnetic Properties of Nd-Fe-B alloys with Addition of Ti and Re

M. Hasiak,[1] and J. Kaleta[1]

[1] *Wrocław University of Technology, Smoluchowskiego 25, 50-370 Wrocław, Poland*

Nanocomposite Nd-Fe-B magnetic materials are very interesting because of their good hard magnetic properties i.e. high coercivity, high remanence and energy product. In this paper, we present the role of Ti and Re additions on microstructure and magnetic properties of $Nd_8Fe_{80}B_{12}$, $Nd_8Fe_{76}B_{12}Ti_4$ and $Nd_8Fe_{76}B_{12}Re_4$ alloys. Moreover, the mechanical and chemical properties i.e. microhardness and corrosion resistance were also studied. The investigated alloys were produced by a rapid quenching method in a form of thin ribbons of about 0.025 mm thick. The microstructure was studied at room temperature by X-ray diffraction and Mossbauer spectroscopy in transmission geometry. The magnetic properties were recorded in the temperature range 2-800 K. The obtained results will be discussed from the point of view of microstructure and magnetic properties.

The research was supported by Wrocław Research Centre EIT + under the project "The Application of Nanotechnology in Advanced Materials" - NanoMat (POIG.01.01.02-02-002/08) financed by the European Regional Development Fund (Innovative Economy Operational Programme, 1.1.2).

P-6-31

Induced anisotropy and domain structure in field-annealed Co-rich nanocrystalline ribbons

Branislav Kunca,[1] Jozef Marcin,[1] Jozef Kováč,[1] Peter Švec,[2] and Ivan Škorvánek[1]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 040 01 Košice, Slovakia*

[2] *Institute of Physics, Slovak Academy of Sciences, Dúbravská cesta 9, 842 28 Bratislava, Slovakia*

In this work, a controllable field-induced magnetic anisotropy is produced in series of (Co1-xFex)81Nb7B12 (x=0, 0.05 and 0.1) alloys with different amount of crystalline phase. We show that nanocrystallization of the parent amorphous melt-spun ribbons in a longitudinal (LF) or transverse (TF) magnetic field with the magnitude 640 kAm-1 is very powerful tool to tailor the shape of the hysteresis loops and to control the domain structure of these materials. Heat treatment under LF-conditions results in squared hysteresis loops, which are accompanied by an appreciable reduction of the coercivity as compared to zero-field annealed samples. Sheared loops with good field linearity were achieved for all investigated alloys after TF-annealing. A marked response of the functional properties of these alloys to thermal processing in external magnetic field can be utilized in their better adaptation to potential applications.

P-6-32

Preferred oriented growth of L10 FePt on Si substrate

Neelam Kaushik,[1] Parmanand Sharma,[2] Shuji Tanaka,[3] Akihiro Makino,[2] and Masayoshi Esashi[1]

[1] *WPI-AIMR, Tohoku Univ., Sendai, Japan*

[2] *Institute for Materials Research, Tohoku Univ., Sendai, Japan*

[3] *Graduate School of Engineering, Tohoku Univ. Sendai, Japan*

Tilting the magnetic easy axis of L10 FePt and/or introducing a magnetic buffer layer is most effective in realizing the L10 FePt based magnetic recording media.Therefore, here we report on the preferred oriented growth of L10 FePt with tilted magnetic easy axis. FePt films of thickness up to 110 nm were deposited on Si substrates with a soft magnetic underlayers of glassy FeSiB, FeSiBP and CoFeTaB. Effects of processing conditions on the structural and magnetic properties were studied.Our results demonstrated that the direct growth of FePt on FeSiB or FeSiBP metallic glass is polycrystalline. The CoFeTaB glassy thin film acts as a very stable underlayer for the growth of FePt. A preferred oriented growth of FePt along (111) crystallographic direction was obtained. The Hc reduces significantly with the introduction of underlayer. The magnetic easy axis of (111) L10 FePt is 36 degree titlted and is very promising for titled magnetic recording. The details on the structural/magnetic properties and its applicability in magnetic recording will be presented.

P-6-33

Temperature resistance of magnetoelastic characteristics of 13CrMo4-5 constructional steel

D. Jackiewicz,[1] K. Rożniatowski,[1] J. Dworecka,[1] R. Szewczyk,[1] J. Salach,[1] A. Bieńkowski,[1] M. Kachniarz,[1] and W. Winiarski[2]

[1] *Warsaw University of Technology*

[2] *Industrial Research Institute for Automation and Measurements*

In the paper the results of investigation on tensile stresses dependence of magnetoelastic characteristics of cores made of 13CrMo4-5 constructional steel are presented. In the investigation step-cooling treated samples were used. The step-cooling process is a type of heat treatment simulating effects of passing time and environmental conditions (temperature and stress) on the sample. In the paper the method of testing the influence of stresses on the magnetics characteristics is presented. Frame shaped samples ensured a closed magnetic path and homogeneous decomposition of stress. It was found that step-cooling process doesn't significantly influence the magnetoelastic characteristics and the structure of the samples. On the other hand, then tensile stresses significantly change of the magnetic characteristics of 13CrMo4-5 constructional steel. That confirms the possibility of using measurements based on the magnetoelastic effect in stress assessment for industrial NDT of steel constructions.

This work was partially supported by The National Centre of Research and Development (Poland) within grant no. PBS1/B4/6/2012.

P-6-34

The influence of thermomagnetic treatment on the magnetoelastic characteristics of $Fe_{61}Co_{19}Si_5B_{15}$ amorphous alloys

J. Salach,[1] R. Szewczyk,[1] P. Svec Sr.,[2] A. Bieńkowski,[1] D. Jackiewicz,[3] P. Svec,[2] and W. Winiarski[3]

[1] *Institute of Metrology and Biomedical Engineering, Poland*

[2] *Institute of Physics, Slovak Academy of Sciences, Slovak Republic*

[3] *Industrial Research Institute for Automation and Measurements, Poland*

Information about magnetoelastic properties of newly developed amorphous magnetic alloys is very important from practical point of view, especially in the case of high permeability materials such as $Fe_{61}Co_{19}Si_5B_{15}$ amorphous alloy. In the case of such materials, effect connected with the influence of external stresses on the magnetic properties of the alloy should be tested.This paper presents experimental results of the magnetoelastic properties of the $Fe_{61}Co_{19}Si_5B_{15}$ amorphous alloy, annealed without magnetic field as well as in the magnetic field. Such thermo-magnetic treatment generated anisotropy, which has significant influence on the total free energy of magnetic material. In the magnetoelastic investigation the compressive stress was applied to the ring core perpendicularly to the magnetizing field direction. Due to the fact, that cores with closed magnetic circuits were used, demagnetization didn't change the balance of total free energy in the material.

P-6-35

Amorphous and nanocrystalline soft magnetic FeCuNbSiB/CoSiB bilayer ribbons

M. Capik,[1] P. Švec,[2] J. Marcin,[1] P. Švec SR,[2] and I. Škorvánek[1]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, 040 01 Košice, Slovakia*

[2] *Institute of Physics, Slovak Academy of Sciences, 845 11 Bratislava, Slovakia*

Magnetic bilayer composites are attracting a great deal of scientific interest from both fundamental and application points of view. Bilayer ribbons studied in this work have been prepared by planar flow casting from a single crucible with two nozzles close to each other and with a partition between them forming two separate vessels. Such arrangement allowed us to obtain bilayer with two homogeneous amorphous layers and contact interlayer between them having submicron thickness. The composition of the individual layers was chosen from the FeCuNbSiB and CoSiB alloy systems. A controlled heat treatment was used in order to transform the FeCuNbSiB layer into the nanocrystalline state. The magnetization and magnetic reversal processes before and after nanocrystallization were investigated in a wide temperature range. We have shown that magnetic reversal process in such bilayers is strongly influenced by interlayer stresses, which are induced in material due to different thermal expansion coefficients of two mechanically solid connected individual layers.

P-6-36

Microstructure and properties of magnets obtained by hydrostatic extrusion of Nd-Fe-B powders

T. Gizynski,[1] W. Kaszuwara,[1] P. Pawlik,[2] M. Kulczyk,[3] M. Leonowicz,[1] and B. Michalski[1]

[1] *Warsaw University of Technology, Faculty of Materials Science and Engineering*

[2] *Czestochowa University of Technology, Faculty of Materials Processing Technology and Applied Physics*

[3] *Institute of High Pressure Physics, Polish Academy of Sciences*

Nd-Fe-B MQ powder, provided by Magnequench, was initially densified in a copper capsule to reach about 60% of the theoretical density. Subsequently, three various processes of hydrostatic extrusion were conducted at room temperature. The values of true strain, obtained during the all three stages, were 1.38, 0.89, 0.94, respectively. The investigation performed showed, that the coercivity of the material decreases as the strain increases. Decrease of the remanence was observed only for the high strain. Size of the particles was strongly reduced during the extrusion processes. The X-ray diffraction showed no changes in the phase structure of the material. Mössbauer study of the sample extruded within all the three stages showed the existence of the $Nd_2Fe_{14}B$ phase and 16% of other phase. Analysis of magnetization versus temperature confirmed, that the additional phase was ferromagnetic.

P-6-37

Thermal stability of the microwave permeability of nanocrystallized glass coated microwires up to 350 °C

Jean-Hugues Le Gallou,[1] and Anne-Lise Adenot-Engelvin[1]
[1] *CEA/Le Ripault - B.P.16 - 37260 Monts - FRANCE*

Ferromagnetic glass coated microwires have been studied for long as soft magnetic materials suitable for a variety of applications [1]. The composition of the ferromagnetic nucleus was generally an amorphous CoFeSiB alloy. In addition to their very good magnetic properties, they possess a very good thermal stability because of a stabilized atomic structure and a higher Curie temperature than their amorphous counterparts (600 °C versus 350 °C for the common alloys of CoFeSiB family). Samples for APC7 coaxial line measurements were then elaborated by winding the microwire into a torus. Microwave permeability measurements were then performed at various temperatures up to 350 °C using a dedicated set-up.

References:

[1] M. Vazquez, A.L. Adenot-Engelvin, J. Magn. Magn. Meter.

