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

The European Conference

PHYSICS OF MAGNETISM 2017

June 26-30, 2017, Poznań, Poland

ABSTRACTS

Poznań 2017

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

The European Conference
PHYSICS OF MAGNETISM 2017 (PM'17)

ABSTRACTS

Poznań 2017

The European Conference
PHYSICS OF MAGNETISM 2017 (PM'17)
June 26-30, 2017
Poznań, Poland
Abstracts

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

The abstracts are reproduced as received from authors

ISBN 978-83-933663-4-7

Published by: Institute of Molecular Physics
Polish Academy of Sciences
Mariana 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 2017

June 26-30, 2017
Poznań, Poland

CHAIRMEN

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

PROGRAMME COMMITTEE

R. Allenspach, Rüschlikon, Switzerland
J.F. Annett, Bristol, United Kingdom
J.-Ph. Ansermet, Lausanne, Switzerland
J. Barnaś, Poznań, Poland
G. Cuniberti, Dresden, Germany
V. Franco, Sevilla, Spain
A. Jezierski, Poznań, Poland
S. Jurga, Poznań, Poland
D. Kaczorowski, Wrocław, Poland
B. Keimer, Stuttgart, Germany
S. Krompiewski, Poznań, Poland
S. Maekawa, Tokai, Japan
D. van der Marel, Geneva, Switzerland
Ph. Mendels, Orsay, France
J.A. Morkowski, Poznań, Poland
A.M. Oleś, Kraków, Poland
H. Puszkarski, Poznań, Poland
S. Robaszkiewicz, Poznań, Poland
F. Stobiecki, Poznań, Poland
A. Ślebarski, Katowice, Poland
M. Vojta, Dresden, Germany
K.I. Wysokiński, Lublin, Poland

ADVISORY COMMITTEE

A. Bonanni, Linz, Austria
B. Bułka, Poznań, Poland
E. Coronado, Burjasot, Spain
M.G. Cottam, London, Canada
R. Czajka, Poznań, Poland
J. Dubowik, Poznań, Poland
M. Fähnle, Stuttgart, Germany
R. Gałązka, Warszawa, Poland
A. Garg, Evanston, USA
H. Hahn, Karlsruhe, Germany
G. Kamieniarz, Poznań, Poland
P. Kopčanský, Košice, Slovakia
L. Kowalewski, Poznań, Poland
S. Lipiński, Poznań, Poland
J. Martinek, Poznań, Poland
A. Maziewski, Białystok, Poland
K. Miyake, Nagakute, Japan
R. Puźniak, Warszawa, Poland
T. Stobiecki, Kraków, Poland
T. Story, Warszawa, Poland
P. Tomczak, Poznań, Poland
M.R. Wegewijs, Jülich/Aachen, Germany
A. Wójcik, Poznań, Poland
T. Wojtowicz, Warszawa, Poland

ORGANIZING COMMITTEE

A. Szajek (secretary), **T. Toliński** (treasurer)
M. Bąk, A. Dyrdał, I. Gościańska, A. Józefczak, P. Kozłowski, D. Krychowski, P. Kuświk, P. Leśniak, M. Lewandowski, M. Matczak, G. Musiał, M. Nowak, I. Olejniczak, M. Pugaczowa-Michalska, Z. Śniadecki, M. Werwiński, M. Zwierzycki

PUBLICATIONS

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

AWARDS JURY

B. Tsukerblat, Beer Sheva, Israel (chairman)
J. Dubowik, Poznań, Poland
G. Kamieniarz, Poznań, Poland
B. Dąbrowski, DeKalb, USA
D. Kaczorowski, Wrocław, Poland

SPONSORS

Faculty of Physics, Adam Mickiewicz University, Poznań

Institute of Molecular Physics of the Polish Academy of Sciences

International Cooperation Department of the Polish Academy of Sciences

Committee of Physics of the Polish Academy of Sciences

The Rector of the Adam Mickiewicz University, Poznań

Polish Physical Society - Poznań Branch

Central European Exchange Program for University Studies

Bureau for academic recognition and international exchange

Institute of Physics of the Polish Academy of Sciences

IOP Publishing

KOMPANIA
PIWOWARSKA

European Physical Society

SCHEDULE

Monday, June 26, 2017

8^{30} - 10^{45} **REGISTRATION**

10^{45} - 11^{15} **OPENING**
R. Micnas, B. Idzikowski

S.1 Recent Developments in Spintronics, Magnetic Semiconductors and Topological Insulators
Chairman: J. Barnaś

11^{15} - 11^{50} **Stuart S.P. Parkin**
Max Planck Institute of Microstructure Physics & Martin Luther University Halle-Wittenberg, Halle, Germany
Spin orbitronics for advanced magnetic memories

11^{50} - 12^{25} **Tomasz Dietl**
Institute of Physics of the Polish Academy of Sciences, Warszawa, Poland
Electric-field control of magnetism by piezoelectric effects

12^{25} - 13^{00} **Warren E. Pickett**
Department of Physics, University of California Davis, Davis, USA
Chern Insulators: from Design, toward Realization

13^{00} - 14^{15} lunch

14^{15} - 15^{30} **ORAL SESSION 1**

(Auditorium Max) Chairman: I. Weymann
A.M. Oleś (O-1-03), K.I. Wysokiński (O-1-11), R.W. Chhajlany (O-1-20), R.K. Kremer (O-2-01), M.M. Maśka (O-2-04)

(Auditorium A) Chairman: J. Dubowik
Rafał Oszwałdowski
South Dakota School of Mines and Technology, Rapid City, USA
Magnetic Polarons in Semiconductor Quantum Dots
D. Krychowski (O-4-09), K. Gusliyenko (O-5-02), I.L. Lyubchanskii (O-5-04)

(Auditorium B) Chairman: J. Martinek
A. Janutka (O-3-08), M. Frankowski (O-3-07), P. Tomczak (O-3-12), M. Lonsky (O-4-04), L. Thevenard (O-4-10)

15^{30} - 15^{50} coffee break

Monday, June 26, 2017

S.2 Correlated Electron Systems, Multiferroics and Nanomaterials
SESSION SPONSORED BY LAKE SHORE CRYOTRONICS
Chairman: R. Puźniak

15^{50} - 16^{25} **Antonio Bianconi**
Rome International Center for Materials Science Superstripes RICMASS, Rome, Italy
Lattice complexity and Fano resonances near a Lifshitz Transition in strongly correlated systems

16^{25} - 17^{00} **Bogdan Dąbrowski**
Department of Physics, Northern Illinois University, DeKalb, USA
Single-phase and single-ion displacive-type manganese perovskite multiferroics

17^{00} - 17^{35} **Maciej Urbaniak**
Institute of Molecular Physics of the Polish Academy of Sciences, Poznań, Poland
Co based multilayer systems for controllable domain wall positioning

17^{35} - 18^{00} coffee break

18^{00} - 19^{15} **ORAL SESSION 2**

(Auditorium Max) Chairman: F. Stobiecki
Stefan Eisebitt
Max Born Institute, Berlin, Germany
Field-free deterministic creation and inertial properties of single skyrmions
P. Kuświk (O-5-16), L. Smardz (O-5-17), A. Wawro (O-5-06)

(Auditorium A) Chairman: A. Jezierski
V.H. Tran (O-1-10), T. Cichorek (O-1-12), P. Potasz (O-1-16), E. Sonin (O-2-02), O. Sikora (O-2-07)

(Auditorium B) Chairman: P. Tomczak
G. Musiał (O-2-05), J. Więckowski (O-1-07), E. Coy (O-1-18), J. Pawlak (O-4-12)

19^{30} - ... **welcome party**

Tuesday, June 27, 2017

S.3 New Directions in Strongly Correlated Condensed Matter
Chairman: J.A. Morkowski

8^{30} - 9^{05} **Ian Affleck**
Department of Physics & Astronomy, University of British Columbia, Vancouver, Canada
Field-induced phase transition in Haldane gap spin chains

9^{05} - 9^{40} **Maciej Lewenstein**
ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain
Quantum Magnetism and Ultracold Atoms

9^{40} - 10^{15} **Peter Prelovšek**
Jožef Stefan Institute, Ljubljana, Slovenia &
Department of Physics, University of Ljubljana, Ljubljana, Slovenia
Many-body localization in disordered spin and Hubbard chains

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

10^{45} - 12^{45} **POSTER SESSION I** (categories: 3, 8)
Chairmen: A. Szytuła, N. Plakida, O. Strbak

12^{45} - 14^{00} lunch

S.4 Strongly Correlated Electrons and High Temperature Superconductivity
PROFESSOR STANISŁAW ROBASZKIEWICZ MEMORIAL SESSION
Chairman: K.I. Wysokiński

14^{00} - 14^{35} **John M. Tranquada**
Condensed Matter Physics & Materials Science Department, Brookhaven National Laboratory, Upton, USA
Probing intertwined orders in cuprate superconductors

14^{35} - 15^{10} **Jorge E. Hirsch**
Department of Physics, University of California, San Diego, USA
Spinning superconductors and ferromagnets

15^{10} - 15^{45} **Józef Spałek**
Marian Smoluchowski Institute of Physics, Jagiellonian University, Kraków, Poland
Universal properties of high-temperature superconductors from real-space pairing: Comparison with experiment

15^{45} - 16^{05} coffee break

Tuesday, June 27, 2017

16^{05} - 17^{20} **ORAL SESSION 3**

(Auditorium Max) Chairman: B.R. Bułka

Kevin Bedell
Department of Physics, Boston College, Chestnut Hill, USA
Non-Equilibrium Quantum Spin Systems: Fermi Liquids Out of Their Fields

T. Story (O-4-13), S. Krompiewski (O-4-06),
M.Ye. Zhuravlev (O-4-07)

(Auditorium A) Chairman: L. Kowalewski

O. Gorobets (O-3-03), V. Kruglyak (O-3-11),
P. Graczyk (O-3-06), C. Gourdon (O-3-09),
K. Zakeri (O-3-10)

(Auditorium B) Chairman: E. Sonin

J. Teyssier (O-1-01), L. Kalinowski (O-1-02),
A. Stupakov (O-1-05), R.J. Radwański (O-1-15),
B. Wiendlocha (O-4-05)

17^{20} - 17^{45} coffee break

17^{45} - 19^{15} **ORAL SESSION 4**

(Auditorium Max) Chairman: R.K. Kremer

Boris Tsukerblat
Department of Chemistry, Ben-Gurion University of the Negev, Beer-Sheva, Israel
A Paradigm of Quantum Cellular Automata: Implementation of Molecular Magnets

D. Kaczorowski (O-4-11), A. Wiśniewski (O-5-07),
R. Puźniak (O-5-08)

(Auditorium A) Chairman: V. Kruglyak

P. Trocha (O-4-14), F. Forte (O-1-17),
K. Szałowski (O-5-14), R. Strzelczyk (O-5-11),
M. Lewandowski (O-5-19)

(Auditorium B) Chairman: A. Wójs

J. Chęciński (O-8-01), O. Strbak (O-8-02),
O. Chumak (O-6-02), S. Lewińska (O-3-02),
A. Szytuła (O-3-04)

Wednesday, June 28, 2017

S.5 Mostly Topological Phases, Transport and Stripes
Chairman: T. Story

8^{30} - 9^{05} **Arun Bansil**
Physics Department, Northeastern University, Boston, USA
Topological Phases of Quantum Matter as Novel Platforms for Fundamental Science and Applications

9^{05} - 9^{40} **Thomas Fischer**
University of Bayreuth, Bayreuth, Germany
Floquet topological crystalline colloidal transport

9^{40} - 10^{15} **Raymond Frésard**
Laboratoire Crismat-ENSICAEN, Caen, France
On superconducting stripes of the two-dimensional Hubbard model

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

10^{35} - 11^{00} coffee break

11^{00} - 13^{00} **POSTER SESSION II** (categories: 2, 5, 7)
Chairmen: L. Smardz, M. Lewandowski, C. Uyeda

13^{00} - 14^{15} lunch

Wednesday, June 28, 2017

14^{15} - 16^{00} **ORAL SESSION 5**

(Auditorium Max) Chairman: S. Krompiewski

N. Plakida (O-3-01), I. Hagymasi (O-1-04),
W. Brzezicki (O-1-06), P. Stefański (O-1-13),
K.J. Kapcia (O-1-09), T. Domański (O-5-09),
K. Ptaszyński (O-4-01)

(Auditorium A) Chairman: G. Kamieniarz

Vitalii Zablotskii
Institute of Physics of the Czech Academy of Sciences,
Prague, Czech Republic
How cells respond to high-gradient magnetic fields

E.E. Vogel (O-5-03), P. Kozłowski (O-2-03),
I. Bakonyi (O-4-02), M. Pohlit (O-5-12),
T. Dohi (O-5-10)

(Auditorium B) Chairman: A. Wiśniewski

A. Ptok (O-1-08), A. Akbari (O-1-14), K. Wójcik (O-1-19),
K. Carva (O-3-13), Z. Śniadecki (O-6-05),
S. Koyiloth Vayalil (O-5-18), G. Chaves (O-6-03)

16^{00} - 16^{30} coffee break

16^{30} - 18^{00} **ERC presentation - Odeta Limaj**
&
SESSION OF SCIENTIFIC EXHIBITORS
Chairmen: D. Krychowski & P. Kuświk

18^{00} - 18^{15} transportation to the concert hall

19^{00} - ... **concert**

Thursday, June 29, 2017

S.6 Quantum Criticality, Superconductivity, Kondo Lattices and Rare-Earth Magnetism
Chairman: D. Kaczorowski

8^{30} - 9^{05} **Gilbert Lonzarich**
Cavendish Laboratory, University of Cambridge,
Cambridge, United Kingdom
Kondo Lattice Systems and Reconsideration of the Doniach Phase Diagram

9^{05} - 9^{40} **Frank Steglich**
Max-Planck-Institute for Chemical Physics of Solids,
Dresden, Germany
Emergence of superconductivity due to nuclear antiferromagnetic order

9^{40} - 10^{15} **Piotr Wiśniewski**
Institute of Low Temperature and Structure Research of the Polish Academy of Sciences, Wrocław, Poland
Rare-earth based half-Heusler phases and monopnictides - magnetotransport, superconductivity and antiferromagnetism

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

10^{45} - 12^{45} **POSTER SESSION III** (categories: 1, 4, 6)
Chairmen: I. Hagymasi, P. Stefański, P. Trocha, M. Zhuravlev

12^{45} - 14^{00} lunch

Thursday, June 29, 2017

14^{00} - 15^{15} **ORAL SESSION 6**

(Auditorium Max) Chairman: T. Domański

Jan Rusz
Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden
Towards quantitative magnetic measurements with sub-nanometer lateral resolution

C. Uyeda (O-7-01), J. Krupka (O-6-01), M. Werwiński (O-6-04)

(Auditorium A) Chairman: M. Maśka

W. Brenig (O-2-06), L. Botsch (O-4-03), J. Martinek (O-4-15), P. Baláž (O-3-05), W. Skowroński (O-4-08)

(Auditorium B) Chairman: A. Szewczyk

M. Stiller (O-5-01), M. Kiwi (O-5-05), A. Calloni (O-5-13), A. Maziewski (O-5-15)

15^{30} - 15^{45} transportation to Ostrów Tumski

Sightseeing of Ostrów Tumski

18^{00} - ... concert in Archcathedral Basilica

19^{00} - ... **banquet**

Friday, June 30, 2017

S.7 New Magnetic Materials, Spin-Lattice Coupling, and Micromagnetism
Chairman: K. Gusliyenko

8^{30} - 9^{05} **Björgvin Hjörvarsson**
Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden
Designing magnetic meta-materials using finite size effects

9^{05} - 9^{40} **Henryk Szymczak**
Institute of Physics of the Polish Academy of Sciences, Warszawa, Poland
Strain modulated microwave spectroscopy as a sensitive method to study mechanisms responsible for spin-lattice coupling in ferromagnets

9^{40} - 10^{15} **Ralph Skomski**
Department of Physics and Astronomy, University of Nebraska-Lincoln, Lincoln, USA
Finite-Temperature Magnetism

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

S.8 Mostly Magnonics and Spin Electronics
Chairman: H. Puszkarski

10^{45} - 11^{20} **Gen Tatara**
RIKEN Center for Emergent Matter Science (CEMS), Hirosawa, Wakō, Saitama, Japan
Doppler shift picture of the Dzyaloshinskii-Moriya interaction and light propagation in systems with broken inversion symmetry

11^{20} - 11^{55} **Maciej Krawczyk**
Faculty of Physics, Adam Mickiewicz University, Poznań, Poland
Spin wave dynamics in magnonic crystals, quasicrystals and areas of graded refractive index

11^{55} - 12^{30} **Paolo Bortolotti**
Unité Mixte de Physique CNRS/Thales, Palaiseau, France
RF applications based on spintronics: latest results and future developments

Friday, June 30, 2017

CLOSING SESSION

Topological Quantum Magnets

Chairmen: R. Micnas, B. Idzikowski

12^{35} - 13^{10} **Frédéric Mila**
Institute of Physics, Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland
Edge states and exact zero modes in topological 1D quantum magnets

13^{10} - 14^{00} **AWARDS**
B. Tsukerblat

SUMMARY
A.M. Oleś, A. Maziewski

CLOSING
R. Micnas, B. Idzikowski

14^{00} - ... lunch

INVITED LECTURES

Monday, June 26th, 2017

Spin orbitronics for advanced magnetic memories

Stuart Parkin[1]

[1] *Max Planck Institute for Microstructure Physics, Halle (Saale), Germany Martin Luther University Halle-Wittenberg*

Over the past few years there have been remarkable discoveries in spin-based phenomena that rely on *spin-orbit coupling* that could spur the development of advanced magnetic memory devices. These include the formation of *chiral* spin textures in the form of Néel domain walls and topological spin textures, skyrmions, that are stabilized by a Dzyaloshinskii-Moriya exchange interaction. The Dzyaloshinskii-Moriya exchange interaction is derived from broken symmetries and spin-orbit interactions at interfaces or within the bulk of materials. Another important consequence of spin-orbit effects are the unexpectedly high conversion efficiencies of charge current to *chiral* spin current from topological spin textures and in conventional metals, via the spin Hall effect[1,2]. Such spin currents lead to giant spin-orbit torques that can be used to switch the magnetization in three terminal magnetic tunnel junction memory elements or can be used to move domain walls in Racetrack Memory memory-storage devices. Indeed record-breaking current-induced domain wall speeds exceeding 1,000 m/sec have recently been reported in atomically engineered synthetic antiferromagnetic racetracks in which the domain walls are "invisible" with no net magnetization[3,4]. Non-collinear spin textures including the recent discovery of antiskyrmions[5] promise novel spintronic applications. I will discuss some of these exciting developments in the emerging field of *spin orbitronics* in my talk.

References:

[1] Zhang, W. *et al.* Giant facet-dependent spin-orbit torque and spin Hall conductivity in the triangular antiferromagnet $IrMn_3$. *Sci. Adv.* **2**, e1600759, (2016).

[2] Demasius, K.-U. *et al.* Enhanced spin-orbit torques by oxygen incorporation in tungsten films. *Nat. Commun.* **7**, 10644, (2016).

[3] Yang, S.-H., Ryu, K.-S. & Parkin, S. S. P. Domain-wall velocities of up to 750 ms^{-1} driven by exchange-coupling torque in synthetic antiferromagnets. *Nat. Nano.* **10**, 221-226, (2015).

[4] Garg, C., Yang, S.-H., Phung, T., Pushp, A. & S.P.Parkin, S. Dramatic influence of curvature of nanowire on chiral domain wall velocity. *Sci. Adv.* **3**, e1602804, (2017).

[5] Nayak, A. K. *et al.* Discovery of Magnetic Antiskyrmions Beyond Room Temperature in Tetragonal Heusler Materials. *arXiv:1703.01017*, (2017).

Monday, June 26th, 2017

Electric-field control of magnetism by piezoelectric effects

Tomasz Dietl[1,2,3]

[1] *International Research Centre MagTop, PL-02-668 Warszawa, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, PL-02-668 Warszawa, Poland*
[3] *WPI-Advanced Institute for Materials Research, Tohoku University, Sendai, Japan*

There is a growing interest in various methods allowing for controlling magnetic properties by an electric field [1]. A strong sensitivity of magnetic properties on carrier density and strain in dilute ferromagnetic semiconductors such as (Ga,Mn)As has allowed to affect magnetism by gaiting or by applying an electric field to a piezoelectric material cemented to a ferromagnetic sample [2]. It has recently been demonstrated that piezoelectricity specific to a wurtzite dilute magnetic insulator (Ga,Mn)N allows to affect magnetization by an magnetoelectric coupling [3]. In this system, the application of an electric field stretches the elementary cell along the wurtzite c axis and, thus, controls the sign and magnitude of single-ion magnetic anisotropy specific to Mn^{3+} ions in GaN. A corresponding theory has been developed and showed that it describes the experimentally determined dependence of magnetization on the electric field as a function of the magnetic field and temperature [3]. In this way, our work bridges two fields of research developed so far independently: piezoelectricity of wurtzite semiconductors and electrical control of magnetization in hybrid and composite magnetic structures containing piezoelectric components.

References:

[1] F. Matsukura, Y. Tokura, and H. Ohno, *Nat. Nanotechnol.* **10**, 209 (2015).
[2] T. Dietl and H. Ohno, *Rev. Mod. Phys.* **86**, 187 (2014).
[3] D. Sztenkiel, M. Foltyn, G. P. Mazur, R. Adhikari, K. Kosiel, K. Gas, M. Zgirski, R. Kruszka, R. Jakiela, Tian Li, A. Piotrowska, A. Bonanni, M. Sawicki, and T. Dietl, *Nat. Commun.* **7**, 13232 (2016).

Monday, June 26th, 2017

Chern Insulators: from Design, toward Realization

Warren E. Pickett[1]

[1] *UC Davis*

Magnetotransport measurements when high magnetic fields were applied to highly conducting two dimensional electron gases (2DEGs) resulted in the discovery of the integer quantum Hall effect (IQHE). At integer band fillings the bulk of the 2DEG becomes insulating, leaving boundary states to carry spin and charge currents. This bulk-boundary dichotomy is an example of topological connections that can produce remarkable behavior in magnetic insulators, akin to analogous boundary transport in topological insulators. A phase related to the quantum Hall and topological insulator classes is the Chern insulator, or quantum anomalous Hall insulator, which displays the characteristics of IQHE systems without the need for an external magnetic field, which is replaced by a spontaneous ferromagnetic insulating phase. Entanglement of valence and conduction bands across the bulk bangap of the ferromagnetic insulator is required to produce a Chern insulator, with this being obtained from integration of the Berry curvature and encoded in the Chern topological invariant (Chern number). A summary of proposed Chern insulators will be provided. Then the discussion will focus on two transition metal oxide systems, on a hexagonal and a honeycomb lattice, that has led to the computational design (prediction) of Chern insulating phases with bulk gaps of up to 130 meV.[1] The design process required understanding the interplay of many energy scales in these compounds: bandwidths, intra-atomic repulsion strength, spin-orbit coupling, crystal field splittings and subsplittings, and Jahn-Teller distortions forces.

References:

[1] H. Guo *et al.*, Wide gap Chern Mott insulating phases achieved by design, npj Quantum Materials 2, **4** (2017)

This work has been done collaboratively with groups of Rossitza Pentcheva, University of Duisburg-Essen, and Kwan-Woo Lee, Korea University. Work was supported by the NSF DMREF program and built on accumulated knowledge obtained from earlier DOE/BES support.

Monday, June 26th, 2017

Magnetic Polarons in Semiconductor Quantum Dots

R. Oszwałdowski,[1] D. Rederth,[1] J. Pientka,[2] and A.G. Petukhov[1]
[1] *South Dakota School of Mines and Technology, Rapid City, USA*
[2] *St. Bonaventure University, New York, USA*

Semiconductor quantum dots (QDs) doped with magnetic impurities have been a focus of continuous research for a couple of decades. A significant effort has been devoted to studies of magnetic polarons (MP) in these nanostructures [1]. These collective states arise through exchange interaction between a carrier confined in a QD and localized spins of the magnetic impurities (typically: Mn). We discuss our theoretical description of various MP properties in self-assembled QDs. First, we present a self-consistent, temperature-dependent approach to MPs formed by a valence band hole. We use the Luttinger-Kohn $\mathbf{k} \cdot \mathbf{p}$ Hamiltonian to account for the important effects of spin-orbit interaction [2]. Next, we propose that in the case of 2 holes, the spins align to form a magnetic "bipolaron" [3]. Finally, we report on a particular QD system, where experiments reveal a robust MP with a surprising temperature dependence [4].

References:

[1] D. Yakovlev, W. Ossau in "Introduction to the Physics of Diluted Magnetic Semiconductors" (Springer 2010).
[2] D. Rederth, R. Oszwałdowski, A. G. Petukhov, in preparation.
[3] R. Oszwałdowski, et al., Phys. Rev. Lett. 106, 177201 (2011); R. Oszwałdowski, et al. Phys. Rev. B 86, 201408 (2012).
[4] B. Barman et. al. Phys. Rev. B 92, 035430 (2015).

Monday, June 26th, 2017

Lattice complexity and Fano resonances near a Lifshitz Transition in strongly correlated systems

Antonio Bianconi[1,2,3]

[1] *RICMASS (Rome Int. Center Materials Science Superstripes) 00185 Rome, Italy*
[2] *Institute of Crystallography, CNR, Monterotondo Roma, I-00015, Italy*
[3] *National Research Nuclear University MEPhI, Moscow Engineering Physics Institute, 115409 Moscow, Russia*

While new functional doped magnetic materials are developed and used in modern nanotechnology the physics of these complex systems is object of active discussions. The multi-scale lattice and electronic complexity from nanoscale to mesoscale in these systems [1,2] pushes the fundamental physics of these systems beyond the solid state physics of XX century using simple models based on single band and rigid band approximations.

Here we show that the physics of all known doped magnetic systems showing high temperature superconductivity is characterized by a dome of Tc controlled by tuning the chemical potential near Lifshitz transitions in strongly correlated multi orbitals systems by adding dopants, pressure, strain, and charge density [3-6]. A major step in the field has been the development of the theory of superconductivity of two components scenarios [7] and in particular of the scenario with coexisting a narrow band and a wide band near a Lifshitz transition [8,9]. The physics is getting very complex because of frustrated phase separation occurring at the Lifshitz transitions in strongly correlated magnetic systems [10]. This very complex lattice scenario has been observed by using scanning micro x-ray diffraction [2] and using the EXAFS method [11] in cuprates single crystals [12], and iron chacogenides [13]. Finally we discuss the emerging role of Fano resonances in p-terphenyl [9] and the complex hyperbolic space for the percolation pathways promoting the emergence of quantum coherence at high temperature [2].

References:

[1] A. Bianconi, Nature Physics **9** (2013) 536-537.
[2] G. Campi, *et al.*, Nature **525**, (2015) 359.
[3] R. Puźniak, *et al.*, Phys. Rev. B **52**, (1995) 3756.
[4] S.M. Kazakov, R. Puzniak, *et al.*, Phys. Rev. B **71**, (2005) 024533.
[5] M. Fratini, *et al.*, Superconductor Science and Technology **21**, (2008) 092002.
[6] R. Puźniak, *et al.*, Physica C **309**, (1988) 161-169.
[7] R. Micnas, S. Robaszkiewicz, A. Bussmann-Holder ''Two-component scenarios for non-conventional (exotic) superconductors." Superconductivity in Complex Systems (2005) 1318-1323.
[8] R. Caivano, *et al.*, Superconductor Science and Technology **22**, (2009) 014004.
[9] M.V. Mazziotti, A. Valletta, G. Campi, D. Innocenti, A. Perali, A. Bianconi, arXiv:1705.09690 (2017)
[10] K.I. Kugel, *et al.*, Phys. Rev. B **78**, (2008) 165124.
[11] A. Bianconi and R.Z. Bachrach, Phys. Rev. Lett. **42** (1979) 104.
[12] A. Bianconi, *et al.*, Physical Review Letters **76**, 3412 (1996).
[13] A. Ricci, *et al.*, Phys. Rev. B **84** (2011) 060511.

Monday, June 26th, 2017

Single-phase and single-ion displacive-type manganese perovskite multiferroics

B. Dabrowski

[1] *Department of Physics, Northern Illinois University, DeKalb, IL, USA*

Coincident ferroelectric and magnetic orderings are intensely investigated due to anticipated applications in advanced spin-based electronics. Single-phase multiferroics (MF) are rare because origins of the two orders are almost mutually exclusive. Recently, in addition to the well known $BiFeO_3$, new MF transition metal oxides have been discovered: the Fe-based perovskite compounds with very small tolerance factors and the hexagonal $R(Mn,Fe)O_3$. Ferroelectricity results from the off-centering of the R-ion in its oxygen cage while the AFM is induced in the Fe/Mn-O lattice for both systems. More recently tilt engineering have been used in layered perovskites to generate ferroelectricity without requiring zone-center displacements. Our research on Ti-substituted $Sr_{1-x}Ba_xMnO_3$ perovskites with large tolerance factor show MF originating exclusively from the displacive-type distortions of magnetic Mn^{4+} in MnO_6 at T_F up to 420 K exceeding the temperature and size of Ti^{4+} distortions in archetypal $BaTiO_3$. The G-type AFM order below 200 K dramatically suppresses distortions showing that order parameters are strongly coupled.

Monday, June 26th, 2017

Co based multilayer systems for controllable domain wall positioning

M. Urbaniak[1]

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

The possibility to actively control position of magnetic domain walls (DWs) in thin film is important for prospective applications in sensors and devices making use of magnetic fields originating from DWs. The positioning of the walls may in general involve the use any constraint to expansion of domains: geometric, like notches in patterned wires, or the ones due to a gradient of the properties of material. I will show how lateral gradients of magnetization switching field (H_S) introduced to the samples by tailoring thicknesses of the constituent layers or using the He^+ ions bombardment can be employed to DW positioning in cobalt based perpendicular magnetic anisotropy (PAM) layers. For Au/Co/Au type films with artificial H_S gradient, both for extended and patterned samples, the external perpendicular magnetic field was capable of setting the DW position with with precision of tens of micrometers over the rang of tenths of millimeter. For PMA films with wedge-shaped platinum spacer layer it will be show that the gradient of interlayer coupling can be used for DW positioning too. The influence of the coupling on the magnetization reversal will be discussed as well.

The work was financed by the National Science Centre Poland under HARMONIA funding scheme for international research projects – decision No. DEC-2013/08/M/ST3/00960 and was done in collaboration of Prof. F. Stobiecki group (Institute of Molecular Physics) in Poznań with University of Kassel group: A. Ehresmann, A. Gaul.

Monday, June 26th, 2017

Field-free deterministic creation and inertial properties of single skyrmions

S. Eisebitt[1]

[1] *Max Born Institute, Berlin, Germany*

Magnetic skyrmions are currently the most promising option to realize current-driven magnetic shift registers. Generation, transport and annihilation of skyrmions are fundamental operations in this context. We study the generation and intrinsic dynamics of skyrmions via static and time-resolved x-ray holography, combining sub-30 nm spatial resolution with sub-100 ps temporal resolution.[1,2] It is demonstrated that single skyrmions can be generated deterministically on subnanosecond timescales in magnetic racetracks using spin orbit torque pulses. Externally applied in-plane magnetic fields are not required in the process.[3] Furthermore, results on the GHz dynamical behavior of bubble skyrmions are presented, where precision observation of the skyrmion trajectory is indicative of the presence of an inertial mass, connected to the skyrmion topology.

References:

[1] S. Eisebitt, J. Lüning, W. F. Schlotter, M. Lörgen, O. Hellwig, W. Eberhardt, and J. Stöhr, Lensless imaging of magnetic nanostructures by X-ray spectro-holography, Nature **432**, 885 (2004).

[2] C. von Korff Schmising, B. Pfau, M. Schneider, C. M. Günther, M. Giovannella, J. Perron, B. Vodungbo, L. Müller, F. Capotondi, E. Pedersoli, N. Mahne, J. Lüning, and S. Eisebitt, Imaging Ultrafast Demagnetization Dynamics after a Spatially Localized Optical Excitation, Phys Rev Lett **112**, 217203 (2014).

[3] F. Büttner, I. Lemesh, M. Scheider, B. Pfau, C. M. Günther, P. Hessing, J. Geilhufe, L. Caretta, D. Engel, B. Krüger, J. Viefhaus, S. Eisebitt, and G. S. D. Beach, Field-free deterministic ultra fast creation of skyrmions by spin orbit torques, arXiv:1705.01927

[4] F. Büttner, C. Moutafis, M. Schneider, B. Krüger, C. M. Günther, J. Geilhufe, Clemens von Korff Schmising, J. Mohanty, B. Pfau, S. Schaffert, A. Bisig, M. Förster, T. Schulz, C. A. F. Vaz, J. H. Franken, H. J. M. Swagten, M. Klaui, and S. Eisebitt, Dynamics and inertia of skyrmionic spin structures, Nat Phys **11**, 225 (2015).

Tuesday, June 27th, 2017

Field-induced phase transition in Haldane gap spin chains

Ian Affleck[1]

[1] *Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia, Canada*

A magnetic field closes the Haldane gap and induces an ordering transition in antiferromagnetic chains of integer spin. I will discuss the nature of the transition, including crystal field terms in the Hamiltonian, and its experimental implications.

Tuesday, June 27th, 2017

Quantum Magnetism and Ultracold Atoms

M. Lewenstein[1,2]

[1] *ICFO-Institut de Ciències Fotòniques, 08860 Castelldefels (Barcelona), Spain*
[2] *ICREA, Lluis Companys 23, 08010 Barcelona, Spain*

Atomic, Molecular and Optical physics and Quantum Optics offer various platforms to study quantum magnetism. In my lecture I will describe some these platforms and present recent experimental and theoretical progress in studies of these system. In particular, I will talk about:

- Ultracold atoms in optical lattices [1]; here I will focus on the Fermi Hubbard models [2], and various non-standard Hubbard models [3,4], synthetic dimensions and synthetic gauge fields [5].
- Ultracold trapped ion chains; here I will focus on 1D models with controlled interaction range [6], and nonlocality in many body systems [7].
- Ultracold atoms trapped close to nano-structures [8].

References:

[1] M. Lewenstein, A. Sanpera, and V. Ahufinger, "Ultracold atoms in Optical Lattices: simulating quantum many body physics", Oxford University Press, Oxford, 2012, ISBN 978-0-19-957312-7, paperback 2017, ISBN 978-0-19-878580-4

[2] Anton Mazurenko, Christie S. Chiu, Geoffrey Ji, Maxwell F. Parsons, Márton Kanász-Nagy, Richard Schmidt, Fabian Grusdt, Eugene Demler, Daniel Greif, Markus Greiner, Experimental realization of a long-range antiferromagnet in the Hubbard model with ultracold atoms, arXiv:1612.08436

[3] Ravindra W. Chhajlany, Przemysław R. Grzybowski, Julia Stasińska, Maciej Lewenstein, and Omjyoti Dutta, Hidden string order in a hole-superconductor with extended correlated hopping, Phys. Rev. Lett. **116**, 225303 (2016).

[4] Omjyoti Dutta, Mariusz Gajda, Philipp Hauke, Maciej Lewenstein, Dirk-Sören Lühmann, Boris A. Malomed, Tomasz Sowiński, Jakub Zakrzewski, Non-standard Hubbard models in optical lattices, Rep. Prog. Phys. **78**, 066001 (2015).

[5] A. Celi, P. Massignan, J. Ruseckas, N. Goldman, I.B. Spielman, G. Jūzeliunas, and M. Lewenstein, Synthetic gauge fields in synthetic dimensions, arXiv:1307.8349, Phys. Rev. Lett. **112**, 043001 (2014).

[6] T. Graß and M. Lewenstein, Trapped-ion quantum simulation of tunable-range Heisenberg chains, arXiv:1401.6414, EPJ Quantum Technology 2014, **1**:8, doi:10.1186/epjqt8.

[7] J. Tura, R. Augusiak, A. B. Sainz, T. Vértesi, M. Lewenstein, and A. Acín, Detecting the non-locality of quantum many body states, Science **344**, 1256 (2014); Jordi Tura, Remigiusz Augusiak, Ana Belén Sainz, Bernd Lücke, Carsten Klempt, Maciej Lewenstein, and Antonio Acín, Nonlocality in many-body quantum systems detected with two-body correlators, Ann. Phys. (N.Y.) **362**, 370–423 (2015); Jordi Tura, Gemma De las Cuevas, Remigiusz Augusiak, Maciej Lewenstein, Antonio Acín, and J. Ignacio Cirac, Energy as a detector of nonlocality of many-body spin systems, arXiv:1607.06090, Phys. Rev. X **7**, 021005 (2017).

[8] J. S. Douglas, H. Habibian, A. V. Gorshkov, H. J. Kimble, D. E. Chang, Atom induced cavities and tunable long-range interactions between atoms trapped near photonic crystals, arXiv:1312.2435, Nature Photonics **9**, 326-331 (2015).

Tuesday, June 27th, 2017

Many-body localization in disordered spin and Hubbard chains

P. Prelovšek[1,2]

[1] *J. Stefan Institute, Ljubljana, Slovenia*

[2] *Faculty of Mathematics and Physics, University of Ljubljana, Ljubljana, Slovenia*

Many-body localization (MBL) is the quantum phenomenon involving the interplay of disorder and particle interaction, characterized mainly by the nonergodic behaviour. It is intensively investigated theoretically within disordered one-dimensional many-body models, and experimentally in optical lattices of cold atoms, but might be relevant also for materials with spin chains. In the talk the evidence for the transition to MBL will be presented as obtained from numerical studies of finite systems. Within a random-field spin chain dynamical staggered correlations can be used as an indicator for the MBL phase and are closely related to the dynamical spin conductivity and d.c. transport. An analytical approach, based on the self-consistent treatment of dynamical correlations, indicates that one dimension might still be singular with the subdiffusion in the ergodic phase. On the other hand, an analogous simulation of the Hubbard chain indicates that disordered potential does not induce full MBL but only charge localization, while spin correlations remain ergodic.

Tuesday, June 27th, 2017

Professor Stanisław Robaszkiewicz (1947–2017)

R. Micnas,[1] T.Kostyrko[1] and B.R. Bułka[2]

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

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

Prof. Stanisław Robaszkiewicz, an outstanding physicist passed away on June 7^{th}, 2017. Born on September 25^{th}, 1947 in Myślibórz, he graduated with MSc in 1970, got PhD degree in 1976, Dr. hab. degree in 1986 at the Adam Mickiewicz University, and became a Professor in 1991. Since 1989 he was the head of the Division of Electronic States of Solids.

His scientific interests were very broad, and included *strongly correlated electronic systems, phase transitions, mixed valence compounds, electron-phonon interactions, low dimensional systems, superconductivity, magnetism, charge orderings and phase separations.* He published over 140 papers, among them the highly cited paper: Rev. Mod. Phys. 62, 113-173 (1990). He gave over 100 conference presentations, including 30 invited talks. Prof. S. Robaszkiewicz had coauthored the theory of superconductivity and electron orderings in narrow band systems with local attractive interactions, with the application to high T_c superconductors, as well as developed the theory of local pair (bipolaronic) superconductivity and "hole superconductivity" and the theory of systems of coexisting charged bosons and itinerant electrons.

Prof. Robaszkiewicz paid research visits to the University of Linköping, Sweden (collaboration with K. A. Chao); ICTP Trieste, Italy; University of Grenoble; the Institute Laue-Langevin, Grenoble; CNRS Grenoble, France (longstanding collaboration with J. Ranninger, 1984-2000); Low Temperature Lab., Kharkiv University, Ukraine; Institute for Scientific Interchange, Torino, Italy.

For his scientific achievements he was honored with the *Maria Skłodowska-Curie Award in Physics of Polish Academy of Sciences* (1989); nine awards of the *Minister of Education; Scientific Secretary of Polish Academy of Sciences Award* (1988), as well as several awards of the *Rector of Adam Mickiewicz University.* Prof. S. Robaszkiewicz took part in organization of a whole series of the Physics of Magnetism conferences and gave the invited talk at PM'93.