P-6-38

Magnetocaloric properties of amorphous $Gd_{65}Fe_{10}Co_{10}Al_{10}X_5$ (X = Al, Si, B) ribbons

N. Pierunek,[1] Z. Śniadecki,[1,2] J. Marcin,[3] I. Škorvánek,[3] and B. Idzikowski[1]
[1] *Institute of Molecular Physics, PAS, Poznań, Poland*
[2] *INT, KIT, Eggenstein-Leopoldshafen, Germany*
[3] *Institute of Experimental Physics, SAS, Košice, Slovakia*

Magnetocaloric effect (MCE) is described as the adiabatic temperature change ΔT_{ad} or the isothermal magnetic entropy change ΔS_M, which is a function of the temperature and magnetic field. Here, we focused our attention on MCE in $Gd_{65}Fe_{10}Co_{10}Al_{10}X_5$ (X = Al, Si, B) alloys. The synthesized melt-spun materials have an amorphous structure confirmed by XRD. The T_C, determined from *M(T)* curves by the inflection method is equal to 145, 160 and 175 K for the alloys with 5 at.% of B, Al and Si, respectively. Maximum value of the magnetic entropy changes for the magnetic fields from 0 to 5 T is 7.1 $Jkg^{-1}K^{-1}$ for X = B, whereas related refrigeration capacity is 748 Jkg^{-1}. The maximum magnetic entropy changes for $Gd_{65}Fe_{10}Co_{10}Al_{15}$ and $Gd_{65}Fe_{10}Co_{10}Al_{10}Si_5$ amount 6.0 $Jkg^{-1}K^{-1}$ and 5.9 $Jkg^{-1}K^{-1}$, while *RC* parameter is equal 700 and 698 Jkg^{-1}, respectively.

References:

[1] C. Mayer, S. Gorsse, G. Ballon, R. Cabalerro-Flores, V. Franco, B. Chevalier, J. Appl. Phys **110** (2011) 053920

P-6-39

Non-hydrolytic synthesis of synthetic MFe_2O_4 ($M - Mn^{2+}$, Fe^{2+}, Co^{2+}, Ni^{2+}) ferrite spinel and their incorporation into the polymeric matrix

E. Piasecka,[1,2] R. Pązik,[1] M. Małecka,[1] B. Idzikowski,[3] Z. Śniadecki,[3,4] and R.J. Wiglusz[1]

[1] *Institute of Low Temperature and Structure Research, PAS, Wrocław, Poland*
[2] *Polymer Engineering and Technology Division, WUT, Wrocław, Poland*
[3] *Institute of Molecular Physics, PAS, Poznań, Poland*
[4] *INT, KIT, Eggenstein-Leopoldshafen, Germany*

The series of the highly crystalline MFe_2O_4 ferrite spinel nanoparticles were synthesized *via* modified Bradley reaction using microwave stimulation. Particle size of 10 to 20 nm was estimated using Scherrer and Rietveld methods as well as TEM and dynamic light scattering (DLS). Hydrodynamic size was measured using DLS technique on non-modified, surfactant free particles of the whole MFe_2O_4 series. Strong asymmetric behavior of the A_{1g} mode was found and deconvoluted revealing additional components. Among all of the products the lowest site inversion was found for the manganese ferrite $MnFe_2O_4$. Typical magnetic behaviour of the MFe_2O_4 family was studied in detail.
The resulting stock particles were incorporated into the polymer PMMA matrix forming bulk and powdered composite organic-inorganic systems.

P-6-40

Normal and inverse magnetocaloric effects in amorphous $R_8Co_{62}B_{30}$ (R = Y, Ho, Tb) alloys

Z. Śniadecki,[1,2] V. Franco,[3] J. Marcin,[4] I. Škorvánek,[4] N. Pierunek,[1] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*
[2] *INT, KIT, Eggenstein-Leopoldshafen, Germany*
[3] *Departamento de Fìsica de la Materia Condensada, Univ. Sevilla, Spain*
[4] *Institute of Experimental Physics, SAS, Košice, Slovakia*

The R–Co–B system possess good glass forming ability (GFA) due to large atomic size difference between rare earth element and boron atoms [1]. $Y_8Co_{62}B_{30}$, $Ho_8Co_{62}B_{30}$ and $Tb_8Co_{62}B_{30}$ ribbons were synthesized by melt-spinning method, as fully amorphous. Investigated alloys exhibit high thermal stability of amorphous structure, as confirmed by differential scanning calorimetry results and expected for good glass formers [2]. Temperature dependence of magnetization for Y-containing alloy is typical for ferromagnet, while for heavy rare earth elements, the antiferromagnetic coupling and strong anisotropy lead to sperimagnetic behavior. In the latter case, combined inverse and normal magnetocaloric effects are observed in broad temperature range.

References:

[1] Z. Śniadecki *et al.*, J. Alloys Compd. **584** (2014) 477–482
[2] K.K. Song, J. Appl. Phys. **112** (2012) 063503

P-6-41

Spin reorientation and magnetocaloric properties of $Y_{1-x}Gd_xCo_2$ ($0 \leq x \leq 1$) compounds

Z. Śniadecki,[1,2] N. Pierunek,[1] V. Franco,[3] R. Puźniak,[4] A. Wiśniewski,[4] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*
[2] *INT, KIT, Eggenstein-Leopoldshafen, Germany*
[3] *Departamento de Fìsica de la Materia Condensada, Univ. Sevilla, Spain*
[4] *Institute of Physics, PAS, Warsaw, Poland*

$Y_{1-x}Gd_xCo_2$ (x = 0, 0.2, 0.4, 0.6, 0.8, 1) alloys were synthesized in the melt-spinning process. Investigated samples crystallize in the $MgCu_2$-type Laves phase. Due to the substitution of Y atoms by Gd, increase of the lattice constant from 7.215 Å for YCo_2 to 7.250 Å for $GdCo_2$ was observed [1]. One can observe noticeable change of $\Delta S_M(T)$ characteristics at low temperatures and in magnetic fields $\leq$ 3 T. Spin reorientation transition with T_{SR} in the range from 30 to 40 K for samples with x = 0.4 and 0.6 was observed. *RC* parameter is rather low for all alloys and for instance is equal to 50 and 85 Jkg^{-1} for $Y_{0.6}Gd_{0.4}Co_2$ (T_C = 204 K) and $Y_{0.4}Gd_{0.6}Co_2$ (T_C = 282 K), respectively. Sample with x = 0.2 is ferromagnetic, while those with higher Gd content are ordered ferrimagnetically below T_C with Co-sublattice oriented antiparallel to Gd one.

References:

[1] T. Nakama, A.T. Burkov, M. Hedo, H. Niki, K. Yagasaki, J. Magn. Mater. **226** (2001) 671

P-6-42

Structural and magnetic properties of $Y_{1-x}Gd_xCo_2$ (x = 0 - 1) alloys

Z. Śniadecki,[1,2] A. Musiał,[1,3] A. Łojewski,[4] M. Jarek,[3] R. Puźniak,[5] A. Wiśniewski,[5] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*
[2] *INT, KIT, Eggenstein-Leopoldshafen, Germany*
[3] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[4] *Poznań University of Technology, Poznań, Poland*
[5] *Institute of Physics, PAS, Warsaw, Poland*

YCo_2 has cubic $MgCu_2$–type crystalline structure typical for intermetallic Laves phase. The ratio of two rare-earth elements in $Y_{1-x}Gd_xCo_2$ alloys can change their magnetic properties from Pauli paramagnetic for YCo_2 to the ferrimagnetic $GdCo_2$ [1]. The fully crystal ribbons was produced by melt-spinning under argon atmosphere. X-ray measurements show that substitution of gadolinium in alloys, determined lattice constant *a* for crystal phase increase from 7.219 to 7.260 Å for YCo_2 and $GdCo_2$ respectively, which can be result of larger ionic radius for gadolinium atoms. AC-susceptibility data for $Y_{0.5}Gd_{0.5}Co_2$ show magnetic ordering below T_C = 251 K.

References:

[1] E. Gratz, A.S. Markosyan, J. Phys.: Condens. Matter **13** (2001) R385

Work was supported by the NCRD within the project no. POKL.04.03.00-00-015/12.

P-6-43

Influence of the existence of nanocrystals to magnetic properties $Hf_2Co_{11}B$ alloys

A. Musiał,[1,2] Z. Śniadecki,[1,3] J. Marcin,[4] I. Škorvánek,[4] J. Kováč,[4] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*
[2] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[3] *INT, KIT, Eggenstein-Leopoldshafen, Germany*
[4] *Institute of Experimental Physics, SAS, Košice, Slovakia*

The $Hf_2Co_{11}B$ can be an example for rare earth free compound with T_C about 500^{o}C and orthorhombic hard magnetic phase $HfCo_7$ which is characterize by anisotropy constant K_1 above 10 Mergs/cm^3 [1]. Melt-spinning under argon atmosphere was used to produce amorphous Hf-Co-B alloy. X–ray diffraction confirmed fully amorphous or partially crystalline structure of the melt-spun ribbons. Two main irreversible exothermic peaks were observed. Crystallization temperatures T_{x1} and T_{x2} of amorphous $Hf_2Co_{11}B$ measured with heating rate $q = 10$ K/min are equal 567^{o}C and 633^{o}C, respectively. The coercivity in partially of fully crystalline samples varies from 1.2 kOe to about 3 kOe and is higher than in amorphous one.

References:

[1] B. Balamurugan, *et al.* IEEE Trans. Magn. **49** (2013) 3330-3333

Work was supported by the NCRD within the project no. POKL.04.03.00-00-015/12

P-7-01

Properties of magnetosomes suspension under the influence of magnetic field

A. Józefczak,[1] M. Molcan,[2] Z. Rozynek,[3] T. Hornowski,[1] A. Skumiel,[1] M. Timko,[2] J. Tóthová,[4] and P. Kopčanský[2]

[1] *Institute of Acoustics, UAM, Poznań, Poland*
[2] *Institute of Experimental Physics, SAV, Košice, Slovakia*
[3] *Department of Physics, NTNU, Trondheim, Norway*
[4] *Department of Physics, TUKE, Košice, Slovakia*

For medical applications nanoparticles require highly biocompatible particle surfaces. Biogenic magnetoparticles such as bacterial magnetosome particles are organelles consisting of magnetite crystals enclosed by a phospholipid membrane that offers a high degree of biocompatibility. Isolated magnetosome particles form stable, well-dispersed suspensions in water solution of HEPES. The objective of the work is to study the influence of magnetic field on rheological and acoustic properties of magnetosomes suspension. The experimental results showed a clear effect of the magnetic field on acoustic parameters: propagation velocity and attenuation of ultrasonic wave and the viscosity of the suspension, which are the result of magnetosomes aggregation.

This work was supported by NCN grant DEC-2011/03/B/ST7/00194 and by Projects 26110230097, 26110230061 and 26220220005 in the frame of Structural Funds of EU.

P-7-02

Microfluid mixing due to domain wall movement assisted transport of superparamagnetic beads

D. Holzinger,[1] D. Lengemann,[1] I. Koch,[1] H. Huckfeldt,[1] and A. Ehresmann[1]

[1] *Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany*

The domain wall movement assisted transport (DOWMAT) of full superparamagnetic particle rows above a magnetic parallel stripe-patterned exchange-bias thin film layer system with in-plane magnetized magnetic domains parallel to the short stripe axes is used for active mixing in a microfluidic device, where the particle rows act as dynamic micro stirring objects while transported.[1] By starting from an initial step-like concentration profile for two different tracer dye solutions used in the experiments, it is shown that the interface and therefore the amount of mixing is strongly related to the particles movement amplitude when applying a sinusoidal movement scheme. Therefore, the mixing speed can be controlledly factored as compared to passive mixing by thermal diffusion.

References:

[1] D. Holzinger, D. Lengemann, F. Goellner, D. Engel and A. Ehresmann, *Appl. Phys. Lett.* **100**, 153504 (2012)

P-7-03

Isotropic-Nematic Phase Transition in Liquid Crystal doped with magnetic particles

N. Tomašovičová,[1] V. Gdovinová,[1] V. Závišová,[1] M. Timko,[1] J. Jadzyn,[2] and P. Kopčanský[1]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Kosice, Slovakia*
[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland*

Recently a mean-field theory has been developed to describe the influence of embedded nanoparticles on the orientation order and on the isotropic–nematic (I-N) phase transition of the host liquid crystal. It was shown that spherically isotropic nanoparticles effectively dilute the liquid crystal medium and decrease the isotropic–nematic transition temperature. On the contrary, anisotropic nanoparticles become aligned by the nematic host and, reciprocally, improve the liquid crystal alignment. The influence of the anisotropy of magnetic particles on the I-N phase transition was studied in nematic liquid crystal 4-(trans-4-n-hexylcyclohexyl)-isothiocyanato-benzene doped with spherical and rod-like magnetic particles. The I-N phase transitions was observed by polarizing microscope as well as by capacitance measurements that demonstrate an influence of the concentration and the shape anisotropy of the magnetic particles on the I-N phase transition in liquid crystal.

Suported by ME SR Agency for Structural Funds of EU project No. 26110230097

P-7-04

Dielectric properties of lyotropic magnetic liquid crystal

P. Kopčanský,[1] L. Tomčo,[1] J. Jadzyn,[2] J. Swiergiel,[2] M. Kubovčíková,[1] M. Timko,[1] K. Šipošová,[1] Z. Gažová,[1] Z. Bednariková,[1] N. Tomašovičová,[1] and O.V. Kovalchuk[3]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*
[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland*
[3] *Kyiv National University of Technologies and Design, Kyiv, Ukraine*

An important feature of lyotropic liquid crystals is the self-assembly of the amphiphilic molecules as supermolecular structures. We have studied the formation of nematic liquid crystal phase in solutions containing lysozyme amyloid fibrils and magnetic nanparticles. Due to interaction of magnetic nanoparticles with fibrils the ordering of the fibrils by applying the external magnetic field was observed. Dielectric spectra of samples with various lysozyme concentrations were investigated. The analysis of the obtained results suggest that decrease in conductivity of solutions in presence of magnetic field is due to decreasing of the ion mobility caused by ordering the solution structure. The obtained results allow determination of the optimum ratio of the components which leads to formation of the solution with a more ordered structure in presence of magnetic field.

Suported by ME SR Agency for Structural Funds of EU project No. 26110230097

P-7-05

Role of Fe-ions in the formation of magnetic and thermomagnetic properties of quasi-binary $Ho(Co_{1-x}Fe_x)_2$ compounds

M.S. Anikin,[1] E.N. Tarasov,[1] V.H. Osadchenko,[1] and A.V. Zinin[1]

[1] *Ural Federal University named after the first President of Russia B.N. Yeltsin, Mira str. 19, 620002 Ekaterinburg, Russia*

Structure, magnetic and thermomagnetic properties of the $Ho(Co_{1-x}Fe_x)_2$ alloy (x = 0.09, 0.12, 0.13) as a perspective material for thermomagnetic machine have been investigated. Magnetic properties were measured by SQUID-magnetometer under the field up to 7 T at temperature varied from 4.2 to 350 K. Curie temperature (T_c) is equal to 199, 258, and 271 K, respectively. Temperature dependencies of the magnetic entropy change $\Delta S(T)$, which were calculated from magnetization isotherms, demonstrated broadening of the maximum at temperatures below Tc both under increasing magnetic field and under increasing of iron concentration. For $Ho(Co_{0.88}Fe_{0.12})_2$ compound the RCP [1] value measured at 5 T exceed the RCP value observed for $Tb(Co_{0.7}Fe_{0.3})_2$ [1] (490 J/kg vs. 299 J/kg, respectively). According to our results, $Ho(Co_{1-x}Fe_x)_2$ alloys exhibit large magnetocaloric effect and can be considered as a promising material for both applied and basic prospective research.

References:

[1] Madhumita Halder, S. M. Yusuf, M. D. Mukadam, *et al.*, Phys. Rev. B 81 (2010) 174402

P-7-06

Thermal stability of liquid crystals doped with magnetic nanoparticles

A. Jurikova,[1] K. Csach,[1] J. Miskuf,[1] N. Tomasovicova,[1] Z. Mitroova,[1] V. Zavisova,[1] M. Koneracka,[1] P. Kopcansky,[1] K. Fodor-Csorba,[2] and A. Vajda[2]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*

[2] *Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, Budapest, Hungary*

Creating mixtures of bent-core and rod-shaped molecules can form liquid crystalline phase at the room temperature and be useful in possible practical applications. In the work phase transitions of binary mixtures of the bent-core and the rod-shaped liquid crystals dopped with different types of magnetic nanoparticles were studied using differential scanning calorimetry. For the binary mixture with the ratio of 50:50 the nematic to smectic transition below 40 °C was appeared and the crystallization temperature was shifted to the sub-ambient temperature. The influence of doping of liquid crystals with magnetic nanoparticles on the kinetics of all observed phase transitions was studied. The phase transition temperatures are shifted depending on the nanoparticle shape and changed significantly with varying cooling rate for all studied samples.

The work was supported by the project in the frame of SF EU No. 26110230097.

P-7-07

Magnetic and Heating Characteristics of various Oil-Based Magnetic Fluids

M. Molcan,[1] A. Skumiel,[2] A. Jozefczak,[2] J. Kovac,[1] P. Kopcansky,[1] and M. Timko[1]
[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Kosice, Slovakia*
[2] *Institute of Acoustics, Faculty of Physics, Adam Mickiewicz University, Poznan, Poland*

The heating ability of magnetic fluids based on various transformer oils with different density of carrier liquid and different concentration of magnetite was studied. The calorimetric measurements were carried out in an alternating magnetic field up to 5 kA/m amplitude and of 500 kHz frequency. The revealed Hn law-type dependence of the temperature increase rate, $(dT/dt)t=0$, on the amplitude of the magnetic field indicates the presence of superparamagnetic nanoparticles in the tested samples since n = 2 for all samples. The specific absorption rate (SAR) defined as the rate of energy absorption per unit mass increases with a decrease of the volume fraction of the dispersed magnetite phase and carrier liquid density. This can be explained by the formation of aggregates in the samples with a higher concentration of magnetic particles.

Suported by ME SR Agency for Structural Funds of EU project No. 26110230097

P-7-08

Magnetic and magnetocaloric properties of severe plastic deformed $Gd_{100-x}Y_x$ alloys (x=0..30)

M. Ulyanov,[1] S. Taskaev,[1] D. Bataev,[1] V. Buchelnikov,[1] K. Skokov,[2] and A. Pellenen[3]
[1] *Chelyabinsk State University, Chelyabinsk, Russia*
[2] *TU Darmshtadt, Darmshtadt, Germany*
[3] *National Research South Ural State University, Chelyabinsk, Russia*

In this work we report the magnetic and magnetocaloric properties of the series of alloys $Gd_{100-x}Y_x$ (x=0..2.5, 5, 7.5, 10, 15, 20, 25, 30) treated with the help of severe plastic deformation (SPD) technique. Here we expand (1) our investigation alloys, which are very convenient materials for room-temperature magnetic refrigeration. During SPD treatment we observe the magnetocaloric effect significantly decreased. The value of reduction magnetocaloric effect as in pure Gd case depends on the degree of plastic deformation. The reduction of the Curie temperature is observed due to reduction exchange interaction with increasing nonmagnetic Y atoms concentration.

References:

[1] S.V.Taskaev, M.D.Kuz'min, K.P.Skokov, D.Yu.Karpenkov, A.P.Pellenen, V.D.Buchelnikov and O.Gutfleisch, JMMM 331 , 33 (2013)

Authors appreciate the RFBR and RF President grants: 12-07-00676-a, MD-770.2014.2

P-7-09

Influence of magnetite nanoparticles on freezing of transformer oil

K. Csach,[1] J. Miskuf,[1] A. Jurikova,[1] M. Hurakova,[1] M. Rajnak,[1] M. Timko,[1] and P. Kopcansky[1]

[1] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*

Magnetic liquids or ferrofluids are new technological materials which are of great interest for many applications. The addition of the magnetite nanoparticles into transformer oil enhances the power transformer properties via the increase of the cooling efficiency. In this contribution the influence of magnetite nanoparticles with the concentrations up to 5 % added into the transformer oil on the freezing and defrosting of the prepared magnetic fluid was studied. The experimental results revealed not very significant influence of magnetite nanoparticles on the studied properties.

The work was supported by the project in the frame of SF EU No. 26110230097.

P-7-10

A comparative studies of magnetocaloric effect in Ni-Mn-Cu-Ga and Ni-Mn-Pb-Ga alloys

K. Sielicki,[1] R. Wroblewski,[1] and M. Leonowicz[1]

[1] *Faculty of Materials Science and Engineering, Warsaw University of Technology, 141 Woloska Street, Warsaw, Poland*

Effect of Pb substitution for Cu on magnetocaloric properties of $Ni_2Mn_{1-x}Cu_xGa$ (x= 0.25, 0.27, 0.29) alloy was investigated experimentally. The magnetic measurements of Ni Mn Pb Ga alloys conducted at low field of 4 kA/m (50 Oe) showed that their Curie temperatures are above the room temperature (RT). The analysis of isothermal magnetic curves allowed the estimation of magnetic entropy change (ΔS_M). The highest calculated value of $|\Delta S_M|$ was for alloys containing 6.25 at.% of Cu and Pb, ∼16 J/(kg*K) and ∼7.5 J/(kg*K) respectively. The adiabatic temperature changes (ΔT) measured near RT are ∼0.4 K.

The project is co-financed by the E. U. within the European Regional Development Fund and by Polish Government within the Innovative Economy Programme, priority 1, activity 1.3, subactivity 1.3.1, agreement with MSHE nr UDA-POIG.01.03.01-00-058/08, 23.02.2009 y.