Tuesday, June 27th, 2017

Probing intertwined orders in cuprate superconductors

John M. Tranquada[1]

[1] *Brookhaven National Laboratory, Upton, NY 11973-5000*

Doping holes into the correlated-insulator state of CuO_2 planes frustrates the antiferromagnetic order and leads to an inhomogeneous state that can take the form of charge and spin stripes. The reduced dimensions of the spin stripes lead to the development of a singlet-triplet gap, while the interaction of the charge carriers with this environment can yield electron pairing. Rather than acting as a competing order, this intertwining of spin and charge correlations can result in superconductivity [1]. We have probed these intertwined orders with neutron [2] and x-ray [3] scattering and with transport measurements [4]. I will discuss the perspective on high-temperature superconductivity provided by these studies.

References:

[1] E. Fradkin, S. A. Kivelson, and J. M. Tranquada, Rev. Mod. Phys. **87**, 457 (2015).
[2] H. Jacobsen *et al.*, Phys. Rev. B **92**, 174525 (2015).
[3] X. M. Chen *et al.*, Phys. Rev. Lett. **117**, 167001 (2016).
[4] Z. Stegen *et al.*, Phys. Rev. B **87**, 064509 (2013).

Work at Brookhaven is supported by the Office of Basic Energy Sciences, U.S. Department of Energy under Contract No. DE-SC0012704.

Tuesday, June 27th, 2017

Spinning superconductors and ferromagnets

J.E. Hirsch[1]

[1] *Department of Physics, University of California, San Diego, La Jolla, CA 92093-0319*

When a magnetic field is applied to a ferromagnetic body it starts to spin (Einstein-de Haas effect). This demonstrates the intimate connection between the electron's magnetic moment $\mu_B = e\hbar/2m_ec$, associated with its spin angular momentum $S = \hbar/2$, and ferromagnetism. When a magnetic field is applied to a superconducting body it also starts to spin (gyromagnetic effect), and when a normal metal in a magnetic field becomes superconducting and expels the magnetic field (Meissner effect) the body also starts to spin. Yet according to the conventional theory of superconductivity the electron's spin only role is to label states, and the electron's magnetic moment plays no role in superconductivity. Instead, within the unconventional theory of hole superconductivity [1], the electron's spin and associated magnetic moment play a fundamental role in superconductivity. Just like in ferromagnets the magnetization of superconductors is predicted to result from an aggregation of magnetic moments with angular momenta $\hbar/2$ [2]. This gives rise to a "Spin Meissner effect" [3], the existence of a spin current in the ground state of superconductors. The theory explains how a superconducting body starts spinning when it expels magnetic fields [4], which we argue cannot be explained by the conventional theory, it provides a dynamical explanation for the Meissner effect [5], which we argue the conventional theory cannot do, and it explains how supercurrents stop without dissipation [6], which we argue the conventional theory fails to explain. Essential elements of the theory of hole superconductivity are that superconductivity is driven by lowering of kinetic energy [7], which we have also proposed is true for ferromagnets [8], that the normal state charge carriers in superconducting materials are holes, and that the spin-orbit interaction plays a key role in superconductivity. The theory is proposed to apply to all superconductors [9].

References:

[1] http://physics.ucsd.edu/∼jorge/hole.html.
[2] J.E. Hirsch, Europhys. Lett. **113**, 37001 (2016).
[3] J.E. Hirsch, Europhys. Lett. **81**, 67003 (2008).
[4] J.E. Hirsch, Phys. Rev. B **95**, 014503 (2017).
[5] J.E. Hirsch, Physica Scripta **91**, 035801 (2016).
[6] J.E. Hirsch, Europhys. Lett. **114**, 57001 (2016).
[7] J.E. Hirsch, Int. J. Mod. Phys. B bf 25, 1173 (2011).
[8] J.E. Hirsch, Physica C **341-348**, 211 (2000).
[9] J.E. Hirsch, Physica C **472**, 78 (2012).

Tuesday, June 27th, 2017

Universal properties of high-temperature superconductors from real-space pairing: Comparison with experiment

Józef Spałek,[1] and Michał Zegrodnik[2,3]

[1] *Institute of Physics, Jagiellonian University, Kraków, Poland*

[2] *ACMIN, AGH University of Science and Technology, Kraków, Poland*

One of the pivotal challenges in high-temperature superconductivity is the designation of a consistent interpretation framework within which one describes quantitatively their universal features. Here we analyze the principal experimental data and compare them quantitatively with the approach based on a single-band model of strongly correlated electrons supplemented with strong antiferromagnetic (super)exchange interaction (the t-J-U model). We use our original full Gutzwiller wave-function solution going beyond the renormalized mean-field theory (RMFT) in a systematic manner. Our approach reproduces very well the observed hole doping (δ) dependence of the kinetic-energy gain in the superconducting phase, one of the principal non-BCS features of the cuprates. The calculated Fermi velocity in the nodal direction is practically δ-independent and its universal value agrees very well with that determined experimentally. A weak doping dependence of the Fermi wave vector leads to an almost constant value of the effective mass, which is observed in experiment [1-2].

References:

[1] J. Spałek, M. Zegrodnik, J. Kaczmarczyk, Phys. Rev. B **95**, 024506 (2017).

[2] M. Zegrodnik, J. Spałek, arXiv 1705.06038.

Tuesday, June 27th, 2017

Non-Equilibrium Quantum Spin Systems: Fermi Liquids Out of Their Fields

Kevin S. Bedell[1]

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

Small moment ferromagnetic metals, in equilibrium, can have rather large spin polarizations. To produce large spin polarizations in strongly correlated metals requires large magnetic fields. Spin polarizations in a metal can be enhanced by spin injection techniques which gives rise to a non-equilibrium magnetization of the metal. We will explore some of the spin transport and dynamic effects of these non-equilibrium Fermi Liquids (FL). Some of the experimental consequences of the non-equilibrium magnetization can be measured using a basic spintronic device, the F/N junction, where F is a ferromagnetic metal and N is a normal metal. These will have some novel characteristics that are enhanced at low temperatures, T (where T is much lower that the lowest Fermi Temperature of the F and N materials), if we can use strongly correlated materials to form the F/N junction. We suggest using a small moment ferromagnetic metal (described by the ferromagnetic FL theory) and a strongly correlated metal (described by a normal FL theory) out of equilibrium for the F/N junction for the maximum effect.

Tuesday, June 27th, 2017

A paradigm of quantum cellular automata: implementation of molecular magnets

Boris Tsukerblat,[1] Andrew Palii,[2,3] Juan M. Clemente-Juan,[4] Eugenio Coronado,[4] and Nicolas Suaud[5]

[1] *Chemistry Department, Ben-Gurion University of the Negev, Beer-Sheva, Israel; e-mail: tsuker@bgu.ac.il*

[2] *Institute of Problems of Chemical Physics, Chernogolovka, Russia*

[3] *Institute of Applied Physics, Academy of Sciences of Moldova, Chisinau, Moldova*

[4] *Instituto de Ciencia Molecular, Universidad de Valencia, Paterna, Spain*

[5] *Laboratoire de Chimie et Physique Quantiques, Université de Toulouse, France*

The concept of molecular quantum cellular automata (QCA) represents a paradigm for nano-electronics, in which binary information is encoded in charge configuration of the redox sites in a molecular magnetic mixed-valence cell. These devices promise nanometer-scale units with ultra-high device densities operating at very high switching speed, at room-temperatures, consuming extremely small amounts of electrical power and very small heat release. The area of QCA is, therefore, placed at the border line between chemistry, physics and material science and constitutes a fascinating field of molecular magnetism. We review the basic issues of the field and present the theoretical background [1-4] for the charge polarized states in the four-dot molecular QCA, based on the vibronic approach in mixed-valency. We report the evaluation of the electronic levels and adiabatic potentials of mixed-valence tetrameric systems for which molecular implementations of QCA was proposed. The cell includes two electrons shared between four sites and correspondingly we employ the model which takes into account the two relevant electron transfer processes (through the side and through the diagonal) as well as the Coulomb energies for different instant positions of localization of the pair. The adiabatic potentials are evaluated for the low lying Coulomb levels in which the antipodal sites are occupied, the case just actual for utilization in molecular QCA. The conditions for the vibronic self-trapping in spin-singlet and spin-triplet states are revealed in terms of the two actual transfer pathways parameters and the strength of the vibronic coupling.

A new concept is discussed within the general trend of molecular implementation of QCA. It is proposed to employ complex polyoxometalate (POM) anion $[V(IV)_8\ V(V)_4\ As_8O_{40}(H_2O)]^{4-}$ (briefly V_{12}) as a quantum inverter. As distinguished from previous ideas in molecular QCA area, in which a molecule was supposed to act as a quantum cell, the proposal reported here employs POM V_{12} as a logical gate. We estimate the Coulombic forces in the different electronic distributions within the mixed-valence $V(IV)_2\ V(V)_2$ network, reveal the role of the electron transfer processes and vibronic coupling. The switching cycle and the non-linear cell-cell response function which are just the key characteristics of QCA inverter, are studied.

References:

[1] B. Tsukerblat, A. Palii, J.M. Clemente-Juan, Pure & Appl. Chem. **87**(3), 271 (2015).

[2] B. Tsukerblat, A. Palii, J.M. Clemente-Juan, E. Coronado, J. Chem. Phys. **143** 134307 (2015).

[3] J.M. Clemente-Juan *et al.*, J. Chem. Theory Comput. **12**, 3545 (2016).

[4] A. Palii, B. Tsukerblat, J.M. Clemente-Juan, E. Coronado, J. Phys. Chem. C. **120**, 16994 (2016).

The work is supported by the COST Action CA15128 "Molecular Spintronics (MOLSPIN)". BTS, AVP and JMC acknowledge support from the Ministery of Education and Science of Russian Federation (Agreement No. 14.W03.31.0001).

Wednesday, June 28th, 2017

Topological Phases of Quantum Matter as Novel Platforms for Fundamental Science and Applications

Arun Bansil[1]

[1] *Physics Department, Northeastern University*

I will discuss how topological phases arise in quantum matter through spin-orbit coupling effects in the presence of protections provided by time-reversal, crystalline and particle-hole symmetries, and highlight our recent work aimed at predicting new classes of topological insulators (TIs), topological crystalline insulators, Weyl semimetals, and quantum spin Hall insulators. [1-10] Surfaces of three-dimensional (3D) topological materials and edges of two-dimensional (2D) topological materials support novel electronic states. For example, the surface of a 3D TI supports gapless or metallic states, which are robust against disorder and non-magnetic impurities, and in which the directions of momentum and spin are locked with each other. Similarly, in 2D TIs, also called quantum spin Hall insulators, the 1D topological edge states are not allowed to scatter since the only available backscattering channel is forbidden by constraints of time-reversal symmetry. The special symmetry protected electronic states in topological materials hold the exciting promise of providing revolutionary new platforms for exploring fundamental science questions, including novel spin textures and exotic superconductors, and for the realization of multifunctional topological devices for thermoelectric, spintronics, information processing and other applications.

Work supported by the U. S. Department of Energy.

References:

[1] Bansil, Lin and Das, Reviews of Modern Physics **88**, 021004 (2016).
[2] Chang *et al.*, Science Advances **2**, e1600295 (2016).
[3] Huang *et al.*, Proc. National Academy of Sciences **113**, 1180 (2016).
[4] Zheng *et al.*, ACS Nano **10**, 1378 (2016).
[5] Xu *et al.*, Science **349**, 613 (2015).
[6] Zeljkovic *et al.*, Nature Materials **14**, 318 (2015).
[7] He *et al.*, Nature Materials **14**, 577 (2015).
[8] Xu *et al.*, Nature Physics **11**, 748 (2015).
[9] Crisostomo *et al.*, Nano Letters **15**, 6568 (2015).
[10] Xu *et al.*, Science Advances **1**, e1501092 (2015).

Wednesday, June 28th, 2017

Floquet topological crystalline colloidal transport

Thomas Fischer[1]

[1] *University of Bayreuth, Universitätsstr. 30, 95440 Bayreuth, Germany*

Topological protection allows robust transport of localized phenomena such as quantum information, solitons and dislocations. The transport can be either dissipative or non-dissipative. Here, we experimentally demonstrate and theoretically explain the topologically protected dissipative motion of colloidal particles above periodic magnetic patterns. By driving the system with periodic modulation loops of an external and spatially homogeneous magnetic field, we achieve total control over the motion of diamagnetic and paramagnetic colloids. We can transport simultaneously and independently each type of colloid along any of the crystallographic directions of the pattern via adiabatic or deterministic ratchet motion. Both types of topological motion are protected by the lattice symmetry of the pattern. As an application, we implement an automatic topologically protected quality control of a chemical reaction between functionalized colloids. The similarities and the differences in the lattice symmetry protected transport of classical over-damped colloidal particles versus the topologically protected transport in quantum mechanical systems are emphasized.

References:

[1] J. Loehr, M. Loenne, A. Ernst, D. de las Heras, and Th. M. Fischer; Topological protection of multiparticle dissipative transport *Nat. Comm.* **7**, 11745 (2016).

[2] D. de las Heras and J. Loehr and M. Loenne and Th. M. Fischer; Topologically protected colloidal transport above a square magnetic lattice, *New J. Phys.* **18**, 105009 (2016).

Wednesday, June 28th, 2017

On superconducting stripes of the two-dimensional Hubbard model

R. Frésard,[1,2] and O. Juillet[3,2]

[1] *Normandie Université, ENSICAEN, UNICAEN, CNRS, CRISMAT, 14050 Caen, France*

[3] *Normandie Université, ENSICAEN, UNICAEN, CNRS, LPC, 14050 Caen, France*

The intertwining of spin-, charge-, and pair-density waves embedded in a uniform d-wave superfluid background is highlighted in the strongly correlated regime of the two-dimensional Hubbard model. As the lattice filling increases, this striped phase emerges from homogenous states exhibiting spiral magnetism and evolves towards a doped antiferromagnet. A concomitant enhancement of long-ranged d-wave pairing correlations is also found. Our variational results are obtained by mixing unrestricted Hartree-Fock and BCS wave-functions with symmetry restoration before variation. It will also be shown that the approach is exact for a four-site cluster, and that it compares very favorably against existing exact results or numerical simulations.

Wednesday, June 28th, 2017

How cells respond to high-gradient magnetic fields

Vitalii Zablotskii,[1] Tatyana Polyakova,[1] and Alexandr Dejneka[1]

[1] *Department of Optical and Biophysical Systems, Institute of Physics AV CR, Prague, 18221, Czech Republic*

Mechanisms underlying cell response to magnetic fields have long been elusive. Nevertheless, several of the underlying mechanisms were identified for different types of cells exposed to a high-gradient magnetic field (HGMF) [1-3]. We present the results towards a fundamental understanding of the cell response to an HGMF, highlighting new directions for the study of living cell machinery: changing the membrane potential and probability of ion-channel on/off switching events by membrane magneto-mechanical stress, inhibition of cell division and suppression of cell growth by magnetic pressure, magnetically induced cell division, and membrane pore formation. We show how the magnetic gradient forces can drive the cell fate. In particular, we explain how stem cells make the fate decision during differentiation process in HGMFs. Timescales of cell response to HGMFs are dependent on the magnitude of the magnetic field gradient and vary from seconds to days [2]. Several hypotheses have been formulated to explain the time delay of the cell response to magnetic fields. An overarching mechanism related to the magnetic gradient forces now unifies these disparate models. By understanding the mechanisms and ways in which HGMFs can be utilized to induce the required cellular responses, we can begin to consider high-gradient magnetic fields as tiny non-invasive tools that can remotely alter the cell machinery, promising broad application potential in cell therapy, neurobiology and nanomedicine.

References:

[1] V. Zablotskii, O. Lunov, S. Kubinova, T. Polyakova, E. Sykova and A. Dejneka. Effects of high-gradient magnetic fields on living cell machinery. J. Phys. D: Appl. Phys. **49** (2016) 493003.

[2] V. Zablotskii, T. Polyakova, O. Lunov, A. Dejneka. How a High-Gradient Magnetic Field Could Affect Cell Life. Scientific Reports **6** (2016) 37407.

[3] V. Zablotskii, O. Lunov, A. Dejneka, L. Jastrabík, et al. Nanomechanics of magnetically driven cellular endocytosis. Appl. Phys. Lett. (2011) **99**, 183701.

Wednesday, June 28th, 2017

ERC - supporting top researchers from anywhere in the world

O. Limaj[1]

[1] *European Research Council Executive Agency, Brussels, Belgium*

European Research Council (ERC)

The European Research Council (ERC) is a research funding body established by the European Commission in 2007 that funds individual scientists based in Europe who carry out research at the frontiers of knowledge. It aims to support the best and most creative researchers and help them identify and explore new opportunities and directions in any field of research.

The ERC provides attractive, long-term grants to pursue ground-breaking, high-risk/high-gain research in any field. Excellence is the sole criterion for selection; there are neither thematic priorities, nor geographical quotas for funding.

The ERC received a budget of over €13 billion under the European Union research programme Horizon 2020 (2014-2020). Currently, it has funded more than 6 000 projects in the domains of life sciences, physical sciences and engineering and social sciences and humanities.

More than 62 000 proposals have been evaluated since 2007 and the successful ERC projects are being pursued in almost 600 institutions in 32 EU Member States and Associated countries. So far, nearly 40 000 publications have derived from ERC projects, out of which 14 500 have been published in peer-reviewed high impact international journals. The ERC expects that its grants will help bring about new and unpredictable scientific and technological discoveries - the kind that can form the basis of future industries, markets and social innovations. The ERC offers three main grant schemes:

- **ERC Starting Grants** targeted at early-career, emerging research leaders: up to €2.0 million per grant
- **ERC Consolidator Grants** aimed at excellent researchers who are already independent: up to €2.75 million per grant
- **ERC Advanced Grants** for established top researchers: up to €3.5 million per grant

ERC Proof of Concept is an additional funding initiative, open only to ERC grantees to help them establish the innovation potential of ideas arising from their frontier research projects (up to €150 000 per grant).

The ERC Panel PE3 Condensed matter physics currently funds close to 300 projects in solid state physics, including structural and transport properties, strongly correlated systems, mesoscopic physics, magnetism, photonics and nanophysics. The panel additionally funds projects in soft and biological condensed matter.

More information
http://erc.europa.eu/
More on ERC funding and grants
https://erc.europa.eu/funding-and-grants
ERC stories
http://erc.europa.eu/erc-stories
Contact
http://erc.europa.eu/contact-us

Thursday, June 29th, 2017

Kondo Lattice Systems and Reconsideration of the Doniach Phase Diagram

G.G. Lonzarich,[1] D. Pines,[2,3] and Y.-f. Yang[4,5]

[1] *Physics Department, University of Cambridge, Cavendish Laboratory, JJ Thomson Avenue, Cambridge CB3 0HE, UK*

[2] *Department of Physics, University of California, Davis, CA 95616, USA*

[3] *Santa Fe Institute, Santa Fe, NM 87501, USA*

[4] *Beijing National Laboratory for Condensed Matter Physics and Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China*

[5] *Collaborative Innovation Center of Quantum Matter, Beijing 100190, China*

A major challenge has been to understand the limits of applicability of the standard model of the metallic state and to identify fruitful areas for the search for novel conducting quantum liquids. Of particular interest are coupled conduction-electron and localized-electron systems usually treated in terms of the Periodic Anderson or Kondo Lattice models. The lecture will re-examine the Pines-Yang two-fluid description of such systems for the normal, magnetic and superconducting states. The description has been helpful in the classification of experimental data and, in particular, has uncovered striking departures from the expectations of the traditional Doniach phase diagram. We consider possible interpretations of the two-fluid phenomenology with reference to recent microscopic treatments of the Periodic Anderson or Kondo Lattice models to help guide further experimental research in this field.

References:

[1] Y.-f. Yang & D. Pines, PNAS **109** E3060 (2012); G. G. Lonzarich, PNAS **109** 18241 (2012); and references cited therein.

[2] G. G. Lonzarich, Y.-f. Yang & D. Pines, Reports on Progress in Physics, **80**, 024501 (2017).

Thursday, June 29th, 2017

Emergence of superconductivity due to nuclear antiferromagnetic order

F. Steglich[1,2,3]

[1] *Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany*
[2] *Center for Correlated Matter, Zhejiang University, Hangzhou, Zhejiang 310058, China*
[3] *Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China*

Unconventional superconductivity often occurs in the vicinity of quantum critical points (QCPs) in antiferromagnetic heavy - fermion metals. However, no superconductivity has so far been observed near some of the canonical heavy - fermion QCPs, such as the one induced by a magnetic field (B) in $YbRh_2Si_2$, raising the question about the generality of this paradigm. Here, we will explore the possibility of reaching the quantum critical regime by sufficiently weakening the antiferromagnetic order through its coupling to nuclear spins at very low temperatures, instead of applying a pair - breaking magnetic field. To this end, we discuss results of magnetic and calorimetric measurements on $YbRh_2Si_2$ down to $T = 1$ mK (Ref. 1). They reveal the onset of a hybrid nuclear - electronic type of antiferromagnetic order dominated by the Yb - derived nuclear spins at T_A slightly above 2 mK and the subsequent development of superconductivity at $T_c = 2$ mK. The initial slope of the upper critical field curve, $B_{c2}(_T)$, at T_c is found to be as large as $-B'_{c2} \simeq 25$ T/K. This indicates that the effective charge - carrier mass must be of the order of several 100 mel, implying that the superconducting state is associated with the Yb - derived $4f$ - *electronic* rather than *nuclear* spins. Therefore, the theoretical possibility of superheavy - fermion superconductivity based upon an underlying nuclear Kondo effect can be ruled out. In conclusion, we ascribe the formation of Cooper pairs in $YbRh_2Si_2$ to the critical fluctuations associated with the unconventional, Mott - type, QCP of this antiferromagnet, which are revealed when the primary electronic order is diminished by the competing nuclear - dominated hybrid order. Our results demonstrate a new means to reach a field - induced QCP and provide further evidence that superconductivity in the vicinity of antiferromagnetic QCPs is a general phenomenon.

References:

[1] E. Schuberth, M. Tippmann, L. Steinke, S. Lausberg, A. Steppke, M. Brando, C. Krellner, C. Geibel, R. Yu, Q. Si and F. Steglich, Science 351, **485** (2016).

Thursday, June 29th, 2017

Rare-earth based half-Heusler phases and monopnictides - magnetotransport, superconductivity and antiferromagnetism.

Piotr Wiśniewski[1]

[1] *Institute of Low Temperature and Structure Research, PAS, Wrocław, Poland*

Experimental studies of half-Heusler phases: R_EPdBi (R_E= Lu, Gd, Tb, Dy, Ho, Er), LuPtBi, YPtBi, and monopnictides: YSb and LuSb are reviewed. Several of presented half-Heusler phases exhibit band inversion effect and superconducting ground state of most likely unconventional nature due to their common non-centrosymmetric crystal structure and very low carrier densities. Moreover, for (R_E= Dy, Ho, Er)PdBi series the superconductivity coexists with antiferromagnetic order. Characteristic features in their magnetotransport (weak antilocalization effect, very large and nonsaturating magnetoresistance, Shubnikov–de Haas oscillations revealing charge carriers of small effective masses and Berry phases close to π) indicate that these materials host topologically nontrivial electronic states, which may be directly involved in forming Cooper pairs. On the other hand, for YSb and LuSb, despite the band inversion, their extraordinary magnetotransport properties (including giant magnetoresistance) may be ascribed in full to nearly perfect charge compensation of bulk 3D Fermi surfaces.

Work in collaboration with O. Pavlosiuk, P. Swatek, M. Kleinert and D. Kaczorowski.
Supported by National Science Centre of Poland, grant no. 2015/18/A/ST3/00057

Thursday, June 29th, 2017

Towards quantitative magnetic measurements with sub-nanometer lateral resolution

J. Rusz[1]

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

X-ray magnetic circular dichroism (XMCD) is a well established technique for measurement of magnetic properties. By measuring x-ray absorption spectra with circularly polarized x-rays the values of spin and orbital magnetic moments can be extracted using sum rules. Due to difficulties to focus x-rays to small spots, the spatial resolution of XMCD-based techniques remains around 10nm [1]. Since 2016 a transmission electron microscopy analogue of XMCD is under intense development. The technique named electron magnetic circular dichroism (EMCD; [2]) should in principle allow to measure magnetic moments with atomic lateral spatial resolution. We will review the present state of the art in EMCD, particularly focusing on recent advances in EMCD measurements with atomic size electron beams [3,4,5].

References:

[1] P. Fischer, Front. Phys 2, **82** (2015).

[2] P. Schattschneider, S. Rubino, C. Hébert, J. Rusz, J. Kuneš, P. Novák, E. Carlino, M. Fabrizioli, G. Panaccione and G. Rossi, Nature **441**, 486 (2006).

[3] J. C. Idrobo, J. Rusz, J. Spiegelberg, M. A. McGuire, C. T. Symons, R. Raju Vatsavai, C. Cantoni, and A. R. Lupini, Adv. Chem. Struct. Imaging **2**, 5 (2016)

[4] J. Rusz, S. Muto, J. Spiegelberg, R. Adam, K. Tatsumi, D. E. Bürgler, P. M. Oppeneer, and C. M. Schneider, Nat. Comm. **7**, 12672 (2016)

[5] T. Thersleff, J. Rusz, B. Hjörvarsson, and K. Leifer, Phys. Rev. B **94**, 134430 (2016)

Friday, June 30th, 2017

Designing magnetic meta-materials using finite size effects

Björgvin Hjörvarsson[1]

[1] *Department of Physics and Astronomy, Uppsala University*

Finite size effects can have profound effects on physical properties of materials. For example, one dimensional confinement strongly alters the ordering temperature of structural and magnetic phase transitions. Confinement in the remaining two dimensions can be used to fabricate meta-materials with e.g. completely unique magnetic and optical properties. For example, one can make arrays of magnetic islands, with well-defined sizes and distances between the islands which can be described as "super-spins". Such "super-spins" have recently been shown to exhibit phase transitions, in which the islands can indeed be viewed and described as gigantic artificial atoms. The criteria for obtaining "super-spin" structures with intrinsic dynamics and ordering will be discussed and exemplified. The results will be used to demonstrate the possibility to design new energy and length-scales in materials. One- and two-dimensional Ising systems will be used to demonstrate the properties of such structures while special emphasis will be devoted to phase transitions and dynamics of artificial spin ices.

Friday, June 30th, 2017

Strain modulated microwave spectroscopy as a sensitive method to study mechanisms responsible for spin-lattice coupling in ferromagnets

Ryszard Zuberek,[1] and Henryk Szymczak[1]

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

We have developed a new method of measuring magnetostriction constants (or components of magnetoelastic tensor) of ferromagnetic thin films. This method is based on the fact that the frequencies of ferromagnetic resonance and spin wave resonance are stress dependent. The character of this dependence is determined by the magnetoelastic tensor components and it may be used to calculate their magnitude. In our previous papers (see [1] and references therein) the strain modulated ferromagnetic resonance was used to evaluate magnetostriction of thin ferromagnetic films. Unfortunately, using this method only one-ion contribution to the magnetostriction constant may be determined since this method is not sensitive to two-ion contribution. Generally, it is not easy to determine this contribution for thin magnetic films. It seems that the most effective way to solve this problem is to measure strain modulated spin wave resonance and to compare it with magnetic field modulated spin wave resonance. An illustrative example will be given and discussed.

References:

[1] K. Nesteruk, R. Zuberek, S. Piechota, M.W. Gutowski and H. Szymczak Meas. Sci. Technol. 25 (2014) 075502

This study was partially supported by the National Center for Research and Development, research project no. PBS2/A5/36/2013

Friday, June 30th, 2017

Finite-Temperature Magnetism

R. Skomski[1]

[1] *University of Nebraska*

Many magnetic materials are used at and above room temperature, but the temperature dependence of intrinsic and extrinsic magnetic properties is only partially understood. Several aspects of finite-temperature magnetism will be discussed. Nanostructuring has a far-reaching impact on the magnetism at nonzero temperatures, as exemplified by the well-known fact that the Curie temperature of zero-dimensional magnets (nanoparticles) and one-dimensional magnets (nanowires) is exactly zero. There are no true finite-size corrections in zero and one dimensions, so the interpretation of experimental data is a nontrivial consideration. The complexity of the problem is enhanced by electronic transitions as the size or diameter of the structure increases. One example is the occurrence of very weak itinerant ferromagnetism in Co2Si nanoparticles, which causes quantum-mechanical effects to be strong over several interatomic distances. From the viewpoint of first-principle theory, density-functional calculations are now able to accurately describe the motion of itinerant electrons in spin-dependent potentials, including potentials with varying spin direction, as encountered near the Curie temperature. However, this approach does not solve the underlying many-body problem, as epitomized by the strongly correlated Heisenberg model. The reason is that density-functional calculations imply well-defined local spin directions, that is, the wave functions are eigenfunctions of the Pauli matrices. Such eigenfunctions are contradictory to the Heisenberg limit, as we will elaborate by explicitly solving a simple many-body model. An even more complicated situation is encountered in the area of finite-temperature magnetocrystalline anisotropy, which will be illustrated by a few examples. Finite-temperature micromagnetism has remained a controversial issue, in spite of decades of research. We will briefly summarize the state of the art and direct attention to some questions that are only partially solved at present, such as the interference between magnons and nanoscale structural features.

Friday, June 30th, 2017

Doppler shift picture of the Dzyaloshinskii-Moriya interaction and light propagation in systems with broken inversion symmetry

Gen Tatara[1]

[1] *RIKEN Center for Emergent Matter Science (CEMS), 2-1 Hirosawa, Wako, Saitama, 351-0198 Japan*

We present a physical picture for the emergence of the Dzyaloshinskii-Moriya (DM) interaction based on the idea of the Doppler shift by an intrinsic spin current induced by spin-orbit interaction under broken inversion symmetry such as the case with Rashba interaction[1]. The picture is confirmed by a rigorous effective Hamiltonian theory, which reveals that the DM coefficient is given by the magnitude of the intrinsic spin current. The expression is directly applicable to first principles calculations and clarifies the relation between the interaction and the electronic band structures. Quantitative agreement with experimental results is obtained for the skyrmion compounds $Mn_{1-x}Fe_xGe$ and $Fe_{1-x}Co_xGe$. The Doppler shift occurs for incoming electromagnetic wave, too, when the Rashba interaction and magnetization are present, resulting in directional dichroism[2,3]. The effective Hamiltonian for the electromagnetic field is shown to the vector type, $\boldsymbol{u}\cdot(\boldsymbol{E}\times\boldsymbol{B})$, where $\boldsymbol{u}$ corresponds to the intrinsic velocity due to the troidal moment[3].

References:

[1] T. Kikuchi, T. Koretsune, R. Arita, G. Tatara, Phys. Rev. Lett., **116**, 247201 (2016).
[2] J. Shibata, A. Takeuchi, H. Kohno and G. Tatara, J. Phys. Soc. Japan, **85**, 033701 (2016).
[3] H. Kawaguchi and G. Tatara, Phys. Rev. B **94**, 235148 (2016).

Friday, June 30th, 2017

Spin wave dynamics in magnonic crystals, quasicrystals and areas of graded refractive index

M. Zelent,[1] P. Gruszecki,[1] J. Rychły,[1] J.W. Kłos,[1] and M. Krawczyk[1]
[1] *Faculty of Physics, Adam Mickiewicz University in Poznan*

Spin waves (SW) frequencies in ferromagnetic materials span the range from hundreds of MHz up to tens of GHz, with the respective wavelengths ranging from micrometers to nanometers. Within these time and space limits SWs can be used for transferring and processing information, and microwave applications. We present our recent advances allowing for manipulation of SW dynamics in ferromagnetic thin films. We interpret SW band structure in magnonic crystals, explain formation of the magnonic band gaps, variation of the band structure resulting from changes in the magnonic crystals geometry, and show their possible utilisation. Quasiperiodicity in magnonics show additional SW properties, which are relevant for technological applications, feasible for transmission signals, and the band structure with multiple band gaps and localized modes that have valuable responds on the uniform microwave field. Further control of SW propagation is achieved by continuous change of the SW refractive index. The results point out an opportunity for developing metamaterials for microwave applications and nanostructures for processing information in nanoscale.

We acknowledge the financial NCN project UMO-2012/07/E/ST3/00538 and the EU Horizon 2020 GA No 644348 (MagIC).

Friday, June 30th, 2017

RF applications based on spintronics: latest results and future developments

P. Bortolotti[1]

[1] *Unité Mixte de Physique CNRS/Thales, Palaiseau, France*

Spintronics consists of manipulating electronic spins rather than, or in addition to, charges through electrical currents and/or magnetic fields. This technology has revolutionized the market of read-head applications and other types of magnetic sensors. Spintronics is considered one of the most serious candidates for Beyond CMOS technology. This opinion is supported worldwide as stated by the ITRS 2.0 roadmap[1] or by a recent article from Intel[2]. Spintronics can create the basis for a new generation of applications permitting EU semiconductor Industry to renovate, opening a new era of growth and market competitiveness. Recently, the attention is on a new generation of magnetic non-volatile memories (STT-MRAM) that will be soon commercialized by SAMSUNG and IBM[3]. Furthermore, magnetic sensors, radio-frequency (rf) and logic devices are other promising paths for spintronic-based applications. Here I will present some of the recent works done in the "Unité Mixte de Physique CNRS/Thales" concerning spintronics and magnonics. I will focus on future RF applications based on spin-transfer torque oscillators (STNOs) like emitters, frequency detectors and neuromorphic architectures based on the synchronization of STNO arrays. Furthermore, I will present some results on RF devices based on spin-wave computing (filtering, oscillators, non-reciprocal devices, etc.) with YIG thin films.

In the second part of the talk I will present the SpinTronicFactory network, founded in 2016, with mission to promote research and innovation in Europe based on spintronics. It is based on a legal Memorandum of Understanding involving academic and industrial actors all across Europe. More details in the website: http://spintronicfactory.eu/

References:

[1] http://www.itrs2.net/itrs-reports.html

[2] https://www.technologyreview.com/s/600716/intel-chips-will-have-to-sacrifice-speed-gains-for-energy-savings/

[3] Samsung announced that they will commercialise STT-RAM in 2017 and IBM researchers, in collaboration with Samsung, demonstrated switching STT-RAM cells for devices with diameters ranging from 50 down to 11 nanometers in only 10 nanoseconds.

Friday, June 30th, 2017

Edge states and exact zero modes in topological 1D quantum magnets

Frédéric Mila[1]

[1] *Ecole Polytechnique Fédérale de Lausanne, Switzerland*

Motivated by recent STM experiments on chains of Co adatoms that have revealed a series of ground state level crossings as a function of an external magnetic field [1], and by their possible connection to Majorana edge states [2], I will discuss the coupling between edge states in two topological phases of 1D quantum magnets, the transverse field Ising model, and the Haldane phase of the spin-1 chain. I will show in particular that, for a fixed length, it is possible to monitor the coupling between the edge states by inducing incommensurate correlations inside the topological phase. This can be achieved by an additional spin-spin coupling in the tranverse field Ising model [3] and by a next-nearest neigbor interaction in the spin-1 chain [4]. This ability to monitor the coupling between the edge states allows one to induce level crossings and to realize exact zero modes in finite chains, hence to reach infinite coherence times without having to go to the thermodynamic limit [5], and to manipulate the edge states by changing the sign of their coupling [4].

References:

[1] R. Toskovic, R. van den Berg, A. Spinelli, I. S. Eliens, B. van den Toorn, B. Bryant, J.-S. Caux, and A. F. Otte, Nat. Phys. **12**, 656 (2016).
[2] F. Mila, Nat. Phys. **12**, 633 (2016).
[3] G. Vionnet, B. Kumar, F. Mila, Phys. Rev. B **95**, 174404 (2017).
[4] N. Chepiga and F. Mila, arXiv: 1705.07868.
[5] I. Maceira and F. Mila, unpublished.

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

Optical probe of correlations in rare-earth nickelates films

J. Teyssier,[1] J. Ruppen,[1] I. Ardizzone,[1] O.E. Peil,[1,2] S. Catalano,[1] M. Gibert,[1] J.-M. Triscone,[1] A. Georges,[1,2] and D. van der Marel[1]

[1] *Department of Quantum Matter Physics, University of Geneva, 24 Quai Ernest-Ansermet, 1211 Geneva 4, Switzerland*

[2] *Collège de France, 11 place Marcelin Berthelot, 75005 Paris, France*

We used infrared reflectometry and spectroscopic ellipsometry in the visible range to investigate electronic properties of rare-earth nickelate films. We study the temperature dependence of the optical conductivity as the composition (rare earth substitution) and strain (lattice mismatch with the substrate) varies close to the charge and magnetic ordering temperatures. The optical spectra show the appearance of a characteristic two-peak structure at 0.6 and 1.3 eV when the material passes from the metal to the insulator phase. Dynamical mean-field theory allows us to associate these spectral changes with a combined effect of bond disproportionation and Mott physics. Moreover, the spectral weight in these two prominent peaks significantly increases when the material passes from paramagnetic to antiferromagnetic state. This observation, very well captured by a Landau model with coupled charge and magnetism order parameters, indicates that charge order is a necessary condition to the emergence of a long range magnetic order. Through a positive reciprocal feedback, onset of magnetic order stabilizes the charge order.

O-1-02

Doping effect on the electronic structure and thermodynamic properties in $Ce_3Ru_4Sn_{13}$

L. Kalinowski,[1] J. Goraus,[1] P. Witas,[1] and A. Ślebarski[1,2]

[1] *Institute of Physics, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

[2] *Centre for Advanced Materials and Smart Structures, Polish Academy of Sciences, Okólna 2, 50-950 Wrocław, Poland*

A comprehensive study of heat and electric transport, magnetic, and electronic structure (experiment and calculations) properties is reported for a skutterudite-related $Ce_3Ru_4Sn_{13}$ heavy fermion system with the respective substitution of Co and Sb into Ru and Sn sites. $Ce_3Ru_4Sn_{13}$ is obtained as a heavy fermion system with high electronic contribution to the specific heat $C(T)/T$ of $\approx 3J/K^2 mol_{Ce}$, and a significant Schottky anomaly below about 10 K. The complex study gives a consistent interpretation of the impact of doping on the crystal electric-field effect and Kondo temperature. For $Ce_3Ru_4Sn_{13}$ we report a field-induced phase transition between the magnetically correlated heavy fermion phase and the single-ion Kondo impurity state, which does not depend on the type of dopant. We also demonstrate that doping does not improve the poor thermoelectric properties of $Ce_3Ru_4Sn_{13}$.

References:

[1] L. Kalinowski, J. Goraus, P. Witas and A. Ślebarski, Physical Review B 94, 235151 (2016)

O-1-03

Order in Quantum Compass and Orbital e_g Models

Piotr Czarnik,[1,2] Jacek Dziarmaga,[1] and Andrzej M. Oleś[1,3]
[1] *Institute of Physics, Jagiellonian University, Kraków, Poland*
[2] *Institute of Physics, Universiteit van Amsterdam, The Netherlands*
[3] *Max Planck Institute for Solid State Research, Stuttgart, Germany*

Exchange interactions in orbital models are frustrated even on a square lattice, where two $T = 1/2$ pseudospin components $T_i^\gamma(\theta)$ parameterized by angle $\theta \in (0, \pi/2]$ interact by terms $JT_i^\gamma(\theta)T_j^\gamma(\theta)$. Maximal frustration in the quantum compass model with $T_i^\gamma(\pi/2) \equiv \frac{1}{2}\sigma_i^\gamma$, where σ_i^γ is the Pauli matrix, is reduced to moderate frustration for the e_g orbital model at $\theta = \pi/3$ [1]. We investigate thermodynamic phase transitions at temperature T_c on an infinite square lattice by variational tensor network renormalization (VTNR) in imaginary time. From the linear susceptibility (order parameter) in the symmetric (symmetry-broken) phase the onset of nematic order in the quantum compass model is estimated at $T_c/J = 0.0606(4)$ [2], in good agreement with Quantum Monte Carlo (QMC). For the e_g orbital model one finds: (*i*) a very accurate VTNR estimate of $T_c/J = 0.3566 \pm 0.0001$ while QMC fails due to the sign problem, and (*ii*) that the critical exponents are within the Ising universality class. Remarkably large difference in frustration and entanglement results in so distinct T_c.

References:

[1] L. Cincio, J. Dziarmaga, and A. M. Oleś, Phys. Rev. B **82**, 104416 (2010).
[2] P. Czarnik, J. Dziarmaga, and A. M. Oleś, Phys. Rev. B **93**, 184410 (2016).

O-1-04

Stability of the topological Kondo insulating phase in one dimension

I. Hagymási,[1] and Ö. Legeza[1]
[1] *Institute for Solid State Physics and Optics, MTA-WRCP, P.O. Box 49, H-1525 Budapest, Hungary*

We investigate the ground state and the low-lying spectrum of a *p*-wave Kondo-Heisenberg model introduced by Alexandrov and Coleman [1] with an Ising-type anisotropy in the Kondo interaction and correlated conduction electrons. Our aim is to understand how they affect the stability of the symmetry-protected topological state obtained in the SU(2) symmetric case without the Hubbard interaction. By applying the density-matrix renormalization group algorithm and calculating the entanglement entropy we show that in the anisotropic case a phase transition occurs and a Néel state emerges above a critical value of the Coulomb interaction. These findings are also corroborated by the examination of the entanglement spectrum and the spin profile of the system which clarify the structure of each phase [2].

References:

[1] V. Alexandrov and P. Coleman Phys. Rev. B **90**, 115147 (2014).
[2] I. Hagymási and Ö. Legeza Phys. Rev. B **93**, 165104 (2016).

O-1-05

Effect of epitaxial strain on electronic and magnetic properties in $NdNiO_3$ thin films

A. Stupakov,[1] O. Pacherová,[1] M. Jelínek,[1] and M. Tyunina[2,1]

[1] *Institute of Physics CAS, Prague, Czech Republic*

[2] *Microelectronics Research Unit, University of Oulu, Finland*

The (20-100)-nm-thick films of $NdNiO_3$ were grown by pulsed laser deposition. The (001) LSAT and LAO were used as substrates providing biaxial strain of +1.5% and -0.4%, respectively. The obtained resistivity values and temperatures of metal-to-insulator transition (MIT) of the thin films is consistent with the lowest reported values. E.g. for the films on LAO, the transition temperature for the thickest film was 100 K, whereas the thin films demonstrated a fully metallic behavior.

An intriguing observation was made under magnetic field applied in the out-of-plane direction of the films. All films demonstrated a pronounced negative magneto-resistance at low temperatures: resistivity drop reached 4-7% at the temperature of 2 K and the field of 9 T. The resistivity drop decreased rapidly on heating until its complete disappearance at 20-50 K. We relate such magneto-resistance behavior to a transition from the low-temperature antiferromagnetic phase to the high-temperature paramagnetic state. The observed resistivity, MIT, magneto-resistance and magnetization behavior will be discussed in terms of lattice strain and strain relaxation across the thickness of the films.

O-1-06

Charge - orbital order and topological effects in presence of zig-zag magnetic textures in 4d – 3d hybrid oxides

W. Brzezicki,[1] and M. Cuoco[1]

[1] *CNR-SPIN, IT-84084 Fisciano, Italy*

The entanglement of spin, orbital and lattice degrees of freedom in correlated systems is known to lead to intricate quantum phenomena [1]. The interplay between more localized 3d and more delocalized 4d states in hybrid oxides tunes the competition between correlated metallic and Mott-insulating states. For instance, the magnetic and orbital patterns in a uniform 4d host can be strongly modified by the inclusion of 3d impurities substituting the 4d ions [2]. After discussing the most suitable microscopic models for different types of 4d-3d hybrids, we determine the phase diagrams assuming different conditions for the spin ordering in the metallic phase [3]. We obtain, inter alia, zig-zag magnetic patterns that host topologically protected Dirac points and lines due to complex non-symmorphic symmetries [4].

References:

[1] A. M. Oles, J. Phys.: Condens. Matter 24, 313201 (2012).
[2] W. Brzezicki, A. M. Oles, and M. Cuoco, Phys. Rev. X 5, 011037 (2015).
[3] W. Brzezicki, C. Noce, A. Romano, M. Cuoco, Phys. Rev. Lett. 114, 247002 (2015).
[4] W. Brzezicki and M. Cuoco, arXiv:1609.06916 (2016).

W.B. acknowledges support by the EU Horizon 2020 grant No. 655515.

O-1-07

Thermal and magnetic properties of $Sr_{1-x}Ba_xMn_{1-y}Ti_yO_3$ (with $x \geq 0.43$ and $y \geq 0$) multiferroics

J. Wieckowski,[1] M.U. Gutowska,[1] A. Szewczyk,[1] M. Kowalczyk,[2] K. Chapagain,[3] and B. Dabrowski[3]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *Faculty of Mat. Science and Eng. Warsaw Univ. of Techn., Warsaw, Poland*
[3] *Department of Physics, Northern Illinois University, DeKalb, USA*

The $Sr_{1-x}Ba_xMn_{1-y}Ti_yO_3$ manganites attract interest because of their multiferroic properties, i.e., the coexistence of magnetically ordered phase and ferroelectric phase. Comparative specific heat and magnetization studies were performed for several compounds with different x and y values. The studies were aimed at explaining an influence of the barium content and the titanium content on thermal and magnetic properties of these compounds. The specific heat studies were performed over the temperature range 2 – 395 K, in the magnetic field up to 5 T. The magnetization studies were performed over the temperature range 3 – 400 K, in the magnetic field up to 9 T. Lattice and magnetic contributions to the specific heat were separated and described theoretically. The temperature of the phase transition to the magnetically ordered phase was determined for studied compositions. Specific heat anomaly accompanying this transition was analyzed. The influence of magnetic field on this phase transition was also investigated.

O-1-08

Magnetic Lifshitz transition in iron-based superconductors

A. Ptok,[1,2] K.J. Kapcia,[3] A. Cichy,[4] A.M. Oleś,[5,6] and P. Piekarz[2]

[1] *Institute of Physics, Maria Curie-Skłodowska University, Lublin, Poland*
[2] *Institute of Nuclear Physics, Polish Academy of Sciences, Kraków, Poland*
[3] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[4] *Institut für Physik, Johannes Gutenberg-Universität Mainz, Mainz, Germany*
[5] *Institute of Physics, Jagiellonian University, Kraków, Poland*
[6] *Max Planck Institute for Solid State Research, Stuttgart, Germany*

In this lecture we address Lifshitz transition (LT) induced by applied external magnetic field in a case of iron-based superconductors (IBSC), in which a difference between the Fermi level and the edges of the bands is relatively small. We introduce and investigate a two-band model with intra-band pairing in the relevant parameters regime to address a generic behavior of a system with hole-like and electron-like bands in external magnetic field. Our results show that two LT can develop in analyzed systems and the first one occurs in the superconducting phase and takes place at approximately constant magnetic field [1]. The chosen sets of the model parameters can describe characteristic band structure of IBSC and thus the obtained results can explain the experimental observations in e.g. FeSe.

References:

[1] A. Ptok, K. J. Kapcia, A. Cichy, A. M. Oleś, and P. Piekarz, Sci. Rep. **7**, 41979 (2017).

This work was supported by Narodowe Centrum Nauki (NCN) through the Grant Fuga, No. UMO-2016/20/S/ST3/00274.

O-1-09

Charge-ordered phases in the extended Hubbard model

K.J. Kapcia[1]

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

Various charge ordered states are relevant to a broad range of materials, e.g. manganites, cuprates, magnetite, doped transition metal compounds ($Ti_{4x}V_xO_7$, WO_{3-x}), heavy-fermion systems and organic compounds. The extended Hubbard model is one of the simplest models that captures the interplay between strong correlations and charge-ordering effects [1-3]. The model can describe the insulator-metal transition between phases with long-range charge-order [1]. We present studies of the model with both (i) on-site interaction U and (ii) intersite density-density interactions between nearest-neighbors W_1 and next-nearest-neighbors W_2 beyond the standard two-sublattice assumption [2,3]. In particular, we investigate the effects of next-nearest-neighbor interactions on phase diagrams of the model in different limits and we show that charge-stripes can occur for repulsive $W_2 > 0$ for both signs of W_1 [2].

References:

[1] K. J. Kapcia, S. Robaszkiewicz, M. Capone, A. Amaricci, Phys. Rev. B (2017), *accepted*; arXiv:1611.03455

[2] K. J. Kapcia, J. Barański, S. Robaszkiewicz, A. Ptok, J. Supercond. Nov. Magn. **30**, 109 (2017).

[3] K. J. Kapcia, S. Robaszkiewicz, Physica A **461**, 487 (2016).

The partial support from National Science Centre (NCN, Poland) under project No. 2016/21/D/ST3/03385 is acknowledged.

O-1-10

Hall effect in pseudoternary $URu_{1-x}Pd_xGe$ intermetallics

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

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

Pseudoternary $URu_{1-x}Pd_xGe$ intermetallics, crystallizing in the TiNiSi-type orthorhombic structure, have been reported to exhibit rich magnetic phase diagram, including the possibility of an Antiferromagnetic (AF) Quantum Critical Point (QCP) at the critical concentration $x_{cr} = 0.32$, AF ordering in the concentration range 0.4 - 0.8 and complex magnetic structures for $x \geqslant 0.85$ [1]. To gain better insight into the evolution of magnetic properties in the system, we investigated the Hall effect. The experiments reveal that Hall coefficient R_H of all studied alloys is positive over the whole measured temperature range. Interestingly, R_H of $x_{cr} = 0.32$ does not saturate at low temperatures. In contrast, $R_H(T)$ of $x > 0.4$ displays a maximum around their magnetic transition temperature. We show that the $R_H(T)$ data can be interpreted as the sum of ordinary R_0 and extraordinary R_s contribution. We found that effective mass estimated from R_0 increases sharply as the system approaches x_{cr}, and retains a value of approaximately 100 m_e at x_{cr}. Our finding provides new support to the development of heavy fermion state nearby AF-QCP in $URu_{1-x}Pd_xGe$.

References:

[1] D. Gralak, V. H. Tran, J. Solid State Chem. 226, 50 (2015).

Financial support from the project 2011/01/B/ST3/04553 NSC of Poland.

O-1-11

On the current flow in superconductors: universal trends and holographic analysis

Marek Rogatko,[1] and Karol Izydor Wysokiński[1]
[1] *Institute of Physics, Maria Curie-Skłodowska University, ul. Radziszewskiego 10, 20-031 Lublin*

The superconducting state can be destroyed by the increase of temperature, magnetic field or current flow beyond their critical values. The critical current I_c is of special interest as most of the practical applications of superconductors crucially depend on its limiting value. Recent analysis of experimental data in many families of superconductors have discovered [1] an interesting universal relation between critical current, critical magnetic field H_c and the penetration depth λ. Using the holographic analogy we have calculated the temperature dependence of the critical current in strongly coupled superconductors [2]. It turns out that the calculated critical current dependence on temperature in 2d systems is $I_c \propto (T_c - T)^{3/2}$ and agrees with observed in thin films. Similar calculations for 3d systems reveals linear T-dependence $I_c \propto (T_c - T)^1$.

References:

[1] E. F. Talantsev and J. L. Tallon, *Universal self-field critical current for thin film superconductors* Nat. Commun. **6**, 7820 (2015).
[2] M. Rogatko and K. I. Wysokiński *Condensate flow in holographic models in the presence of dark matter* J. High Energy Phys. **10**, 152 (2016).

O-1-12

Two-channel Kondo physics due to As vacancies

T. Cichorek,[1] L. Bochenek,[1] M. Schmidt,[2] R. Niewa,[3] A. Czulucki,[2]
G. Auffermann,[2] F. Steglich,[2,4,5] R. Kniep,[2] and S. Kirchner[5]
[1] *Institute of Low Temperature and Structure Research, PAS, Wroclaw, Poland*
[2] *Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany*
[3] *Institute of Inorganic Chemistry, University of Stuttgart, Germany*
[4] *Institute of Physics, Chinese Academy of Science, Beijing, China*
[5] *Center for Correlated Matter, Zhejiang University, Hangzhou, China*

We address the origin of the magnetic-field independent $-|A|\,T^{1/2}$ term frequently observed in the low-temperature resistivity $\rho(T)$ of As-based metallic systems of the PbFCl structure type. This low-T behavior is in line with the non-magnetic version of the two-channel Kondo (2CK) effect. Up to date, this type of 2CK physics has never been convincingly verified in any bulk metallic system for two reasons: first, a $-|A|\,T^{1/2}$ term in $\rho(T)$ can also be caused by electron-electron interactions; second, no precise information about the underlying structural defects has yet been provided. The combination of chemical and structural investigations with physical property measurements for two closely related compounds $ZrAs_{1.58}Se_{0.39}$ and $ZrP_{1.54}S_{0.46}$ shows that the B-independent $-|A|\,T^{1/2}$ upturn observed over almost two decades in temperature originates from vacancies in the pnictogen layer. Finally, we offer a theoretical model for 2CK impurity formation near these vacancies in terms of a dynamical Jahn-Teller deformation and the concomitant dynamic bond formation of As dimers or oligomers. Our findings should be relevant to a wide class of metals with disordered pnictogen layers.

References:

[1] T. Cichorek *et al.*, Phys. Rev. Lett. 117 (2016) 106601.

O-1-13

Majorana states in presence of electron interactions: spinful fractional Josephson junction with a quantum dot

Piotr Stefański[1]

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

Typically a quantum dot in contact with the end Majorana bound state of a topological wire is effectively non-interacting due to large Zeeman splitting, caused by the external magnetic field required for topological state to emerge. However, if the dot is created inside a topological Josephson junction, the magnetic fields creating topological phases in the junction wires can be oriented anti-parallel and cancel inside the dot. It allows electron interactions to operate in the dot. We investigate such a junction for variable Zeeman splitting; from the maximal one (non-interacting dot) to the one when the both dot spin-sublevels are in the superconducting gap. In consistency with the recent experiments, we assume that the dot is made from the same materials as the wires, which allows the formation of the bound fermionic state of the dot out of two adjacent Majoranas. Possible pairing of the end Majoranas inside the wires is also taken into account. The density of states of the dot is probed by an additional tunnel electrode at the top of the junction. We show that electron interactions renormalize height of the Majorana peak and introduce characteristic asymmetry of the gate voltage dependence of the transverse zero-bias conductance through the dot.

O-1-14

Mixed-pairing superconductivity in $5d$ Mott insulators with antisymmetric exchange: Application to Sr_2IrO_4

M. Hossein Zare,[1] Mehdi Biderang,[2] and Alireza Akbari[2,3]

[1] *Department of Physics, Isfahan University of technology, Isfahan, Iran*

[2] *Asia Pacific Center for Theoretical Physics, Pohang, Korea*

[3] *Department of Physics, POSTECH, Pohang, Korea*

We investigate the potential existence of a superconducting phase in $5d$ Mott insulators with an eye to hole doped Sr_2IrO_4. Using a mean-field method, a mixed singlet-triplet superconductivity is observed due to the antisymmetric exchange originating from a quasi-spin-orbit-coupling. Our calculation on ribbon geometry shows possible existence of the topologically protected edge states while the spin-triplet component of the order parameter is larger than the spin-singlet one. These edge modes emerge as zero-energy flat bands, supporting a symmetry protected Majorana states. We propose an innovative approach for experimental observation of these edge states based on the quasi-particle interference (QPI) technique.

O-1-15

f electrons are localized in heavy-fermion intermetallic: $YbRh_2Si_2$

R.J. Radwanski,[1,2] D.M. Nalecz,[1,2] S.S. Fedyk,[1,2] and Z. Ropka[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*

After 40 years of intensive studies of heavy-fermion (h-f) intermetallics, of numerous papers in most prestigious journals and the invited talks underlying f-electron itinerant origin of heavy-fermion phenomena, there is more and more experiments showing the almost perfect localization of the f-electrons in the canonical h-f system: $YbRh_2Si_2$. The successful revealing of the Yb^{3+} crystal-field (CEF) states confirms the Quantum Atomistic Solid State Theory (QUASST) worked out by Radwanski *et al.* (Acta Phys Pol. B 31 (2000) 3079, Acta Phys. 7-8 (2007)). QUASST was the only theory, which has claimed from 1992 the existence of the discrete CEF electronic structure and the Kramers doublet ground state in heavy-fermion intermetallics.
The removal of the Kramers degeneracy via spin-dependent interactions is origin of the large specific heat at low temperatures (a hallmark of the h-f phenomena) and of low-energy neutral spin-like excitations. The existing h-f theories will be reviewed, in particular with respect to the theoretical description of f electrons in intermetallics. Such studies should lead to a better understanding of the origin of the magnetism and the formation of the magnetic state.

O-1-16

Wigner Crystallization in Chern Insulators with flat bands

B. Jaworowski,[1] P. Potasz,[1] P. Kaczmarkiewicz,[1] M. Kupczynski,[1] A. Wojs,[1] and A.D. Guclu[2]

[1] *Department of Theoretical Physics, Wroclaw University of Science and Technology, Wrocław, Poland*

[2] *Department of Physics, Izmir Institute of Technology, Izmir, Turkey*

Wigner crystallization of spinless particles on flat bands with nontrivial (Chern insulators) and trivial topology is investigated. Recent theoretical works on Fractional Chern Insulators (FCI) have shown rich variety of strongly correlated phases for different filling factors on flat Chern insulator energy bands [1,2]. They were found to be stable for relatively high densities (filling factor $> 1/7$) and short-range interactions. In this work we study a transition between high and low density limits of flat bands filled by spinless particles, interacting via long-range Coulomb potential. We perform exact diagonalization for partially filled energy bands obtained on checkerboard, kagome and honeycomb lattices. An arrangement of Wigner particles in a lattice is observed after crossing critical low density limit. Creation of a periodic structure is confirmed by calculation of angular Fourier transform, proving square or hexagonal lattice formations.

References:

[1] N. Regnault and B. A. Bernevig, Phys. Rev. X 1, 021014 (2011).

[2] E. J. Bergholtz and Z. Liu, Int. J. Mod. Phys. B 27,1330017 (2013).

O-1-17

Strong spin-orbit effects in transition metal oxides with tetrahedral coordination

F. Forte,[1,2] D. Guerra,[1] A. Avella,[1,2] C. Autieri,[3] A. Romano,[1,2] and C. Noce[1,2]

[1] *Physics Department 'E. R. Caianiello', University of Salerno, Italy*

[2] *CNR-SPIN, Operative Unit of Salerno, Italy*

[3] *CNR-SPIN, Operative Unit of L'Aquila, Italy*

We analyze the effects of strong spin-orbit coupling (SOC) in heavy transition metal oxides with tetrahedral coordination and eg^1 configuration. We show that the interplay between strong Hubbard interaction, large SOC strength and crystal field leads to an unquenched orbital momentum and a deviation from a conventional s=1/2 Heisenberg antiferromagnet, to an extent that crucially depends on the ratio between the microscopic parameters. The specific case of the insulating $KOsO_4$ is analyzed by combined ab-initio and exact diagonalization approaches. We show that, due to the peculiar hopping connectivity and structural deformation, an entangled spin/orbital state emerges, which is marked by strong anisotropy.

References:

[1] D. Pesin and L. Balents, Nat. Phys. **6**, 376 (2010)

O-1-18

Multiferroic behaviour in double-perovskite $Y(Ni_{0.5}Mn_{0.5})O_3$ thin films

E. Coy,[1] I. Fina,[2] L. Yate,[3] K. Załęski,[1] M.C. Polo,[4] C. Ferrater,[4] S. Estrade,[5] F. Peiro,[5] and M. Varela[4]

[1] *NanoBioMedical Centre - Adam Mickiewicz University - Poland*

[2] *Institut de Ciència de Materials de Barcelona(ICMAB) - Spain*

[3] *CIC BiomaGUNE - Spain*

[4] *Departament Física Aplicada i Òptica - Universitat de Barcelona - Spain*

[5] *Departament d'electrònica- Universitat de Barcelona - Spain*

We report on the functional properties of the $Y(Ni_{0.5}Mn_{0.5})O_3$ epitaxial thin films, growth by pulsed laser deposition, observing the clear features of their ferroelectric and ferromagnetic nature at cryogenic temperature. The characterization of temperature-dependent complex impedance spectroscopy has shown a dielectric anomaly around the ferromagnetic Curie temperature (≈100K) indicative of coupling between magnetic and electric orders.

Authors thank the National Science Centre of Poland (NCN) for the grant PRELUDIUM (UMO-2015/17/N/ST5/01988)s

O-1-19

The Kondo effect in a single-molecule magnet coupled to a superconductor

K.P. Wójcik,[1] M. Misiorny,[1] and I. Weymann[1]

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

We study transport properties of a single-molecule magnet embedded between two ferromagnetic leads and proximized by the third, superconducting electrode. The emphasis is put on the Kondo physics in the regime of strong magnet-leads coupling and large superconductor gap. The conductance of the device is analyzed as a function of temperature and detuning from the particle-hole symmetry point. The role of the coupling to the superconducting lead is determined in the wide range of the relevant coupling strength. The cases of *easy-axis* and *easy-plane* magnetic anisotropy, both realizable experimentally [1,2], are discussed. The calculations are performed with the aid of the numerical renormalization group procedure. We show that in general the transport properties of the device stem from subtle interplay between different types of correlations: the Kondo effect, the induced dipolar and the quadrupolar exchange fields, the intra-molecular exchange, and the superconductor-originated pairing.

References:

[1] M. Misiorny *et al.*, Phys. Rev. B **91**, 035442 (2015).

[2] B. W. Heinrich *et al.*, Nat. Phys. **9**, 765 (2013).

We acknowledge the support by the National Science Centre in Poland through the Project No. 2013/10/E/ST3/00213.

O-1-20

Hidden string order and hole-superconducting correlations from extended correlated hopping in optical lattices

Ravindra W. Chhajlany,[1,2] Przemysław R. Grzybowski,[2] Julia Stasińska,[1,3] Maciej Lewenstein,[1] and Omjyoti Dutta[4,5]

[1] *ICFO-Institut de Ciències Fotòniques, Barcelona, Spain*

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

[3] *Institute of Physics of the PAS, Warsaw, Poland*

[4] *Instytut Fizyki, Uniwersytet Jagielloński, Kraków, Poland*

[5] *Donostia International Physics Center DIPC, Donostia-San Sebastian, Spain*

Ultracold fermions in 1-dimensional, spin-dependent non-overlapping optical lattices are described by a non-standard Hubbard model with next-nearest-neighbor correlated hopping [PRL 116, 225303 (2016)]. We discuss the engineering of such systems in state-of-the-art experiments, where the correlated hopping can be naturally very strong and can dominate the observable physical phenomena. We discuss the ground state phase diagram and elementary excitations of our model. At a high symmetry point, exact spin-charge separation is manifest and we obtain for arbitrary filling: ground state collective order characterized by a spin gap that we ascribe to an unconventional critical hole superconductor with finite long range nonlocal string order. Away from the integrable point, both long range string order and spin gap persist for a wide range of parameters before a transition to a ferromagnetic-like state.

O-2-01

Multiferroicity due to Competing Spin Exchange in Antiferromagnetic Quantum Ribbon Chain Systems

Reinhard K. Kremer[1]

[1] *MPI for Solid State Research, Heisenbergstraße 1, D-70569 Stuttgart, Germany*

Due to complex entanglement of spin and orbital degrees of freedom, sometimes combined with charge ordering effects the magnetism of low dimensional quantum antiferromagnets is of special interest. In this respect the magnetic properties of antiferromagnetic quantum spin-systems with competing intrachain spin-exchange interactions recently have attracted particular attention since they may exhibit unconventional magnetic groundstates. Of special interest are systems that develop incommensurate magnetic structures and induce multiferroicity. This has been observed in a number compounds containing CuX_2 ribbon chains. Such ribbon chains form when Jahn-Teller distorted anion octahedra enclosing the Cu^{2+} cations are linked via opposite edges of their basal planes to form infinite aggregates. In such ribbon chain systems, nearest neighbor spin exchange interaction via a Cu - X - Cu bond with bonding angle close to 90^o is small and typically ferromagnetic so that next-nearest super-super exchange interaction via two intermediate anions can dominate the spin exchange interactions. I shall report on our recent research on some new systems featuring such ribbon chain compounds and discuss magnetoelastic anomalies associated with the onset of multiferroic ordering.

O-2-02

Spin superfluidity in YIG films

E.B. Sonin[1]

[1] *Racah Institute of Physics, Hebrew University of Jerusalem, Givat Ram, Jerusalem 91904, Israel*

Recently it was suggested that spin supercurrents analogous to supercurrents in superfluids are possible in the magnon BEC observed in yttrium-iron-garnet (YIG) magnetic films under strong external pumping. Bozhko *et al.* [1] declared experimental detection of spin supercurrent in a decay of the magnon condensate in YIG. Here we analyze possibility of spin superfluidity in YIG films. From topology of the equilibrium order parameter in YIG one must not expect energetic barriers making spin supercurrents metastable. However, some small barriers of dynamical origin are possible nevertheless. The critical phase gradient (analog of the Landau critical velocity in superfluids) is proportional to intensity of the coherent spin wave (number of condensed magnons). The conclusion is that although spin superfluidity in YIG films is possible in principle, the published claim of its observation [1] is not justified. A byproduct of the analysis is revision of the widely accepted spin-wave spectrum in YIG films after properly taking into account the magnetostatic and exchange boundary conditions on film surfaces.

References:

[1] D. A. Bozhko *et al.*, Nat. Phys. **12**, 1057 (2016)

O-2-03

Frustration and quantum entanglement in the family of ring-shaped chromium nanomagnets

P. Kozłowski[1]

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

Molecular nanomagnets can serve as a perfect testbed for studying the interplay between quantum entanglement and frustration. In this contribution, the relation between frustration and entanglement is investigated in the family of ring-shaped chromium nanomagnets with odd number of magnetic ions. It is demonstrated by numerical simulations that though larger frustration generates stronger entanglement between complementary spin blocks and weaker between nearest neighbor spins, the relation between entanglement and frustration is not strictly monotonic and can be used to reconcile different classifications of frustration. It is shown that in the geometrically frustrated phase the region in which the lower bound on the universal frustration measure is saturated increases as geometric frustration is diluted. The entanglement between particular complementary spin blocks can attain almost the maximal value for a proper choice of Hamiltonian parameters. The influence of single ion anisotropy, magnetic field and size of the molecules on frustration and entanglement measures is also investigated.

References:

[1] P. Kozłowski Phys. Rev. B **91** 174432 (2015)

O-2-04

Phase coherence in a coupled boson-fermion model

Maciej M. Maśka,[1] and Nandini Trivedi[2]

[1] *Department of Theoretical Physics, University of Silesia, Katowice, Poland*

[2] *Department of Physics, The Ohio State University, Columbus, USA*

We consider a coupled boson-fermion model in two dimensions, that describes itinerant fermions hybridizing with localized bosons composed of pairs of tightly bound opposite-spin fermions. We trace out the fermionic degrees of freedom and perform a Monte Carlo simulation for the effective classical Hamiltonian of boson phases. We find that the fermions generate an effective long-range temperature-dependent boson-boson coupling that at low temperature generates a quasi long range order. With increasing temperature the stiffness drops to zero and the bosonic subsystem undergoes the Kosterlitz-Thouless transition. Also the fermionic subsystem has nontrivial properties, what results from the interactions with the classical phases. At low temperature the phases are uniform and the fermions form a BCS state for any boson-fermion coupling. However, at higher temperature the fermions interact with inhomogeneous distribution of the boson phases. Depending on the coupling they form a metallic state, Anderson insulator or a disordered bosonic insulator.

This work was supported by National Science Centre (NCN) under Grant No. DEC-2013/11/B/ST3/00824

O-2-05

Computation of latent heat based on the energy distribution histogram in the 3D Ashkin-Teller model

D. Jeziorek-Knioła,[1] Z. Wojtkowiak,[1] and G. Musiał[1]

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

This paper presents a method of computation of latent heat based on the energy distribution histogram [1] for the first time applied to the 3D standard Ashkin-Teller (AT) model, one of the most important reference points in statistical physics. This model is of current interest (a dozen papers published every year). Similarly as in the original method for the q-state Potts model [1], for strong order phase transitions we observe characteristic histogram with two peaks in the critical region. Positions of two minima of negative logarithm of internal energy E probability for samples of finite size $L \times L \times L$ appearing at E_+ and E_- show good linear scalability to the thermodynamic limit (E_+ is the E value at a critical point on the ordered side and E_- on the disordered one). The latent heat values are consistent with the ones obtained by us using the analysis of the behavior of the cumulants of the type of Challa V_L [1] and Lee U_L [1], modified by Musiał [2,3].

References:

[1] J. Lee, J. M. Kosterlitz, Phys. Rev. 43, 3265 (1991)
[2] G. Musial, Phys. Rev. B 69, 024407 (2004)
[3] D. Jeziorek-Kniola, G. Musial, Z. Wojtkowiak, Acta Phys. Polon. A 127, 327 (2015)

O-2-06

Thermal transport in Kitaev-Heisenberg spin systems

Wolfram Brenig,[1] Alexandros Metavitsiadis,[1] and Angelo Pidatella[2]

[1] *Institute for Theoretical Physics, Technical University Braunschweig, Braunschweig, Germany*

[2] *Institute for Theoretical Physics, Technical University Dresden, Dresden, Germany*

We present results for the dynamical thermal conductivity of the Kitaev-Heisenberg model on ladders and the Kitaev model on honeycomb lattices. In the pure Kitaev limit [1], and in contrast to other integrable spin systems [2], the ladder represents a perfect heat insulator. This is a fingerprint of fractionalization into mobile Majorana matter and a static Z2 gauge field. We find a full suppression of the Drude weight and a pseudogap in the conductivity. With Heisenberg exchange, we find a crossover from a heat insulator to conductor, due to recombination of fractionalized spins into triplons [3]. For the honeycomb lattice, we show, that our findings persist in 2D. Our results rest on several approaches comprising a mean-field theory, complete summation over all gauge sectors, exact diagonalization, and quantum typicality [2] calculations.

References:

[1] A. Metavitsiadis, W. Brenig, arXiv:1605.09390.
[2] R. Steinigeweg, J. Gemmer, and W. Brenig, Phys. Rev. Lett. 112, 120601 (2014).
[3] R. Steinigeweg, J. Herbrych, X. Zotos, and W. Brenig, Phys. Rev. Lett. 116, 017202 (2016).

Work supported in part by DFG through SFB 1143 and PSM Dresden.

O-2-07

Spin liquid and order in quantum ice

Olga Sikora,[1] Paul A. McClarty,[2] Roderich Moessner,[3] Karlo Penc,[4]
Frank Pollmann,[5] Ying-Jer Kao,[6] and Nic Shannon[7]

[1] *Institute of Physics, Jagiellonian University, Kraków, Poland*
[2] *ISIS Facility, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[3] *Max Planck Institute for the Physics of Complex Systems, Dresden, Germany*
[4] *Wigner Research Centre for Physics, Budapest, Hungary*
[5] *Department of Physics, Technical University of Munich, Garching, Germany*
[6] *Department of Physics, National Taiwan University, Taipei, Taiwan*
[7] *Okinawa Institute for Science and Technology Graduate University, Okinawa, Japan*

The geometrical frustration in spin ice leads to a highly degenerate classical ground state manifold supporting monopole excitations. Here we discuss some of the new phenomena which result from quantum tunneling between spin ice configurations. Using Monte Carlo simulation methods we investigate the stability of the quantum liquid phase against ordered "chain states" in a realistic model of spin ice including long-range dipolar interactions. We also explore an effective model of spin ice with short range exchange interactions by examining the nature of spin ordered states in an external magnetic field and their competition with the quantum liquid phase.

References:

[1] P. McClarty, O. Sikora *et al.*, Phys. Rev. B **92**, 094418 (2015)

O-3-01

Spin excitations and thermodynamics of the Heisenberg model on the layered honeycomb lattice

N.M. Plakida,[1] A.A. Vladimirov,[1] and D. Ihle[2]

[1] *Joint Institute for Nuclear Research, 141980 Dubna, Russia*

[2] *Institute for Theoretical Physica, Leipzig University, D-04109 Leipzig, Germany*

We present the spin-rotation-invariant Green-function theory for the dynamic spin susceptibility in the spin-1/2 antiferromagnetic Heisenberg model on a stacked honeycomb lattice for various interlayer couplings. Employing a generalized mean-field approximation for arbitrary temperatures, the thermodynamic quantities (two-spin correlation functions, internal energy, magnetic susceptibility, staggered magnetization, Néel temperature, correlation length) and the spin-excitation spectrum are calculated by solving a coupled system of self-consistency equations for the correlation functions. Our results are in good agreement with numerical computations for finite clusters and with available experimental data. The spin-wave excitation spectrum, the sublattice magnetization, and transition temperatures are also calculated for the pseudo-spin-1/2 Kitaev - Heisenberg model in the random phase approximation for four ordered phases observed in the model: antiferomagnetic, stripe, ferromagnetic, and zigzag phases. The Néel temperature and temperature dependence of the sublattice magnetization are compared with the experimental data on Na_2IrO_3.

O-3-02

Nonlinear off-digonal magnetic susceptibility of $LiNiPO_4$

S. Lewinska,[1] A. Szewczyk,[1] M.U. Gutowska,[1] Yu. Kharchenko,[2] R. Puzniak,[1] and M.F. Kharchenko[2]

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

[2] *B. Verkin Institute for LTPE of the NASU, Kharkiv, Ukraine*

Among orthorhombic (*Pnma*) olivines, suitable for cathodes of Li-ion batteries, $LiNiPO_4$ is a unique one, because it orders magnetically in two steps, i.e., at 21.8 K, the 2^{nd} order transition to an incommensurate phase and then, at 20.9 K, the 1^{st} order transition to an antiferromagnetic phase appear. We focused our studies on magnetic properties of the ordered phases and on the phase diagram. For a $LiNiPO_4$ single crystal, angular dependences of torque and magnetic moment were measured for magnetic field, **B**, rotating within *a*-*c* and *b*-*c* planes, for several $|\mathbf{B}|$ values, at several temperatures. We explained uncommon shapes of these dependences by assuming the magnetic moment induced along *a*, *b*, and *c* axes by **B** to be proportional not only to the **B**-component parallel to the particular axis but also to the square of the **B**-component perpendicular to it. Then, a very good agreement between the theoretical and the measured dependences was achieved, which confirmed validity of the model proposed. We called this effect the "nonlinear off-diagonal magnetic susceptibility". The temperatures of both transitions were found to decrease proportionally to B^2 for **B** parallel to *c*, and to be insensitive to **B** for **B** parallel to the *a* and *b* axes.

O-3-03

Spin waves in a two-sublattice antiferromagnet. A new class of self-similar solutions of the Landau-Lifshitz equation

Yu. Gorobets,[1,2] O. Gorobets,[1,2] and V. Kulish[2]
[1] *Institute of Magnetism of NASU and MESU, 36-b Vernads'kogo st., 03142, Kyiv, Ukraine*
[2] *National Technical University of Ukraine "Igor Sikorsky KPI", 37 Peremogy prosp., 03056, Kyiv, Ukraine*

In the paper, spin waves in a uniaxial two-sublattice antiferromagnet are investigated. A new class of self-similar solutions of the Landau-Lifshitz equation is obtained and, therefore, a new type of spin waves is described. Examples of solutions of the found class are presented. New type of solution admits both linear and non-linear spin waves, including solitons. Space transformations used in the solution are mathematically analogous to the relativistic space transformations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348 (MagIC).

O-3-04

Magnetocaloric effect and physical properties of slowly cooled $\mathbf{NiMn_{1-x}Cr_xGe}$ $(0.04 \leq x \leq 0.25)$

A. Szytuła,[1] S. Baran,[1] T. Jaworska-Gołąb,[1] M. Marzec,[1] A. Deptuch,[1] Yu. Tyvanchuk,[2] B. Penc,[1] A. Hoser,[3] A. Sivachenko,[4] V. Val'kov,[4] V. Dyakonov,[5] and H. Szymczak[5]
[1] *Institute of Physics, Jagiellonian University, Kraków, Poland*
[2] *Ivan Franko National University of Lviv, Lviv, Ukraine*
[3] *Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany*
[4] *Donetsk National Academy of Sciences of Ukraine, Donetsk, Ukraine*
[5] *Institute of Physics, Polish Academy of Sciences, Warszawa, Poland*

The compounds undergo a martensitic phase transition. The temperature of the structural phase transition significantly decreases with increasing x. AF helicoidal ordering with the propagation vector $\vec{k} = (k_x, 0, 0)$ for x = 0.04 and 0.11 and F one for x = 0.25 has been found. The sample with x = 0.18 shows a coexistence of a helicoidal AF structure and the F one below ~170 K while at higher temperatures the ferromagnetic ordering remains stable up to 362 K. Maximum entropy change (-ΔS) increases with increasing Cr concentration from about 8 J/(kg K) at 90 kOe, found for x = 0.04 and 0.11 at the Nèel temperature, up to 29 J/(kg K) observed for x = 0.25 in cooling regime at the magnetostructural phase transition temperature.

O-3-05

Ultrafast Spin Transfer Torque Generated by a Femtosecond Laser Pulse

P. Baláž,[1] M. Žonda,[1] K. Carva,[1] P. Maldonado,[2] and P. Oppeneer[2]
[1] *DCMP, Charles University, Ke Karlovu 5, CZ-12116 Prague 2, Czech Republic*
[2] *Department of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden*

In transition metals and their alloys, featuring spin polarized 3d valence band and conduction 4s band, a laser pulse can excite electrons from the d band into the s one with higher electron mobility. The nonequilibrium hot charge carriers migrate away from the laser spot and reduce the local magnetic moment as described by the superdiffusive spin transport model [1], which takes into account scattering of hot electrons on atomic sites leading to nonequilibrium avalanches of excited electrons. Here, we theoretically study the spin transfer torque and magnetization dynamics induced by femtosecond laser pulse in a spin valve consisting of two magnetic layer with perpendicular magnetizations separated by a nonmagnet. To this end, we have developed a four-channel model of spin transport, which allows us to calculate spin transfer torque and describe magnetization dynamics.

References:

[1] M. Battiato, K. Carva, P. Oppeneer Phys. Rev. Lett. 105, 027203 (2010); Phys. Rev. B 86, 024404 (2012).

O-3-06

Bulk and surface magnetoelastic waves

P. Graczyk,[1] Jarosław Kłos,[1] and Maciej Krawczyk[1]
[1] *Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

We will present the existence of broadband magnetoelastic waves in optimized one-dimensional periodic structure (magphonic crystal). The system consists of two ferromagnetic layers alternating in space. We have taken into consideration materials prominent in magnonics: YIG, CoFeB, permalloy, and cobalt. The coupled mode theory (CMT) formalism have been successfully implemented for the first time to describe magnetoelastic interaction as a periodic perturbation in the magphonic crystal. We have demonstrated how the energy is spatially exchanged between spin wave and acoustic wave in the magphonic crystal if the resonance condition is satisfied. We have shown, that CMT analysis of magnetoelastic coupling allows to effectively design a spin wave-acoustic wave transducer based on a magphonic crystal. Moreover, we propose thin film – substrate systems optimized for the experimental investigation of the linear coupling between surface spin waves and surface acoustic waves.