P-7-11

Spin-Wave Peculiarities of Acoustic of Semi–Infinite Ferromagnet (Antiferromagnet) in Static External Magnetic Field

O. Prikhodko,[1] O. Sukhorukova,[1] S. Tarasenko,[1] and V. Shavrov[2]

[1] *Donetsk Institute for Physics and Engineering of the National Academy of Sciences of Ukraine, 83114, Donetsk, Ukraine*

[2] *Kotel'nikov Institute of Radio Engineering and Electronics of the Russian Academy of Sciences, 125009, Moscow, Russia*

The study of the necessary conditions for localization of elastic wave near the boundary of magnetic and nonmagnetic mediums under external magnetic field plays important value for designing of the tunable magnetic phononic crystal. Our investigation shows that a traditional approach to the calculation of a Parekh wave [1] only on the base of magnetoelastic and magnetodipole interaction inadequately describes the spectrum of the surface elastic wave in the high-frequency range. It is determined that the magnetostriction plays an important role for high-frequency surface magnetoelastic dynamic of ferromagnet or antiferromagnet. The necessary conditions for existence of the "new" Parekh wave and for amplification of evanescent SH wave and leaky Parekh wave are derived

References:

[1] 1.J.P.Parekh, Electron.Lett 6, 322 (1969)

P-7-12

Magnetocaloric effect of Gd_5Si_4 – influence of mechanical milling

T. Toliński,[1] K. Synoradzki,[1] and P. Nowotny[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

[2] *Institute of Physics, Poznań University of Technology, Poznań, Poland*

The magnetic susceptibility, magnetization curves, heat capacity, and magnetocaloric effect (MCE) measurements are reported both for the bulk and mechanically milled Gd_5Si_4 compound. X-ray diffraction studies show that already the milling time of 10 hours is enough to destroy the crystallographic order. Simultaneously, the magnetic phase transition at 340 K is strongly suppressed implying a breaking of the long-range magnetic order. For the bulk sample the maximum isothermal magnetic entropy change is equal to 6.1 $J.kg^{-1}K^{-1}$ at the magnetic field change of 9 T, whereas it is negligible after the milling. The temperature dependence of the specific heat confirms the presence of the transition at $T_C = 340$ K for the bulk sample.

P-7-13

Eco-friendly magnetic fluids as effective nanocatalysts for wastewater remediation

C. Nadejde,[1] and M. Neamtu[1]

[1] *'Alexandru Ioan Cuza' University, Interdisciplinary Research Department-Field Science, Lascar Catargi St., no. 54, 700107, Iasi, Romania*

Magnetic nanostructured materials have been found to be very effective in wastewaters decontamination [1]. Among the various synthesis methods, co-precipitation is a cost-effective technique for the manufacturing of magnetic nanoparticles, while the 'green' approach for their stabilization in water, using natural non-toxic capping agents, makes them good candidates as nanocatalytic formulations for water remediation. Several types of eco-friendly magnetic fluids were synthesized and further characterized, revealing excellent stability in suspension, a relatively uniform size distribution and suitable magnetic properties. Preliminary tests showed the good catalytic response and reusability of these magnetic fluids in the degradation of emerging pollutants from waters.

References:

[1] S.R. Pouran, A.A.A. Raman, W.M.A.W. Daud, Review on the application of modified iron oxides as heterogeneous catalysts in Fenton reactions, Journal of Cleaner Production, 64 (2014) 24-35.

The present work was financially supported by the Romanian Ministry of National Education: CNCS – UEFISCDI, project no. PN-II-ID-PCE-2012-4-0477.

P-7-14

Structure and magnetic properties of amorphous $Fe_{74}Hf_4Ta_1Cu_1Gd_1La_xSi_{15-x}B_4$ (x = 0, 7) ribbons

P.J. Bardziński,[1] M. Kopcewicz,[2] M. Rybaczuk,[1] M. Hasiak,[1] A. Musiał,[3] V. Kinzhybalo,[4] and B. Idzikowski[3]

[1] *Wrocław University of Technology, Wrocław, Poland*

[2] *Institute of Electronic Materials Technology, Warsaw, Poland*

[3] *Institute of Molecular Physics PAS, Poznań, Poland*

[4] *Institute of Low Temperature and Structure Research PAS, Wrocław, Poland*

The multicomponent $Fe_{74}Hf_4Ta_1Cu_1Gd_1La_xSi_{15-x}B_4$ (x = 0, 7) alloys are promising candidates in the search for materials with unusual mechanical and magnetic properties. Amorphous nature of melt-spun samples was confirmed by XRD diffractometry and Mössbauer spectroscopy. The XRD patterns revealed a distinct amorphous halo. The low-field components of magnetic hyperfine field distributions on iron nuclei are observed in the Mössbauer spectra, with average hyperfine field values of 19.9 and 15.7 T for x = 0 and x = 7, respectively. Coercivity studied by vibrating sample magnetometer was 518 A/m for x = 0 and 135 A/m for x = 7 at 300 K and 596 A/m for x = 0 and 1197 A/m for x = 7 at 400 K. Remanence also changed with temperature, amounting to 0.70 T for x = 0 and 0.45 T for x = 7 at 300 K, while at 400 K it was 0.57 and 0.21 T for x = 0 and x = 7, respectively. It is shown that La addition has beneficial effect of shifting the Curie point towards lower temperatures together with the increase of magnitude of magnetization.

P-8-01

Investigation of magnetocaloric effect in the alumina ceramics

R. Tarasenko,[1,2] V. Tkáč,[1] A. Orendáčová,[1] M. Orendáč,[1] and A. Feher[1]

[1] *Centre of Low Temperature Physics of P.J. Šafárik University and SAS, Park Angelinum 9, SK-040 01 Košice, Slovak Republic*

[2] *Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Charles University, Ke Karlovu 5, CZ-12116 Prague 2, Czech Republic*

Investigation of the magnetocaloric effect (MCE) in the commercial alumina ceramics was realized within a program focused at a design of experimental holder for MCE measurement. Previous magnetic studies of the material indicated the presence of ions with spin 5/2 with a concetration of 2000 ppm [1]. The study of MCE was performed in the temperature range from 90 mK to 1 K in magnetic fields up to 2 T in a commercial dilution refrigerator TLE 200. The normal MCE was observed which is in qualitative agreement with the theoretical calculations. The potential use of alumina ceramics as an experimental holder for MCE will be discussed in the paper.

References:

[1] R. Tarasenko *et al.*, Acta Phys. Pol. A 118, 1067 (2010).

This work has been supported by project APVV LPP-0202-09.

P-8-02

Thermal Compensation Model of Magnetic Circuits with Modern Magnetic Materials

T. Szumiata,[1] and M. Gzik-Szumiata[1]

[1] *Department of Physics, University of Technology and Humanities in Radom, Krasickiego 54, 26-600 Radom, Poland*

In this work a quantitative analysis of thermal compensation has been performed for a magnetic circuit producing magnetic field in the air gap. The considered system consisted of Sm_2Co_{17} type permanent magnet (as a source of magnetic field), nanocrystalline FINEMET alloy (as ultra-soft magnetic medium) and Fe-Ni low Curie temperature compensative material with approx. 30% nickel (as magnetic shunt). A distribution of magnetic field induction in the circuit was calculated numerically within standard one-dimensional approximation, however nonlinearities of magnetic characteristics of compensative material have been taken into account as well as demagnetization susceptibility of permanent magnet. As a result of the optimization procedure a thermal stability of magnetic field in the air gap appeared to be 10 times better than the stability of permanent magnet remanence, which was achieved by appropriate choice of the compensative element thickness. The improvement was reached at the expense of the only 1% loss of the magnetic field compared to the case without compensative shunt. An effective thermal compensation of magnetic circuits is crucial e.g. in construction of electric energy meters and tachometers.

P-8-03

Superconductivity in non-centrosymmetric compound ThCoSi

K. Domieracki,[1] and D. Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P. O. Box 1410, 50-950 Wrocław, Poland*

The silicide ThCoSi crystallizes with an orthorhombic crystal structure of the LaPtSi-type (space group $I4_1md$) that lacks an inversion center. Its low-temperature properties were studied by means of magnetization, electrical resistivity and heat capacity measurements, performed down to 0.35 K in magnetic fields up to 9 T. The compound was revealed to exhibit bulk superconductivity below $T_c = 3.14$ K, characterized by the upper critical field comparable to the Pauli-Clogston limit. From the experimental data, the key parameters of the superconducting state were derived and compared with a few related systems. The discussion will be focused on the role of non-centrosymmetricity on the superconducting features of this weakly correlated material.

P-8-04

^{57}Fe hyperfine parameters in vitamins and dietary supplements

Marlena Michałowska,[1] and M. Kądziołka-Gaweł[1]

[1] *Institute of Physics, University of Silesia, Katowice, Poland*

Mössbauer (nuclear gamma-resonance) spectroscopy was used to study various industrial samples of vitamins and dietary supplements containing iron ions which are use in treatment of anemia.. Determination of the iron state (Fe^{2+} or Fe^{3+}) in medicaments is important for evaluation of pharmaceuticals quality. The investigated samples containing ferrous bisglycinate, ferrous fumarate, ferrous gluconiate and ferric diphosphate are non magnetic in room temperature. ^{57}Fe hyperfine parameters of studied pharmaceuticals indicate on existing of major iron ferrous compounds. However, Mössbauer spectra of investigated samples demonstrated presence of additional ferrous and ferric components probably related to impurities or to partially modified main component.

P-8-05

Magnetic ordering in Pt/Co/Pt trilayer studied by PMOKE using 3D magnetic field.

P. Mazalski,[1] W. Dobrogowski,[1] I. Sveklo,[1] J. Fassbender,[2] L.T. Baczewski,[3] A. Wawro,[3] and A. Maziewski[1]

[1] *Faculty of Physics, University of Bialystok, Bialystok, Poland*
[2] *Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*
[3] *Institute of Physics, Polish Academy of Sciences, Warszawa, Poland*

We have recently presented [PRB, 85, 054427 (2012)] new possibilities of Ga^+ ion irradiation driven changes of magnetic and magnetooptical properties in $Pt/Co(d_{Co})/Pt$ trilayer where especially two branches with out-of-plane magnetization states were found. In the present work the ion driven evolution of magnetic ordering is studied in series of samples irradiated by different fluences F. Samples were measured using polar magnetooptical Kerr effect (PMOKE) in recently developed set-up with specially designed system of electromagnets allowing to apply magnetic field in any direction defined by θ_H, ϕ_H angles. The irradiation induced changes of easy direction of magnetization is obtained from the analysis of magnetization curves measured at different θ_H, ϕ_H. Similar analysis might be performed in samples with e.g. different thicknesses, after thermal/light treatments.

Work supported by: Team SYMPHONY project of the FNP, co-financed by the EU from ERDF, OPIE 2007–2013.