This work was supported by the National Science Centre Poland from grants UMO-2012/07/ST3/00538 and UMO-2016/21/B/ST3/00452

O-3-07

Electric field control of standing spin waves in PMN-PT/NiFe heterostructure

Marek Frankowski,[1] Jakub Chęciński,[1] Sławomir Ziętek,[1] Witold Skowroński,[1] and Tomasz Stobiecki[1]

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

We present experimental results on spin-diode effect in a PMN-PT/NiFe heterostructure tuned by electric field [1]. By utilizing micromagnetic simulations we are able to get an insight into parameters and details of dynamics that are hard or impossible to obtain experimentally, namely standing spin-waves (SSW) spatial distribution, phase and length. Experimental results are compared with micromagnetic simulations, showing good quantitative agreement. In this manner we verify which experimentally observed modes are SSW modes. We apply an electric field to change SSW modes frequencies and reproduce this effect by micromagnetic simulations to find the anisotropy change ampitude in an external electric field.

References:

[1] S. Ziętek, J. Chęciński, M. Frankowski et al. Electric-field tunable spin waves in PMN-PT/NiFe heterostructure: Experiment and micromagnetic simulations, Journal of Magnetism and Magnetic Materials 428 (2017) 64–69 .

This work was supported by grant Preludium 2015/17/N/ST3/02276 from National Science Center, Poland. Numerical calculations were supported by PL-GRID infrastructure. TS. acknowledges the statutory Grant 11.11.230.017.

O-3-08

Application of $\pi/2$ domain walls in cubic-crystalline films to domain-wall racetracks and spin-transfer oscillators

Andrzej Janutka,[1] and Przemysław Gawroński[2]

[1] *Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, 50-370 Wrocław, Poland*

[2] *Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, 30-059 Krakow, Poland*

We outline our micromagnetic simulations and analytical studies of the current-driven dynamics of the $\pi/2$ domain walls (DWs) in cubic-crystalline magnetic nanostripes and of the rotation of $\pi/2$-DW-containing and vortex-centered texture (of four closure domains) in a circular cubic-crystalline magnetic dot [1], [2]. Ultra-thin films of Fe_3Pt and Fe_3O_4 are of our especial interest. Several topic make the cubic-crystalline films an attractive alternative to the soft-magnetic films or PMA films for designing the DW- or vortex-based spintronic devices. These are: a small width od the $\pi/2$ DWs (a dense packing), their large maximum velocity, a stability of the current-driven vortex-state oscillations (a cyclic motion of the vortex-surrounding $\pi/2$ DWs). We present simulation data on the DW dynamics in Fe_3Pt nanostripes and on the current-driven fast generation of the $\pi/2$ DWs in series using the confined vortex texture.

References:

[1] A. Janutka, P. Gawroński, P. S. Ruszała, J. Phys. D 48 (2015) 495001
[2] A. Janutka, P. Gawroński, J. Phys. D 50 (2017) 145003

O-3-09

Optically detected counter-rotating spin waves in ferromagnetic layers: the key role of the optical phase shift

S. Shihab,[1] L. Thevenard,[1] A. Lemaître,[2] and C. Gourdon[1]

[1] *Sorbonne Universités, UPMC Univ Paris 06, CNRS-UMR 7588, Institut des NanoSciences de Paris, F-75005, Paris, France*

[2] *Centre de Nanosciences et Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91460 Marcoussis, F-91460 France*

We excite perpendicular standing spin waves by a laser pulse in a (Ga,Mn)(As,P) ferromagnetic semiconductor layer and detect them using time-resolved magneto-optical effects. The full trajectory of the magnetization vector can be reconstructed using two magneto-optical effects, the polar Kerr effect and the Voigt effect. Quite counter-intuitively, we find that the first two excited modes are of opposite chirality. We show that this is an optical illusion that can perfectly be explained by taking into account absorption and optical phase shift inside the layer [1]. These results provide a correct identification of spin waves modes, enabling a trustworthy estimation of their respective amplitudes as well as an unambiguous determination of the spin stiffness parameter.

References:

[1] S. Shihab, L. Thevenard, A. Lemaître, C. Gourdon. https://hal.archives-ouvertes.fr/hal-01490261

O-3-10

Lifetime of terahertz magnons in ultrathin ferromagnets: Temperature effects

Khalil Zakeri[1,2]

[1] *Heisenberg Spin-dynamics Group, Physikalisches Institut, Karlsruhe Institute of Technology, Karlsruhe, Germany*

[2] *Max-Planck Institute of Microstructure Physics, Halle, Germany*

Utilizing spin-polarized high resolution electron energy loss spectroscopy we investigate the ultrafast terahertz magnons, excited in an ultrathin ferromagnet. We demonstrate that the engineering of the electronic structure of a ferromagnetic metal, by reducing its dimensionality and changing its chemical composition, opens a possibility to strongly suppress the relaxation channels of terahertz magnons and thereby enhance the magnons' lifetime. For the first time, we report on the long-living terahertz magnons excited in ultrathin metallic alloy films and explain the microscopic nature of this long lifetime [1]. We further monitor the terahertz magnons as a function of temperature and across the magnetic transition temperature T_C. We demonstrate that although at T_C these excitations are affected by different damping mechanisms, they still behave as well-defined collective excitations [2].

References:

[1] H.J. Qin, Kh. Zakeri, A. Ernst, L. M. Sandratskii, P. Buczek, A. Marmodoro, T.-H. Chuang, Y. Zhang and J. Kirschner, Nature Communications, 6, 6126 (2015)

[2] H.J. Qin, Kh. Zakeri, A. Ernst and J. Kirschner, Phys. Rev. Lett, accepted, arXiv:1702.06104.

O-3-11

Excitation of spin waves in thin film magnetic structures

V.V. Kruglyak,[1] C.S. Davies,[1] and F.B. Mushenok[1]

[1] *University of Exeter, United Kingdom*

We will describe and provide demonstrations for the Schlomann mechanism of spin wave excitation from graded magnonic index landscapes in thin film magnetic structures driven by microwave magnetic fields. In particular, we will show that different variations of this mechanism of spin wave excitation are reponsible for several recent high-profile experimental observations.

The research leading to these results has received funding from the Engineering and Physical Sciences Research Council of the United Kingdom.

O-3-12

A Monte Carlo study of critical properties of strongly diluted magnetic semiconductor (Ga,Mn)As

P. Tomczak,[1] H.T. Diep,[2] P. Jabłoński,[1] and H. Puszkarski[1]

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

[2] *Laboratoire de Physique Theorique et Modelisation, Universite de Cergy-Pontoise, Avenue Adolphe Chauvin, 95302 Cergy-Pontoise, France*

Within a Monte Carlo technique we examine critical properties of diluted bulk magnetic semiconductor (Ga,Mn)As modeled by a strongly diluted ferromagnetic Heisenberg spin-$\frac{5}{2}$ system on a face centered cubic lattice. We assumed that 5% of Ga atoms is substituted by Mn atoms and the interaction between them is of the RKKY-type. The considered system is randomly quenched and a double average was performed: firstly, over the Boltzmann probability distribution and secondly - over 2048 configurations related to the quenched disorder. We estimated the critical temperature: $T_c = 97 \pm 6$ K, which is in agreement with the experiment. The calculated high value of critical exponent ν seems to point to a possibility of non-universal critical behavior. Note that similar behavior was observed for Heisenberg spin glasses.

— *This work is a part of a project financed by Narodowe Centrum Nauki (National Science Centre of Poland), Grant No.DEC-2013/08/M/ST3/00967. Numerical calculations were performed at Poznań Supercomputing and Networking Center under Grant No. 284.*

O-3-13

Ultrafast demagnetization: understanding magnetic states out of equilibrium

K. Carva,[1] and P. Baláž[1]

[1] *Charles University, DCMP, Ke Karlovu 5, CZ-12116 Prague, Czech Republic*

Femtosecond lasers allow to observe magnetization dynamics on unprecedently short timescale. It has been commonly described employing the three temperature model. By means of ab initio calculations we look at situations when the demagnetized system deviates significantly from the assumptions of this model.

The observed decrease of magnetooptical signal can be ascribed to three possible effects: a reduction of exchange splitting (longitudinal spin excitation), disorder of magnetic moments (transversal spin excitation), and the increase of electronic temperature. High harmonics has been used to understand the nature of the magnetic state in demagnetized Co and disentangle the three above contributions by a careful comparison to an ab initio predicted spectrum [1]. In Gd metal pumped by a fs laser we have studied how the relation between 4f and 5d magnetization is changed compared to a thermal state, employing first principles exchange interaction between atomic moments, as well as the intra-atomic exchange between 4f and 5d orbitals [2].

References:

[1] E. Turgut et al., Phys. Rev. B 94, 220408 (2016)

[2] Frietsch, B. et al. , Nat. Comm. 6, 8262 (2015)

O-4-01

Noise enhancement due to telegraphic switching in a two-level quantum dot coupled to spin-polarized leads

K. Ptaszyński[1]

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

As already known, in quantum dots attached to spin-polarized leads the competition between transport of electrons with different spin polarizations may lead to super-Poissonian noise enhancement due to phenomenon referred to as the dynamical channel blockade [1]. This study shows, that in the case of two-level quantum dot the another mechanism of the noise enhancement may appear – the telegraphic switching between different transport channels associated with the spin state of a quantum dot. In contrast to the dynamical channel blockade, the telegraphic switching is associated with the breaking of the renewal property – the subsequent waiting times between successive tunneling events are correlated [2]. Correlations between waiting times can be detected by measuring the second-order current correlation function, which enables the distinction between different mechanisms of the noise enhancement.

References:

[1] B. R. Bułka, *Phys. Rev. B* **62**, 1186 (2000); W. Belzig, *Phys. Rev. B* **71**, 161301(R) (2005).
[2] K. Ptaszyński, *Phys. Rev. B* **95**, 045306 (2017).

This work has been supported by the National Science Centre, Poland, under the project 2016/21/B/ST3/02160.

O-4-02

Giant magnetoresistance in metallic magnetic nanostructures: a unified view on granular and multilayer systems

I. Bakonyi[1]

[1] *Wigner Research Centre for Physics, Hungarian Academy of Sciences H-1121 Budapest, Konkoly-Thege út 29-33, Hungary*

A description of spin-dependent scattering processes leading to giant magnetoresistance (GMR) will be given for various magnetic nanostructures. The two limiting cases are (i) granular metals in which nanoscale ferromagnetic (FM) particles with superparamagnetic (SPM) characteristics are embedded in a non-magnetic matrix and (ii) perfect nanoscale ferromagnetic(FM)/non-magnetic multilayers. In the first case, the field dependence of the magnetoresistance is proportional to the square of the Langevin function L(x) describing the field dependence of the magnetization where x is proportional to the magnetic field and the average SPM magnetic moment. In perfect multilayers (i.e., without SPM entities), the field dependence of the GMR is governed by the interplay between the FM layer coupling and the magnetic anisotropy. In non-perfect magnetic nanostructures, both FM and SPM magnetic entities can be present and in this case the GMR field dependence is proportional to L(x). We will show how to separate the SPM contribution from the measured GMR in multilayers [for details, see: I. Bakonyi and L. Péter, Progr. Mater. Sci. 55, 107 (2010)].

O-4-03

Defect induced magnetism in ZnO: a first spintronic device application

L. Botsch,[1] P. Esquinazi,[1] I. Lorite,[1] and Y. Kumar[1]

[1] *Division of Superconductivity and Magnetism, Felix-Bloch Institute for Solid State Physics, University of Leipzig, Linnéstrasse 5, D-04103 Leipzig, Germany*

The phenomenon Defect-Induced Magnetism (DIM) has been found in a broad spectrum of materials, like graphite and several oxides. The evidence obtained by very different experimental methods leaves no doubt about its intrinsic origin. An interesting example of DIM in oxides is found in ZnO, which is induced by increasing the concentration of Zn vacancies through, e.g., proton irradiation [1], with a Curie temperature far above 300K [1-2]. In this work we present a first working spintronic application of DIM, namely a spin filter and magnetic sensor based on ZnO nanostructures, in which vacancies were produced through low-energy plasma treatment.

References:

[1] M. Khalid et al., New J. Phys. 13, 063017 (2011)
[2] I. Lorite et al., Appl. Phys. Lett. 106, 082406 (2015)

O-4-04

Strongly Enhanced 1/f Noise in the Diluted Magnetic Semiconductors (Ga,Mn)As and (Ga,Mn)P

M. Lonsky,[1] J. Teschabai-Oglu,[1] K. Pierz,[2] S. Sievers,[2] H.W. Schumacher,[2] Y. Yuan,[3] S. Zhou,[3] and J. Müller[1]

[1] *Goethe-University, Frankfurt, Germany*
[2] *Physikalisch-Technische Bundesanstalt, Braunschweig, Germany*
[3] *Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*

Diluted magnetic semiconductors are promising candidates for future spintronics applications. In the case of (Ga,Mn)As and (Ga,Mn)P, a ferromagnetic order between substitutional Mn ions is mediated by holes, but there is no consensus on the development of spontaneous magnetization. An intriguing theoretical concept is the percolation of magnetic polarons as a possible origin [1]. Motivated by results of a diverging 1/f noise magnitude in EuB_6, where the existence of percolating nanoscale magnetic clusters has been demonstrated [2], we study the low-frequency carrier dynamics by fluctuation spectroscopy. Besides insights into the defect physics of the materials, we find indications for an electronic phase separation in samples with localized charge carriers, which we compare with the results for metallic (Ga,Mn)As.

References:

[1] A. Kaminski and S. Das Sarma, Phys. Rev. Lett. **88**, 247202 (2002)
[2] P. Das et al., Phys. Rev. B **86**, 184425 (2012)

O-4-05

Mixed Eu^{2+} - Eu^{3+} valence state in Eu- and Na-doped PbSe

B. Wiendlocha,[1,2] SunPhil Kim,[2] Yeseul Lee,[3] Bin He,[2] G. Lehr,[4] M.G. Kanatzidis,[3] D.T. Morelli,[4] and J.P. Heremans[2,5]

[1] *Faculty of Physics and Applied Computer Science, AGH-UST Krakow, Poland*
[2] *Department of Mech. Eng., The Ohio State University, Columbus, OH*
[3] *Department of Chemistry, Northwestern University, Evanston, IL*
[4] *Deptartment of Chem. Eng., Michigan State University, East Lansing, MI*
[5] *Department of Physics, The Ohio State University, Columbus, OH*

The Eu atoms in $Pb_{1-x}Eu_xSe$ have long been assumed to be divalent. We show that p-type doping of this semiconductor with Na can modify the Eu valence: a mixed, Eu^{2+} - Eu^{3+} state appears in $Pb_{1-x-y}Eu_xNa_ySe$. Magnetization, carrier concentration, resistivity, and thermopower of $Pb_{1-x-y}Eu_xNa_ySe$ are reported for a number of samples with different x and y. An increase in thermopower at a given carrier concentration was identified and attributed to the presence of enhanced ionized impurity scattering. A strong decrease in the hole concentration is observed in $Pb_{1-y}Na_ySe$ when Eu is added to the system, which we attribute to a Eu^{2+} – Eu^{3+} self-ionization process. This is evidenced by magnetization measurements, which reveal a significant reduction of the magnetic moment of $Pb_{1-x}Eu_xSe$ upon alloying with Na. The conclusions are supported further by the electronic structure calculations, which show an instability of the $4f^7$ configuration of the Eu^{2+} ion appears with Na doping.

O-4-06

Effect of magnetic zigzag edges in graphene-like nanoribbons on the thermoelectric power factor

Stefan Krompiewski,[1] and Gianaurelio Cuniberti[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznan, Poland*
[2] *Dresden Center for Computational Materials Science (DCMS), TU Dresden, 01062 Dresden, Germany*

This study shows that magnetic edge states of graphenelike nanoribbons enhance effectively the thermoelectric performance. This is due to the antiparallel alignment of magnetic moments on opposite zigzag edges and the confinement effect, which jointly lead to the appearance of a gap in the electronic energy spectrum. Consequently, the Seebeck coefficient as well as the thermoelectric power factor get strongly enhanced at room temperature for energies not far away from the charge neutrality point. Moreover the corresponding figure of merit (ZT) is also improved as a result of the reduced electronic thermal conductance.

This project was supported by the Polish National Science Centre from funds awarded through the decision No. DEC-2013/10/M/ST3/00488.

O-4-07

New mechanism of magneto-optic effect

A.V. Vedyayev,[1] M.Ye. Zhuravlev,[2] and A.V. Lobachev[1]

[1] *Faculty of Physics, Lomonosov Moscow State University, 119899 Moscow, Russia*

[2] *Faculty of Liberal Arts and Sciences, St Petersburg State University, 190000 St. Petersburg, Russia*

We consider a new magneto-optic effect based upon spin-orbit interaction of the conducting electrons in ferromagnetic metal with the electric field of plane polarized light wave. We calculated off-diagonal components of conductivity tensor for this mechanism of a.c. conductivity. These components determine the current induced by the light wave in the direction perpendicular to the plane of the light polarization. Numerical evaluation shows that the conductivity for this new effect exceeds the off-diagonal components of conductivity tensor for ordinary magneto-optic effect [1]. The components appear to be still considerably smaller than the diagonal elements of the conductivity tensor.

References:

[1] Petros N. Argyres, Phys. Rev. 97, 334 (1955).

O-4-08

Stability diagram of magnetization switching in perpendicular magnetic tunnel junctions

W. Skowroński,[1] M. Czapkiewicz,[1] S. Ziętek,[1] J. Chęciński,[1] M. Frankowski,[1] P. Rzeszut,[1] J. Wrona,[2] and T. Stobiecki[1]

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

[2] *Singulus Technologies, Kahl am Main, 63796, Germany*

Perpendicular magnetic tunnel junctions (MTJs) with a composite free layer (FL) of different thicknesses are investigated to balance tunneling magnetoresistance (TMR) ratio and perpendicular magnetic anisotropy energy. After annealing at 400 °C, the TMR ratio reached 180 % at room temperature and 280 % at 20 K. The voltage vs. magnetic field stability diagrams measured in pillar-shaped MTJs with 130 nm diameter indicate the competition between spin transfer torque (STT), voltage controlled magnetic anisotropy (VCMA) and temperature effects in the switching process. An extended stability phase diagram model enabled the determination of both STT and VCMA coefficients responsible for the FL magnetization switching [1].

References:

[1] W. Skowroński et al. arxiv.org/abs/1701.06411 (2017)

Project supported by Polish National Center for Research and Development No. LIDER/467/L-6/14/NCBR/2015. TS acknowledges Statutory Grant 11.11.230.017.

O-4-09

Spin and orbital polarizations of conductance of the carbon nanotube quantum dot in the presence of Majorana Fermion in topological superconductor

D. Krychowski,[1] S. Lipiński,[1] and G. Cuniberti[2]

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

[2] *Institute for Materials Science and Max Bergmann Center of Biomaterials, TU Dresden, D-01062 Dresden, Germany*

Conductance of carbon nanotube quantum dot (CNTQD) coupled to a pair of normal electrodes (N-QD-N) or to normal lead and topological superconductor (N-QD-TS) is studied in the Kondo range using Kotliar Ruckenstein slave bosons approach. Gate-dependent spin-orbit interaction (SOI) in CNTQD lowers the SU(4) symmetry of Kondo state to SU(2) symmetry and spin-orbital polarizations arise. The helical Majorana zero mode at the ends of topological superconductor filters selectively only one spin-orbital contribution of the Andreev conductance. For strong SOI and for weak coupling of the dot with topological superconductor, spin-orbital polarizations of conductance of N-QD-TS reproduce with a good accuracy spin-orbital polarizations of N-QD-N.

This project was supported by the Polish National Science Centre from the funds awarded through the decision No. DEC-2013/10/M/ST3/00488.

O-4-10

Spin transfer and spin-orbit torques in in-plane magnetized (Ga,Mn)As tracks

Laura Thevenard,[1] Benoît Boutigny,[1] Loic Becerra,[1] Nicholas Güsken,[1] Aristide Lemaître,[2] Joo-Von Kim,[2] Vincent Jeudy,[3] and Catherine Gourdon[1]

[1] *Institut des Nanosciences de Paris, UPMC CNRS, Paris, France.*

[2] *Centre de Nanosciences et de Nanotechnologies, CNRS, Universite Paris Sud, Orsay, France.*

[3] *Laboratoire de Physique des Solides, CNRS Université Paris Sud, Orsay, France*

Current-driven domain wall motion is investigated experimentally in in-plane magnetized GaMnAs tracks [1]. The wall dynamics is found to differ in two important ways with respect to perpendicularly magnetized GaMnAs or GaMnAsP: the wall mobilities are up to ten times higher and the walls move in the same direction as the hole current. We demonstrate that these observations cannot be explained by spin orbit field torques (Rashba and Dresselhaus types) but are consistent with non-adiabatic spin transfer torque driven by the strong spin-orbit coupling of GaMnAs. This mechanism opens the way to domain wall motion driven by intrinsic (bulk) rather than interface spin-orbit interaction as in ultrathin ferromagnet/heavy metal multilayers

References:

[1] L. Thevenard et al., Phys. Rev. B 95 054422 (2017)

O-4-11

Quantum oscillations in the nodal-line Dirac semimetal ZrSiS

M. Szlawska,[1] P. Swatek,[1] and D. Kaczorowski[1]

[1] *Institute of Low Temperature and Structure Research PAS, Wrocław, Poland*

By means of angle-resolved photoemission spectroscopy (ARPES), ZrSiS has been established to harbor a 3D topological nodal-line semimetallic phase as well as multiple surface Dirac states protected by nonsymmorphic crystal symmetry [1,2]. Here, we report on our observation of de Haas – van Alphen (dHvA) and Shubnikov – de Haas (SdH) oscillations in high-quality single crystals investigated in Ref. 2. The combined dHvA and SdH study revealed five independent quantum oscillations for magnetic field applied along the tetragonal axis and four oscillations for the perpendicular direction. Analysis of the associated phase shifts indicated that the quantum oscillations in ZrSiS arise from the linearly dispersed 3D and 2D bands observed by ARPES. Moreover, the angular dependencies of the frequencies could be well reproduced by the results of our ab-initio electronic band structure and Fermi surface calculations. Notably, our dHvA and SdH data appeared fully consistent with those derived recently from the quantum oscillations in the thermoelectric power of ZrSiS [3].

References:

[1] L. M. Schoop, et al., Nature Commun. **7**, 11696 (2016).
[2] M. Neupane, et al., Phys. Rev. B **93**, 201104(R) (2016).
[3] M. Matusiak, J. R. Cooper, and D. Kaczorowski, Nature Commun., in print.

O-4-12

Multiferroic multilayer as a base for future spintronics nanodevices

J. Pawlak,[1] A. Żywczak,[2] and M. Przybylski[1,2]

[1] *Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland*
[2] *Academic Centre for Materials and Nanotechnology, AGH University of Science and Technology, Kraków, Poland*

Multiferroic tunnel junction (MTFJ) is promising device for future memory with discrete and different logic states which are controlled by combination of electric and magnetic fields. The goal of ongoing research is ferroelectric and ferromagnetic properties, especially at room temperature (RT), represented as high values of Tunnel Electroresistance (TER) and Tunnel Magnetoresistance (TMR). A key aspect is the appropriate preparation of sample allowing epitaxial growth. The thin layers were prepared by Pulsed Laser Deposition on atomically smooth monocrystalline $SrTiO_3$ (STO) substrate. Ferromagnetic metal layers $La_{0.67}Sr_{0.33}MnO_3$ (LSMO) are separated by a layer of ferroelectric insulator - $BaTiO_3$ (BTO). The same structure of LSMO, BTO and STO (perovskite) and similar lattice constant makes possible to obtain high quality heterostructures. Magnetic measurements confirm different magnetic coercivity of top and bottom LSMO layer, which allow to obtain their parallel and antiparallel magnetization orientation. The modification of interfaces of BTO by thin MgO allows to increase the value of TER effect.

O-4-13

Topological phase diagram of $Pb_{1-x-y}Sn_xMn_ySe$

T. Story,[1] P. Dziawa,[1] A. Łusakowski,[1] B.J. Kowalski,[1] A. Szczerbakow,[1]
B.M. Wojek,[2] O. Tjernberg,[2] and T. Balasubramanian[3]
[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *KTH Royal Institute of Technology, Kista, Sweden*
[3] *MaxIV Laboratory, Lund University, Sweden*

$Pb_{1-x}Sn_xSe$ is a topological crystalline insulator (TCI) exhibiting metallic, spin-polarized surface electron states with linear energy dispersion. These states are topologically protected by crystalline mirror plane symmetry and form four Dirac cones. In this work, we study the effect of incorporating Mn ions into TCI materials on their magnetic, structural and topological properties, in particular the band gap inversion and the transition temperature to the TCI state. We applied angle-resolved photoemission (ARPES) spectroscopy technique to study the electronic structure of (001) surface of $Pb_{1-x-y}Sn_xMn_ySe$ (x=0.28-0.385, y=0-0.03) bulk crystals. In the crystals with inverted band structure we found the Dirac-like topological surface states and show that the incorporation of just 1 at.% of Mn decreases the topological transition temperature by about 100 K. These experimental observations are summarized in the form of temperature-composition topological phase diagram and are analyzed based on band structure calculations. Increasing Mn content results in a rapid increase the gap for the trivial band ordering but a decrease for the inverted one.

O-4-14

Spin-resolved thermoelectric effects in a quantum dot devices coupled to ferromagnetic and superconducting electrodes

Piotr Trocha[1]
[1] *Faculty of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland*

Although, superconductors perfectly conduct electric current and are poor thermal conductors, they exhibit very small thermoelectric response. In the low-temperature limit, the transport occurs mainly through Andreev states. Due to particle-hole symmetry the resulting thermopower vanishes. To observe thermoelectricity one has to break the particle-hole symmetry which can be done using quantum-dot-based hybrid devices. The thermoelectric properties of hybrid systems based on a quantum dots attached to one superconductor and one metallic ferromagnet has been investigated. The interplay of Andreev tunneling of Cooper pairs and single-particle tunneling is examined. The latter is responsible for relatively large thermopower and figure of merit due to a diverging density of single-particle states at the superconducting gap edges. System with ferromagnetic and superconducting leads can also reveal spin thermoelectric phenomena. Finite superconducting gap is considered within the BCS theory, and the thermoelectric coefficients are calculated by means of nonequilibrium Green's function technique within Hartree-Fock like approximation with respect to the intradot Coulomb interaction.

O-4-15

Josephson current of split nonlocal Cooper pairs

D. Tomaszewski,[1] P. Busz,[1] J. Barnaś,[1,2] 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 Poznań, Poland*

Quantum entanglement is a basic property necessary for applications in both quantum computation and communication. One attractive proposal for a solid-state entangled electron source utilizes a superconductor as a natural reservoir for spin entangled Cooper pairs of electrons, which could be extracted and separated on-demand. Recently, Andreev entanglers based on two quantum dots connected in parallel to two superconducting electrodes, has been used to adiabatically split and separate electrons of Cooper pairs, as confirmed by measurements of the Josephson current [1]. We demonstrate theoretically that the evidence for this non-local transport can be confirmed through study of the Josephson supercurrent while tuning independently the dots with local electrical gates. Depending on the occupation parity the Josephson current of nonlocal Cooper pairs can experience a negative amplitude - so called π-junction. We also show that the Josephson current of nonlocal Cooper pairs can be controlled by the spin-active Rashba interaction without any time reversal symmetry breaking.

References:

[1] R. S. Deacon, A. Oiwa, J. Sailer, S. Baba, Y. Kanai, K. Shibata, K. Hirakawa, and S. Tarucha, Nature Communications **(**6), 7446 (2015)

O-5-01

Strong out-of-plane magnetic anisotropy in ion irradiated anatase TiO_2 thin films

M. Stiller,[1] J. Barzola-Quiquia,[1] P. Esquinazi,[1] D. Spemann,[2] J. Meijer,[2] M. Lorenz,[3] and M. Grundmann[3]

[1] *Division of Superconductivity and Magnetism, Institute for Experimental Physics II, University of Leipzig, 04103 Leipzig, Germany*

[2] *Division of Nuclear Solid State Physics, Institute for Experimental Physics II, University of Leipzig, 04103 Leipzig, Germany*

[3] *Semiconductor Physics Group, Institute for Experimental Physics II, University of Leipzig, 04103 Leipzig, Germany*

The temperature and field dependence of the magnetization of undoped anatase TiO_2 thin films on $SrTiO_3$ substrates was investigated. Low-energy ion irradiation was used to modify the surface of the films within a few nanometers. The as-prepared thin film shows ferromagnetism which increases after irradiation. A magnetic anisotropy opposite to the expected form anisotropy, was observed after the first irradiation. Titanium vacancies as di-Frenkel pairs appear to be responsible for the ferromagnetism and the strong anisotropy. Magnetic impurities are ruled out as a source of the ferromagnetism by means of particle-induced X-ray emission measurements.

O-5-02

Spin waves on the skyrmion background in thin cylindrical dots

K. Guslienko,[1,2] and Z. Gareeva[3]

[1] *Depto. Fisica de Materiales, Universidad del Pais Vasco, UPV/EHU, 20018 San Sebastian, Spain*

[2] *IKERBASQUE, the Basque Foundation for Science, 48013 Bilbao, Spain*

[3] *Institute of Molecule and Crystal Physics, Russian Academy of Sciences, 450075 Ufa, Russia*

We calculate high-frequency (10 GHz range) spin wave excitations of the skyrmion ground state thin cylindrical magnetic dots. The skyrmion ground state is represented as combination of two radially symmetric bubble domains. To consider the skyrmion dynamics we apply an approximation of ultrathin domain wall between the circular domains and assume that the magnetic dot is thin enough (magnetization does not depend on the thickness coordinate). The eigenfunctions/eigenfrequencies of spin wave excitations over the skyrmion background are calculated as a function of the skyrmion radius and classified according to number of nodes of the dynamical magnetization in the radial (n) and azimuthal (m) directions (1). Recent experiments on magnetic skyrmion dynamics in patterned nanostructures are discussed.

References:

[1] Z.V. Gareeva, K.Y. Guslienko, phys. stat. sol. – Rapid Res. Lett. 10, 227 (2016).

O-5-03

Prevalence and recovery of information stored in bundles of parallel magnetic nanowires

D. Ceballos,[1] E. Cisternas,[1] and E.E. Vogel[1]

[1] *Dept. of Physics, Universidad de La Frontera, Temuco, Chile*

Magnetic nanowires grown within the pori produced in alumina membranes provide a set of parallel nanomagnets subject to orientation by a strong enough magnetic tip [1]. In this way sectors of the membrane can be forced to present a desired magnetic orientation representing symbols or any kind of information. However, parallel magnetized wires forming the symbol raise the energy of the system which could trigger magnetization reversals and partial loss of information. In this paper we tackle two related problems. On one hand, we calculate the interaction energy [2] within different symbols for the case of segmented nanowires trying to stabilize the system in the presence of external magnetic fields. On the other hand, we develop algorithms to recover the original information after it has been partially lost. Recommendations for a safer design of the system are formulated.

References:

[1] M. Jaafar, J. Gómez-Herrero, A. Gil et al., Ultramicroscopy **109**, 693 (2009)

[2] E. Cisternas, J. Faúndez, and E. E. Vogel, J. Magn. Magn. Mater. **426**, 588 (2017)

We acknowledge partial support from Universidad de La Frontera DI17-0027, Fondecyt (Chile) 1150019 and Cedenna FB0807

O-5-04

Lateral shift of light beam transmitted trough photonic-magnonic crystals

Y.S. Dadoenkova,[1,2,3] N.N. Dadoenkova,[2,3] J.W. Kłos,[4] M. Krawczyk,[4] and I.L. Lyubchanskii[3]

[1] *Ulyanovsk State University, Ulyanovsk, Russian Federation*

[2] *Novgorod State University, Veliky Novgorod, Russian Federation*

[3] *Donetsk Physical and Technical Institute of the NAS of Ukraine, Donetsk, Ukraine*

[4] *Adam Mickiewicz University in Poznań, Poznań, Poland*

The Goos-Hänchen effect (lateral shift of a reflected or tramsmitted light beam with respect to the geometric optics prediction) is a topic of intensive studies in different systems, including magnetic photonic crystals, and has application in the design of integrated optics devices, such as optical switchers and chemical sensors. We present a theoretical investigation of the lateral shift of the Gaussian light beam transmitted through one-dimensional bi-periodic photonic-magnonic crystals consisting of equidistant magnetic layers separated by finite size dielectric photonic crystals. We show that increase of the number of magnetic super-cells in the structure leads to the increase of lateral shift in the vicinity of the modes inside the photonic band gap.

The work is supported by Ministry of Education and Science of Russian Federation (Projects 3.7614.2017/П220 and 14.Z50.31.0015); European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie (Grant 644348).

O-5-05

Exchange bias in dipole coupled trilayers: experimental results and theoretical interpretation

Miguel Kiwi,[1] Rafael Morales,[2,3] Ivan.K. Schuller,[4] and Felipe Torres[1]

[1] *Depto. de Física, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile 7800024*

[2] *Department of Chemical-Physics and BCMaterials, University of the Basque Country, 48940 Leioa, Spain*

[3] *IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain*

[4] *Department of Physics and Center for Advanced Nanoscience, University of California San Diego, La Jolla, California 92093, USA.*

Trilayer (AFM-PM-FM) exchange bias (EB) is studied, focusing on the switching from negative to positive EB. The same cooling field yields negative EB for thin spacers, and positive EB for thicker ones. The coupling betwen the FM and the AFM is attributed to long-ranged dipole coupling. The dipole field is generated in the AFM by symmetry breaking due to quantum fluctuations. The magnetic domains imprinted on the AFM, that are responsible for EB, are created during field cooling. Our model accounts quantitatively for the experimental results, but ignores the short range interfacial exchange interactions of the usual EB theories, retaining solely the long range dipole field. Novel switching capabilities emerge.

O-5-06

Abundance of magnetic coupling modes in the Co/Mo multilayers

A. Wawro,[1] Z. Kurant,[2] M. Tekielak,[2] P. Dłużewski,[1] K. Morawiec,[1] E. Milińska,[1] A. Pietruczik,[1] M. Matczak,[3] F. Stobiecki,[3] and A. Maziewski[2]

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

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

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

Co/Mo layered structures display numerous interlayer coupling modes depending on the Co layer and Mo spacer thickness (d_{Co} and d_{Mo}), repetition number, thickness and type of a buffer layer. In the low d_{Co} limit (< 1.5 nm) oscillations with d_{Mo} between parallel (P) and antiparallel (AP) couplings of perpendicular magnetization in the Au/Co/Mo(d_{Mo})/Co/Au structures are observed. Thicker Co layers (3 nm) in the Mo/Co/Mo(d_{Mo})/Co/Mo systems, magnetized in the plane, exhibit P-AP-P or P-AP-BQ (biquadratic) coupling sequences with d_{Mo}, depending on the buffer thickness and repetition number. Moreover, the Mo buffer induces an additional in-plane two-fold anisotropy, contrary to Au. Observed couplings are reflected in magnetoresistance measurements. Abundance of coupling modes designates the Co/Mo system for possible applications in spintronics.

Support from the National Science Centre in Poland under the project 2014/13/B/ST5/01834 is acknowledged.

O-5-07

Chemical substitutions tuned exchange bias effect in $Sm_{0.1}Ca_{0.9-x}Sr_xMnO_3$ ($x = 0.2$, 0.3) manganites

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

[1] *Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, PL-02668 Warsaw, Poland*

[2] *Department of Physics, Ben-Gurion University of the Negev, P.O. Box 653, 84105 Beer Sheva, Israel*

Magnetic properties of antiferromagnetic (AFM) manganite $Sm_{0.1}Ca_{0.9-x}Sr_xMnO_3$ ($x = 0.2$, 0.3) have been investigated, focusing mainly on the exchange bias (EB) effect. The studied compounds exhibit the ground state with heterogeneous spin configuration, consisting of the C-type and G-type AFM phases, and a FM-like phase with very weak spontaneous magnetic moment. For both compositions, EB effect is observed. Contributions from different interfaces between coexisting magnetic phases to the EB effect are discussed. For $x = 0.3$ compound, the phase separation leads to unusual magnetic properties: narrowing of $M(H)$ loops in field cooling process, unconventional EB effect associated with spontaneous magnetization at temperatures below T_{N-G}, strong magnetic field dependence of the negative EB at cooling fields below 100 Oe turning into practically field independent one for cooling fields above 0.5 kOe, significant shift of EB with temperature with a change of the sign from negative at 10 K to positive above 40 K. The atypical magnetic properties are discussed.

O-5-08

Evolution of magnetic properties of manganites with pressure and doping at Mn-site

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

[1] *Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, PL-02668 Warsaw, Poland*

[2] *Department of Physics, Ben-Gurion University of the Negev, P.O. Box 653, 84105 Beer Sheva, Israel*

Systematic study of magnetic properties of low tungsten doped $CaMn_{1-x}W_xO_3$ ($x \leq 0.1$) demonstrates the evolution of weak ferromagnetic-antiferromagnetic ground state with increasing W doping level from the G-type AFM state with a weak FM component for ($x = 0$ and 0.04 cases) to the C-type AFM associated with orbital ordering ($x = 0.1$) with no spontaneous magnetic moment. The evidence of exchange bias (EB) effect in $CaMn_{0.93}W_{0.07}O_3$ appears as shifts along both field and magnetization axes of magnetic hysteresis loops. Systematic studies of magnetic properties of low niobium doped $CaMn_{1-x}Nb_xO_3$ ($x \leq 0.1$) reveal the evolution of the ground state with increasing Nb doping level from the G-type AFM state with a weak FM component for $x = 0.02$–0.08 to mostly C-type AFM associated with charge ordering and tiny spontaneous FM moment ($x = 0.1$). Application of the hydrostatic pressure results in a significant increase of magnetization, related to the growth of FM clusters under pressure and significantly suppresses the EB effect observed for $CaMn_{0.9}Nb_{0.1}O_3$.

O-5-09

Spin-resolved Andreev spectroscopy as a tool for probing the Majorana quasiparticles

T. Domański,[1] and M.M. Maśka[2]

[1] *Institute of Physics, M. Curie-Skłodowska University, 20-031 Lublin, Poland*
[2] *Institute of Physics, University of Silesia, 40-007 Katowice, Poland*

We discuss a feasible protocol for distinguishing between the exotic Majorana and the fermionic Shiba quasiparticles of the Rashba chain deposited on the superconducting substrate. Our proposal relies on the selective equal spin Andreev reflections (SESAR) operating exclusively for the topologically nontrivial superconducting state, manifested by the zero-energy Majorana modes at its edges. We argue that this spectroscopy can unambiguously probe the spatial extent of the Majorana quasiparticles [1], their leakage to the normal quantum impurities [2], unusual interplay with the correlations (responsible for the Kondorana effect) [3], and other unique properties.

References:

[1] M.M. Maśka, A. Gorczyca-Goraj, J. Tworzydło, T. Domański, Phys. Rev. B **95**, 045429 (2017).
[2] J. Barański, A. Kobiałka, T. Domański, J. Phys.: Condens. Matter **29**, 075603 (2017).
[3] I.J. van Beek, B. Braunecker, Phys. Rev. B **94**, 115416 (2016).

This work is supported by the National Science Centre (Poland) under the contracts DEC-2014/13/B/ST3/04451 (TD) and DEC-2013/11/B/ST3/00824 (MMM)

O-5-10

Electric-field modulation of exchange stiffness constant in CoFeB/MgO investigated by spin-wave resonance

T. Dohi,[1] S. Kanai,[1,2,3] F. Matsukura,[1,2,3,4] and H. Ohno[1,2,3,4,5]

[1] *Laboratory for Nanoelectronics and Spintronics, RIEC, Tohoku Univ., Japan*
[2] *CSIS, Tohoku Univ., Japan*
[3] *CSRN, Tohoku Univ., Japan*
[4] *WPI-AIMR, Tohoku Univ., Japan*
[5] *CIES, Tohoku Univ., Japan*

In our previous work, we showed a possible electric-field modulation of the exchange stiffness constant in CoFeB/MgO from the observation of domain structures [1]. In this work, we investigate the electric-field effect on A_S through spin-wave resonance in nanoscale CoFeB/MgO magnetic tunnel junctions. The observed homodyne-detected spectra show multi-peak resonance, indicating the presence of spin-wave modes in addition to uniform mode. The resonance fields are shifted by the application of electric fields mainly due to the modulation of magnetic anisotropy. We find that A_S is also modulated by a few percent by applying 0.4 V/nm from the electric-field dependence of the difference in resonance fields between spin-wave and uniform modes.

References:

[1] T. Dohi *et al.*, AIP Adv. **6**, 075017 (2016).

This work was supported in part by R&D Project for ICT Key Technology of MEXT and Grants-in-Aid for Scientific Research from JSPS (No. 16H06081) as well as MEXT (No. 26103002). T. Dohi acknowledges support from GP-Spin at Tohoku University.

O-5-11

The edge magnetism in graphene oxide

R. Strzelczyk,[1] M. Maćkowiak,[1] A. Marczyńska,[1] L. Smardz,[1]
M.A. Augustyniak-Jabłokow,[1] and O. Kazakova[2]
[1] *Institute of Molecular Physics of Polish Academy of Sciences, Poznań, Poland*
[2] *National Physical Laboratory, Teddington, Greater London, England*

The aim of presented study was to detect and investigate the nature of the magnetic ordering of graphene oxide. For this purpose we have coupled highly accurate SQUID magnetometry with electron paramagnetic resonance (EPR), which allows observations of ferromagnetic resonance (FMR) signal. We have studied graphene oxide "paper" –the bulk sample prepared by drying the graphene oxide suspension in air and the isolated graphene oxide flakes deposited on nanometric SiO2 powder and dried in vacuum. Analysis of the temperature dependence of the FMR/EPR spectra allows identification of paramagnetic and ferromagnetic contributions. The ferromagnetic signal can be removed by deep penetration of atmospheric oxygen into GO paper. It can be restored by sonification of GO water suspension resulting in breaking of GO flakes. Additionally, the magnetic susceptibility of GO flakes diluted in diamagnetic matrix and kept in vacuum is significantly higher than that of the GO paper. These results suggest that ferromagnetic response of GO is associated with unsaturated, ferromagnetically ordered dangling bonds on zig-zag edges.

O-5-12

Micro-Hall-Magnetometry: Stray Field Studies of Directly Written Nanostructures

M. Pohlit,[1] M. Akbari,[1] F. Porrati,[1] L. Keller,[1] M. Huth,[1] and J. Müller[1]
[1] *Goethe-University Frankfurt am Main (Institute of Physics), Germany*

Micro-Hall-magnetometry is a sensor-based magnetic measurement technique that has proven to be a highly versatile tool to study individual and interacting magnetic micro- and nanostructures. Recently, the technique was combined with focussed electron beam induced deposition (FEBID), which is a promising direct-writing sample preparation technique with nanometer resolution. Functional magnetic nanostructures fabricated by FEBID can be deposited directly onto the surface of a (sub-)μm-sized Hall-sensor array enabling studies of the nanostructures' magnetic stray field. The application of these synergizing techniques will be illustrated by a recent investigation of thermally induced switching processes in a single building block of the artificial square spin ice lattice and their constituent macrospin-nanoislands. Results from temperature and magnetic field-dependent stray field measurements, including minor loops, will be discussed and compared to micromagnetic simulations. An outlook on the future prospects of the methods regarding possible studies of three dimensional magnetic nanostructures will be given.

O-5-13

Magnetic behavior of metastable Fe films grown on Ir(111)

A. Calloni,[1] M. Cozzi,[1] G. Berti,[1] G. Bussetti,[1] M. Finazzi,[1] F. Ciccacci,[1] and L. Duò[1]

[1] *Politecnico di Milano, Milano, p.za Leonardo da Vinci 32 I-20133, Italy*

Fe on fcc Ir is a well known model system for the study of the magnetic behavior of ultra-thin films. At low Fe coverages and applying external stimuli such as electric and magnetic fields, a variety of magnetic configurations, from ferromagnetic to non-collinear, as in the skyrmion lattice, can be stabilized and exploited for applications (such as, for instance, magnetic data storage) [1]. We provide a layer by layer characterization of filled and empty electronic states by means of spin-polarized photoemission and inverse photoemission spectroscopy on ultrathin Fe films magnetized $in-situ$ and analyzed at magnetic remanance. We find a critical thickness of about five monolayers (ML) for the detection of a not nil in-plane polarization signal in the photoemission spectra from Fe. In spite of the apparent complexity of the film evolution, many similarities are found with the growth of Fe on 2 ML Ni/W(110) a prototypical system we have recently investigated by combining photoemission spectroscopy and $ab-initio$ simulations [2].

References:

[1] Hsu et al., Nature Nanotechnology 12 (2017) 123
[2] Calloni et al., Phys Rev. B 94 (2016) 195155

O-5-14

Magnetic phases in bilayer graphene nanoflake controlled with external electric fields

K. Szałowski[1]

[1] *Department of Solid State Physics, Faculty of Physics and Applied Informatics, University of Łódź, ul. Pomorska 149/153, PL90-236 Łódź, Poland*

The paper presents a computational study of the ground-state magnetic phases in a bilayer rectangular graphene nanoflake [1]. The presence of external electric field with in-plane and perpendicular component is assumed, together with the possible Zeeman splitting of energy levels. The calculations are based on Hubbard model in Mean Field Approximation. The magnetic phase diagram reveals the presence of phases with total spin of 0 and 1. Moreover, significant stability ranges of antiferromagnetic states with layer spin imbalance are predicted within the phase with the total spin equal to 0. All the phases can be controlled with both electric field components. In particular, the antiferromagnetic order parameter can be varied continuously by the field.

References:

[1] K. Szałowski, Carbon **118**, 78–85 (2017).

The computational support on Hugo cluster (P. J. Šafárik University in Košice) is gratefully acknowledged. 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.

O-5-15

Tailoring of magnetic properties of ultrathin Co films by electromagnetic radiation pulses in a wide spectral range

A. Maziewski,[1] J. Kisielewski,[1] I. Sveklo,[1] R. Sobierajski,[2] A. Wawro,[2] L. Juha,[3] and A. Bartnik[4]

[1] *Faculty of Physics, University of Bialystok, Bialystok, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[3] *Institute of Physics, Czech Academy of Sciences, Prague, Czech Republic*
[4] *Institute of Optoelectronics, Military University of Technology, Warsaw, Poland*

Molecular beam epitaxy deposited ultrathin Pt/Co/Pt layers were irradiated by electromagnetic radiation pulses in a wide: spectral range (from $1nm$ until $1\mu m$); pulse width range (between tens fs and tens ns) and the pulse fluence density up to films ablation threshold. The pulses driven irreversible changes of magnetic and structural properties were studied. Using available sources, a possibility of irreversible transition between in-plane magnetization state into perpendicular state was observed. This effect was compared with similar phenomena of ion bombardment driven transition in Co layers reported in the paper [1]. Electromagnetic radiation pulses could be used for magnetic structures patterning with a sub-micrometer period.

References:

[1] A. Maziewski *et al.*, Phys. Status Solidi A, **211**, 1005 (2014) and references therein.

Sponsored by Polish Harmonia project, NCN DEC-2012/06/M/ST3/00475

O-5-16

The interfacial Dzyaloshinskii-Moriya interaction in exchange-biased Au/Co/NiO layer system

P. Kuświk,[1] M. Matczak,[1] B. Szymański,[1] M. Kowacz,[2] F. Lisiecki,[1] A. Ehresmann,[3] and F. Stobiecki[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Faculty of Technical Physics, Poznan University of Technology, Poznań, Poland*
[3] *Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Kassel, Germany*

The interfacial Dzyaloshinskii-Moriya interaction (DMI) is a well-known phenomenon in thin layered films, especially in ferromagnetic(FM)/heavy metal or FM/nonmagnetic oxide systems. Here, we unambiguously show that this interaction can be also found in FM/antiferromagnetic oxide layer systems (i.e. Au/Co/NiO). Using polar magneto-optical Kerr effect (PMOKE) measurements we show that in the exchange-biased Au/Co/NiO layer system the Néel domain wall (N-DW) with clockwise chirality is stabilized by a strong negative DMI. In such system, the DMI and as a consequence chirality in N-DWs are independent of the direction of perpendicular interlayer exchange bias coupling.

This work was supported by the National Science Center Poland under the SONATA-BIS (UMO-2015/18/E/ST3/00557)

O-5-17

Interlayer exchange coupling and proximity effect in V-Fe multilayers

A. Marczyńska,[1] K. Synoradzki,[1] M. Pugaczowa-Michalska,[1] T. Toliński,[1] and L. Smardz[1]

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

Two series of V-Fe multilayers (MLs) with either constant Fe (0.6 nm) and variable V sublayer thickness or constant V (1.45 nm) and variable Fe sublayer thickness were prepared by UHV magnetron sputtering. Results on magnetic hysteresis measurements up to 9 T showed that the interlayer exchange coupling (IEC) energy strongly depends on both vanadium and iron layer thicknesses. Furthermore, the strength of the antiferromagnetic (AFM) coupling of the Fe sublayers oscillates with short and long periods as a function of V spacer thickness. The positions of the AFM peaks were also revealed by magnetoresistance measurements. The strongest AFM coupling energy of about 0.84 mJ/m2 at 300 K was observed for V layer thickness equal to 1.45 nm. On the other hand, V/Fe ML with V spacer thickness of about 1.6 nm showed the maximal negative magnetic moment on interface V atoms. The short period of the AFM peak oscillation in the strongly coupled region (below V spacer thickness of about 2 nm) could be explained by a competition between the indirect RKKY coupling of the Fe layers and the direct coupling of the induced negative magnetic moment on V atoms near V-Fe and Fe-V interfaces.

O-5-18

Tailoring of uniaxial magnetic anisotropy in Permalloy thin films using self-organized nano rippled templates

S. Koyiloth Vayalil,[1] S.V. Roth,[2] K. Aswathi,[3] and P.S. Anil Kumar[1]

[1]*Department of Physics, Indian Institute of Science, Bangalore, 560012, Karnataka*

[2]*Photon Science, Deutsches Elektronen-Synchrotron (DESY), D-22607 Hamburg, Germany*

[3]*Department of Physics, Amrita School of Arts and Science, Amritapuri Campus, Kollam, Kerala,690525, India*

In this work we have employed nanopatterned substrates as a template to tailor uniaxial magnetic ansiotropy in Permalloy thinfilms deposited on it. Periodic Si ripple substrates having different value of wavelength have been prepared using oblique angle low energy ion beam erosion. Strong uniaxial magnetic anisotropy (UMA) with magnetization in a direction normal to the ripple wave vector has been observed. UMA is found to be gradually decreasing with increasing thickness of Permalloy thin films. Also thin films deposited on low value of (24 nm)ripple wavelength Si substrates are found to be exhibiting strong uniaxial magnetic anisotropy. In order to correlate the structure and morphology of the substrates with observed magnetic anisotropy variation we did a detailed growth study of the films using in-situ grazing incidence small angle x ray scattering. We have found that both periodicity as well as depth of the ripples is crucial in determining the strength of UMA.

O-5-19

Intercalation of graphene on Ru(0001): possible mechanisms

M. Lewandowski,[1] E. Madej,[2] Z. Miłosz,[1] D. Wilgocka-Ślęzak,[2] M. Hermanowicz,[3] N. Spiridis,[2] J. Korecki,[2] S. Jurga,[1] and F. Stobiecki[1]

[1] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

[2] *Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Niezapominajek 8, 30-239 Kraków, Poland*

[3] *Institute of Physics, Poznań University of Technology, Piotrowo 3, 60-965 Poznań, Poland*

We used scanning tunneling microscopy (STM), low energy electron microscopy (LEEM) and low energy electron diffraction (LEED) to study the mechanisms of intercalation of epitaxial graphene (EG) grown on Ru(0001) by thermal decomposition of ethylene (C_2H_4) [1]. The results revealed direct influence of graphene's preparation method on its structure and the intercalation mechanisms. The experimental results were supported by theoretical ab initio calculations.

References:

[1] S. Marchni, S. Günther, and J. Wintterlin, Phys. Rev. B 76 (2007) 075429.

The work was financially supported by the National Science Centre of Poland (OPUS project No. 2014/15/B/ST3/02927).

O-6-01

Ferromagnetic resonance and the linewidth in spherical samples – revision of the standard measurement techniques

J. Krupka,[1] P. Aleshkevych,[2] B. Salski,[1] P. Kopyt,[1] and A. Pacewicz[1]
[1] *Warsaw University of Technology, Warsaw, 00662, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, Warsaw, 02668, Poland*

Our recent findings revealed that, despite common understanding, the fundamental resonance, often called the mode of uniform precession, observed in experiments with magnetized YIG spheres performed at microwave frequencies is not located at static magnetic field corresponding to the ferromagnetic resonance. In fact, the fundamental resonance occures at the frequency where the real part of the effective permeability for the clockwise circularly polarized RF magnetic field is negative and close to -2. This is characteristic feature of the magnetic plasmon resonance. However, that novel finding has prompted a lot of fundamental questions, such as those related to the meaning of the ferromagnetic linewidth which we now realize is not measured at the ferromagnetic resonance but at the magnetic plasmon resonance. We have performed rigorous theoretical and experimental study of the relationship between the quality factor of the magnetic plasmon resonance and the ferromagnetic linewidth, indicating essential aspects of the nature of electromagnetic losses in the resonance structures containing magnetized ferromagnetic spheres.

O-6-02

Magnetocrystalline anisotropy and magnetoelastic properties of the $Co_2Fe_{0.4}Mn_{0.6}Si$ and $Co_2FeGa_{0.5}Ge_{0.5}$ Heusler alloys films

O.M. Chumak,[1] A. Nabiałek,[1] R. Żuberek,[1] I. Radelytskyi,[1] P. Aleshkevych,[1]
T. Yamamoto,[2] T. Seki,[2,3] K. Takanashi,[2,3] L.T. Baczewski,[1] and H. Szymczak[1]
[1] *Institute of Physics, Polish Academy of Sciences*
[2] *Institute for Materials Research, Tohoku University*
[3] *Center for Spintronics Research Network, Tohoku University*

Two series of half-metallic $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) and $Co_2FeGa_{0.5}Ge_{0.5}$ (CFGG) Heusler alloys thin films with the thickness between 15 and 50 nm, have been investigated. Perpendicular magnetocrystalline anisotropy and magnetoelastic properties have been examined by means of the strain modulated ferromagnetic resonance (SMFMR), the ferromagnetic resonance technique and by SQUID magnetometer. For both types of the Heusler alloys, magnetic layer thickness dependences of the anisotropy constant as well as magnetoelastic constant have been obtained. These alterations have been caused by surface anisotropy in conjunction with the changes of chemical ordering. Also the volume and surface contributions to the magnetic anisotropy and magnetoelastic constant have been found.

O-6-03

Magnetocrystalline effects in narrow ferromagnetic patterns

Gabriel D. Chaves-O'Flynn,[1,2] and Cyrill Muratov[1]
[1] *New York University*
[2] *New Jersey Institute of Technology*

We introduce a reduced micromagnetic framework for the study of narrow ferromagnetic patterns on thin films with cubic magneto-crystalline anisotropy. The relevant patterns are curves of arbitrary shape that could be described as "curves with a width", such as annuli and magnetic tracks. In these geometries, the magnetization is constant in the directions perpendicular to the curve and changes smoothly in the longitudinal direction. The curve makes an angle α with the easy axis and the magnetization is described by its tilt from the easy axis, θ. We define a parameter Δ that measures the ratio of crystalline to shape anisotropy energies and study the existence of stable configurations (energy minimizers) as Δ varies. For $\Delta<0.5$ the magnetization is closely aligned along the longitudinal direction and only π domain walls produce discontinuities in θ. These π walls are charged and interact magnetostatically. For $0.5<\Delta$ there are charge-free domain walls whenever α makes a $\pi/4$ angle with the easy axis. We apply this framework on nanorings and find the global energy minimizers in the presence on non-negligible anisotropy.

O-6-04

Ab initio studies of selected Fe/Co alloys for permanent magnet applications

M. Werwiński,[1] A. Edström,[2] O. Eriksson,[2] and J. Rusz[2]
[1] *Institute of Molecular Physics Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznań, Poland*
[2] *Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden*

The $(Fe_{1-x}Co_x)_2B$ [1], $(Fe_{1-x}Co_x)_5SiB_2$ [2], and $(Fe_{1-x}Co_x)_5PB_2$ alloys have been investigated theoretically as candidates for rare-earth free permanent magnets. Magnetocrystalline anisotropy energies MAE, identified as the leading magnetocrystalline anisotropy constants K_u, have been calculated with the virtual crystal and coherent potential approximations (VCA and CPA) for a full range of Fe/Co compositions. The variations of MAE versus magnetization have been addressed with a full relativistic fixed spin moment method. The optimal compositions with the highest MAE's were determined. The *ab initio* results have been confronted with experiment.

References:

[1] A. Edström et al. Phys. Rev. B 92, 174413 (2015)
[2] M. Werwiński et al., Phys. Rev. B 93, 174412 (2016)

M. Werwiński acknowledges the financial support from the Foundation of Polish Science grant HOMING. The HOMING programme is co-financed by the European Union under the European Regional Development Fund.

O-6-05

Magnetic properties and electronic structure of structurally disordered YCo_2 Pauli paramagnet

Z. Śniadecki,[1] N. Pierunek,[1] M. Werwiński,[1] Yu. Ivanisenko,[2] and B. Idzikowski[1]

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

[2] *Institute of Nanotechnology, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany*

The development of magnetic properties with increasing disorder in the exchange-enhanced Pauli paramagnet YCo_2 is discussed. The structural disorder is initially introduced by rapid quenching and further changes are caused by a high pressure torsion. Values of the magnetic moment determined for the plastically deformed ribbons reach 0.10 μ_B/Co (deformation at $p = 4$ GPa) and 0.25 μ_B/Co (6 GPa) at 2 K and arise not only from the surface of nanocrystals but also from their volume. *Ab initio* calculations confirm and explain the influence of different types of structural defects and chemical disorder on the electronic structure and magnetism of YCo_2-based Laves phases. The calculated magnetic ground states are in qualitative agreement with experimental results for all considered structures with point defects.

The authors acknowledge the financial support of DAAD/MNiSW Project Based Personal Exchange Program (PPP) in years 2016–2017. M.W. acknowledges the financial support from the Foundation of Polish Science grant HOMING.

O-7-01

Attempt to separate various diamagnetic and paramagnetic materials using a neodymium handy magnet

C. Uyeda,[1] K. Hisayoshi,[1] and K. Terada[1]

[1] *Graduate School of Sicence, Osaka University, Toyonaka Osaka Japan*

A strong magnetic field above several Tesla is generally required to induce a dynamic motion in a diamagnetic or paramagnetic substance. We recently showed that a grain mixture that consist of heterogeneous materials can be separated into groups of different materials by releasing the mixture in an area where field distribution monotonically decreases[1]; the field was produced by a compact NdFeB magnet (see [2] for movie). The translation of the grains were realized in the diffused area (<100Pa) by introducing microgravity condition. The separation of grains was realized because magnetic force induced in the particle was proportional to mass m of particle, and its acceleration was independent to m [1]. By improving the present apparatus, most solid materials can be separated and identified by their susceptibility obtained from terminal velocity[2]. It is important to develop an simple and effective method to extract minor particles from heterogeneous grain samples, and the proposed principle may lead to new finding in material science.

References:

[1] K. Hisayoshi, C.Uyeda, K. Terada (2016) Sci. Rep. 6, 38431

[2] https://www.youtube.com/watch?v=SBUmSsNKM5c

O-8-01

Micromagnetic simulations of a spin-torque oscillator reader

J. Chęciński,[1,2] M. Frankowski,[1] and T. Stobiecki[1]
[1] *AGH University, Department of Electronics, Al. Mickiewicza 30, 30-059 Kraków, Poland*
[2] *AGH University, Faculty of Physics and Applied Computer Science*

Spin-torque oscillators (STOs) have been proposed as candidates for magnetic field sensors for hard disk drive (HDD) purposes because of their potential high spatial resolution, energy efficiency and frequency resolution [1]. However, their practical implementation has been hindered by a potential vulnerability to noise. We investigate a novel two-bit STO reader configuration, which could allow for simultaneous detection of two independent magnetic fields originating from adjacent HDD bit tracks, resulting in faster readout as well as bigger size of the device and thus inreased resilience to noise. We conduct micromagnetic simulations of an example system and find that the magnetization response to a non-uniform field remains unimodal with respect to frequency. We investigate the STO frequency dependence on the values of both external fields and perform a successful two-tracks readout simulation.

References:

[1] Chęcinski, J., et al., Magnetics, IEEE Transactions on, DOI: 10.1109/TMAG.2016.2611652 (2016).

We thank the National Science Center, Poland grant Preludium no. 2015/17/N/ST7/03749 and KNOW Scholarship. Numerical calculations were supported by PL-GRID infrastructure. TS acknowledges the statutory Grant 11.11.230.017.

O-8-02

Magnetic Resonance Contrast Imaging of Magnetoferritin

O. Strbak,[1] L. Balejcikova,[2] L. Baciak,[3] J. Kovac,[2] M. Masarova-Kozelova,[4] A. Krafcik,[4] D. Dobrota,[5] and P. Kopcansky[2]
[1] *Biomedical Center Martin, Martin, Slovakia*
[2] *Insitute of Experimental Physics SAS, Kosice, Slovakia*
[3] *Faculty of Chemical and Food Technology STU, Bratislava, Slovakia*
[4] *Institute of Measurement Science SAS, Bratislava, Slovakia*
[5] *Jessenius Faculty of Medicine CU, Martin, Slovakia*

It is believed that a precursor of pathological iron accumulation in human body is ferritin, which is normally poorly detected by MRI. However, pathological ferritin is associated with structural changes that should increase the hypointensive artefacts in MRI. On the basis of recent findings in respect to the pathological ferritin structure, we prepared the magnetoferritin particles as a possible pathological ferritin model system. The particles were characterised with DLS, as well as with SQUID measurements. With the help of low-field (0.2 T) and high-field (4.7 T) MRI systems we found that it is possible to clearly distinguish between native ferritin as a physiological model system, and magnetoferritin as a pathological model system. The T2-weighted STIR protocol at 0.2 T showed the optimum contrast differentiation. Such findings are highly promising for exploiting the use of iron accumulation as a noninvasive diagnostics tool of pathological processes.

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

Evolution of Structure and Magnetic Behavior by Pr doping in $SrRuO_3$

R. Gupta,[1] and A.K. Pramanik[1]

[1] *School of Physical Sciences, Jawaharlal Nehru University, New Delhi- 110067, India*

We report the evolution of structure and magnetic properties in perovskite ruthenates $Sr_{1-x}Pr_xRuO_3$ ($x = 0.0$ and 0.1). Our main expectations, to induce the structural modification and change the Ru charge state by Pr doping at Sr site. By the Pr doping on Sr site retains orthorhombic structure while we find minor change in structural parameters. The $SrRuO_3$ have itinerant type of ferromagnetism with ordering temperature $\sim$ 160 K. By Pr doping, the magnetic moment decrease and ZFC shows three distinct peaks (three transition temperature; T_{M1}, T_{M2} and T_{M3}). Further analysis of magnetization of both samples, at high temperature follow modified CWL and Pr doping gives Curie temperature $\sim$ 129 K which is close to T_{M2}. Above T_{M2} to T_{M3}, the inverse susceptibility shows upward deviation from CW behavior, indicating the existence AFM like clustered in this regime. The low temperature isothermal magnetization M (H) shows moment is decreases by Pr doping. The Arrott plot gives spontaneous magnetization (M_s) which is also decreases by Pr doping. The evolution of Rhodes-Wohlfarth ratio increases which suggests the FM in this system evolves toward the itinerant type by Pr doping.

P-1-02

On the neglect of on-site Coulomb interactions on oxygen-ions in transition metal oxides described by multiband d-p model

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

[1] *Marian Smoluchowski Institute of Physics, Jagiellonian University ul. prof. S. Lojasiewicza 11, 30-348 Kraków, Poland*

The electronic structure of transition metal oxides is frequently investigated using the multiband $d-p$ models, as in cuprates [1], ruthenates [2], and iridates [3]. On the example of TiO_4 layer we study the electronic structure within the multiband $d-p$ model. In agreement with experiment (for Sr_2TiO_4) we find that the studied system is predicted to be a robust nonmagnetic insulator. As expected, $d-p$ hybridization strongly redistributes electrons and leads to Ti ions between d^1 and d^2 ionic configurations. A realistic treatment of electronic structure requires one to introduce non-zero Coulomb local interactions at $2p$ oxygen orbitals [1-3]. We show that a simplified treatment which neglects Coulomb interactions on oxygen ions does not lead to serious problems in predictions of the electronic structure provided the Coulomb interactions at titanium ions and charge-transfer gap are suitably renormalized (so they become entirely different from those used in the microscopic $d-p$ model).

References:

[1] A. M. Oleś, J. Zaanen, and P. Fulde, Physica B **148**, 260 (1987).
[2] K. Rościszewski and A. M. Oleś, Phys. Rev. B **91**, 155137 (2015).
[3] K. Rościszewski and A. M. Oleś, Phys. Rev. B **93**, 085106 (2016).

P-1-03

Stability of unconventional superfluid phases in the honeycomb lattice with population imbalance

Agnieszka Cichy,[1] and Andrzej Ptok[2,3]

[1] *Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 9, D-55099 Mainz, Germany*

[2] *Institute of Physics, Maria Curie-Skłodowska University, Plac M. Skłodowskiej-Curie 1, PL-20031 Lublin, Poland*

[3] *Institute of Nuclear Physics, Polish Academy of Sciences, ul. E. Radzikowskiego 152, PL-31342 Kraków, Poland*

We study the superconducting properties of population-imbalanced ultracold Fermi mixtures in the honeycomb lattice that can be effectively described by the spin-imbalanced attractive Hubbard model (AHM) in the presence of a Zeeman magnetic field. We use the mean-field theory approach to obtain the ground state phase diagrams including some unconventional superconducting phases such as the Fulde–Ferrell–Larkin–Ovchinnikov (FFLO) phase, and spatially homogeneous spin-polarized superfluidity (SC_M) (called Sarma phase). We discuss the possibility of realization of the reentrant FFLO superconductivity. Finally, we examine the influence of the next-nearest-neighbor hopping integrals (t_2) on the stability of the SC_M phase.

This work was supported by Narodowe Centrum Nauki (NCN) through the Grant Fuga, No. UMO-2016/20/S/ST3/00274.

P-1-04

Finite temperature cluster mean-field calculation of spin-orbital state of $LaMnO_3$ crystal

Mateusz Snamina,[1] and Andrzej M. Oleś[2]

[1] *Faculty of Chemistry, Jagiellonian University, Kraków, Poland*

[2] *Institute of Physics, Jagiellonian University, Kraków, Poland*

$LaMnO_3$ crystal is a textbook example of interplay between spin and orbital degrees of freedom. In this crystal there is one e_g electron per each manganese ion which together with three t_{2g} electrons gives a total spin $S = 2$. In this case Kugel-Khomskii-like superexchange model is supplemented by the Jahn-Teller orbital interactions between Mn ions [1]. Commonly disentanglement of spin-orbital terms and on-site mean field approximation are used to estimate the transition temperatures. In our work [2] we went beyond these approximations and performed cluster calculations at finite temperature to verify them and to determine bond correlations. We have found opposite trends: $(i) \sim 10\%$ increase of the Néel temperature (T_N) due to on-site, and $(ii) \sim 10\%$ decrease of T_N due to on-bond spin-orbital entanglement. Altogether our results confirm that the spin-orbital interactions are indeed disentangled in $LaMnO_3$.

References:

[1] A. M. Oleś, G. Khaliullin, P. Horsch, and L. F. Feiner, Phys. Rev. B **72**, 214431 (2005).

[2] M. Snamina and A. M. Oleś, Phys. Rev. B **94**, 214426 (2016).

P-1-05

Thermodynamic studies of YB_6

M. Marcin,[1] J. Kačmarčík,[1] Z. Pribulová,[1] P. Diko,[1] V. Cambel,[2] J. Šoltýs,[2] T. Mori,[3] N.Yu. Shitsevalova,[4] and P. Samuely[1]

[1] *Institute of Experimental Physics, SAS, Košice, Slovakia*

[2] *Institute of Electrical Engineering SAS, Bratislava, Slovakia*

[3] *Advanced Materials Laboratory, NIMS, Tsukuba, Japan*

[4] *Frantsevich Institute for Problems of Materials Science of NASU, Kiev, Ukraine*

Here we present a comprehensive study of five YB_6 samples with slightly different Y/B ratios with $T_c \sim 4$ K, 5.8 K, 6 K, 7.1 K and 7.4 K using a combination of ac-calorimetry and local magnetometry. We measured the heat capacity behaviour in different fields up to 0.5 T and at various temperatures during temperature and magnetic field sweeps respectively. Thus, we obtained temperature dependencies of the upper critical magnetic fields H_{c2}. Using an array of miniature Hall probes, we also inspected mechanism of magnetic field penetration into and vortex distribution inside the sample. From measurements at different temperatures, the temperature dependencies of the lower critical magnetic field H_{c1} were determined for all samples. Evolution of the H_{c1}, H_{c2} and related parameters λ, ξ respectively with the critical temperatures were determined. The coupling ratios $2\Delta/k_BT_c$ were determined from both heat capacity and magnetometry measurements performed on the same crystals as well.

P-1-06

Magnetism of multiferroic materials seen by Mössbauer spectroscopy

Elżbieta Jartych[1]

[1] *Institute of Electronics and Information Technology, Lublin University of Technology, Nadbystrzycka 38a Str., 20-618 Lublin, Poland*

Multiferroic materials containing iron ions attract much attention of scientists due to their unusual magnetic structure, including collinear and non-collinear spin arrangement, and possessing magneto-electric coupling. Magnetism of multiferroics primarily depends on peculiarities of the electronic structure and crystal local environment of iron ions. Thus, ^{57}Fe Mössbauer spectroscopy is one of the most powerful tools for studying multiferroic materials. In the presentation, the examples of Mössbauer studies for ABO_3 perovskite-like oxides (i.e., Aurivillius $Bi_{m+1}Ti_3Fe_{m-3}O_{3m+3}$ compounds, (1-x)$BiFeO_3$–(x)$BaTiO_3$ and $Bi_{1-x}Nd_xFeO_3$ solid solutions) and ABO_2 delafossite-like oxides (i.e., $AgFeO_2$ and $CuFeO_2$) will be shown and discussed.

P-1-07

Density functional study of La and Y-doped $BiFeO_3$

J. Kaczkowski[1]

[1] *Institute of Molecular Physics PAS, ul. M. Smoluchowskiego 17, 60-179 Poznan, Poland*

$BiFeO_3$ is the only known room-temperature multiferroic, i.e. material that is both ferroelectric and magnetic. The theoretically predicted value of the spontaneous polarization is 90 $\mu C/cm^2$. Experimentally measured values are usually much lower, which is caused by leakage currents in samples. The usual assumption is that a leakage current occurs as a results of O-vacancies which arise from the variable oxidation state of Fe [1]. Recent theoretical works based on DFT calculations have shown that the Bi- and Fe-vacancies are dominant defects in BFO [2]. In this work we investigated La and Y-doped BFO using DFT calculations. We find that under O-rich condition these dopants have lower formation energies than Bi vacancies (V_{Bi}=6.9 eV, La_{Bi}=-1.4 eV, Y_{Bi}=-2.3 eV). The calculated spontaneous polarization for undoped BFO is 91 $\mu C/cm^2$, and for La and Y-doped is 83 $\mu C/cm^2$, 85 $\mu C/cm^2$, respectively [3].

References:

[1] K. Chybczyńska *et al.*, J. Alloys Compd. 671 (2016) 493

[2] Q. Wu *et al.*, Dalton Trans. 43 (2014) 10787

[3] M. Pugaczowa-Michalska, J. Kaczkowski, J. Mater. Sci. 50 (2015) 6227

This work was supported by the National Science Centre (Poland), Grant no. DEC-2016/21/D/ST3/03444 (SONATA 11)

P-1-08

Properties of the antiferromagnetic Cr8 ring calculated from a multi-band Hubbard Hamiltonian

J. Matysiak,[1] and R. Lemański[1]

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

Molecular magnets are clusters composed of finite numbers of magnetic centers surrounded by organic ligands. In these materials magnetic phases are formed mostly due to strong intra-cluster interactions. Theoretical tools most often used to describe molecular magnets consist of spin Hamiltonian approach [1] or density functional theory calculations [2]. Recently, it has been proposed to study these systems by applying a perturbation theory to the multi-band Hubbard like Hamiltonian [3]. We elaborate this approach by performing exact numeric calculations on a version of the multi-band Hubbard Hamiltonian. It allows us to calculate an approximate energetic spectrum and thermodynamic properties. We then compare our results with available experimental data and with oucomes obtained by other, aforementioned theoretical methods. In particular, we focus our attention on $Cr_8F_8(O_2CH)_{16}$ molecule ($Cr8$ in short), which is a ring-like shaped antiferromagnetic molecular magnet.

References:

[1] A. Furrer, O. Waldmann, Rev. Mod. Phys., **85**, 1 (2013)

[2] B. Brzostowski, R. Lemański, T. Ślusarski, D. Tomecka and G. Kamieniarz, J. Nanopart. Res. **15**, 1528 (2013)

[3] A. Chiesa, S. Carretta, P. Santini, G. Amoretti, E. Pavarini, Phys. Rev. Lett. **110**, 15 (2013)

P-1-09

Peculiar behaviour of thermodynamic properties in the Falicov-Kimball model for small U couplings

J. Krawczyk,[1] and R. Lemanski[1]

[1] *Institute of Low Temperature and Structure Research Polish Academy of Science, Wroclaw, Poland*

We analyse a behaviour of the order parameter between the large and small U limit. In the large U limit, the Falicov-Kimball model maps onto the effective Ising model with the order parameter of the Curie-Weiss form[1]. However, in the small U limit the order parameter takes on unusual shape with a sharp reduction near $T \approx T_C/2$[2,3]. Then we calculate the specific heat for different values of U. We investigate a crossover between these two limits using dynamical mean field theory(DMFT) formalism, which provides the exact solution in the limit of large spatial dimensions. We find the behaviour of the order parameter and specific heat as a function of temperature to be quite unusual.

References:

[1] P.G.J. van Dongen, Phys. Rev. B 45, 2267 (1992)
[2] Ling Chen, J. K. Freericks, and B. A. Jones, Phys. Rev. B 68, 153102 (2003)
[3] M. M. Maska and K. Czajka, Phys. Rev. B 74, 035109 (2006)

P-1-10

Specific heat and magnetocaloric effect in Cu_2MnBO_5 ludwigite

A.G. Gamzatov,[1] A.M. Aliev,[1] E. Moshkina,[2] and L. Bezmaternykh[2]

[1] *Amirkhanov Institute of Physics, DSC of RAS, 367003, Makhachkala, Russia*
[2] *L.V. Kirensky Institute of Physics SB RAS, 660036 Krasnoyarsk, Russia*

Presents the results of the study specific heat and magnetocaloric effect in a single crystal Cu_2MnBO_5 ludwigite in the temperature range 60-350 K and in magnetic fields up to 18 kOe. On the temperature dependence of the specific heat at T=91 K is observed lambda anomaly, which is suppressed in the magnetic field. The magnetocaloric effect was investigated by the direct method, and was estimated from the data of the temperature dependence the specific heat. The maximum value of the MCE according to direct measurements in a magnetic field of 18 kOe is equal $\Delta T = 0.45$ K. Investigated the anisotropy of the MCE. Maximum of the MCE depending on the field direction is decreased by 1.5 times, by $\Delta T = 0.45$ K in a parallel orientation to $\Delta T = 0.3$ K at a perpendicular magnetic field orientation. The change of the magnetic entropy due to the magnetocaloric effect in a magnetic field of 6.2 kOe is equal $\Delta S = 1.07$ J / kg K. Influence of the frequency (10 Hz) of the magnetic field on the MCE are investigated also.

P-1-11

Landau levels and quantum oscillations in nano-film of Weyl semimetals under crossed electric and magnetic fields

Z. Alisultanov[1,2]

[1] *Amirkhanov Institute of Physics RAS, Dagestan Science Centre, Makhachkala, Russia*

[2] *Dagestan State University, Makhachkala, Russia*

In this paper, we investigated the Landau band and quantum oscillations in the Weyl semimetal under crossed magnetic and electric fields. We obtained an expression for the energy spectrum of such system using three different methods: an algebraic approach, an Lorentz boost approach and quasi-classical approach. It is interesting that the quasi-classical expression for the energy spectrum completely coincides with the expression obtained in the framework of the microscopic approaches. We have shown that the electric field leads to a cardinal change the Landau bands. In addition, we investigated the classical motion of a three-dimensional Dirac fermions in crossed fields. When an electric field is equal to $\vartheta_F H/c$, the collapse of the Landau levels occurs, and the motion becomes completely linear. But, this linearization occurs in a special way. Under this electric field, the wave function for the bulk states vanishes. The states with only preserved. It will fundamentally change the character of the surface states, called the Fermi arcs. The electric field affects on the character of the quantum oscillations. The density of states has a singularity at $E = \vartheta_F H/c$.

P-1-12

Phase separations in the narrow band-width limit of the Penson-Kolb-Hubbard model

K.J. Kapcia,[1] W.R. Czart,[2] and S. Robaszkiewicz[2]

[1] *Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, PL-02668 Warsaw, Poland*

[2] *Faculty of Physics, Adam Mickiewicz University in Poznań, ul. Umultowska 85, PL-61614 Poznań, Poland*

The Penson-Kolb-Hubbard model is one of the conceptually simplest phenomenological models for studying correlations and for description of superconductivity in very narrow-band systems [1,2]. The relevant question is how accurate the standard broken-symmetry Hartree-Fock mean-field approximation is when applied to the on-site term U (for both repulsive and attractive U) [3]. We present phase diagrams and investigate the thermodynamic properties of the model derived within the Hartree-Fock approach in the narrow-bandwidth regime. The results are compared with those exact ones in the atomic limit for the limit of high dimensions. Our investigation of the general case, focussing on phase separated states, shows that results obtained within both approaches are consistent, at least in the low temperature regime.

References:

[1] S. Robaszkiewicz, B. R. Bułka, Phys. Rev. B **59**, 6430 (1999).

[2] K.J. Kapcia, W.R. Czart, A. Ptok, J. Phys. Soc. Jpn. **85**, 044708 (2016).

[3] K.J. Kapcia, W.R. Czart, Acta Phys. Pol. A 130, 617 (2016).

P-1-13

Penetration depth of alternate magnetic field into yttrium based superconductors

R. Zalecki,[1] W.M. Woch,[1] M. Kowalik,[1] and M. Giebułtowski[1]

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

The alternate magnetic field penetration depths into bulk $YBa_2Cu_3O_y$ superconductor with the critical temperature 90K as well as for YBCO grains were determined from the *a.c.* susceptibility measurements. When the sample is in the Meissner state, the dispersive component of *a.c.* susceptibility and its temperature dependence reflects the changes of the penetration depth at various temperatures. In the ceramic superconductors the penetration depths into bulk superconductors are of the order of a few micrometers and they are comparable to the grains size of the ceramics. On the other hand, the results obtained for the grains are much smaller. The influence of the *d.c.* applied magnetic field on the results was studied via the measurements taken for the zero-field-cooled as well as for the field-cooled samples.