P-8-06

Magnetic order and SdH effect in half-Heusler phase ErPdBi

O. Pavlosiuk,[1] K. Filar,[2] P. Wiśniewski,[1] and D. Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, P.Nr. 1410, 50-950 Wrocław, Poland*
[2] *International Laboratory of High Magnetic Fields and Low Temperatures, Gajowicka 95, 53-421 Wrocław, Poland*

It has recently been reported that superconductivity and magnetic order coexist in ErPdBi [1]. Single crystals of this compound were grown from Bi-flux, with crystal structure of MgAgAs-type confirmed using X-ray diffraction. Magnetization, magnetic susceptibility, electrical resistance and heat capacity measurements revealed an antiferromagnetic phase transition at $T_N = 1.2$ K. At high temperatures, the electrical resistivity has semiconducting-like character ($dR/dT < 0$). The resistance starts decreasing with decreasing T below 15 K and shows a sharp drop below T_N but remains finite down to 0.4 K. Hence, no obvious, clear-cut evidence of superconductivity was found in $R(T)$ data. On the other hand, the real part of the ac magnetic susceptibility is negative below $T_C = 1.6$ K, and its imaginary component has a clear maximum at this temperature that might be associated with the onset of superconducting state. The electrical resistance revealed Shubnikov - de Haas oscillations in magnetic fields 8-33 T. The SdH amplitude decreases with increasing T and disappears above 10 K.

References: [1] Y. Pan, A. M. Nikitin, T.V. Bay *et al.* Eur. Phys. Lett. **104**, 27001 (2013)

P-8-07

Magnetooptical analysis of ultrathin Co films modified by femtosecond laser pulses

W. Dobrogowski,[1] J. Kisielewski,[1] Z. Kurant,[1] K. Kościuk,[1] I. Sveklo,[1] K. Postava,[2] L.T. Baczewski,[3] A. Wawro,[3] and A. Maziewski[1]

[1] *Faculty of Physics, University of Białystok, Poland*
[2] *VŠB - Technical University of Ostrava, Czech Republic*
[3] *Institute of Physics, Polish Academy of Sciences, Poland*

Polar Kerr effect microscope-based setup with a CCD camera and a specially constructed electromagnet, supported by software for both data acquisition and image processing, was developed to investigate local magnetic and magnetooptical properties of ultrathin metallic systems with a micrometer resolution. Ultrathin cobalt films with femtosecond laser pulses-induced out-of-plane magnetization states [1] were studied using this method. The laser-annealed regions were characterized in detail by giving the two-dimensional maps of remanence, coercivity, saturation field, and maximal Kerr rotation, as well as some statistical information concerning distributions of these quantities.

References:

[1] J. Kisielewski *et al.*, J. Appl. Phys. **115**, 053906 (2014)

FNP Team Programme, European Regional Development Fund, OPIE 2007-2013; National Science Centre Poland (DEC-2012106/M/ST3/00475)

P-8-08

Application of Coulomb's Law on Electric Currents Explain Several Electromagnetic Phenomena

Jan Olof Jonson

The competence of Coulomb's Law has historically been assumed to be restricted to pure electrostatics. As soon as electric charges are being studied in motion, a new set of laws have been introduced in order to explain the electromagnetic forces that are impelled by the motion. Among those is Neumann's law of induction, Lenz' law, Grassmann's force law, Lorentz' force law, and Ampère's force law. Light, in turn, is explained to be regarded as simultaneously particles and waves, though the origin is predominantly electric. Beginning in 1997, research results have become public that succeed in showing that the basic force behind all cases involving electricity can be derived from Coulomb's law. The so-called Ampère forces between collinear currents, as in Ampère's bridge and in exploding wires have been explained to be due to Coulomb's law, provided the propagation delay due to the motion of charges is being taken into account correctly. The Lorentz force law fails in this case. Also electromagnetic induction can be explained using Coulomb's law, whereas Neumann's induction law fails. Light can be explained using Coulomb's law on the orbit electrons in the atoms involved in excitation and de-excitation of states, something that already Compton predicted but did not prove. Bohr, on the contrary denied this, but did not convincingly show why. The appearance of light at an atom hit by electromagnetic radiation can be shown to constitute a case of electromagnetic induction. The conclusion is that Coulomb's law is the only necessary force law within electromagnetism.

P-8-09

The behavior of Jurkat cells with superparamagnetic nanoparticles in magnetic field

E. Szoch,[1] I. Kamińska,[2] K. Fronc,[2] M. Szewczyk,[3] B. Sikora,[2] V. Zablotskii,[4] P. Stępień,[3,5,2] D. Elbaum,[2] and A. Maziewski[1]

[1]*Faculty of Physics, University of Białystok, Poland*

[2]*Institute of Physics, PAS, Poland*

[3]*Institute of Genetics and Biotechnology, University of Warsaw, Poland*

[4]*Institute of Physics ASCR, Czech Republic*

[5]*Institute of Biochemistry and Biophysics, PAS, Poland*

T lines - Jurkat cancer cells (diameter about 15 μm) were fed Fe_2O_3 magnetic **N**ano**P**article**s NPs** (diameter about 10 nm). Transfection and incubation of these cells with NPs were performed. Behaviors of these cells, deposited in culture-liquid medium, were studied in the following surrounding: (i) single small neodymium magnets plate; (ii) magnetic matrix - teflon plate with small cylindrical neodymium magnets and (iii) surface of thin garnet film with labyrinth domain structure (with period above 100 μm). All experiments were performed in function of time and NPs concentration Fe_2O_3 (100 μl/ml, 500 μl/ml) using different optical microscopy techniques. Real time movements of NPs fed cells in magnetic field gradient were observed and recorded in the aqueous suspensions. Followed incubation, majority of the NPs loaded cells were confined to the surface of the cylindrical magnets.

P-8-10

Pressure study of molecular magnet based on 3D and 4D metals: critical point

P. Konieczny,[1] R. Pełka,[1] D. Pinkowicz,[2] B. Sieklucka,[2] and T. Wasiutyński[1]

[1]*Institute of Nuclear Physics PAS, Department of Structural Research, Kraków, Poland*

[2]*Jagiellonian University, Faculty of Chemistry, Kraków, Poland*

The pressure measurements of magnetic materials give the opportunity to study the fundamental aspects of magnetism. In this study a molecular ferromagnet $\{[Co^{II}(pyrazole)_4]_2[Nb^{IV}(CN)_8]\cdot 4H_2O\}$ has been studied with the use of ac/dc magnetometry under hydrostatic pressure up to 1.3 GPa. The studied compound crystallizes in the $I4_{1/a}$ space group where cyanido-bridged structure is decorated with pyrazole molecules coordinated to Co^{II} centers. It is a unique structure with one type of Co^{II}-NC-Nb^{IV} linkage. The spin values of both magnetic ions are 1/2, with $g_{Co}\approx 4.55$, $g_{Nb}\approx 2.0$ for cobalt and niobium respectively. The phase transition in ambient pressure occurs at T_c=5.4 K. Initially applying pressure shifts the temperature of phase transition to lower values down to a critical point, after which further applied pressure starts to increase the T_c. Phase diagram was established on the basis of ac susceptibility measurements.

P. Konieczny has been partly supported by the EU Human Capital Operation Program, Polish Project No. POKL.04.0101-00-434/08-00

P-8-11

Fast minute magnetic field coil for nanotechnology

Ł. Pawliszak,[1] M. Tekielak,[2] and M. Zgirski[1]
[1] *SL2, Institute of Physics, PAN, Warszawa, POLAND*
[2] *Laboratory of Magnetism, University of Bialystok, POLAND*

We designed and fabricated sub-mm-sized magnetic field coils capable of delivering fast magnetic field pulses (rise times of order of 10ns) in the plane of the sample. We use magnetic field outside the single layer coil which achieves up to 40mT in the sample plane when driven with 10A current pulses. Placement of the sample above the coil allows for easy access to its surface. The proposed design can be very useful when direct optical observation (i.e. Kerr microscopy, photospectroscopy) and/or access with manipulators is required. We validated our coil by studying magnetic domain wall dynamics in permalloy nanowires.The design is currently the subject of patent application.

P-8-12

Non-Equilibrium Molecular Dynamics Simulations of Temperature Profiles at the Front of a Shock Wave

P.M. Pigłowski,[1] and K.W. Wojciechowski[1]
[1] *Institute of Molecular Physics*
Polish Academy of Sciences
ul. Mariana Smoluchowskiego 17
60-179 Poznań, Poland

Using Non-Equilibrium Molecular Dynamics Simulations (NEMD), we determined profiles of kinetic and configurational temperatures at the front of two-dimensional, stationary, plane shock waves. Shock waves travelled through (1) a crystal and (2) through a gas. In both cases the particles in the systems interacted by short-range, repulsive, smooth and finite pair potential. In spite of shear stress and heat flow, which were present in both cases, the equivalence between kinetic and configurational temperatures appeared only in the second case, which is not too far from equilibrium.

P-8-13

Elasticity of polydisperse Yukawa particles in two-dimensions

Konstantin V. Tretiakov,[1] and K.W. Wojciechowski[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17/19, 60-179 Poznań, Poland*

The Yukawa potential (YP) is one of widely used approximation to describe the interaction between particles in the field of condensed matter to model colloidal suspensions [1]. Recently, the equilibrium properties and phase diagram of two-dimensional (2D) Yukawa systems (YS) have been investigated [2]. In present study, the elastic properties of a crystalline 2D YS with a size polydispersity of particles are determined by MC simulations. The particles, interacting through hard-core repulsive YP, form a triangular structure. Effects of the size polydispersity and the Debye screening length on the elastic properties of the system are studied. It is found that an increase of size polydispersity in the system leads to an increase of the bulk modulus and a decrease of the shear modulus. It is also observed that the elastic moduli increase with the density, and the growth rate depends largely on the screening length. A smaller screening length causes an accelerated increase of the elastic moduli with the density. **References:**

[1] A. P. Hynninen et. al. Phys. Rev. E **68**, 021407 (2003)
[2] P. Hartmann et. al. Phys. Rev. E **72**, 026409 (2005).

This work was supported by the grant NN202 261 438 of the Polish Ministry of Science and Higher Education.

P-8-14

Partially auxetic behavior in Degenerate Crystalline phase of soft dimers with size polydispersity

J.W. Narojczyk,[1] K.W. Wojciechowski,[1] and M. Kowalik[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17/19, 60-179 Poznań, Poland*

In the *aperiodic phase* of dimers, known also as the Degenerate Crystal [1], it was found that for a particular model of polydisperse dimers [2], the Poisson's ratio [3] in the direction $[110]$ $\left[1\bar{1}0\right]$ decreases, down to negative values, with increasing polydispersity in the system. This is in contrast to observations in other directions, where an increase of the size polydispersity causes an increase of the Poisson's ratio. This indicates that the system is *partially auxetic* [4]. Studies of a broader class of polydisperse dimer models, that are easy to make in practice, have been undertaken. The obtained results confirm partial auxeticity of the models [5].

References:

[1] K. W. Wojciechowski, D. Frenkel and A. C. Brańka, Phys. Rev. Let **67**, pp. 3168–3171 (1991).
[2] J. W. Narojczyk and K. W. Wojciechowski, J. of Non-Cryst. Solids **356**, pp. 2026–2032 (2010).
[3] L. D. Landau and E. M. Lifshitz, Theory of Elasticity Pergamon Press, London (1986).
[4] A. C. Branka and D. M. Heyes and K. W. Wojciechowski, Phys. Stat. Sol. (b) **246**, pp. 96–104 (2011).
[5] J. W. Narojczyk, K. W. Wojciechowski and M. Kowalik, *to be published*

P-8-15

Crystal structures of ternary gadolinium silicides

V. Mykhalichko,[1] R. Kozak,[2] P. Demchenko,[1] and R. Gladyshevskii[1]

[1]*Department of Inorganic Chemistry, Ivan Franko National University of Lviv, Kyryla i Mefodiya St. 6, UA-79005 Lviv, Ukraine*

[2]*Laboratory of Crystallography, Department of Materials, ETH Zurich, Vladimir-Prelog-Weg 5, CH-8093 Zurich, Switzerland*

The crystal structure of $Gd_2Re_3Si_5$ was solved by direct methods in space group $P4/mnc$, using the SHELX-97 program package. The crystal structure of $Gd_2Pt_3Si_5$ was refined by the Rietveld method, using the CSD program package. The crystal structure of the ternary compound $Gd_2Re_3Si_5$ belongs to the structure type $U_2Mn_3Si_5$ ($tP40$, $P4/mnc$, a = 10.95564(13), c = 5.56326(11) Å, atom coordinates: Gd 8*h* 0.26249(5) 0.42271(5) 0; Re1 8*h* 0.14676(4) 0.12315(4) 0; Re2 4*d* 0 1/2 1/4; Si1 8*h* 0.0267(3) 0.3149(3) 0; Si2 8*g* 0.17183(18) 0.67183(18) 1/4; Si3 4*e* 0 0 0.2567(9)), whereas the crystal structure of $Gd_2Pt_3Si_5$ adopts the $U_2Co_3Si_5$ type ($oI40$, *Ibam*, a = 9.9224(2), b = 11.3997(2), c = 5.99300(9) Å, atom coordinates: Gd 8*j* 0.2671(2) 0.3717(3) 0; Pt1 8*j* 0.1122(2) 0.1374(2) 0; Pt2 4*b* 1/2 0 1/4; Si1 8*j* 0.356(1) 0.116(1) 0; Si2 8*g* 0 0.2710(9) 1/4; Si3 4*a* 0 0 1/4). The structures of $Gd_2Re_3Si_5$ and $Gd_2Pt_3Si_5$ can be described as arrangements of one-dimensional structural columns parallel to the crystallographic direction [001], also found in the structure type $CaBe_2Ge_2$.

P-8-16

Crystal structure and magnetic properties of $PrNi_9Si_4$

S. Pukas,[1] B. Belan,[1] M. Manyako,[1] Ya. Tokaychuk,[1] D. Kaczorowski,[2] and R. Gladyshevskii[1]

[1]*Department of Inorganic Chemistry, Ivan Franko National University of Lviv, Lviv, Ukraine*

[2]*Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland*

The existence of a new rare-earth nickel silicide, $PrNi_9Si_4$, was established. Its crystal structure was determined from X-ray powder diffraction data. The profile and structure parameters were refined using the Rietveld method starting from coordinates of the structure type $CeNi_{8.5}Si_{4.5}$ in space group $I4/mcm$ (a=7.8377(12), c=11.4861(17) Å). At the first stages of the refinement the sites occupied by small atoms (Ni and Si) were considered as statistical mixtures. The refined compositions of the sites indicated fully ordered distribution of atoms. Magnetic measurements were carried out in the temperature range 1.72-400 K in magnetic fields up to 5 T using SQUID magnetometer. The $PrNi_9Si_4$ compound is a temperature dependent paramagnet with no distinct feature in its $\chi(T)$ that might hint at any phase transition at low temperatures. The isothermal magnetization measured at T=1.72 K exhibits paramagnetic behavior. Above 50 K the magnetic susceptibility can be approximated by a modified Curie-Weiss law (μ_{eff}=3.43 μ_B, θ=-3.7(2) K, χ_0= 8.76(9)·10^{-4} emu/mol).

INDEX OF AUTHORS

Wielkopolska Centre for Advanced Technologies (WCAT) and its mission

Wielkopolska is among the leading academic centres in Poland, harbouring a great R&D potential. The essence of the comprehensive knowledge transfer model, generated and pursued in the city of Poznań, the capital of Wielkopolska region, is building an effective relationship between *invention*, pursued at universities and research institutes, and *innovation*, developed at the Poznań Science and Technology Park of Adam Mickiewicz University Foundation, by creating all elements necessary for the effective transfer of knowledge, especially Polish scientific and technological achievements, to business practice. At the core of the model is the Wielkopolska Centre for Advanced Technologies (WCAT) in Poznań, a multi-disciplinary institution focused on design and characterisation of new materials and biomaterials of multiple applications.

The main aim of the foundation of Wielkopolska Centre for Advanced Technologies–Materials and Biomaterials (WCAT) in Poznan, is to create a multidisciplinary research centre in the field of high-tech materials, biomaterials and nanomaterials based on recent achievements in related fields of chemistry, chemical technologies, physics, biotechnology, biology, medicine, pharmacy and agriculture sciences.

WCAT brings together the best specialists of natural and engineering sciences and is an infrastructural venture of the Poznań scientific community. The Centre is a consortium of five universities: the Adam Mickiewicz University (AMU), which is the project coordinator, Poznań University of Technology, Poznań University of Life Sciences, Poznań University of Medical Sciences and Poznań University of Economics; four institutes of the Polish Academy of Sciences: the Institute of Bioorganic Chemistry, Plant Genetics, Human Genetics, and Molecular Physics; Institute of Natural Fibres and Medicinal Plants; and the Poznań Science and Technology Park of the Adam Mickiewicz University Foundation and City of Poznań. The project is based on the research know-how and credibility of leading scientists, working in the key institutes of the regions.

The objective of the multidisciplinary activity of the centre is to develop original methods for synthesis of chemicals, biochemicals and agrochemicals, called fine chemicals, and a new generation of biomaterials and nanomaterials and their precursors, designed in cooperation between the chemists, physicochemists and biochemists. These research activity will be followed by the development of advanced technologies and biotechnologies

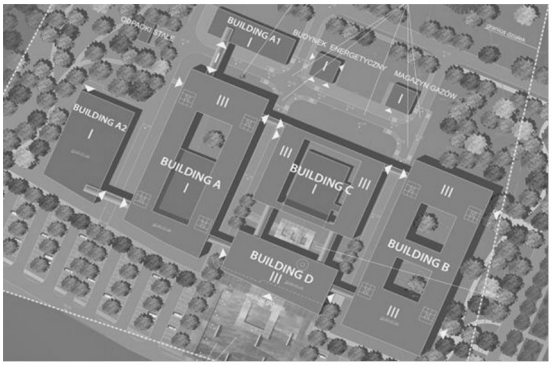
INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

wcat
WIELKOPOLSKA CENTRE OF ADVANCED TECHNOLOGIES

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

for the production of these fine (bio)chemicals and precursors of materials to be used in optoelectronics, ceramics, medicine, pharmacy, agriculture and other fields of high-tech industry. Another objective of WCAT is to create a technological basis for a number of applications for bioorganic chemistry and biotechnology in healthcare as well as applications in agricultural engineering and in the food industry.

The special mission of WCAT is to develop multidisciplinary projects involving fundamental research in the material sciences but simultaneously leading to advanced technologies and/or products subsequently implemented in incubators of the innovative firms localized in Poznań Science and Technology Park, and other industrial and technological parks, and innovative small and medium firms as well as by international industry. The start-up companies and innovative SMEs will be at the heart of the WCAT mission.



To reach the complex goals mentioned above, we committed to ensure permanent cooperation between all units of WCAT i.e. Centre of Chemical Technology and Nanotechnology, Centre of Industrial Biotechnology with a Greenhouse, Centre of Medical Biotechnology with an Animal House, Centre of Material Sciences with a Regional Laboratory of Unique Equipment, functioning as one research organism.

As emphasized, the Regional Laboratory of Unique Equipment should be of service to all other units of WCAT. The Laboratory has highly specialized equipment which will be available for use by the scientific community and small and medium enterprises from the region as well as R&D centres of Polish and international (European) companies. The Service and Technical Facilities with the Technology Transfer Centre will ensure efficient collaboration among all parts of WCAT.

The vision of WCAT is to include existing organizations (universities, research institutes, and science-technology park) to act like one independent entity, which will generate synergies by combining the work of the best scientists, as an independent institute modelled on the Fraunhofer Society (most experienced of R&D Centres in Europe with 60-70 years tradition).

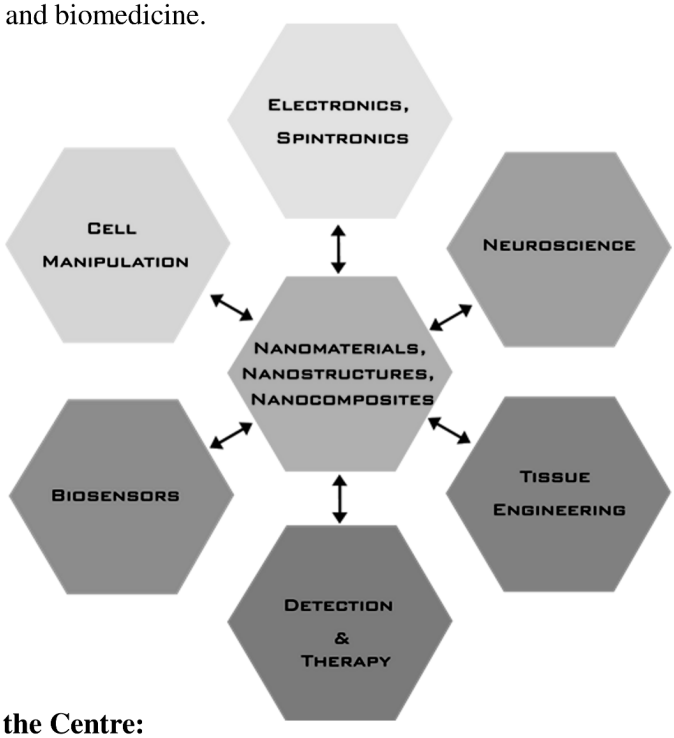
The WCAT project is co-financed (85%) by the European Regional Development Fund under the Operational Programme Innovative Economy 2007-2013 with total budget 63million EUR

---------- **w w w .w c a t . p l** ----------

Wielkopolska Centre for Advanced Technologies, Umultowska 89c, 61-614 Poznan, Poland

NanoBioMedical Centre (NBMC) as an interdisciplinary unit

NanoBioMedical Centre (NBMC) at Adam Mickiewicz University in Poznan is an **interdisciplinary unit** focused on research and training of PhD and master students with the aim to stimulate the development of nanotechnology and its application in different research areas, especially in material science, biology and medicine, including novel nanomaterials and their applications to electronics, photovoltaic and biomedicine.