P-1-14

Exchange bias in $Sc_{0.8}Zr_{0.2}MnO_3$ induced by electron doping

Tanushree Sarkar,[1] Suja Elizabeth,[1] and P S Anil Kumar[1]

[1] *Dept. of Physics, Indian Institute of Science, Bangalore-560012*

We report exchange bias phenomenon in electron-doped multiferroic compound $Sc_{0.8}Zr_{0.2}MnO_3$. Parent compound $ScMnO_3$ is a frustrated antiferromagnet and due to electron doping, antiferromagnetic ordering (T_N=90 K) is partially suppressed in $Sc_{0.8}Zr_{0.2}MnO_3$ [1]. Additionally, ferromagnetic interaction (T_C=60 K) develops in the system and it shows glassy nature below T_g=17 K. Field-cooled magnetic hysteresis loops exhibit shifts in both field axis and magnetization axis. Exchange bias field (H_E) decays exponentially with rise in temperature. These observations follow conventional exchange bias model of ferromagnetic (FM) clusters embedded in a spin glass (SG) or antiferromagnetic host material [2]. Nevertheless, here we find slight deviations: 1) H_E and remanence asymmetry (M_E) has non-zero value even after crossing T_g and vanishes completely only near T_C. 2) Both H_E and M_E increases sharply with increase in magnitude of cooling field (H_{FC}) up to 3 T beyond which the increment slow down but does not saturate even up to 9 T. Detailed investigation using training effect is carried out in order to elucidate the real nature of observed exchange bias.

References:

[1] T. Sarkar *et al.*, Journal of Magnetism and Magnetic Materials **Under review**, (2017)

[2] S. Karmakar *et al.*, Phys. Rev. B **77**, 144409 (2008)

P-1-15

Orthorhombic phase of $La_{0.5}Bi_{0.5}NiO_3$ studied by first principles

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

The electronic density of states near the Fermi level is an important physical quantity for understanding metal-insulator transition, charge transfer induced negative thermal expansion in perovskite $BiNiO_3$. The aim of presented first principles study of $La_{0.5}Bi_{0.5}NiO_3$ is to investigate electronic structure of orthorhombic phase *Pbnm*. The calculations show that metallicity and magnetism of the system are strongly related with hybridization between Ni *3d* and O *2p*. To improve the quality of the electronic structure description of the system, especially the treatment of correlation for the Ni *3d*, we employ GGA, LDA, and GGA + *U*, LDA + *U*. The LSDA results give good agreement with experiment [1]. Thus, the screening effects originating from the hybridized *3d* and O *2p* electrons are sufficiently strong that they reduce the electronic correlations in the $La_{0.5}Bi_{0.5}NiO_3$, making it a weakly correlated metal. The charge disproportionation of Bi ions into Bi^{3+} and Bi^{5+} is suppresed by La ions [2].

References:

[1] S. Ishiwata et al., Physica B 329-333 (2003) 813.
[2] M.Pugaczowa-Michalska, J. Kaczkowski, Comp. Mater. Sci. 126 (2017) 407.

P-1-16

Lower critical field in the two-band superconductor $LaRu_4As_{12}$

J. Juraszek,[1] R. Wawryk,[1] Z. Henkie,[1] M. Konczykowski,[2] and T. Cichorek[1]
[1] *Institute of Low Temperature and Structure Research, PAS, Wrocław, Poland*
[2] *Université Paris Saclay, École Polytechnique, Palaiseau, France*

The filled skutterudite compound $LaRu_4As_{12}$ displays several features which point at a non-singlet superconducing order parameter (T_c = 10.4 K) [1], although the cubic crystal structure does not favor the emergence of multiple energy gaps. Here, we present results of a comparative study of the lower critical field (H_{c1}) for $LaRu_4As_{12}$ and the one-band BCS superconductors $LaOs_4As_{12}$ (T_c = 3.2 K) and $PrRu_4As_{12}$ (T_c = 2.3 K). The $H_{c1}(T)$ dependences were determined utilizing miniaturized 2DEG Hall sensors. Exceptionally for $LaRu_4As_{12}$, we have observed a pronounced enhancement of $H_{c1}(T)$ below $T/T_c \approx 0.35$. Since such enhancement is absent in the closely related superconductors down to $T/T_c \approx 0.1$, anisotropy effects must be of minor significance. Furthermore, a sharp kink in the $H_{c1}(T)$ behavior correlates with anomalies in the penetration depth [2]. Apparently, these findings reflect a faster drop of the superfluid density at low temperatures due to different contributions from two bands. Our results indicate that $H_{c1}(T)$ is a very useful tool to investigate multiband superconductivity.

References:

[1] Ł. Bochenek, *et al.*, Phys. Rev. B 86 (2012) 060511(R).
[2] T. Shibauchi *et al.*, private communication.

P-1-17

Magnetic properties of single crystal $Ce_3Ru_4Al_{12}$

K. Vlášková,[1] A.V. Andreev,[2] and P. Javorský[1]

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

[2] *Institute of Physics, Czech Academy of Sciences, Na Slovance 2, 182 21 Prague, Czech Republic*

$Ce_3Ru_4Al_{12}$ crystallizes in the hexagonal $Gd_3Ru_4Al_{12}$-type crystal structure (space group $P6_3/mmc$). The magnetic properties of $Ce_3Ru_4Al_{12}$ were investigated by specific heat, electric resistivity and magnetization measurements on single crystalline sample. Paramagnetic state seems to persist to the lowest measured temperatures (0.4 K) contrary to previous results on polycrystalline sample [1], possible source of disagreement will be discussed. The specific heat shows a logarithmic increase at low temperatures. The temperature dependence of magnetisation does not obey the Curie-Weiss law and indicates presence of valence fluctuations. The experimental results will be compared with theoretical models.

References:

[1] Ge, W., Michioka, Ch., Ohta, H. et al., Solid State Communications 195, 1-5 (2014).

P-1-18

Statistics of tunneling events in three-terminal hybrid devices with quantum dot

G. Michałek,[1] B.R. Bułka,[1] T. Domański,[2] and K.I. Wysokiński[2]

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

[2] *Institute of Physics, M. Curie-Skłodowska University, Lublin, Poland*

To fully characterize the charge current fluctuations in mesoscopic systems it is necessary to study statistics of tunneling events, *e.g.* by means of the full counting statistics (FCS) or the waiting time distribution (WTD) in the long or the short time limit, respectively. We investigate here the WTD, defined as the probability for a delay time between two subsequent transitions of particles, and consider it for a quantum dot (QD) strongly coupled to a superconducting and weakly coupled to two normal electrodes. Our study focuses on the WTD in the subgap transport, when coherent exchange of the Cooper pairs occurs between the QD and the superconductor. The dynamics can be described in terms of a Markovian generalized master equation for the reduced density matrix [1]. We observe coherent oscillations between the Andreev bound states in the correlated jumps, both for the local and non-local WTDs.

References:

[1] L. Rajabi, Ch. Pöltl, and M. Governale, Phys. Rev. Lett. **111**, 067002 (2013).

The research was financed by National Science Centre, Poland – project numbers 2016/21/B/ST3/02160 (GM, BRB) and DEC-2014/13/B/ST3/04451 (TD, KIW).

P-1-19

Structural characterization of $Gd_2Mo_3O_{12}$ thin films grown onto YSZ(001) and YSZ buffered Si(001) substrates

P. Graczyk,[1] C. Ferrater,[2] M. Bernal,[2] E. Coy,[1] M.C. Polo,[2] J.M. Bassas,[2] and M. Varela[2]

[1] *NanoBioMedical Centre - Adam Mickiewicz University*

[2] *Departament Física Aplicada i Òptica - Universitat de Barcelona*

$Gd_2Mo_3O_{12}$ (GMO) is a metallic oxide that can be obtained in different crystalline phases (orthorhombic, monoclinic and tetragonal) in bulk samples. In its orthorhombic structure, GMO shows ferroelastic and ferroelectric behaviors, which make it to be interesting for technological applications. In this study, we have deposited GMO thin films onto YSZ buffered silicon substrates and onto STO single-crystals, and we have characterized the crystal structure of the films by means of the reciprocal space maps, obtained with a four-axis diffractometer. Films showed good crystallinity, with out-of-plane and in-plane alignments. The crystal structure of GMO films is very similar to the monoclinic bulk GMO one, but slightly strained to epitaxially fit the substrate net. The epitaxial relationship with the Si is (080)GMO//(004)Si;[100]GMO//[110]Si. Films grown onto STO also show good crystallinity, being the epitaxial relationship: (080)GMO//(002)STO;[100]GMO//[100]STO.

Author thank the National Science Centre of Poland (NCN) for the grant PRELUDIUM (UMO-2015/17/N/ST5/01988)

P-1-20

One-dimensional limit of two-band Fractional Chern Insulators

Błażej Jaworowski,[1] Piotr Kaczmarkiewicz,[1] Paweł Potasz,[1] and Arkadiusz Wójs[1]

[1] *Department of Theoretical Physics, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland*

We analyze the stability of Fractional Chern Insulators (FCIs) [1-4] against interband excitations within the thin-torus limit [5-6]. Although initially the FCIs were thought to be destroyed by interband interactions, it was shown that they may remain stable even for infinite interactions [4]. Using Density Matrix Renormalization Group method, we study the conditions of their stablilty in the 1D limit. We show that for special values of parameters, for which the system can be mapped to a fully dimerized Su-Schriefer-Heeger model [6], the energy gap remains finite for arbitrary strength of interaction. Next, we analyze the effects of deviations from this limit. Both particle and hole Laughlin-like states are investigated.

References:

[1] T. Neupert, L. Santos, C. Chamon, and C. Mudry, Phys. Rev. Lett. 106, 236804 (2011).
[2] D. Sheng, Z.-C. Gu, Gu, K. Sun, and L. Sheng, Nat. Commun. 2, 389 (2011).
[3] N. Regnault and B. A. Bernevig, Phys. Rev. X 1, 021014 (2011).
[4] S. Kourtis, T. Neupert, C. Chamon, C. Mudry, Phys. Rev. Lett. 112, 126806 (2014)
[5] E.J. Bergholtz, A. Karlhede Phys. Rev. B 77, 155308 (2008)
[6] B. A. Bernevig, N. Regnault, arXiv:1204.5682 (2012)

P-1-21

Stability of FCI states on kagome lattice

M. Kupczyński,[1] P. Kaczmarkiewicz,[1] B. Jaworowski,[1] P. Potasz,[1] and A. Wójs[1]
[1] *Wroclaw University of Science and Technology, Wroclaw, Poland*

We investigate Fractional Chern Insulator (FCI) phases on kagome lattice. FCI are quantum phases related to partially filled Chern Insulators - insulators with nontrivial bands topology exhibiting a nonzero Hall conductance and preserving lattice translational symmetry. [1] While FCI phases were observed for several lattice models and different filling fractions, [3] factors responsible for their stability are not fully determined. In this work we focus on FCI phases on kagome lattice. [2] We consider states with filling factors 1/3, 1/5, 1/7, 2/5, 3/7. Exact diagonalization is performed and phase stability maps are analyzed to show a set of parameters for FCI phase existance in a thermodynamic limit. FCI phases are confirmed by looking at many-body ground state degeneracy and spectral flow upon flux insertion. A correlation between large many-body energy gap separating the ground state manifold with low energy excitations and constant berry curvature is shown. [4]

References:

[1] F. D. M. Haldane, *Phys. Rev. Lett.*, **61**, 2015 (1998)
[2] Evelyn Tang, Jia-Wei Mei, and Xiao-Gang Wen, *Phys. Rev. Lett.*, **106**, 236802 (2011)
[3] A. M. Lauchli, Zhao Liu, E. J. Bergholtz, and R. Moessner *Phys. Rev. Lett*, **111**, 126802 (2013)
[4] B. Jaworowski, A. Manolescu, and P. Potasz, *Phys. Rev, B*, **92**, 245119 (2015)

P-1-22

Physical properties study of the $CeOsGa_4$ compound

B.M. Sondezi,[1] and A.M. Strydom[1]
[1] *Highly Correlated Matter Research Group, Department of Physics, University of Johannesburg, South Africa.*

A polycrystalline sample of $CeOsGa_4$ was prepared by arc-melting stoichiometric quantities of high purity elements. The subsequent Rietveld refinement performed on the powder X-ray diffraction data confirmed that the compound crystallizes in the hexagonal P_{63}/mmc structure. The magnetic susceptibility $\chi(T)$ data showed a distinct anomaly at $T_N = 3.9$ K, while the high-T data obeys Curie-Weiss law. The calculated effective moment of 2.52 μ_B was obtained, agreeing with the theoretical moment for a Ce^{3+} ion of $2.54\mu_B$. Magnetization data at T = 2 K depicts that $CeOsGa_4$ does not saturate up to applied magnetic field of 7 T, while the data measured at 9 K indicates that the compounds is purely paramagnetic at that temperature. The low-T specific heat data is characterized by an anomaly at $T_N = 3.8$ K confirming the $\chi(T)$ data. Electrical resistivity shows a metallic behaviour at high temperatures with a deviation at low temperatures. In this work we present the study of the effect of the applied magnetic field on the antiferromagnetic ordering temperature in $CeOsGa_4$.

BMS acknowledges South African National Research Fund (SA-NRF), Thuthuka grant, number 99231, for financial support . AMS acknowledges SA-NRF grant, number 93549, for financial support.

P-1-23

Magnetism and the spin-orbit coupling in Sr_2IrO_4 and $LaCoO_3$

Z. Ropka,[1] D.M. Nalecz,[1,2] S.S. Fedyk,[1,2] and R.J. Radwanski[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*

Sr_2IrO_4 becomes scientifically intriguing in last 8 years after announced by Kim *et al.* (Phys. Rev. Lett. **101** (2008) 076402) formation in Sr_2IrO_4 of new quantum state bands produced predominantly by the strong spin-orbit coupling. The successful revealing of the Ir^{4+} many-electron crystal-field (CEF) states with the importance of the spin-orbit coupling confirms the Quantum Atomistic Solid State Theory (QUASST) worked out by Radwanski *et al.* (Acta Phys Pol. B **31** (2000) 3079, Acta Phys. **7-8** (2007)). QUASST was the only theory, which has claimed from 1995 the existence of the discrete CEF electronic structure and the foundamental importance of the spin-orbit coupling in $3d/4d/5d/$ oxides for physically-adequate description of the magnetism and the low-energy electronic structure. Thus, it is of scientific importance to present our studies at the conference, where many-electron crystal-field based analyses have been largely ignored or even expelled. We have performed calculations of the low-energy electronic structure and the magnetic properties, like the value and the direction of the magnetic moment, at the atomic scale and in the meV energy scale. Comparison will be made with $LaCoO_3$, where the low-spin Co state is also realized. The role of electron, intra- and inter-site, correlations will be discussed.

P-1-24

Non-linear least squares fit of specific heat data within Schotte-Schotte model using web page

Jerzy Goraus[1]
[1] *Institute of Physics*
University of Silesia

Specific heat of rare-earth based materials at low temperatures can often be described by Schotte-Schotte model for Kondo impurity [1]. Since several decades thousands of papers were published which were devoted to physics of rare-earth based compounds and often presented specific heat measurements for Kondo systems. Schotte-Schotte model for Kondo impurity in a magnetic field requires evaluation of trigamma function for complex argument values. Typical graphing software for general use does not provide such capability. Therefore, very few papers related to Kondo effect in rare-earth based compounds provided analysis within that model. In this report we present a web page which fits specific heat data with a sum of electronic, lattice and Schotte-Schotte terms. The interface is written in Javascript, whereas back-end fitting engine is written in C and compiled to Javascript asm.js code using Emscripten compiler.

References:

[1] K. D. Schotte, U. Schotte, Phys. Lett. 55 (1975) 38–40

P-1-25

Enhanced thermoelectric power factors in the $Ce(Cu_{1-x}Ni_x)_2Si_2$ and $CeNi_2(Si_{1-y}Ge_y)_2$ alloys

K. Synoradzki,[1,2] T. Toliński,[2] and M. Koterlyn[3,4]

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

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

[3] *Institute of Physics, Kazimierz Wielki University, Bydgoszcz, Poland*

[4] *Faculty of Electronics, Ivan Franko National University of L'viv, Ukraine*

In the presence of hybridization of the f states with the conduction electrons Ce-based compounds can show large peaks in the temperature dependence of the Seebeck coefficient, which makes them interesting materials for applications. The Seebeck coefficient, electrical resistivity, and thermal conductivity of the bulk, arc-melted, single phase samples of $Ce(Cu_{1-x}Ni_x)_2Si_2$ and $CeNi_2(Si_{1-y}Ge_y)_2$ alloys were measured over the temperature range of 2 K to 300 K. All the samples exhibited a positive Seebeck coefficient, which reaches up to $\sim$50 μV/K at 150 K and it can be shifted up to 300 K by appropriate doping. The thermoelectric power factor, $PF = S^2/\rho$, reached a maximum of $1.4\times10^{-3}Wm^{-1}K^{-2}$ at 290 K and $1.1\times10^{-3}Wm^{-1}K^{-2}$ at 110 K for x = 0.25 and y = 0.75, respectively. For selected representatives of the studied series thermoelectric properties have been measured up to 1000 K. The wide temperature range enabled a plausible determination of the magnetic and nonmagnetic contributions.

P-1-26

Crystal structure and physical properties of the $CeFe_{1-x}Cr_xGe_3$ and $CeFe_{1-x}V_xGe_3$ systems

P. Skokowski,[1] K. Synoradzki,[1,2] and T. Toliński[1]

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

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

Ternary Ce-based germanides with the composition $CeTGe_3$ (T – 3d element) crystallize in structures, which can be different for various T substitutions. For example, the $CeFeGe_3$ compound is a well-known paramagnet with a large Kondo temperature (around 150 K) and a tetragonal noncentrosymmetric $BaNiSn_3$–type structure. On the other hand, $CeCrGe_3$ and $CeVGe_3$ crystallize in the hexagonal $P6_3/mmc$ $BaNiO_3$–type structure, where the former compound is a ferromagnet with $T_C = 73$ K and a Kondo behaviour and the latter one is an antiferromagnet with $T_N = 6$ K. As the physical properties of these compounds can be easy modified by the change of the chemical composition, we focused our attention on the $CeFe_{1-x}Cr_xGe_3$ and $CeFe_{1-x}V_xGe_3$ series. In this work we have shown by means of X-ray diffraction (XRD), magnetic susceptibility and heat capacity measurements that a small doping of the 3d element can keep the crystal structure but changes strongly the magnetic and thermodynamic properties. However, it is found that a large doping deteriorates the starting structure.

P-1-27

Raman studies of the charge ordering in organic electronic ferroelectrics $(TMTTF)_2X$ (X = SbF_6, AsF_6, PF_6, ReO_4, ...)

B. Barszcz,[1] R. Świetlik,[1] A. Pustogow,[2] and M. Dressel[2]

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

[2] *1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany*

The organic donor TMTTF (teramethyl-tetrathiafulvalene) and various anions (octahedral: X= Sb_6, AsF_6, PF_6; and tetrahedral: X = ReO_4, ClO_4, BF_4) form one-dimensional 2:1 charge-transfer salts with metallic properties. At low temperatures (T = 64 - 230 K) in these salts a charge ordering (CO) is observed which is mainly due to strong electron-electron correlations. The CO effect is directly related with the so-called electronic ferroelectricity. We studied temperature dependence of Raman spectra of the $(TMTTF)_2X$ salts focusing mainly on the charge sensitive C=C and C-S stretching modes which can be used for evaluation of the charge distribution in conducting TMTTF stacks. The C-S bands of molecules with charge +0.5 are assigned to ferroelectric domains, while the bands of neutral $TMTTF^0$ and fully ionized $TMTTF^+$ molecules to domain walls [1].

References:

[1] R. Świetlik, B. Barszcz, A. Pustogow, M. Dressel, Phys. Rev. B 95, 085205 (2017).

P-1-28

Infrared and Raman Studies of Temperature Induced Neutral-Ionic Phase Transition in (EDT-TTF-I_2)$_2$TCNQF

A. Frąckowiak,[1] I. Olejniczak,[1] R. Świetlik,[1] O. Jeannin,[2] and M. Fourmigué[2]

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

[2] *Institut des Sciences Chimiques de Rennes, Université Rennes 1, CNRS UMR 6226, 35042 Rennes (France)*

The low-dimensional charge-transfer (EDT-TTF-I_2)$_2$TCNQF complex is a unique organic material of 2:1 stoichiometry that undergoes a neutral-ionic phase transition (NIT). The crystal lattice is composed of the iodinated ethylenedithiotetrathiafulvalene (EDT-TTF-I_2) donors (D) and the fluorinated tetracyanoquinodimethane (TCNQF) acceptors (A). Donor dyads alternate with acceptor along a stack.

To study the charge distribution and the origin of the phase transition in (EDT-TTF-I_2)$_2$TCNQF we have measured polarized infrared and Raman spectra of the single crystals in the 8-293 K temperature range. In our spectral analysis we focus on charge sensitive C-S, C-I and C≡N stretching modes of EDT-TTF-I_2 and TCNQF, respectively. We present the schematic representation of the NIT in the 2:1 material and discuss the charge distribution in the ionic phase.

References:

[1] A. Frąckowiak et al., J. Phys. Chem. C 120, 23740 (2016).

[2] J. Lieffrig et al., Chem. Eur. J. 19, 14804 (2013)

P-2-01

Reconciling magnetism with valence state in mixed-valent $VO_2F_2@HV_{22}O_{54}$ with localized and unlocalized electrons

P. Kozłowski,[1] K.Yu. Monakhov,[2] O. Linnenberg,[2] J. van Leusen,[2] C. Besson,[2] T. Secker,[2] U. Englert,[2] P. Kögerler,[2] X. López,[3] and J.M. Poblet[3]

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

[2] *Institut für Anorganische Chemie RWTH Aachen University, Germany*

[3] *Departament de Química Física i Inorgànica, Universitat Rovira i Virgili, Tarragona, Spain*

Polyoxovanadate molecular clusters due to large structural variety and many oxiddation states of vanadium exhibit very reach magnetic behaviour and therefore find many technological applications. In this contribution two complementary theoretical approaches: DFT and effective Hamiltonian calculations are used to elucidate magnetism of mixed-valent $VO_2F_2@HV_{22}O_{54}$ with localized and unlocalized electrons. Extending the simplified modeling presented in [1] by taking into account kinetic energy of itinerant electrons and results of DFT we demonstrate that this compound differs from other members of $X@HV_{22}O_{54}$ family (X=ClO_4, SCN) not only by the presence of ferro- and antiferromagnetic interactions, but also by the valence state.

References:

[1] K. Yu. Monakhov, O. Linnenberg, P. Kozłowski, J. van Leusen, C. Besson, T. Secker, A. Ellern, X. López, J.M. Poblet, P. Kögerler, Chemistry – A European Journal **21**, 2387 (2015)

P-2-02

Thermodynamics of a model solid with magnetoelastic coupling

K. Szałowski,[1] T. Balcerzak,[1] and M. Jaščur[2]

[1] *Department of Solid State Physics, Faculty of Physics and Applied Informatics, University of Łódź, ul. Pomorska 149/153, PL90-236 Łódź, Poland*

[2] *Department of Theoretical Physics and Astrophysics, Faculty of Science, P. J. Šáfárik University, Park Angelinum 9, 041 54 Košice, Slovak Republic*

In the paper a computational study of a model solid with magnetoelastic coupling is presented. A system is based on s.c. crystalline lattice with nearest-neighbour ferromagnetic interactions, the long-range Morse interatomic potential and the Debye model. Exploiting the self-consistent, Gibbs energy-based formalism [1], the entropy, specific heat and magnetic susceptibility as well as lattice response functions are calculated. The influence of external pressure and magnetic field on the mentioned quantities is studied, with special emphasis put on the magnetoelastic coupling consequences. In addition the magnetocaloric effect is investigated by discussing isothermal entropy change and adiabatic temperature change in the presence of external pressure.

References:

[1] T. Balcerzak, K. Szałowski, M. Jaščur, J. Magn. Magn. Mater. **426**, 310-319 (2017)

P-2-03

Variational approach to spin-orbital polarons in $KCuF_3$

K. Bieniasz,[1,2] M. Berciu,[2] and A.M. Oleś[1,3]

[1] *Institute of Physics, Jagiellonian University, Kraków, Poland*

[2] *Department of Physics, University of British Columbia, Vancouver, Canada*

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

Copper-fluoride perovskite, $KCuF_3$, is a quintessential spin-orbital system that exhibits long range order in both spin $S = 1/2$ and orbital e_g degrees of freedom. Its ground state has alternating-orbital order in the ab planes (C-AO) and antiferromagnetic chains along the c direction (A-AF). An electron injected into the system can move freely within the ferromagnetic ab planes, or couple to either of the polaronic degrees of freedom by generating excitations in the system. Coupling to orbital excitations produces quasiparticle states with a well developed band in the whole Brillouin zone and an increased effective mass [1], whereas magnetic excitations seem to primarily scatter the electron. We develop a spin-orbital, t-J-like model, whose full treatment has never been attempted before, and solve it using the variational approximation, which is an exact, primarily analytical method for solving Green's functions by means of equations of motion. We present a number of spectral results and analyse the nature and properties of the quasiparticles arising in the system.

References:

[1] K. Bieniasz, M. Berciu, M. Daghofer, and A.M. Oleś, Phys. Rev. B **94**, 085117 (2016)

P-2-04

An analytical and combinatoric approach of the XXX Heisenberg model for the two-magnon sector

M. Labuz,[1] T. Lulek,[1,2] and J. Milewski[3]

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

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

[3] *Institute of Mathematics, Poznań University of Technology, Piotrowo 3A, 60-965 Poznań, Poland*

XXX Heisenberg s-1/2 model has been examined in detail during last decades, however, recently one may find some new insights into that issue. Among several approaches describing the eigenproblem for the finite case, a close look into the structure of Bethe equations (BE) for the two-magnon sector case seems to be particularly interesting. Bethe equations enable us to evaluate parameters labeling eigenstates of a magnet, however to find appropriate sets of winding numbers, which parametrize BE, one has to apply the famous TQ equation of Baxter, combined with the Inverse Bethe Ansatz method, or a combinatoric approach, with the use of rigged string configurations. The latter appears to be a tool which ensures the completeness of solutions, and, at the same time, combinatorial numbers enable to indicate precise winding numbers, so that one can obtain all parameters describing eigenfunctions.

P-2-05

Collinear and noncollinear configurations in classical geometrically frustrated ringshaped systems

M. Grajek,[1] T. Kopyciuk,[1] and W. Florek[1]

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

Geometrically frustrated quantum spin systems (with competing antiferromagnetic couplings) show Kahn's degenerate frustration [1] for some specific values of Heisenberg Hamiltonian parameters [2,3]. We show that in the case of classical counterparts of systems considered in Ref. 3 (rings with a defect bond and centered rings) degenerated configurations with the lowest energy are present for Hamiltonian parameters lying in the well-determined intervals. In these domains such configurations are planar but noncollinear with continuous changes of the net magnetic moment with respect to the Hamiltonian parameters. Outside these domains there is unique collinear ground state configuration (neglecting choice of the net magnetic moment direction). These domains are separated by well determined critical values of the Hamiltonian parameters. Numerically exact calculations for quantum systems [3] strongly confirm that determined properties of their classical counterparts realize the classical limit $s \to \infty$.

References:

[1] O. Kahn, Chem. Phys. Lett. **265**, 109 (1997); J. Schnack, Dalton Trans. **39**, 4677 (2010)
[2] M.L. Baker *et al.*, Proc. Nat. Acad. Sci. USA **109**, 19113 (2012)
[3] G. Kamieniarz, W. Florek, and M. Antkowiak, Phys. Rev. B **92**, 140411(R) (2015); W. Florek. M. Antkowiak, and G. Kamieniarz, Phys. Rev. B **94**, 224421 (2016)

P-2-06

Verifying of nonuniversal behavior in the 3D Ashkin–Teller model

Z. Wojtkowiak,[1] and G. Musiał[1]

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

The Ashkin-Teller (AT) model [1,2] is one of the most important in statistical physics and every year a dozen works are devoted to it. The aim of this study was to investigate precisely the phase transition line in the 3D AT model phase diagram, in which the universality class of phase transitions has not been clearly resolved yet [1,2]. This paper presents the results for the transitions between paramagnetic and Baxter phases for negative coupling between neighboring spin pairs. This is the most complex area in the phase transition diagram. The results published so far [1,2] suggest occurring of the nonuniversal behavior here. For this analysis we used cumulants of the type of Binder Q_L and Challa V_L, and also U_L proposed by Lee and Kosterlitz [3], all modified by Musial [1] and applied to the AT model. Our Monte Carlo experiment results confirm the existence of the continuous phase transitions in this area and explain the reasons for the ambiguity data obtained so far (see [1,2] and the papers cited therein).

References:

[1] G. Musial, Phys. Rev. B 69, 024407 (2004)
[2] G. Musiał, J. Rogiers, Phys. Status Solidi B 243, 335 (2006)
[3] Lee, J. M. Kosterlitz, Phys. Rev. 43, 3265 (1991)

P-2-07

Analysis of competing interactions in some rings modeled by the Ising spins

W. Florek,[1] M. Antkowiak,[1] G. Kamieniarz,[1] and K. Jaśniewicz-Pacer[1]
[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Poland*

Recently, a new classification of spin frustration in geometrically frustrated quantum spin systems described by the Heisenberg model has been put forward [1] and pursued [2,3]. In particular, the notion of the third type of frustration was introduced in Ref.[1] which does not alter the nonfrustrated ground state. Here we discuss three Ising ring systems with competing interactions which are analogs of quantum systems considered in Ref. [2] and show that they exhibit similar properties. For example, the archetypal system of three antiferromagnetically coupled spins s has two *magnetically* degenerated ground states with $|M| = s$, when $0 < J_{1\,3} = \alpha < 1 = J_{1\,2} = J_{2\,3}$. The same effect is observed in the centered rings and systems with antiferromagnetic couplings between the second neighbors which are the geometrically frustrated systems due to the competing interactions.

References:

[1] M.L. Baker *et al.*, Proc. Nat. Acad. Sci. USA **109**, 19113 (2012)
[2] G. Kamieniarz, W. Florek, and M. Antkowiak, Phys. Rev. B **92**, 140411(R) (2015)
[3] W. Florek, M. Antkowiak, and G. Kamieniarz, Phys. Rev. B **94**, 224421 (2016)

P-2-08

Spin-Peierls transition in (Et-2,6diMe-Pz)(TCNQ)$_2$

D. Šoltésová,[1] E. Čižmár,[1] V. Tkáč,[1] P. Doležal,[2] D. Kriegner,[2,3] M. Dušek,[3] D. Ziolkovskiy,[4] and A. Feher[1]
[1] *Institute of Physics, P. J. Šafárik University, Košice, Slovakia*
[2] *Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic*
[3] *Institute of Physics of the Academy of Sciences of the Czech Republic, Prague, Czech Republic*
[4] *Department of Chemistry, V. N. Karazin Kharkiv National University, Kharkiv, Ukraine*

The crystal structure and magnetic properties of the new organic anion-radical salt (Et-2,6diMe-Pz)(TCNQ)$_2$ were investigated. The temperature dependence of magnetic susceptibility was measured in the temperature range from 1.8 K to 300 K and a spin-Peierls transition was observed at a temperature 165 K. Investigation of the crystal structure above and below the transition temperature confirms a crystal structure change related to the spin-Peierls transition. The observed transition is further accompanied by the appearance of a λ-anomaly in the temperature dependence of specific heat at the transition temperature.

This work was supported by the Slovak Research and Development Agency under contract No. APVV-14-0073.

P-2-09

Chirality domain walls in frustrated spin system

P. Rusek[1]

[1] *Wroclaw University of Technology, Wroclaw,PL*

In noncollinear spin system, states have additional quantum number - the chirality: spins can rotate clock- or counter-clock-wise on plaquette. The relevant order parameter of frustrated spins is rotation matrix $O\varepsilon SO(3)$. In this case space of available states is disconnected $\Pi_1(SO(3)) = Z_2$ and consequently linear topological defects - Z_2 vortices can be spontaneously excited in a system. If a chirality distribution in long distance from the vortex is uniform (by inclusion the spin orbit interaction) the Z_2 vortex generates the singular planar defect that is terminated on the vortex- the chirality domain wall(ChDW). In the ChDW the chirality changes its sign. We argue that ChDW has peculiar topology: in ChDW one can go from the ground state with the given chirality to the ground state with the opposite one *continueosly*, encircling Z_2 vortex. We claim that this feature of ChDW topology gives rice to spontaneuos creation of holes which edge is(closed) Z_2 vortex. Thus ChDW can colapse to Z_2 vortex and the barrier energy that stabalized ChDW is equal to nucleation energy of Z_2 loops with diameter of order of thickness of ChDW. This, in turn, is equal to the spin orbit length, i.e. the ChDW thickness as well as the energy barrier stabilizing ChDW are *not* macroscopically large. The application our ideas to the underdoped $La-$based cuprates in spiral phase is discussed.

P-2-10

Bose glass behavior in diluted quantum spin $(Yb_{1-x}Lu_x)_4As_3$ chain

R. Matysiak,[1] G. Kamieniarz,[2] P. Gegenwart,[3,4] A. Ochiai,[5] and F. Steglich[4]

[1] *Institute of Engineering and Computer Education, University of Zielona Góra, Poland*

[2] *Computational Physics Division, Faculty of Physics, Adam Mickiewicz University, Poland*

[3] *Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, Germany*

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

[5] *Center for Low Temperature Science, Tohoku University, Japan*

We have measured and analyzed the field-dependent effects in the specific heat C of the poly-domain site-diluted compound $(Yb_{1-x}Lu_x)_4As_3$, where $x = 0.01$ and 0.03, which is an ideal realization of the linear Heisenberg antiferromagnet for $x = 0$. We demonstrate [1] that the fraction of C arising from the chains perpendicular to the applied field fulfils at low temperature the scaling behavior which is considered the thermodynamic signature of the Bose-glass phase and is rarely observed in low dimensional spin systems.

References:

[1] G. Kamieniarz, R. Matysiak, P. Gegenwart, A. Ochiai, F. Steglich, Physical Review B **94**, 100403(R) (2016).

P-2-11

The magnetocaloric effect in $\{[Cu(bapa)]_3[Cr(CN)_6]_2\}_n.6nH_2O$ at low temperatures

K. Ráczová,[1] M. Vavra,[2] M. Hegedüs,[2] and E. Čižmár[1]

[1] *Institute of Physics, Faculty of Science of P.J. Šafárik University, Park Angelinum 9, SK-041 54 Košice, Slovakia*

[2] *Institute of Chemistry, Faculty of Science of P.J. Šafárik University, Moyzesova 11, SK-041 54 Košice, Slovakia*

The crystals of $\{[Cu(bapa)]_3[Cr(CN)_6]_2\}_n.6nH_2O$ (bapa = bis(3-aminopropyl)amine) are formed by infinite Cu(II)–Cr(III) antiparallel chains, which are connected into the third direction by additive [Cu(bapa)] moieties. The temperature dependence of susceptibility, field dependence of magnetization and EPR spectra of complex are influenced by the presence of strong ferromagnetic exchange interaction between Cu(II) and Cr(III) ions ($J/k_B = 63$ K). The onset of long-range magnetic order at 3 K was observed by AC susceptibility. The study of the magnetocaloric effect from magnetization measurements in title complex is presented. At low temperature a large entropy change at 4 K was observed with peak value $-\Delta S_M = 13.1$ J.K^{-1}.mol^{-1} ($-\Delta S_M = 11.8$ J.kg^{-1}.K^{-1}) at field change from 0 T to 3 T.

This work was supported by APVV-14-0073.

P-2-12

Magnetocaloric effect in $CsDy(MoO_4)_2$

R. Tarasenko,[1] V. Tkáč,[1] A. Orendáčová,[1] M. Orendáč,[1] V. Sechovský,[2] and A. Feher[1]

[1] *Institute of Physics, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic*

[2] *Department of Condensed Matter Physics, Charles University, Ke Karlovu 5, CZ-12116 Prague 2, Czech Republic*

$CsDy(MoO_4)_2$ belongs to the family of double alkaline rare-earth molybdates, with detectable low-temperature structural phase transitions, caused by the cooperative Jahn-Teller effect. Magnetocaloric studies of a single crystal of $CsDy(MoO_4)_2$ have been performed in magnetic field applied along the *a* axis in the temperature range from 1.9 K to 48 K in magnetic fields up to 7 T. Isothermal magnetization curves were measured in a commercial Quantum Design SQUID magnetometer. Large conventional magnetocaloric effect was found around 5 K ($-\Delta S_M = 8$ J/(kgK) for 5 T) and around 44 K ($-\Delta S_M = 9$ J/(kgK) for 5 T). The latter can be associated with the presence of a structural phase transition occuring at $T \approx 40$ K.

This work has been supported by the projects APVV-14-0073, VEGA 1/0269/17, ERDF EU project No. ITMS 26220120047 and the program of Czech Research Infrastructures (project no.LM2011025).

P-2-13

Experimental study of magnetostructural correlations in low-dimensional quantum magnets Cu(en)Cl_2 and Cu(tn)Cl_2

Róbert Tarasenko,[1] Lívia Lederová,[1] Alžbeta Orendáčová,[1] Martin Orendáč,[1] and Alexander Feher[1]

[1] *Institute of Physics, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic*

Previous studies of powder Cu(tn)Cl_2, (tn = $C_3H_{10}N_2$), did not observe a phase transition to long range order down to 50 mK and the compound was identified as a good realization of the $S = 1/2$ two-dimensional Heisenberg antiferromagnet with an effective intra-layer exchange coupling $J/k_B \approx 3$ K. Application of magnetic field induced a response characteristic for a Berezinskii-Kosterlitz-Thouless transition. While the replacement of tn by en = $C_2H_8N_2$ did not introduce significant changes of the local environment of Cu(II) ion, the symmetry of crystal structure was lowered from orthorhombic to monoclinic. This change affected magnetic properties of Cu(en)Cl_2. Our comparative study of powder susceptibilities revealed a significant decrease of exchange coupling, projecting in Curie temperatures θ = -4.17 K and -0.75 K for Cu(tn)Cl_2 and Cu(en)Cl_2, respectively. As expected, g-factors were found very similar, $g = 2.01 \pm 0.05$ for Cu(en)Cl_2 and 2.07 ± 0.05 for Cu(tn)Cl_2. In the future, the study of magnetic properties in both magnetic systems will be investigated on the monocrystalline samples.

P-2-14

Accurate DFT estimates of magnetic couplings in chromium-based molecular rings

S. Weissman,[1] M. Antkowiak,[2] G. Kamieniarz,[2] and L. Kronik[1]

[1] *Weizmanm Institute of Science, Israel*

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

Estimating accurately the magnetic couplings from first principle calculations has proven to be difficult despite a lot of effort [1]. Here we present significant progress in this area for three extensively studied prototypical molecular Cr7M (M=Cr, Ni, Zn) rings, using an optimally-tuned range-separated hybrid functional that was shown to provide an accurate description of the electronic structure in a variety of more simple molecular systems [2]. We show that improving the overall description of frontier orbitals, especially with respect to a balanced description of localized and delocalized states, as well as taking into account the structure optimizationwe, we get magnetic coupling values distinguished by a unique site distribution along the heterometallic ring. Using the couplings calculated within DFT as the input parameters for the spin model simulations, we obtain excellent agreement with magnetic susceptibitlity measurements performed for all molecules considered.

References:

[1] A. Chiesa *et al.*, Physical Review Letters **110**, 157204 (2013).

[2] D.A. Egger *et al.*, J. Chem. Theory Comput., 10, 1934 (2014)

P-2-15

Sequences of ground states in frustrated rings disturbed by a single bond defect or additional central spin

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

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

We have found the universal sequence of the ground states for antiferromagnetic frustrated rings with the odd number of the local spins s and a single bond defect α described by the isotropic Heisenberg Hamiltonian [1] and we extended the analysis to the centered rings [2]. The sequence revealed is characterized by the total spin $S \leq s$ and contains all the spin numbers belonging to the interval allowed. It validates the classification of spin frustration in this type of nanomagnets. The conclusions are similar for the centered rings. Interestingly, the Lieb-Mattis level ordering [1] $E(S'+1) > E(S')$ for $S' \geq S$ is valid despite the lack of bipartiteness, where $E(S')$ is the lowest energy of the states described by the quantum number S'. Our calculations, pointing out the role of bipartiteness [1,2], have revealed the unexpected features of the model in question: the rings with enlarged nonbipartite structure seem to inherit the Lieb-Mattis theorem consequences of their bipartite archetypes. Our findings may facilitate the modeling of these systems and prompt the routes of rationalized search for new nanomagnets with designed properties.