Potential of the Centre:

- laboratories with high-performance instruments worth over 30 million of Euros
- scientific staff with over 20 professors from Adam Mickiewicz University and partner Poznan universities, over 20 professors from foreign institutions and over 35 professionals (PhDs) in physics, biophysics, chemistry, biology, engineering and medicine
- around 40 PhD students in nanoscience and nanotechnology
- over 40 master projects realized in our laboratories
- wide international and national collaboration
- annual conferences and seminars

Laboratories:

NMR Spectroscopy an Imaging Laboratory for studying molecular dynamics and structure of nanomaterials with usage of: NMR Spectrometer 800 MHz for determining of structure of biochemical samples, NMR Spectrometer 600 MHz for diffusion measurements and microimaging with extremely high resolution, NMR 400 MHz Spectrometer for solids and routine studies of liquids. The Imaging part of this laboratory is also equipped with Magnetic Resonance Imager 400 MHz for investigations of small animals.

Microscope Laboratory: Scanning Tunnelling Microscope (STM/AFM) operating at Ultra High Vacuum conditions and low temperature, High Resolution Transmission Electron Microscope HRTEM 200kV for imaging at sub-angstrom level and analysis of chemical compounds, Scanning Electron Microscope (SEM) for solids and soft matter, Focused Ion Beam, Near-Field Scanning Optical Microscope (NSOM), Atomic Force Microscopes (also integrated with Raman spectrometer) for solids, liquids and biological samples, Super Resolution Optical Microscope - STED, Fast Multibeam Scanning Confocal Microscope.

Optical Spectroscopy Laboratory for optical analysis and photonic interaction with nanomaterials and biological materials, and also for quantum effects research, specific to this class of materials mainly by means of Fluorescence Correlation Spectroscopy (FCS).

Chemistry Laboratory for studies of chemical and physical properties of nanoparticles and nanostructures mainly by means of optical spectroscopy and for sample preparation.

Biology Laboratory for studies of processes in nanobiology including cellular sensors, biomembranes, nanocapsules, drug therapies monitoring at cellular level with usage of: In Cell Analyser, Surface Plasmon Resonance Biosensor, fluorescence microscopy, flow cytometry.

Medical Laboratory for tissue engineering, detection and therapy with Fluorescence Molecular Tomography system, Electron Spin Resonance Scanner, and uses animal MRI.

Nanostructures Laboratory for nanomaterials' production and their characterization with physical methods, equipped with Atomic Layer Deposition, Reactive Ion Etching and systems for growth of carbon nanotubes.

Clean Room for nanomaterials' production in extremely clean conditions (class: 1000 and 100).

Vision and Neuroscience Laboratory with electroencephalography system (EEG), transcranial magnetic stimulation (TMS), motion analysis measuring system, corneal topograph, spectral optical coherent tomography, ophtalmological ultrasonography scanning apparatus.

ABE-IPS Sp. z o.o.
Ul. Grzybowska 37A
00-855 Warszawa

ABE MARKETING Sp. z o.o. and International Publishing Service Sp. z o.o. for many years have kept leading position among the distributors of foreign language publications in Poland. After twenty years of competing with one another, responding to dynamic changes in the market, the companies decided to join forces and in April this year have signed an agreement for integration of their business activities. The new structure increased our organizational potential and is helping us better fulfill our customers' wishes and their ever growing expectations. We are continuing our work in the field of distribution of foreign literature and scientific information, constantly broadening the scope of our activities, increasing the range of products we offer as well as the variety of services we provide.

From August 2011 on we are operating under unified name and brand ABE-IPS, which is represented by a sale force of over 25 reps all over Poland and Ukraine, offering our customers whole range of services, providing them with the latest information on newly published works a well as organizing exhibitions of textbooks and other publications. Our excellent customer service is possible thanks to direct contact with leading publishers and eContent providers. Currently we are working with over 300 publishers from around the globe.

Marek Jazikowski
e-mail: marek.jazikowski@abe.pl
phone num.: +48 691 512 975

Bookstore ABE-IPS/Branch in Poznań
ul. Powstańców Wlkp. 2B
61-895 Poznań
tel. +48 61 856 02 79

High- performance ceramics FRIALIT® - DEGUSSIT®
The material of our time

Components made of advanced ceramics, optimally designed to meet the extreme demands set by modern industrial clients and research and development, are the mainstay of our portfolio. The mechanical, thermal and electrical properties enable us to provide brilliant solutions for innumerable sectors and for the most varied tasks:

Chemical:

- Optimum corrosion resistance without compromise

Mechanical:

- Exceptional hardness and abrasion resistance
- High pressure and bending strength, even at higher temperatures

Thermal:

- Extremely low and high application temperatures
- Good thermal conductivity

Elektrical / **Physical**:

- High electrical volume and surface resistance
- High electrical strength
- Low dielectric losses at high frequencies
- Low neutron absorption cross-section

For details please visit: **www.friatec.de** or **www.frialit.pl**

NOTES

NOTES

NOTES

NOTES

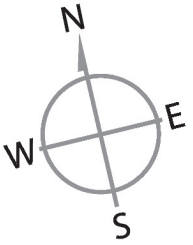
NOTES

VENUE

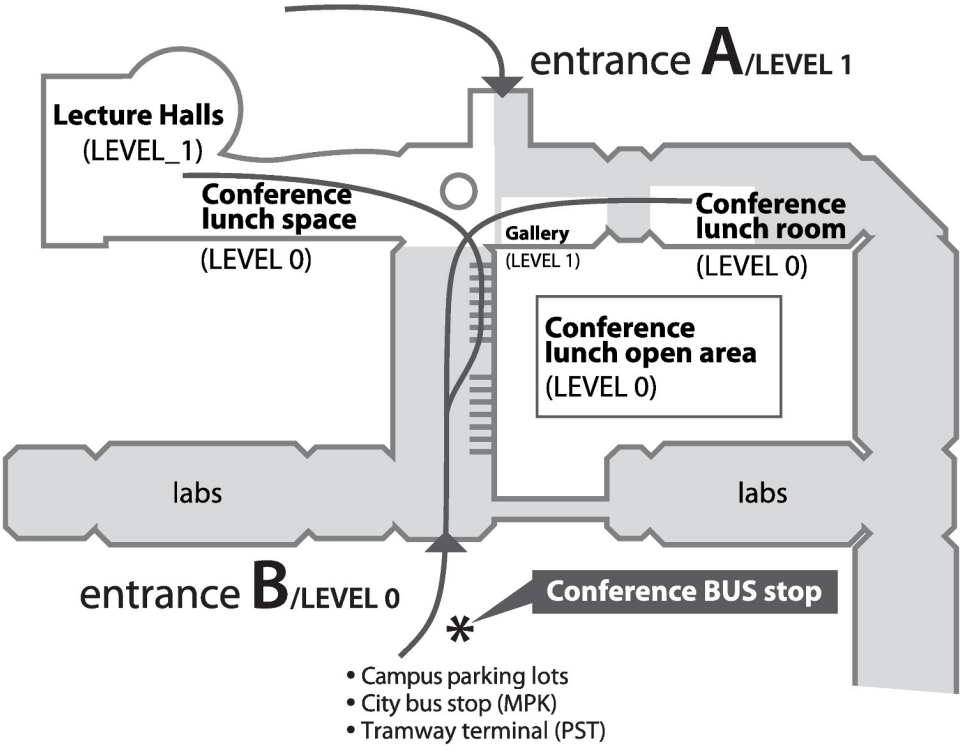
The European Conference
PHYSICS OF MAGNETISM 2014

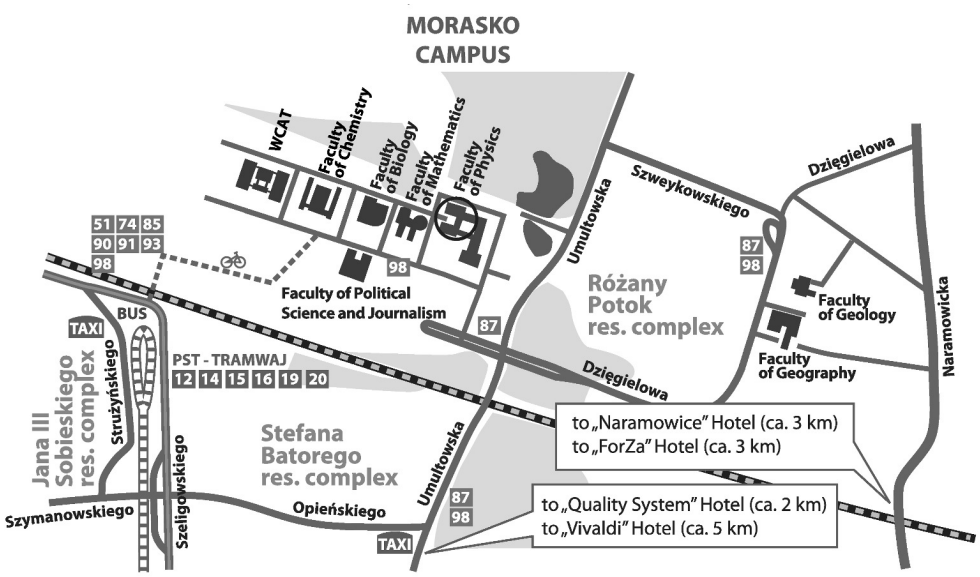
June 23-27, 2014, Poznań, POLAND

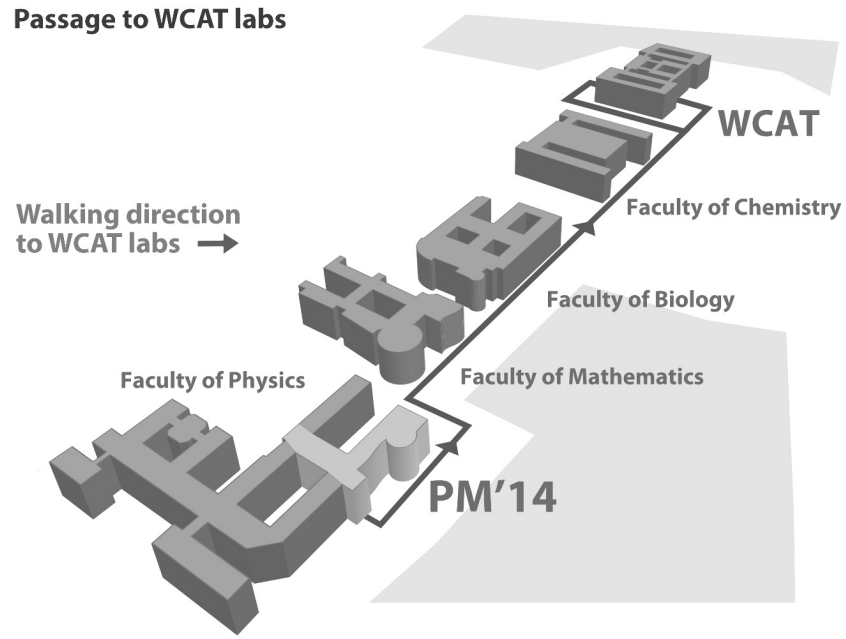
Adam Mickiewicz University in Poznań
Faculty of Physics
Umultowska 85
61-614 Poznań

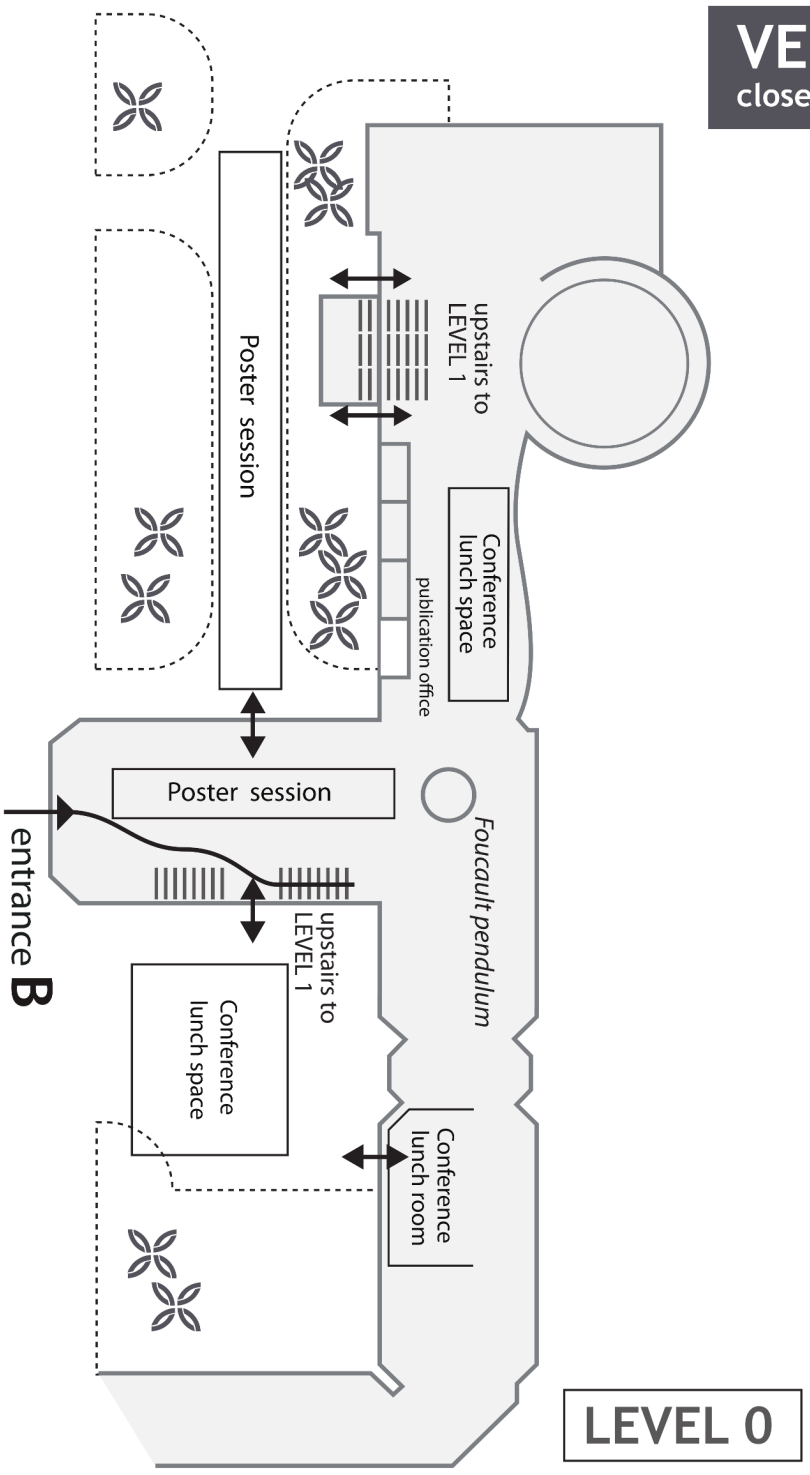


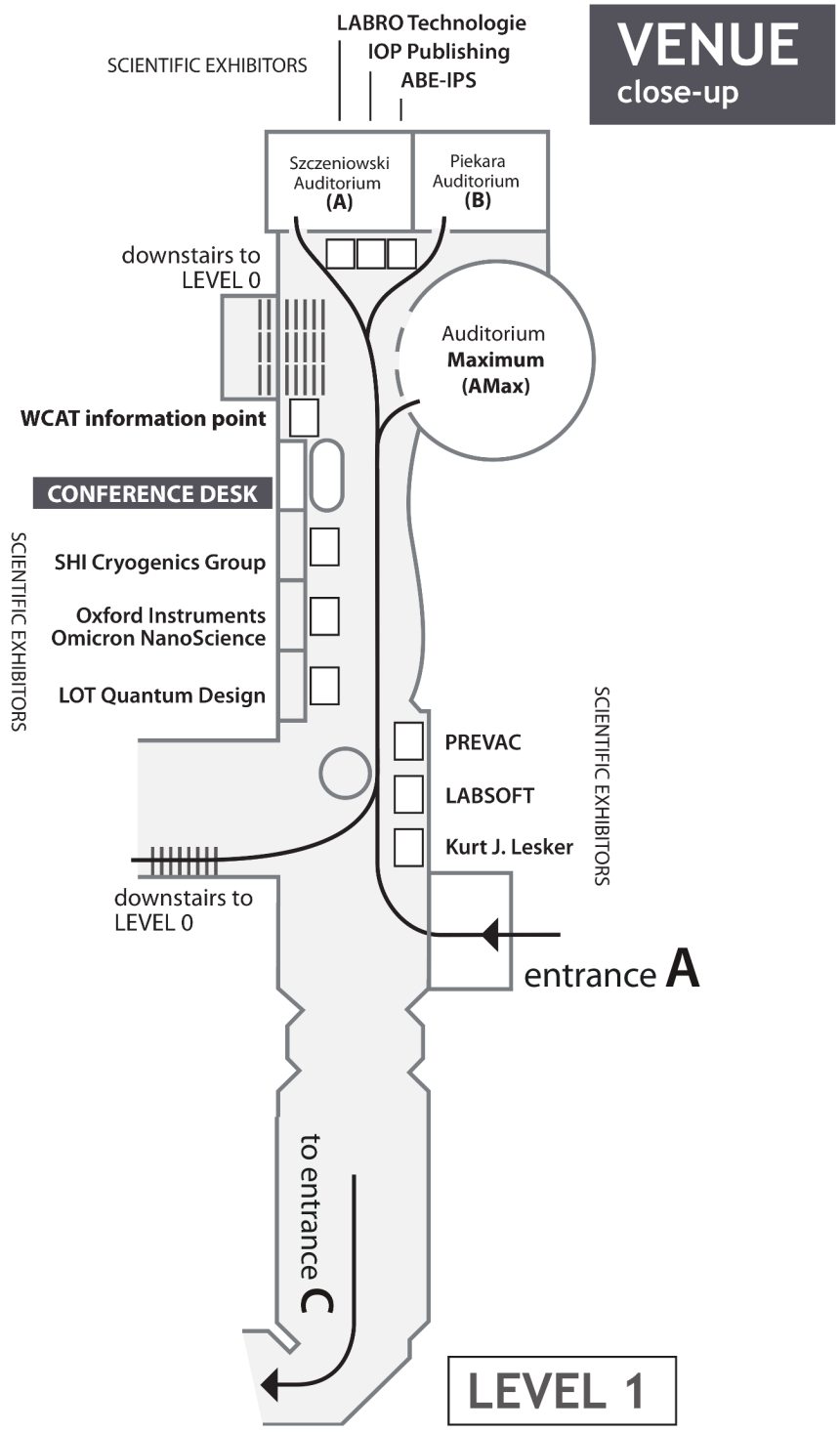
GPS coordinates
52°28'03'' N
16°55'45'' E




MORASKO
CAMPUS
WCAT
Faculty of Chemistry
Faculty of Biology
Faculty of Mathematics
Faculty of Physics
Umultowska
Szweykowskiego
Dzięgielowa
51 74 85
90 91 93
98
98
87
98
Faculty of Political Science and Journalism
Różany Potok res. complex
Faculty of Geology
Faculty of Geography
Naramowicka
BUS
TAXI
PST - TRAMWAJ
12 14 15 16 19 20
87
Dzięgielowa
Jana III Sobieskiego res. complex
Strużyńskiego
Stefana Batorego res. complex
Umultowska
to „Naramowice" Hotel (ca. 3 km)
to „ForZa" Hotel (ca. 3 km)
Szymanowskiego
Szeligowskiego
Opieńskiego
87
98
TAXI
to „Quality System" Hotel (ca. 2 km)
to „Vivaldi" Hotel (ca. 5 km)


Passage to WCAT labs
WCAT
Walking direction to WCAT labs
Faculty of Chemistry
Faculty of Biology
Faculty of Physics
Faculty of Mathematics
PM'14


VENUE
close-up
upstairs to LEVEL 1
Poster session
Conference lunch space
publication office
Poster session
entrance B
Foucault pendulum
upstairs to LEVEL 1
Conference lunch space
Conference lunch room
LEVEL 0


VENUE
close-up
LABRO Technologie
IOP Publishing
ABE-IPS
SCIENTIFIC EXHIBITORS
Szczeniowski Auditorium (A)
Piekara Auditorium (B)
downstairs to LEVEL 0
Auditorium Maximum (AMax)
WCAT information point
CONFERENCE DESK
SCIENTIFIC EXHIBITORS
SHI Cryogenics Group
Oxford Instruments
Omicron NanoScience
LOT Quantum Design
PREVAC
LABSOFT
Kurt J. Lesker
SCIENTIFIC EXHIBITORS
downstairs to LEVEL 0
entrance A
to entrance C
LEVEL 1

Wireless Connection

How to connect to wireless network?

- wireless network name: **NetworkForGuest**
- password **is not** required

www.ifmpan.poznan.pl/pm14

PM'14 book of abstracts