References:

[1] G. Kamieniarz, W. Florek, M. Antkowiak, Phys. Rev. B **92** (2015) 140411(R)

[2] W. Florek, M. Antkowiak, G. Kamieniarz, Phys. Rev. B **94** (2016) 224421

P-2-16

The low and high spin ground states in molecules containing $[Mn_3^{II}Mn^{III}]$ and $[Mn_2^{II}Mn_2^{III}]$ metallic cores

M. Antkowiak,[1] M. Sobocińska,[2] M. Wojciechowski,[3]

G. Kamieniarz,[1] J. Utko,[2] and T. Lis[2]

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

[2] *Faculty of Chemistry, University of Wrocław, Poland*

[3] *Institute of Physics, University of Zielona Góra, Poland*

We present the experimental and theoretical results for two recently synthesized [1] tetranuclear magnetic clusters containing $[Mn_3^{II}Mn^{III}]$ (**1**) and $[Mn_2^{II}Mn_2^{III}]$ (**2**) metallic cores. From the theoretical point of view, we have analyzed the magnetic susceptibility and magnetization of both compounds in terms of the Heisenberg spin model using exact diagonalization technique. We have achieved quantitative agreement between theory and experiment for **2** and semi-quantitative for **1**. Moreover, the model predictions for **1** are supported by DFT calculations, using the PBE functional. Analyzing the energy structure of both compounds, we have found that the topology of interactions in **1** molecule is particularly suitable for synthesis of molecules with the ground state $S = 1/2$ and the interactions between Mn^{II} ions are crucial to get the lowest energy gap higher than that observed in the chromium-based molecules.

References:

[1] M. Sobocińska *et al.*, Dalton Trans. **45** (2016) 7303

P-2-17

Kosterlitz–Thouless transition in 1D Heisenberg antiferromagnet: An evidence based on topological properties of the ground state

Piotr Tomczak,[1] and Piotr Jabłoński[1]

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

A Kosterlitz–Thouless phase transition in the ground state of an antiferromagnetic spin-$\frac{1}{2}$ Heisenberg chain with nearest and next-nearest-neighbor interactions is re-investigated from a new perspective: A mapping of the components of the scalar product onto a set of loops is found. One can classify these loops according to whether any two of them can be transformed into each other in a continuous way (i.e., whether they have the same winding number). A finite size scaling of the fidelity susceptibility and geometrical phase calculated within each class of above mentioned loops leads to the accurate critical coupling constant value and enables one to find that the critical exponent $\nu = 2.000 \pm 0.001$.

P-2-18

Strongly anisotropic S=1 (pseudo)spin systems: from mean field to quantum Monte-Carlo

A.S. Moskvin,[1] Yu.D. Panov,[1] V.V. Konev,[1] E.V. Vasinovich,[1] and V.A. Ulitko[1]

[1] *Ural Federal University, Ekaterinburg, 620083, Russia*

The S=1 pseudospin formalism was suggested to describe the charge degree of freedom in a model high-T_c cuprate [1] with the on-site Hilbert space reduced to the three effective valence centers, nominally $Cu^{1+;2+;3+}$. With small corrections the model becomes equivalent to a strongly anisotropic S=1 quantum magnet in an external magnetic field. We have applied several techniques from a generalized mean-field approach, special algorithm for CUDA architecture for NVIDIA graphics cards and classical Monte-Carlo technique [2], to two different quantum Monte-Carlo methods to find the ground state with its evolution under deviation from half-filling and T-n phase diagrams for the model S=1 system. Special attention is given to the role played by on-site correlation (single-ion anisotropy) and emergent topological structures.

References:

[1] A.S. Moskvin, JETP 121, 477 (2015); Journal of Physics: Conference Series 592 012076 (2015).

[2] A.S. Moskvin, Yu.D. Panov, F.N. Rybakov, A.B. Borisov, J. Supercond. Nov. Magn. 30, 43 (2017).

P-2-19

Singularities of Bethe Ansatz via Robinson numbers

Jan Milewski,[1] Andrzej Koper,[2] and P. Krasoń[3]

[1] *Institute of Mathematics, Poznań University of Technology, ul. Piotrowo 3A, 60-965 Poznań, Poland*

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

[3] *Department of Mathematics and Physics, Szczecin University, 70-415 Szczecin, al. Wielkopolska 15, Poland*

In this work we suggest a rigorous mathematical approach for explanation of singular solutions of Bethe Ansatz by means of Robinson numbers. There are several approaches towards these singular solutions. Our aim is to make them precise and show that they are essentially equivalent. The results will be explained using the sequential interpretation of Robinson numbers.

P-2-20

Heisenberg and Bethe field extensions applied to magnetic rings

G. Banaszak,[1] D. Blinkiewicz,[1] P. Krasoń,[2] and J. Milewski[3]

[1] *Department of Mathematics and Computer Science, Adam Mickiewicz University, Poznań 61-614, Poland*

[2] *Department of Mathematics and Physics, Szczecin University, 70-415 Szczecin, Poland*

[3] *Institute of Mathematics, Poznań University of Technology, ul. Piotrowo 3A, 60-965 Poznań, Poland*

We consider striking connections between the theory of homogenous isotropic Heisenberg ring (XXX-model) and algebraic number theory. We explain the nature of these connections especially applications of Galois theory for computation of the spectrum of the Heisenberg operators and Bethe parameters. The solutions of the Heisenberg eigenproblem and Bethe Ansatz generate interesting families of algebraic number fields. Galois theory yields additional symmetries which not only simplify the analysis of the model but may lead to new applications and horizons.

P-2-21

Phase separation in the ground state of the model 2D spin-pseudospin system

Yu. Panov,[1] A. Moskvin,[1] A. Chikov,[1] K. Budrin,[1] and F. Rybakov[2,3]
[1] *Ural Federal University, Ekaterinburg, 620002, Russia*
[2] *KTH Royal Institute of Technology, Stockholm, SE-10691 Sweden*

Competition of charge and spin orders is a challenging problem for high-T_c cuprates. We addressed a simplified static 2D spin-pseudospin model [1] which takes into account both conventional Heisenberg spin exchange coupling and the on-site and intersite charge correlations. Classical Monte-Carlo calculations for large square lattices show that homogeneous ground-state solutions found in a mean-field approximation are unstable with respect to phase separation with the charge and spin subsystems behaving like immiscible quantum liquids. For instance, with lowering the temperature one can observe two sequential phase transitions: first, antiferromagnetic ordering in the spin subsystem diluted by randomly distributed charges, then, the charge condensation in the charge droplets. Thermodynamic properties and phase diagram of the 2D spin-pseudospin system are studied by Monte-Carlo simulation.

References:

[1] Yu. Panov, A. Moskvin, A. Chikov *et al.*, J. Supercond. Nov. Magn. **29**, 1077 (2016)

P-2-22

Field-induced multiple slow magnetic relaxation in $[Co(dcnm)(H_2O)(phen)_2](dcnm)$ complex with easy-plane anisotropy

E. Čižmár,[1] K. Ráczová,[1] I. Potočňák,[2] L. Váhovská,[2,3] O. Bukrynov,[4] S. Vitushkina,[4] and L. Findoráková[5]
[1] *P.J. Šafárik University, Institute of Physics, Košice, Slovakia*
[2] *P.J. Šafárik University, Institute of Chemistry, Košice, Slovakia*
[3] *University of Veterinary Medicine and Pharmacy, Košice, Slovakia*
[4] *V.N. Karazin Kharkiv National University, Kharkhiv, Ukraine*
[5] *Institute of Geotechnics SAS, Košice, Slovakia*

Magnetic relaxation in ionic cobalt(II) complex $[Co(dcnm)(H_2O)(phen)_2](dcnm)$ (dcnm = dicyanonitrosomethanide, phen = 1,10-phenantroline) was studied. Magnetic properties of title compound are dominated by a strong easy-plane anisotropy with energy difference between the two lowest Kramers doublets of 150 cm^{-1}. Two field-induced relaxation channels with distinct dependence on the applied field were observed by ac susceptibility study at low temperatures. It is suggested that a direct spin-phonon relaxation is realized within the ground Kramers doublet and one of the relaxation channels is identified to be mediated by the electron-nuclear interaction.

Supported by APVV-14-0078, ITMS26220120005, and VVGS-PF-2017-273.

P-3-01

Effect of Co substitution on Ni_2MnGe Heusler alloy: first principles study

M. Pugaczowa-Michalska[1]

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

Many studies of Ni_2MnGe and Co_2MnGe indicated several intriguing properties of these alloys. Both Ni_2MnGe and Co_2MnGe are known as Heusler alloys with the $L2_1$ crystallographic structure. The study is focused on the effect on the magnetic properties induced by substitution of Ni by Co. The unit cell of the studied $Ni_{2-x}Co_xMnGe$ ($0 \leq x \leq 1.0$) system is the cubic $L2_1$, which contains four *fcc* sublattices at A(0 0 0), B($\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$), C($\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$) and D($\frac{3}{4}$ $\frac{3}{4}$ $\frac{3}{4}$) sites. These sites are occupied by Ni, Mn, Ni and Ge atoms, respectively. Due to the Co substitution the chemical disorder between A and C sites is assumed, and the studied system is treated in band calculations within the CPA as implemented in FPLO. It follows that, the Co substitution instead of Ni may lead to a decrease of the lattice constant and an increase of the total magnetic moment of compound. The Mn(B) has the largest local moment (above 3 μ_B) coupled parallel to moments on the Ni(A,C) and Co(A,C), which are found in the ranges of $0.19 \div 0.26$ μ_B for Ni(A,C) and $1.03 \div 0.97$ μ_B for Co(A,C). Since Co_2MnGe has been previously predicted to be half-metallicity, it is interesting to track the spin-polarization at changing Co content and disorder rate.

P-3-02

Finite size effects and Hofstadter butterfly in a bosonic Mott insulator with relativistic dispersion background

A.S. Sajna,[1] and T.P. Polak[1]

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

Gauge potentials with different configurations have been recently realized in the optical lattice experiments. It is remarkable that one of the simplest gauge can generate particle energy spectrum with the self-similar structure known as a Hofstadter butterfly. We investigate theoretically the impact of strong on-site interaction on such a spectrum in the Bose-Hubbard model. In particular, it is shown that the fractal structure is encoded in the quasi-particle and hole bosonic branches. A square lattice and other structures (brick-wall and staggered magnetic flux lattice) with relativistic energy dispersions which are currently accessible in the experiments are considered. Moreover, although in brick-wall and staggered flux lattices the quasi-particle densities of states looks qualitatively similar, the corresponding Hofstadter butterfly assumes different forms. In particular, we use a superposition of two different synthetic gauge fields which appears to be a generator of non-trivial phenomena in the optical lattice systems.

This work was supported by the National Science Centre, Poland, project no. 2014/15/N/ST2/03459 (A. S. S.).

P-3-03

Low Frequency Skyrmion Excitations in Skyrmion lattice

Michal Mruczkiewicz,[1] Maciej Krawczyk,[2] Pawel Gruszecki,[2] and Konstantin Y. Guslienko[3,4]

[1] *Institute of Electrical Engineering, Slovak Academy of Sciences, Dubravska cesta 9, 841 04 Bratislava, Slovakia*

[2] *Faculty of Physics, Adam Mickiewicz University in Poznan, Umultowska 85, Poznan, 61-614, Poland*

[3] *Depto. Física de Materiales, Universidad del País Vasco, UPV/EHU, 20018 San Sebastián, Spain*

[4] *IKERBASQUE, the Basque Foundation for Science, 48013 Bilbao, Spain*

An isolated magnetic soliton is known to possess a set of zero frequency excitations that can acquire a finite frequency when symmetry is broken, also known as Goldstone modes. Here, we are investigating with numerical simulations (mumax3) how the shape of a nanodot influences on the low frequency skyrmion excitations and give rise to finite frequency excitations. Particular interest is put on the hexagonal shape nanodot that potential possesses symmetry of the potential profile of Skyrmion Lattice (SkL). The different influence on frequency between the fixed potential due to boundary of the nanodot and potential arising from moving freely neighboring skyrmions in SkL is discussed.

P-3-04

Magnetic and magnetocaloric properties of cobalt substituted Fe_7Se_8 single crystals

Y. Konopelnyk,[1] I. Radelytskyi,[1] P. Iwanowski,[1] D.J. Gawryluk,[1] M. Berkowski,[1] R. Diduszko,[2] J. Fink-Finowicki,[1] and H. Szymczak[1]

[1] *Institute of Physics PAS, Warsaw, Poland*

[2] *Tele and Radio Research Institute, Warsaw, Poland*

The main purpose of this research is to determine magnetocaloric effect(MCE) in iron selenide Fe_7Se_8(3c type) single crystals doped with 2% of cobalt atoms. The single crystals have been grown applying modified Bridgman's method. Magnetization measurements have been carried out using magnetometer SQUID MPMS 7XL. MCE has been determined based on M(H,T) measurements. The compound is ferrimagnetic metal with high Neel temperature. The 3c type structure derives from the hexagonal (NiAs-type) by introducing ordered Fe vacancies. The first order phase transition of the spin reorientation type from easy c-axis to easy c-plane has been observed near the temperature $T_r \approx 132$ K. Conventional magnetocaloric effect related to the metamagnetic transitions has been found above T_r while below T_r inverse MCE was identified. The magnetization and magnetic anisotropy as a function of temperature have been measured and discussed in relation to the observed rotational magnetocaloric effect.

This study was partially supported by the National Center for Research and Development, research project no. PBS2/A5/36/2013.

P-3-05

Magnetic and magnetocaloric properties of NiMnIn single crystals

A. Lynnyk,[1] R. Szymczak,[1] I. Radelytskyi,[1] M. Berkowski,[1] R. Diduszko,[2]
J. Fink-Finowicki,[1] D. Gawryluk,[1] and H. Szymczak[1]
[1] *Institute of Physics, PAS, 02-668 Warsaw, Poland*
[2] *Tele and Radio Research Institute, 03-450 Warsaw, Poland*

Single crystals of $Ni_{48.6}Mn_{22.5}In_{28.7}$ Heusler alloys have been grown applying Bridgman's method. The sample was found to be single phase as all observed Bragg reflections could be indexed using the cubic L21. The refined lattice parameter was 6.070 Å. The present sample does not undergo a martensitic phase transition and retains its cubic structure down to 5K. A second order magnetic phase transition was shown to be fully reversible. The magnetocaloric effect and magnetic properties of the samples have been investigated by the magnetization M (T, H) measurements in the temperature range 5 – 300K. The magnetic field was applied parallel to the [100] and [110] crystallographic directions. The magnetocaloric parameters, i.e., the magnetic entropy change, refrigeration capacity have been shown to be isotropic. It confirms presence of austenite phase of alloy in the whole temperature range of measurements.

This study was partially supported by the National Center for Research and Development, research project no. PBS2/A5/36/2013

P-3-06

Spin wave excitations of the interacting two-dimensional in-plane nano-vortices

S. Mamica[1]
[1] *Faculty of Physics, Adam Mickiewicz University in Poznań*

The aim of this work is to study spin-wave excitations in the system of interacting two-dimensional nanodots in the vortex state. We use a discrete dipole model taking into account the nearest-neighbour exchange and dipolar interactions [1]. Magnetic configuration of each dot is assumed to form an in-plane vortex (circular magnetization). We examine the dependence of the frequencies and profiles of spin-wave modes vs. the dipolar-to-exchange interaction ratio, the size of the dot, and the dot separation. Special attention is paid to some particular modes, including the lowest-frequency mode, the localized modes, and the fundamental mode, an analogue of the uniform excitation. Some conclusions regarding the influence of the chirality of neighbouring vortices are provided as well.

References:

[1] S. Mamica, "In-plane magnetic vortices in two-dimensional nanodots" in "Magnetic Structures of 2D and 3D Nanoparticles: Properties and Applications" ed. J.-C. S. Lévy, Pan Stanford Publishing, Singapore 2016.

The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348.

P-3-07

Complete band gap opening in the spin-wave spectrum of two-dimensional bi-component magnonic crystals

S. Mamica,[1] and M. Krawczyk[1]

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

Two dimensional (2D) magnonic crystals (MCs) with tunable band gap in the spin-wave spectrum have potential applications in different types of magnonic devices, such as microwave resonators, spin-wave filters or switches, and current-controlled delay lines. To examine possibilities of the magnonic band gap opening we employ the plane-wave method (PWM) and solve linearised Landau-Lifshitz equation together with magnetostatic Maxwell equations [1]. We study spin-wave propagation in 2D bi-component MCs of finite thickness consisting of the scattering centres of elliptical cross section distributed in ferromagnetic matrix in sites of a square or hexagonal lattice with the in-plane structure distorted (squeezed) in one direction. We show that such squeezing leads to the spin-wave spectrum very sensitive to external magnetic field which can be used to opening / closing complete magnonic gaps.

References:

[1] S. Mamica, *et al.*, Adv. Cond. Mat. Phys. 2012, 161387 (2012).

The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348 and the National Science Centre, Poland grant no. UMO-2012//07/E/ST3/00538.

P-3-08

Magnetic Microwave Planar Metamaterials: Experimental Results

S. Tarapov,[1,2] A. Girich,[2] S. Polevoy,[2] S. Nedukh,[1,2] and R. Vovk[1]

[1] *Karazin Kharkiv National University, 4 Svobody Sq, Kharkiv, 61022, Ukraine*

[2] *O.A.Usikov Institute for Radiophysics and Electronics NASU, 12 Ak. Proskura Str., Kharkiv, 61085, Ukraine*

The results of numerical and experimental investigation of spectral features of artificial structures (metamaterials) included a magnetic elements with strong frequency dispersion are prsented. Among them are the planar chain-like photonic crystals, loaded with magnetically controlled elements. These structures have been considered both in linear and nonlinear regimes. As well the hyperbolic type metasurfaces features are considered. The experimental verification of the models proposed has been carried out for microwave band. The special features of the waves propagate through these structures, their constitutive parameters formation and the areas of the magnonic application in microwave and optical regimes are described.

References:

[1] Microwaves in Dispersive Magnetic Composite Media (Review Article), S.I.Tarapov, and D.P.Belozorov, Low Temperature Physics (AIP Publ.), 2012, v.38, p.603-625.

P-3-09

Electric field control of magnon power flow in thin ferromagnet films

V.N. Krivoruchko,[1] A.S. Savchenko,[1] and V.V. Kruglyak[2]

[1] *Donetsk Institute for Physics and Engineering, the NAS of Ukraine, 46, Nauki Ave., 03028, Kyiv, Ukraine*

[2] *University of Exeter, Stocker road, EX4 4QL, Exeter, UK*

External electric field can modify the strength of the spin-orbit interaction between spins of ions in magnetic crystals. This influence results in a spin wave frequency shift, which is linear in both the applied electric field and the wave vector of spin waves. We apply these findings to examine theoretically how the spin wave power flow is affected by the external electric field in ultrathin ferromagnets. We also analyze how the spin wave caustics can be tuned by the electric field. In particular, the spin wave focusing pattern is obtained from the slowness surfaces by finding the normal to the slowness surface and then evaluating the curvature at each point of the curves. We show that the combination of the dipole-dipole interaction and field-induced nonreciprocity of spin wave propagation can result in unidirectional caustic beams of dipole-exchange spin waves. Our findings open a novel important avenue for spin wave manipulation and development of electrically tunable magnonic devices.

This work was supported by the MagIC project: 644348-H2020-MSCA-RISE-2014 and the Ukrainian State Fund for Fundamental Research (project: F71/73-2016).

P-3-10

Transmission of spin waves through a layer of incommensurate magnetic material

A.N. Kuchko,[1] V.N. Krivoruchko,[2] F.B. Mushenok,[3] and V.V. Kruglyak[3]

[1] *Institute of Magnetism of the NAS of Ukraine, 36b, Vernadsky Str., 03142, Kiev, Ukraine*

[2] *Donetsk Institute for Physics and Engineering the NAS of Ukraine, 46, Nauki Avenue, 03028, Kyiv, Ukraine*

[3] *University of Exeter, Stocker road, Exeter, EX4 4QL, UK*

Incommensurate magnetic structures are an exotic type of magnetic materials in which the periods of the magnetic and crystal lattices differ by more than an order of magnitude. Currently, the exotic and complex micromagnetic states and dynamic characteristics observed in such structures attract enormous attention of both theorists and experimentalists, offering numerous opportunities for design of novel magnonic devices. In this work, we will report on a theoretical study of the peculiarities of spin wave propagation through and scattering from a layer of incommensurate magnetic material sandwiched between two commensurate (i.e. conventional) magnetic materials. Analytical expressions for the scattering coefficients will be presented and analyzed.

This work was supported by the MagIC project: 644348-H2020-MSCA-RISE-2014.

P-3-11

Substitution effects on the magnetic properties of Fe-containing chalcogenides with NiAs-type structures

N.V. Baranov,[1] N.V. Selezneva,[2] E.M. Sherokalova,[2] A.S. Volegov,[2] and D.A. Shishkin[1]

[1] *Institute of Metal Physics, Russian Academy of Science, 620990, Ekaterinburg, Russia*

[2] *Institute of Natural Sciences and Mathematics, Ural Federal University, 620083, Ekaterinburg, Russia*

Iron-containing chalcogenides $(Fe,M)_{1-z}X$ (X = S, Se) with layered crystal structures of the NiAs-type exhibit a rich variety of magnetic behaviors depending on the kind and concentration of substituting M atoms as well as on the Se for S substitution. The present work aims to study the magnetization processes in $(Fe,Ti)_{1-z}X$ compounds (z = 0.125 – 0.25; X = S, Se) with antiferromagnetic and ferrimagnetic orderings. At low temperatures, unusually high values of the coercive fields (up to 50 kOe) associated with the presence of an unquenched orbital moment on Fe ions have been observed in some $(Fe,Ti)_{1-z}X$. A cation distribution between layers together with changes in the metal-chalcogen ratio are observed to affect the magnetic properties of $(Fe,Ti)_{1-z}X$.

This work was supported by the RFBR (projects No 16-02-00480 and 16-03-00733) and by the Ministry of Education and Science of Russia (project No 3.2916.2017)

P-3-12

Influence of electric and magnetic fields on dielectric response of oil-based ferrofluid

Š. Hardoň,[1] J. Kúdelčík,[1] and P. Bury[1]

[1] *Univerity of Zilina, Department of Physics*

The changes in dielectric parameters and structural arrangement of transformer oil-based ferrofluid with magnetic nanoparticles upon the effect of an external magnetic field and an electric field were studied by dielectric spectroscopy. The frequency dependence of complex permittivity and dissipation factor were measured within the frequency range from 1 mHz to 10 kHz by a capacitance method. In whole measured frequency range these parameters have been studied in the magnetic field applied to the sample in either parallel or perpendicular configurations in regard to the electric field. In the presence of the magnetic field the interaction between the magnetic field and magnetic moments of nanoparticles led to the aggregation of magnetic nanoparticles. The electric field also had effects on the reduction in the electric dipole moment of particles and their orientation to the electric field direction connected also with formation of chains. The observed low frequency relaxation maximum of dissipation factor was explained by Schwarz theory of electric double layer polarization. The change of the strength of electric field had influence on this maxima shift what was caused by change of relaxation time of the nanoparticles-counterions system.

VEGA 1/0510/17

P-3-13

Electronic structure and x-ray magnetic circular dichroism in Sm-Doped Bi_2Se_3

V.N. Antonov,[1,2] L.V. Bekenov,[1] A. Ernst,[3] and S. Uba[2]

[1] *G.V. Kurdyumov Institute for Metal Physics of the N.A.S. of Ukraine, 36 Vernadsky Street, 03142 Kiev, Ukraine*

[2] *Faculty of Mathematics and Informatics, University of Bialystok, K. Ciolkowskiego 1M, PL-15-245 Bialystok, Poland*

[3] *Max-Planck Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle*

One of the most striking discoveries in recent years which has emerged from research into spin-orbit coupling (SOC) is a new state of matter known as a topological insulator (TI). The electronic structure of Sm-doped TI Bi_2Se_3 has been investigated in the generalized gradient approximation (GGA) and GGA+U approximations using the fully relativistic spin-polarized Dirac LMTO method. The effects of the subtle interplay among the SOC and electron correlations on the electronic structure of the Sm-doped Bi_2Se_3 has been studied. The x-ray absorption spectra (XAS) and x-ray magnetic circular dichroism at the Sm $M_{4,5}$ edges were investigated theoretically from first principles. The calculated results are in good agreement with experimental data (T. Chen *et al.* Adv. Mater. 2015, **27**, 4823–4829). The complex fine structure of the Sm $M_{4,5}$ XAS in Sm-doped Bi_2Se_3 was found to be not compatible with a pure Sm^{3+} valency state. The interpretation demands mixed valent states.

P-3-14

Electronic structure and x-ray magnetic circular dichroism in hybrid heterostructure $Sr_2CrReO_6/BaTiO_3$

V.N. Antonov,[1,2] L.V. Bekenov,[2] S. Uba,[1] A. Bonda,[1] and L. Uba[1]

[1] *Faculty of Mathematics and Informatics, University of Bialystok, K. Ciolkowskiego 1M, PL-15-245 Bialystok, Poland*

[2] *G. V. Kurdyumov Institute for Metal Physics of the N.A.S. of Ukraine, 36 Vernadsky Street, 03142 Kiev, Ukraine*

The integration of ferromagnetic and ferroelectric materials into hybrid heterostructures yields multifunctional systems with improved or novel functionality. We here report on the electronic structure and magnetic properties of hybrid heterostructure combined the ferromagnetic double perovskite Sr_2CrReO_6 and ferroelectric $BaTiO_3$ calculated in the local spin density approximation (LSDA) as well as the LSDA+U approach using the fully relativistic spin-polarized Dirac LMTO method. The x-ray absorption spectra (XAS) and x-ray magnetic circular dichroism at the Re and Cr $L_{2,3}$ edges were investigated from first principles. A qualitative explanation of the XMCD spectra shape is provided by the analysis of the corresponding selection rules, orbital character and occupation numbers of individual orbitals. The complex fine structure of the Cr $L_{2,3}$ XAS in Sr_2CrReO_6 was found to be not compatible with a pure Cr^{3+} valency state. The interpretation demands mixed valent states. We found that possible oxygen vacancies lead to a mixed valency at the Cr site.

P-3-15

Magnetic properties of rapidly cooled Gd_6YPd_3

M. Oboz,[1] E. Talik,[1] A. Guzik,[1] P. Zajdel,[1] and G. Ziółkowski[1]

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

Magnetic materials with relatively high Curie temperatures and large magnetocaloric effects (MCE) are researched as potential candidates for magnetic refrigeration [1-3]. The rc-cast Gd_6YPd_3 sample was prepared by the mould casting technique. The results were compared to the data of single crystal obtained by the Czochralski method from a levitating melt. The samples were characterized by means of X-ray diffraction, SQUID magnetometry and scanning electron microscopy in order to comparison magnetic and magnetocaloric properties in relation to the technological aspects. The Gd_6YPd_3 compound crystallizes in the hexagonal Th_7Fe_3 type of crystal structure. The investigated ferromagnetic system is sensitive to grain size. The Gd_6YPd_3 single crystal orders ferromagnetically at 299 K while the rc-cast Gd_6YPd_3 displays also ferromagnetic transition but at about 305 K. For the Gd_6YPd_3 single crystal the saturation magnetic moment per Gd ion is enhanced in relation to the theoretical value while for the rc-cast Gd_6YPd_3 only a slight overestimation is observed. The magnetocaloric effect decreases with the decrease of the grain size.

References:

[1] V.K. Pecharsky, K.A. Gschneidner, Jr.: Int. J. Refrig. 29 (2006) 1239.
[2] K.A. Gschneidner, Jr., V.K. Pecharsky, A.O. Tsokol: Rep. Prog. Phys. 68 (2005) 1479.
[3] E. Brück E: J. Phys. D: Appl. Phys 38 (2005) R381.

P-3-16

Functionalization of atomic force microscopy Akiyama tips for magnetic force microscopy measurements

M. Stiller,[1] J. Barzola-Quiquia,[1] P. Esquinazi,[1] S. Sangiao,[2] and J.M. De Teresa[2]

[1] *Felix-Bloch Institute for Solid State Physics, University of Leipzig, 04103 Leipzig, Germany*

[2] *Instituto de Nanociencia de Aragón (INA), Universidad de Zaragoza, E-50018 Zaragoza, Spain*

We have investigated a method to functionalize atomic force microscopy Akiyama tips, for application in magnetic force microscopy experiments. Magnetic tip-shaped structures were grown on Akiyama tips using focused electron beam induced deposition of cobalt. After exposure to ambient air, the grown tips have a Co content of 85%. The prepared magnetic tips were characterized using electron dispersive X-ray spectroscopy and scanning electron microscopy. In order to investigate the magnetic properties, such as effective magnetization or the coercive field, current loops, prepared by electron beam lithography, were used. Measurements at room as well as at low temperature (T = 4.2 K) were carried out, and compared with simulation. Magnetic Akiyama tips open new possibilities for low-temperature magnetic force microscopy measurements.

P-3-17

Various behavior of the ferromagnetic resonance in epitaxially grown $Co_2Fe_{0.4}Mn_{0.6}Si$ Heusler alloys thin films

O. Chumak,[1,2] A. Nabiałek,[1] I. Radelytskyi,[1] P. Aleshkevych,[1] T. Yamamoto,[3] T. Seki,[3,4] K. Takanashi,[3,4] V.V. Chabanenko,[2] V.N. Krivoruchko,[2] and L.T. Baczewski[1]

[1] *Institute of Physics, Polish Academy of Sciences*
[2] *A. Galkin Donetsk Institute for Physics and Engineering NASU*
[3] *Institute for Materials Research, Tohoku University*
[4] *Center for Spintronics Research Network, Tohoku University*

Magnetic properties and ferromagnetic resonance of the two series of epitaxially grown $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) Heusler alloys thin films, *i.e.* MgO/Cr/CFMS/Au and MgO/Cr/Ag/CFMS/Au of different thicknesses of the magnetic layer were investigated. In the case of 30 nm magnetic layer deposited on additional silver buffer layer two resonances were observed in the external magnetic field near the perpendicular to the sample surface angle, suggesting heterogeneous structure of the magnetic layer. One of these resonances has a spectacular fine structure consisting of over a dozen of lines, which can be related to the spin wave resonance. The most interesting observation features are superposition of two resonances in strictly perpendicular external magnetic field position and surprising angle dependence of multilinear effect.

P-3-18

Slow magnetic relaxation in the single-ion magnet $CsNd(MoO_4)_2$

Vladimír Tkáč,[1] Alžbeta Orendáčová,[1] Róbert Tarasenko,[1] Martin Orendáč,[1] and Alexander Feher[1]

[1] *Institute of Physics, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic*

The present work is devoted to the study of the magnetic relaxation in $CsNd(MoO_4)_2$. The absence of a phase transition to the ordered state down to 50 mK predetermines $CsNd(MoO_4)_2$ as the candidate for novel mononuclear lanthanide-based single-ion magnets. Nd^{3+} ions with the ground state $^4I_{9/2}$ are responsible for the magnetic properties. Low-symmetry crystal field splits this state into 5 doublets with large energy separation between the ground and first excited doublet, inducing easy-axis anisotropy. AC susceptibility measurements performed in various magnetic fields (B = 0 – 5 T) and frequencies (f = 1 Hz – 1kHz) revealed rather complex field-induced slow magnetic relaxation. Temperature dependencies of the relaxation times at the different time scale extracted from Cole-Cole diagrams indicate several relaxation channels. Possible origin of the nontrivial observed relaxation phenomenon considering quantum tunnelling and nuclear degrees of freedom is discussed.

This work has been supported by VEGA grant 1/0269/17, ITMS26220120047, APVV-14-0073 and APVV-14-0078.

P-3-19

Magnetization dynamics in heavy metal/ferromagnet/heavy metal trilayers induced by spin Hall effect

S. Zietek,[1] W. Skowroński,[1] J. Chęciński,[1] J. Kanak,[1] M. Cecot,[1] P. Kuświk,[2] M. Schmidt,[2] J. Aleksiejew,[2] F. Stobiecki,[2] and T. Stobiecki[1]

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

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

The spin Hall effect in heavy metals (HM) converts a charge current into a pure spin current, which may exert a torque on the magnetization in the adjacent ferromagnet (FM). In HM/FM/HM trilayers, the additional Oersted fields induced by the current flow may cancel each other out, which leads to pure spin-Hall-induced dynamics. In this work, trilayers consisting of W/CoFeB/Pt were deposited using magnetron sputtering. Pt and W were chosen due to the opposite sign of spin Hall angle. The ferromagnetic resonance (FMR) spectra in microstrips were measured using spin diode technique. The developed model based on FMR line-shape analysis enables derivation of the total spin Hall angle.

The project is supported by Polish National Center for Research and Development grant No. LIDER/467/L-6/14/NCBR/2015. SZ. acknowledges the Dean's Grant and TS. acknowledges the statutory Grant 11.11.230.017.

P-3-20

Hysteresis behaviour of skyrmions in Pt/Co/Au multilayer nanodots

M. Zelent,[1] M. Mruczkiewicz,[2] J. Tobik,[2] M. Krawczyk,[1] and K.Y. Guslienko[3,4]

[1]*Faculty of Physics, AMU, Umultowska 85, Poznan, Poland*

[2]*IEE, SAS, Dubravska cesta 9, Bratislava, Slovakia*

[3]*Depto. Fisica de Materiales, Universidad del País Vasco, 20018 San Sebastian, Spain*

[4]*IKERBASQUE, the Basque Foundation for Science, 48013 Bilbao, Spain*

The magnetic skyrmion stability is studied theoretically in circular Pt/Co/Au multilayer stacks with perpendicular magnetic anisotropy and interface Dzyaloshinskii-Moriya interaction (DMI). We are focusing on skyrmion behaviour in dependence on different parameters like a diameter of the dot and number of multilayer repetitions. For patterned structures consisting of several repetitions we observed two stable skyrmion magnetic configurations with a significant difference in their skyrmion diameters. We found reversible hysteresis loops of the skyrmion radius as a function of the external magnetic field. It gives realistic opportunities to create memory cells where change of the magnetization state, defined by the skyrmion diameter, would be realised with sweeping the external magnetic field or change in the spin-polarized current.

P-3-21

Magnetism of PrFeAsO parent compound for iron-based superconductors studied by Mössbauer spectroscopy

K. Komędera,[1] A. Pierzga,[1] A. Błachowski,[1] K. Ruebenbauer,[1] S. Katrych,[2] and J. Karpinski[2]

[1] *Mössbauer Spectroscopy Laboratory, Pedagogical University, PL-30-084 Kraków, ul. Podchorążych 2, Poland*

[2] *Institute of Condensed Matter Physics, EPFL, CH-1015 Lausanne, Switzerland*

The PrFeAsO was studied by Mössbauer spectroscopy in temperature range 4.2 – 300 K. An itinerant 3d magnetic order develops at about 165 K and it is accompanied by an orthorhombic distortion of the chemical unit cell. A complete longitudinal 3d incommensurate spin density wave (SDW) order develops at about 140 K. A region between above two temperatures is called a "nematic" phase with poorly understood microscopic magnetic properties. Significant part of SDW along propagation direction is almost free of the ordered electronic spins in the "nematic" region. Hence, it is likely that somewhat "mysterious nematic" phase is a region of incoherent spin density wavelets typical for a critical region.

P-3-22

Controllable transport of surface electrons in a topological-insulator-based magnetic structure

S. Kudła,[1] P. Rzeszutko,[1] and V.K. Dugaev[1]

[1] *Department of Physics and Medical Engineering, Rzeszów University of Technology, al. Powstańców Warszawy 6, 35-959 Rzeszów, Poland*

We discuss the possibility of using a structure with a local magnetization region on top of a topological insulator (TI) to control transport of surface electrons. If the magnetization is oriented perpendicularly to the surface of TI, it opens the gap in the energy spectrum of surface electrons. The structures of this type attracted a lot of attention recently due to the possibility of effective control of magnetization and resistance by the electric current [1]. We consider the cases of one- and two-dimensional motion of electrons. For the 1D case we find similar formulae like presented in [2] for a different choice of the Hamiltonian describing Bi_2Se_3 TI. We have calculated conductance and thermoelectric coefficient [3]. Both of them reveal some oscillations because the main effect is related to the dependence of transmission on the length of magnetic region.

References:

[1] B. Scharf et al., Phys. Rev. Lett. **117**, 166806 (2016)
[2] T.Yokoyama, Phys. Rev. B **84**, 113407 (2011)
[3] P.R. Rzeszutko et al., arXiv:1702.07568 (2017)

P-3-23

Influence of temperature on the magneto-dielectrics effect of oil-based ferrofluid

J. Kúdelčík,[1] Š. Hardoň,[1] P. Bury,[1] M. Timko,[2] and P. Kopčanský[2]
[1] *Department of Physics, University of Žilina, Žilina, Slovakia*
[2] *Institute of Experimental Physics, SAS, Košice, Slovakia*

Magneto-dielectrics effect of the transformer oil-based ferrofluid with magnetic nanoparticles upon the effect of an external magnetic field and temperature were studied by dielectric spectroscopy. The frequency dependence of complex permittivity and dissipation factor were measured within the frequency range from 1 mHz to 10 kHz by a capacitance method. The dielectrics parameters were measured as a function of the external magnetic field in the range of 0 – 200 mT, parallel to the direction of the electric field and as a function of temperature in the range of 15 – 35 ^{o}C. In the presence of the magnetic field the interaction between the magnetic field and magnetic moments of nanoparticles led to the aggregation of magnetic nanoparticles to new structures which had influence on dielectric parameters. The dependence of these parameters at constant magnetic field on angle between the direction of the electric and magnetic fields (anisotropy) has been measured, too.

VEGA 2/0016/17 and 1/0510/17

P-3-24

Temperature influence on Matteucci Effect in Fe-based amorphous wire

T. Charubin,[1] and M. Kachniarz[2]
[1] *Institute of Metrology and Biomedical Engineering, Warsaw University of Technology*
[2] *Industrial Research Institute for Automation and Measurement PIAP*

The Matteucci Effect (ME) is one of the magnetomechanical effects, among others, like magnetostriction, magnetoelasticity, etc. The main result of this effect is a change in circular magnetization of the sample under the influence of applied variable axial magnetic field. In the case of wire samples, the ME manifests itself as induced sharp voltage spikes at the ends of the sample.

Environmental conditions, such as temperature, often change some of the magnetic parameters of materials, such as coercivity. The influence of the temperature change of devices which utilize ME sensors could have significant impact on the device's operation.

The ME voltage spikes response in amorphous Fe-based wires in the function of temperature was investigated in this paper.

P-3-25

Electronic and magnetic properties of cathode materials for Li-ion batteries studied by electronic structure calculations

M. Rybski,[1] J. Molenda,[1] and J. Tobola[1]

[1] *AGH University of Science and Technology, Krakow, Poland*

The close correlations between electronic structure and electrochemical properties of lithium-ion cathode materials have been investigated in recent years. In particular, the impact of electronic structure features on the discharge curve in A_xMO_2 (A=Li, Na, M=Mn, Co, Ni) has recently been reported based on experimental and theoretical investigations [1,2]. We present results of electronic structure calculations for a novel variant of the well-known Li-ion battery material $Li_xCo_{1-y-z}Ni_yMn_zO_2$, using the Korringa-Kohn-Rostoker method with the coherent potential approximation, which is especially well adapted to account for complex chemical disorder. Electronic densities of states computed for different Li and Co/Ni/Mn concentrations show that electronic structure of $Li_xCo_{1-y-z}Ni_yMn_zO_2$ exhibits half-metallic properties in wide range of Li content. Noteworthy, magnetic moments of Co, Ni and Mn can be a subject of magnetic frustration due to the rhombohedral crystal structure. It is found that computed density of states details are sensitive to assumed magnetic ordering and also to deformation of O octahedra.

References:

[1] J. Molenda *et al.*, Physical Chemistry Chemical Physics, **16** (2014) 14845.

[2] A. Milewska *et al.*, Solid State Ionics, **263** (2014) 110–118.

P-3-26

Influence of transition metal substitution on the low-field magnetic properties in the $Gd(Ni_{1-x}T_x)_3$ (T=Fe, Co) intermetallic compounds

Anna Bajorek,[1,2] and Grażyna Chełkowska[1,2]

[1] *A. Chełkowski Institute of Physics, University of Silesia in Katowice, Uniwersytecka 4, 40-007 Katowice, Poland*

[2] *Silesian Center for Education and Interdisciplinary Research, University of Silesia in Katowice, 75 Pułku Piechoty 1A, 41-500 Chorzów, Poland*

The low-field magnetic properties of polycrystalline $Gd(Ni_{1-x}T_x)_3$ (T = Fe, Co) intermetallic compounds are presented. The whole system crystallizes in the rhombohedral $PuNi_3$ type of crystal structure. The composition dependence of the Curie temperature $T_C(x)$ is associated with the change in the number of 3d electrons. Moreover, the field cooled and zero field cooled (FC-ZFC) curves at low applied magnetic field are related to the anisotropy of T element. The saturation magnetic moment $M_S(x)$ upon doping was estimated based on the hysteresis loops M(H). The values of T_C for several compounds were confirmed by electrical resistance measurements.

P-3-27

BCC to FCC transformation in Fe_2MnGa Heusler alloy films

Y.V. Kudryavtsev,[1] A.K. Melnyk,[2] I. Gościańska,[3] and J. Dubowik[4]

[1] *Inst. of Metal Physics, NAS of Ukraine, 03142 Kiev, Ukraine*

[2] *Inst. for Sorption and Problems of Endoecology NAS of Ukraine, 03164 Kiev, Ukraine*

[3] *Faculty of Physics, A. Mickewicz University, 61-614, Poznań, Poland*

[4] *Inst. of Molecular Physics, PAS, 60-179 Poznań, Poland*

A BCC to FCC transformation is observed in microcrystalline Fe-Mn-Ga Heusler alloy (HA) films. The transformation results in a drastic increase in the magnetization, the Curie temperature as well as in a change of the sign of temperature coefficient of resistivity from negative to positive. These effects are discussed in terms of band structures of $L2_1$ and $L1_2$ phases of stoichiometric Fe_2MnGa HA.

This work has been supported by the project "Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)" Contract No. 644348 with the European Commission, as part of the Horizon2020 Programme.

P-3-28

Spin waves eigenoscillations in ferromagnetic thin film with the single hole

O. Busel,[1] M. Zelent,[2] O. Gorobets,[1] Yu. Gorobets,[1,3] and M. Krawczyk[2]

[1] *Faculty of Mathematics and Physics, NTUU "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine*

[2] *Faculty of Physics, AMU, Poznan, Poland*

[3] *Institute of Magnetism NAS and MES of Ukraine, Kyiv, Ukraine*

We investigate the influence of alternating microwave magnetic field on a Py thin film with a single circular antidot. We found that the main reason of non-uniform oscillations occurrence, i.e. emergence of spin waves, is a magnetostatic field, caused by the presence of a hole. In order to create an analytical model of small deviations from the equilibrium values of the magnetic moment and magnetic field, we solve the linearized L-L equation as an eigenproblem in the direct space. Our model shows that in the direction perpendicular to the applied static field, there is maximum magnetization amplitude which is localized near the antidot edge and it decreases amplitude with increasing the distance from the edge. We also define the conditions of the local ferromagnetic resonances, which are different in different directions, and finaly visualize the resonance frequency dependency on the field magnitude.

P-3-29

Tamm and Shockley states in 1D planar magnonic crystals

J. Rychły,[1] and J.W. Kłos[1]

[1] *Faculty of Physics, Adam Mickiewicz University in Poznan, Umultowska 85, Poznań, 61-614, Poland*

We have investigated spin wave surface states (SSs), localized on the surfaces resulting from the breaking of the periodic structure of 1D planar magnonic crystals (MCs). We have considered (i) MC in an exchange regime with periodic changes of anisotropy field (ii) bi-component MC in dipolar-exchange regime. To implement the symmetry related criteria for existence of the SSs we chose the symmetric unit cell for both systems. We also investigated SSs induced by the presence of perturbation of the surface areas of the MCs. We showed, that the system with modulated anisotropy is a direct analog of the electronic crystal. For SSs existing in MCs in dipolar regime we demonstrated that spin waves preserve distinct differences to the electronic crystals, which are due to long-range dynamic dipolar interactions. We found that tuning of the strength of magnetization pinning resulting from the surface anisotropy or dipolar effect is vitally important for existence of the SSs in MCs. [1]

References:

[1] J. Rychły, J. W. Kłos, 2017, J. Phys. D: Appl. Phys., DOI: 10.1088/1361-6463/aa5ae1

This work was supported by grants: NSC Poland grants - UMO-2012/07/E/ST3/00538, UMO-2016/21/B/ST3/00452 and EUs Horizon2020 grant - GA No. 644348(MagIC).

P-3-30

Spin waves excitations in cylindrical nanowire in crosover dipolar-exchange regime

J. Rychły,[1] V.S. Tkachenko,[2] R.I. Peleschak,[3] J.W. Kłos,[1] A. Kuchko,[4] and M. Krawczyk[1]

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

[2] *Vasyl' Stus Donetsk National University, Vinnytsia, Ukraine*

[3] *Drohobych Ivan Franko State Pedagogical University, Drohobych, Ukraine*

[4] *Institute of Magnetism of NAS of Ukraine, Kyiv, Ukraine*

We investigated the spin wave dynamics in solid Ni nanowire of circular cross section[1]. We use semi-analytical calculations and numerical computation based on finite element method to find spin wave eigenmodes using the Landau-Lifshitz equation. We identified the dispersion branches and their (anti)crossing by: (i) calculating the contribution of exchange and dipolar energies, (ii) plotting the spatial profiles of spin wave amplitudes and magnetostaic potential. We showed that the frequency and the group velocity of different waveguide modes can be tuned by the application of external magnetic field.

References:

[1] T. K. Das and M. G. Cottam, J. Appl. Phys. 109, 07D323 (2011)

This work was supported by grants: NSC Poland grant - UMO-2012/07/E/ST3/00538, EUs Horizon2020 grant - GA No. 644348(MagIC).

P-3-31

Graded index spin wave fibers

P. Gruszecki,[1] and M. Krawczyk[1]
[1] *Faculty of Physics, Adam Mickiewicz University in Poznań, Umultowska 85, 61-614 Poznań, Poland*

Spin waves (SWs) are promising information carriers that can be used in designing of a new class of efficient and low energy consuming information processing devices – magnonic units. However, before their practical realization and commercialization, the development of structures for efficient SWs guiding is required. We propose to exploit continuous variation of the SW's refractive index (SWRI). Using iso-frequency dispersion contours analysis supported by micromagnetic simulations we study the SW beam propagation in thin ferromagnetic films with slowly varied in space SWRI. Then, we use acquired knowledge to study influence of SWRI variation at the edges of the narrow ferromagnetic stripes on the SW transmission. Such systems can be considered as a magnonic graded-index waveguides, which have improved properties required for magnonic applications.

We acknowledge the financial assistance from National Science Centre of Poland project UMO-2012/07/E/ST3/00538 and the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348 (MagIC).

P-3-32

Magnetic properties and magnetic structures in $R_2Ni_{2-x}In$ (R = Gd–Tm) for x = 0 and (0.22 or 0.3)

S. Baran,[1] A. Szytuła,[1] Yu. Tyvanchuk,[2] A. Hoser,[3] T. Jaworska-Gołąb,[1] J. Przewoźnik,[4] R. Duraj,[5] B. Penc,[1] and Ya. Kalychak[2]
[1] *Jagiellonian University, Kraków, Poland*
[2] *Ivan Franko National University of Lviv, Lviv, Ukraine*
[3] *Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany*
[4] *AGH University of Science and Technology, Kraków, Poland*
[5] *Technical University of Cracow, Kraków, Poland*

The $R_2Ni_{2-x}In$ (R=Gd–Tm) compounds were investigated by means of different experimental techniques including X-ray diffraction, magnetic and specific heat measurements as well as powder neutron diffraction. The title compounds show two different crystal structure variants, namely: an orthorhombic one of the Mn_2AlB_2-type in the stoichiometric composition R_2Ni_2In and a tetragonal one of the Mo_2FeB_2-type in the nonstoichiometric composition $R_2Ni_{2-x}In$. All compounds show antiferromagnetic ordering at low temperatures, however, for a selected rare earth element the Néel temperature found for stoichiometric composition is higher than the one found for nonstoichiometric composition. Neutron diffraction experiments, performed for selected compounds, indicate that rare earths magnetic moments form collinear magnetic structures which are commensurate with the crystallographic unit cells.

P-3-33

Spin-waves transmission through the interface with broken spatial inversion symmetry

Y. Gusieva,[1] J. Rychły,[2] P. Gruszecki,[2] M. Krawczyk,[2] O. Gorobets,[1,3] and Y. Gorobets[3]

[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine*

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

[3] *Institute of Magnetism, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

One of the biggest challenge in magnonics is spin waves (SWs) amplitude and phase manipulation at subwavelength distances. We study analytically and numerically transmission of normally incident SWs through an ultra-narrow interface with asymmetrical properties. In analytical model we consider the system consisting of two semi-infinite ferromagnetic medias separated by an interface. Between those medias we assume boundary conditions with broken spatial inversion symmetry (BSIS). These results are then verified numerically with assumed few-nanometres narrow interface region with a non-symmetrical magnetic properties. We present that transmission in such systems varies if wave incident from the one or the another side of the interface.

This work was supported by Horizon2020 - GA No. 644348(MagIC).

P-3-34

Spin waves in planar quasicrystal of Penrose tiling

J. Rychły,[1] S. Mieszczak,[1] and J.W. Kłos[1]

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

We investigated two-dimensional magnonic structures which are the counterparts of photonic quasicrystals forming Penrose tiling. We considered the slab composed of Ni (or Py) disks embedded in Fe (or Co) matrix. The disks were arranged in quasiperiodic Pernose-like structure. The infinite quasicrystal was approximated by its rectangular section with periodic boundary conditions applied. This approach allowed us to use the plane wave method to find the frequency spectrum of eigenmodes for spin waves and their spatial profiles. The calculated integrated density of states shows more distictive magnonic gaps for the structure composed of materials of high magnetic contrast (Ni and Fe) and relatively high filling fraction. This proves the impact of quasiperiodic long-range order on the spectrum of spin waves. We also investigated the localization of SW eingenmodes resulting from the quasipeiodicity of the structure.

References:

[1] J. Rychły, S. Mieszczak, J.W. Kłos, https://arxiv.org/abs/1701.09125

This work was supported by grants: NSC Poland - UMO-2012/07/E/ST3/00538, EUs Horizon2020 - GA No. 644348(MagIC).

P-3-35

Spin waves in waveguide with zig-zag antidot pattern

S. Pan,[1] J.W. Kłos,[2] S. Mieszczak,[2] A. Barman,[1] and M. Krawczyk[2]

[1] *Department of Condensed Matter Physics and Material Sciences, S. N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata, India*

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

We considered[1] the planar magnonic waveguide with a periodic sequence of antidots forming zig-zag pattern, where two neighboring antidots are shifted towards the opposite edges of the waveguide. We have shown that new frequency gaps can be opened due to the complex base of the system and their width can be controlled by the shift of the antidots. We found that, the different strength of spin wave pinning at the edges of the periodic waveguide (and their antidots) determines the dependence of the width of gap on the shift of antidots. We indentified an optimum shift of antidot for maximzing the width of the gap for the system with pinned magnetization. We noticed that for this kind of geometry of the waveguide, the majority of the modes are doubly degenerate at the edge of Brillouin zone and have a non-zero group velocity at the very close vicinity of the edge of Brillouin zone, for larger values of antidot shift.

References:

[1] S. Pan, J. W. Kłos, S. Mieszczak, A. Barman, M. Krawczyk, https://arxiv.org/abs/1702.04667v2

This work was supported by grants: Indo-Polish Project - DST/INT/POL/P-11/2014, NSC Poland grant - UMO-2012/07/E/ST3/00538, Eus Horizon2020 gran - GA No. 644348(MagIC), Govt. of India for INSPIRE fellowship.

P-3-36

Crystal structure and magnetic properties of pyrrhotite-type compounds $Fe_{7-y}V_yS_8$

N.V. Selezneva,[1] P.N. Ibrahim,[1] N.M. Toporova,[1] E.M. Sherokalova,[1] and N.V. Baranov[1,2]

[1] *Institute of Natural Sciences and Mathematics, Ural Federal University, 620083, Ekaterinburg, Russia*

[2] *Institute of Metal Physics, Russian Academy of Science, 620990, Ekaterinburg, Russia*

The magnetic behavior of the ferrimagnetic compound Fe_7S_8 (pyrrhotite) with a layered superstructure of the NiAs type is strongly dependent on the distribution and ordering of vacancies and substitutions [1]. The aim of the present work is to study how the substitution of V for Fe affects the crystal structure, phase transition and magnetic properties of $Fe_{7-y}V_yS_8$ compounds. Together with changes in the period of superstructure the growth of the V content in $Fe_{7-y}V_yS_8$ is observed to result in a sharp decrease in the resultant magnetization, non-monotonous change of the coercive field and reduction of the magnetic ordering temperature. This work was supported by the RFBR (projects No 16-02-00480 and 16-03-00733) and by the Ministry of Education and Science of Russia (project No 3.2916.2017).

References:

[1] N. N.V. Baranov *et al.*, J. Physics: Condensed Matter. 27 (2015) 286003

P-3-37

Goos-Hänchen shift of spin-wave beam in transmission and reflection through interface between two ferromagnetic films

M. Mailian,[1] P. Gruszecki,[2] O. Gorobets,[1] and M. Krawczyk[2]

[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", 37 Peremogy ave., 03056, Kyiv, Ukraine*

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

Spin waves (SWs) are promising information carrier, for practical applications the control over SWs amplitude and phase is crucial. We analyse analytically and numerically reflection and refraction of SWs at the interface between two ferromagnetic materials. In analytical model we consider the system of two semi-infinite ferromagnetic medias separated by the interface region. These results are verified by micromagnetic simulations for thin film geometry. We have found the Goos-Hänchen shift for SWs in transmission and reflection and performed detailed investigations of its dependence on the incidence angle, anisotropy of the interface and surrounding materials.

We acknowledge the financial assistance from National Science Centre of Poland project UMO-2012/07/E/ST3/00538 and the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie No 644348 (MagIC).

P-3-38

Linear spin chains in paramagnetic and in ordered bulk magnets

A. Hoser,[1] and U. Köbler[2]

[1] *Helmholtz-Zentrum Berlin, 14109 Berlin, Germany*

[2] *Peter Grünberg Institute , Research Centre Jülich, 52425, Germany*

It is shown that magnons are not specific to the magnetically ordered state. Magnons near zone boundary exhibit nearly no anomaly at the magnetic ordering transition and persist into the paramagnetic phase. As we have shown earlier, in the ordered state, spin dynamics is controlled by coherent boson fields instead by magnons. The field bosons are essentially magnetic dipole radiation emitted by the precessing spins. Since emission is by stimulated emission, the basic field resembles the radiation field of a LASER. One-dimensional boson fields are the origin of the perfect collinear spin structure within each domain. Three-dimensional dynamics results by some vector coupling of the one-dimensional basis fields. Here we discuss examples of perfectly one-dimensional magnon modes in magnets with high lattice symmetry. Magnon propagation is along domain axis and is as for the linear spin chain. In contrast to the one-dimensional boson fields of the differently oriented domains that can couple to an isotropic global field, magnons are confined to the volume of the domain and remain one-dimensional also in magnets with isotropic global dynamics.

P-3-39

Are there optical magnons?

U. Köbler[1]

[1]*Research Center Jülich, Institute PGI, 52425 Jülich, Germany*

Optical magnons can occur in magnets with two chemically different magnetic species only. However, exchange interactions between in-equivalent magnetic moments are weak because free exchange of electrons appears not generally possible. To the best of our knowledge optical magnons have never been identified experimentally. Confusion is provided by the fact that two magnon branches commonly occur in antiferromagnets with ferromagnetically ordered crystallographic planes and opposite spin orientations from plane to plane. This applies to $MnO, EuTe, CoCl_2, Fe_2O_3, K_2MnF_4$. Associated with the ferromagnetic planes is a particular low-energy magnon branch. The high-energy magnon branch is the antiferromagnetic magnon branch and not an optical magnon. Because of weak exchange interactions between chemically different magnetic moments, the two magnon branches in Fe_3O_4 can be attributed to the FeO and to the Fe_2O_3 subsystem, respectively. The order parameters of the FeO subsystem and of the Fe_2O_3 subsystem have different temperature dependencies. In $Rb_2Mn_{0.5}Ni_{0.5}F_4$ the two magnon branches can be attributed to the Rb_2MnF_4 and to the Rb_2NiF_4 subsystem, respectively. Search for low-energy optical magnons remains a big challenge for inelastic neutron scattering.

P-3-40

The study of structure and magnetic properties of $Cr_6Fe_{18}Mo_5$ phase compound

J. Rzącki,[1] and K. Gruszka[1]

[1]*Institute of Physics, Faculty of Production Engineering and Materials Technology, Czestochowa University of Technology,*
19 Armii Krajowej street, 42-200 Czestochowa, Poland

Paper presents results of structure and magnetic properties investigation for phase $Cr_6Fe_{18}Mo_5$ obtained in the isothermal annealing process. Structural and magnetic inestigations for preparated samples were conducted using XRD and VSM equipement and using ab initio calculations. X-Ray diffraction patterns were submitted to the Rietveld refinement analysis. From the density functional theory (DFT) calculations, an equilibrium lattice parameters and magnetic properties were obtained.

P-3-41

Interplay of crystal structure preference and magnetic ordering in Cr-Co-Fe-Ni-Al high entropy alloys

K. Jasiewicz,[1] S. Kaprzyk,[1] and J. Tobola[1]

[1] *AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Al. Mickiewicza 30, 30-059 Krakow, Poland*

Recently, Korringa-Kohn-Rostoker method with coherent potential approximation (KKR-CPA) was successfully applied to investigate theoretically the crystal structure transition (bcc/fcc) in $CrCoFeNiAl_x$ [1] as well as the superconducting properties in Ta-Nb-Hf-Zr-Ti [2]. In this work, some relations between crystal structure and magnetic ordering in $CrCoFeNiAl_x$ HEAs are discussed in view of the KKR-CPA calculations. Remarkably, it is noticed that the transition between bcc and fcc phases in all analysed alloys is closely related to re-arrangement of the local magnetic moments, namely the magnetic moment on Cr is either parallel (ferromagnetic) or antiparallel (ferrimagnetic) to the magnetic moments of other atoms (Co, Fe and Ni). Finally, the results of KKR-CPA calculations of $CrCoFeNiAl_x$ in 'paramagnetic-like' state are also discussed.

References:

[1] K. Jasiewicz, J. Cieslak, S. Kaprzyk, J. Tobola, J. Alloys Compd 648, 307 (2015)

[2] K. Jasiewicz, B. Wiendlocha, P. Korbeń, S. Kaprzyk and J. Tobola , Phys. Stat. Sol. (RRL) 10 (2016)

P-3-42

The investigation of magnetic susceptibility of compound a-Tb_3Sn_7

V. Kordan,[1] I. Oshchapovsky,[1] B. Harbrecht,[2] C. Pietzonka,[2] and V. Pavlyuk[1,3]

[1] *Department of Inorganic Chemistry, Ivan Franko National University of Lviv, Kyryla i Mefodiya Str. 6, 79005 Lviv, Ukraine.*

[2] *Department of Chemistry and Materials Science Centre, Philipps University of Marburg, Hans-Meerwein-Strasse 4, 35032 Marburg, Germany.*

[3] *Institute of Chemistry and Environmental Protection, Jan Dlugosz University, Armii Krajowej 13/15 Ave., 42-200 Czestochowa, Poland.*

The title compound crystallizes in own structure type (sp. group Cmmm, a=4.3633Å, b=4.4378 Å, c=26.336 Å) and has split position, consisting of three Sn atoms. This, together with presence of magnetic rare-earth metal stimulated us to study a-Tb_3Sn_7. The alloy, synthesised by arc melting and annealed at 700 C, had a-Tb_3Sn_7 as main phase and traces of Tb_2O_3 and Sn. DC magnetization measurements were carried out on SQUID magnetometer at T=2-350 K and fields up to 5.5 T. The compound is Curie-Weiss paramagnet at T>50 K with magnetic moment per Tb atom 9.56 μB, close to value for ion Tb (3+).

P-3-43

Influence of the Cu doping on the Electronic Structure and Magnetic Properties of the Mn_2VAl Heusler compound

R. Gavrea,[1] A. Bolinger,[1] V. Pop,[1] O. Isnard,[2,3] M. Coldea,[1] and D. Benea[1]

[1] *Babes-Bolyai University Faculty of Physics, 400084 Cluj-Napoca, Romania*

[2] *Université Grenoble Alpes, Institut Néel, Grenoble, F 38042, France*

[3] *CNRS, Institut Néel, 25 rue des Martyrs, F-38042 Grenoble, France*

Detailed investigations on the electronic and magnetic properties of the Heusler compounds $Mn_{2-x}Cu_xVAl$ (x = 0 to 0.5) with $L2_1$ structure have been performed. The $Mn_{2-x}Cu_xVAl$ ingots were prepared by induction melting under a purified Ar atmosphere. The resulting samples have been studied by X-ray diffraction (XRD) and magnetization measurements. The degrees of the B2 and $L2_1$ atomic ordering were obtained by using the Takamura's extended order model. The Curie temperatures decrease with Cu content, from 771 K (x = 0) to 580 K (x = 0.5). Additionally, electronic band structure calculations using the KKR Greens function method have been performed, taking into account the site occupation obtained by XRD measurements. The substitutional disorder was accounted by the means of the Coherent Potential Approximation (CPA). Our study gives insight on the evolution of the half-metallic fully compensated ferrimagnet (HMF) character with disorder and Cu doping.

The financial support of the UEFISCDI grant PN-II-RU-TE-2014-4-0009 is acknowledged.

P-3-44

Spin Wave Propagation through the System of two RKKY Coupled Ferromagnets

O.Y. Gorobets,[1,2] Y.I. Gorobets,[2] M. Mailian,[1] M. Zelent,[3] and M. Krawczyk[3]

[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", 37 Peremogy ave., 03056, Kyiv, Ukraine*

[2] *Institute of Magnetism, National Academy of Sciences of Ukraine, 36-b Vernadskogo st., 03142, Kyiv, Ukraine*

[3] *Faculty of Physics, Adam Mickiewicz University in Poznan, Umultowska 85, Poznań, 61-614, Poland*

The new possibility to introduce a controlled phase shift of the propagating spin-waves is in transmission through an ultrathin nonmagnetic metallic spacer separating two ferromagnets, with a thickness much less than the spin-wave wavelength. This allows controlling the phase of the spin-waves by means of application of external magnetic field. In the case of the two Co films, the change of the Cu spacer thickness by one monolayer may allow to introduce the change of the spin-wave phase.

We acknowledge the financial assistance from National Science Centre of Poland project UMO-2012/07/E/ST3/00538 and the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie No 644348 (MagIC).

P-3-45

Antiferromagnetic order in the half-Heusler phase TbPdBi

O. Pavlosiuk,[1] M. Kleinert,[1] D. Kaczorowski,[1] and P. Wiśniewski[1]

[1] *Institute of Low Temperature and Structure Research, PAS, Wrocław, Poland*

In recent years, half-Heusler compounds became particularly attractive from the point of view of their possible topologically non-trivial electronic structure. Antiferromagnetic half-Heusler compounds are especially interesting due to the fact that some of them were theoretically predicted to be antiferromagnetic topological insulators [1,2]. In fact, antiferromagnet GdPtBi has recently been verified experimentally as a Weyl semimetal [3]. In this work, we studied single crystals of TbPdBi, another representative of the group of half-Heusler bismuthides. By means of magnetic susceptibility, heat capacity, electrical resistivity, magnetostriction and thermal expansion measurements, the compound was characterized as an antiferromagnet with the Néel temperature $T_N \approx 5.3\,\mathrm{K}$. Neutron diffraction experiment confirmed the antiferromagnetic ordering and yielded the propagation vector $k = (0.5, 0.5, 0.5)$. Remarkably, this k vector is in accord with the theory of antiferromagnetic topological insulators [1] and equal to that reported for GdPtBi [2].

References:

[1] R.S.K. Mong A.M. Essin, J.E. Moore, Phys. Rev. B **81**, 245209 (2010).
[2] Müller, et al. Phys. Rev. B **90**, 041109(R) (2014).
[3] M. Hirschberger, et al. Nat. Mater. **15**, 1161 (2016).

Work supported by the National Science Centre (Poland); grant no. 2015/18/A/ST3/00057

P-3-46

Propagation of spin waves in ferrite films with metasurface

S. Vysotskii,[1] G. Dudko,[1] V. Sakharov,[1] Y. Khivintsev,[1] Y. Filimonov,[1]
N. Novitskii,[2] A. Stognij,[2] and S. Nikitov[1]

[1] *Kotelnikov SBIRE RAS, 38 Zelenaya str., 410019, Saratov, Russia*
[2] *SPMRC NAS of Belarus, 66 Independence Avenue, 220072, Minsk, Belarus*

MSSW propagation in YIG films with "leaky" and "resonant" subwave-length periodic metasurfaces (MS) was studied. "Leaky" MS was formed by ion-etching, while "resonant" MS - by stacking the array of magnetic microparticles and plane YIG film. The filtering effects and dispersion of MSSW in the film with 1D "leaky" MS were studied as functions of the angle θ between the directions of magnetic field and grooves. Measured MSSW dispersion had anomalous regions whose number and width were minimal for $\theta = 0$ and maximal for $\theta = 90°$ (Laue geometry). Formation of such regions was explained as the resonant interaction of the MSSW with leaky exchange modes of the periodic structure. The long-wavelength part of MSSW dispersion could be described as the dispersion of a homogeneous film in the magnetic field averaged over the structure period. MSSW diffraction in the Laue geometry and an analogy with the formation of the Borrmann and anti-Borrmann modes were also discussed.

This work was partially supported by RFBR grants # 16-57-00153 Bel-a, 17-07-01452

P-3-47

Mn_2-type Heusler compounds as possible half-metallic fully compensated ferrimagnets

D. Benea,[1] R. Gavrea,[1] M. Coldea,[1] O. Isnard,[2,3] and V. Pop[1]

[1] *Babes-Bolyai University Faculty of Physics, 400084 Cluj-Napoca, Romania*

[2] *Université Grenoble Alpes, Institut Néel, Grenoble, F 38042, France*

[3] *CNRS, Institut Néel, 25 rue des Martyrs, F-38042 Grenoble, France*

We show detailed theoretical and experimental investigations on the electronic and magnetic properties of the Heusler compounds $Mn_{2-x}Co_xVAl$ with $L2_1$ structure and of the $Mn_2Co_{1-x}V_xAl$ with Hg_2CuTi structure type, respectively. Polycrystalline samples have been examined by X-ray and neutron diffraction and by magnetization measurements. The degrees of the atomic ordering have been evaluated from the intensity ratios of the X-ray patterns by using the Takamura's model. The Curie temperatures decrease with Co content in $L2_1$ compound, ranging between 770 K (x = 0) and 254 K (x= 1). Magnetization measurements are consistent with those predicted by Slater-Pauling rule. In addition, electronic band structure has been determined theoretically using the KKR Green's function method and the substitutional disorder was accounted for by the means of the Coherent Potential Approximation. Our study discuss the possibility to obtain a half-metallic fully compensated ferrimagnet (HMFi) in Heusler compound of Mn_2-type.

UEFISCDI grant PN-II-RU-TE-2014-4-0009 is acknowledged.

P-3-48

Competing magnetic states and magnetic character of $R\mathbf{Mn_2X_2}$ (R: rare earth; X: Si, Ge)

E. Duman,[1] and M. Acet[2]

[1] *Department of Energy and Materials Engineering, Ankara University, 06380, Gölbaşı, Ankara*

[2] *Experimentalphysik, Universität Duisburg-Essen,D-47048 Duisburg, Germany*

Intermetallic $R\mathrm{Mn_2X_2}$ compounds (R: rare earth; X: Si, Ge) exhibit a variety of temperature-induced magnetic phase transitions and order in diverse magnetic configurations as a result of the exchange interactions between the f and d electronic states. For this reason, these compounds have attracted particular attention and were thoroughly investigated for their magnetic properties.In the present work, we have extended the investigations on the magnetic properties of $R_{1-x}R'_x\mathrm{Mn_2}X_2$ to various rare earth combinations of the silicides to access smaller lattice spacings than those which are accessible with the germanides. We found that the critical lattice spacings determining the type of magnetic exchange are not unique for both germanides and silicides and are affected by the exchange mechanism mediated by Si and Ge onto the Mn sites. Furthermore, the nature of magnetic coupling is found to influence the unit cell dimensions causing c to shrink with the onset of interlayer antiferromagnetic exchange. We provide a general magnetic phase diagram of rare earth silicides and germanides and discuss their properties.

P-3-49

Magnetic and structural studies of GeMnSnTe epitaxial layers

A. Grochot,[1] W. Knoff,[1] B. Taliashvili,[1] W. Wołkanowicz,[1] R. Minikayev,[1] A. Pieniążek,[1] M. Sawicki,[1] W. Jantsch,[2] T. Story,[1] and H. Przybylińska[1]

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

[2] *Johannes Kepler University, Linz, Austria*

Multiferroic (MF) materials which are simultaneously ferroelectric (FE) and ferromagnetic (FM) are interesting due to their potential applications, yet very rare. $Ge_{1-x}Mn_xTe$ is a semiconductor MF, with FE and FM orders coupled to each other, which leads to FE domain switching under applied magnetic field. However, ferroelectric (rhombohedral)/paraelectric (cubic) phase transition in GeMnTe cannot be investigated with the ferromagnetic resonance (FMR) technique due to FE Curie temperature,T_C^{FE}, significantly higher than T_C^{FM}. To lower T_C^{FE} GeMnTe layers co-doped with tin were grown.

We present results of XRD, SEM, SQUID and FMR studies of MBE grown GeMnSnTe layers. All were found to be both ferromagnetic and rhombohedral, with the distortion axis perpendicular to the layer surface. Only in the case of the highest Sn and Mn content the rhombohedral axis was found to be tilted from the substrate normal. Addition of Sn changes considerably the magnetocrystalline anisotropy, from purely uniaxial in GeMnTe to distorted cubic in GeMnSnTe. Moreover, domain switching is supressed.

P-3-51

Resonant magneto-acoustic switching for in-plane and out-of-plane anisotropy using Rayleigh waves

Laura Thevenard,[1] Ibrahima Camara,[1] Catherine Gourdon,[1] Aristide Lemaître,[2] and Jean-Yves Duquesne[1]

[1] *Institut des Nanosciences de Paris, UPMC CNRS, Paris, France*

[2] *Centre de Nanosciences et de Nanotechnologies, CNRS, Universite Paris Sud, Orsay, France*

Precessional switching allows sub-nanosecond and deterministic reversal of magnetic data bits: a large angle, highly non-linear, precession of magnetic moments is triggered around a bias field, and stopped at the right moment. Whereas this trigger is usually a pulsed external field, we use the effective rf field generated by inverse magnetostriction by a surface acoustic wave (SAW) on a magnetic layer. Here we show that SAW bursts can irreversibly switch the magnetization in both in-plane and out-of-plane materials: (Ga,Mn)As and (Ga,Mn)(As,P)[1], and that it is directly correlated to their resonant absorption. The influence of the SAW wave-vector and frequency were studied. By exciting a stationary wave with two counter-propagating SAWs, we have moreover imprinted and positioned with sub-micron precision a striped magnetic pattern.

References:

[1] L. Thevenard, I. S. Camara, S. Majrab, M. Bernard, P. Rovillain, A. Lemaître, C. Gourdon, and J.-Y. Duquesne, Phys. Rev. B (2016)

P-3-52

Spatial and dynamic control of magnetization with optically excited surface acoustic waves

P. Kuszewski,[1] L. Thevenard,[1] L. Belliard,[1] J.-Y. Duquesne,[1] B. Loïc,[1] S. Hidki,[1] M. Kraimia,[1] T. Amarouche,[1] M. Eddrief,[1] M. Marangolo,[1] I. Camara,[1] and C. Gourdon[1]

[1]*Sorbonne Universites, UPMC Universite de Paris 06, CNRS, Institut des Nanosciences de Paris, 4 place Jussieu, 75252 Paris, France*

Magnetoelastic interaction is a non-inductive way of controlling the magnetization using static and dynamic strain. In previous works magnetization precession has been excited using quasi plane monochromatic acoustic waves generated electrically[1]. Here we propose a different approach: ultrafast laser pulses are used to generate broadband, isotropic surface acoustic waves(SAWs), which can excite the spin waves via the magnetoelastic coupling. Extensive studies of thin FeGa and Nickel films will be shown including the mapping of acoustic and magnetic signals. The influence of SAWs on the magnetization and the optimal conditions for coupling will be discussed.

References:

[1] Thevenard, L. et al. Phys. Rev. B 93, 134430 (2016).

P-3-53

Kinetic and Relaxation Processes in Vicinity of Phase Transition in Prospective Magnetocaloric Materials

A. Kamantsev,[1] V. Koledov,[1] V. Shavrov,[1] and I. Tershina[2]

[1]*Kotelnikov IRE RAS, Moscow 125009, Russia*

[2]*Lomonosov Moscow State University, Moscow 119991, Russia*

The problem of rate of phase transitions (PTs) requires an indispensable solution, because the creation of new technologies based on "giant" effects in vicinity of PTs in magnetic materials is impossibly without solving of this problem. The rate of PT limits the frequency of thermodynamic cycles. We present a new technique for experimental study of the kinetics of the magnetic PTs under low alternating magnetic field. The new dynamic thermo-magnetometer (DTM) is proposed for solving the problem of the rate of the magnetic PT with response time of 10 ms. DTM is designed for measuring the time dependence of the magnetic susceptibility of thin plates of ferromagnets at an abrupt temperature change in water flow. As a result of experiments for Gd near Tc = 20 C relaxation time of magnetization is 50 ms (1). Recently DTM was developed for working on materials with the first order PTs. The last experiments shown big difference at heeting and cooling in relaxation time in Ni-Mn-Ga(Fe) Heusler alloys. This difference may achieves hundreds of milliseconds.

References:

[1] A.P. Kamantsev, et al. Solid State Phenomena, Vol. 215, pp. 113-118 (2014).

P-3-54

Magnetic properties of the RENi$_2$Ga$_3$In (RE = Y, Dy, Ho) compounds

M. Horiacha,[1] G. Nychyporuk,[1] D. Kaczorowski,[2] and V. Zaremba[1]

[1] *Inorganic Chemistry Department, Ivan Franko National University of Lviv, Lviv, Ukraine*

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

The quaternary indides RENi$_2$Ga$_3$In (RE = Y, Dy, Ho) were synthesized from the elements by arc-melting and subsequent annealing at 873 K. X-ray powder data for these compounds revealed isotypism with orthorombic GdNi$_2$Ga$_3$In type structure, space group *Pnma*, Pearson symbol *oP*56 [1]. Magnetic properties of the RENi$_2$Ga$_3$In compounds with RE = Y, Dy and Ho were studied down to 1.72 K. YNi$_2$Ga$_3$In appeared a Pauli paramagnet, while DyNi$_2$Ga$_3$In and HoNi$_2$Ga$_3$In were found to order antiferromagnetically below T_N = 10.5 K and 4.4 K, respectively. In the ordered state, distinct metamagnetic-like transitions were observed for both materials. At higher temperatures, strong crystalline electric field interactions were found, which significantly influence the magnetic behaviors essentially governed by Dy^{3+} and Ho^{3+} ions.

References:

[1] Ya.V. Galadzhun, M.M. Horiacha, G.P. Nychyporuk, U.Ch. Rodewald, R. Pöttgen, V.I. Zaremba, *Z. Anorg. Allg. Chem.* **2016**, 642 (16), 896-901.

P-3-55

Analysis of the impact of d- and p-electron elements on the magnetic properties of ternary intermetallic compounds of RT$_x$X$_2$ type (R – rare earth, T – transition metal, X – p-electron element)

A. Gil[1]

[1] *Faculty of Mathematics and Natural Sciences, Jan Dlugosz University in Czestochowa, Al. Armii Krajowej 13/15, 42-200 Częstochowa*

Studies of rare earth compounds with transition metals are one of the dominant trends in modern magnetism and cover a wide range of research both basic and applicative nature. The main aim of the study of lanthanide compounds is to find answers to questions concerning mechanisms of interaction between the magnetic moments. A systematic study of the magnetic properties of rare-earth compounds gives hope for full understanding of magnetism in these families of compounds.

For many years the RT$_x$X$_2$ compounds with the crystal structure of CeNiSi$_2$ – type are in the circle of my interests. Based on my own research and the results published in the literature by other authors, the impact of d- and p-electron elements on magnetic properties of the RT$_x$X$_2$ compounds, where x≤1 and T = Ni, Co, Cu, Fe, Mn, Cr will be analyzed.

P-3-56

A New Class of Hybrid Dipole Waves

A.S. Savchenko,[1] O.S. Sukhorukova,[1] A.S. Tarasenko,[1] S.V. Tarasenko,[1] and V.G. Shavrov[2]

[1]*Donetsk Institute for Physics and Engineering named after A.A. Galkin, Donetsk, Ukraine*

[2]*Kotelnikov Institute of Radio Engineering and Electronics, RAS, Moscow, Russia*

In recent years, the physics of electromagnetic metamaterials has been actively studied. In magnonics (one of the most dynamically progressing fields of the modern physics of magnetic phenomena), the creation of controllable magnetic metamaterials is also based on implementing a system of locally resonating and electromagnetically coupled structural elements (spins) Up to now, the main attention in this field has traditionally been focused on the usage of potentialities provided by the magnetic-dipole and exchange types of spin waves.

We have demonstrated that a previously unknown class of hybrid dipole waves (magnetoelectric magnons) and the additional resonances related to them can be formed in a magnetoelectric layer (for the special structure of magnetoelectric interaction tensor).

P-3-57

Features of the Ferromagnetic State of Lanthanum Manganite Weakly Doped by Bismuth

T.N. Tarasenko,[1] Z.F. Kravchenko,[1] V.V. Burkhovetskiy,[1] and A.I. Linnik[1]

[1]*Donetsk Institute for Physics and Engineering named after A.A. Galkin, Donetsk, 83114 Ukraine*

The investigation of complex oxide systems as functional materials for spintronics is of great interest today, both in solid state physics and from a practical point of view. Solid solutions based on multiferroic $BiMnO_3$ and lanthanum manganite $LaMnO_3$ are examples of systems with string correlations of magnetic and electric characteristics. Much interest has been devoted to manganites in which La^{3+} ions are replaced with Bi^{3+}. Up to now, however, there have been few works dedicated to $LaMnO_3$ weakly doped with bismuth. In addition, the question of the nature of ferromagnetism in Bi-doped lanthanum manganites remains open.

Polycrystalline samples of lanthanum manganite weakly doped with bismuth $Bi_xLa_{1-x}MnO_3$ ($x \leq 0.1$) were synthesized using the sol–gel technique. Structural and magnetic studies are performed. The considerable growth of the grain size that was is observed in the samples upon increasing the degree of doping was a consequence of the volume diffusion of Bi^{3+} ions. Studies of imaginary part of magnetic susceptibility found inhomogeneity of the ferromagnetic state and the presence of several ferromagnetic phases in the lanthanum manganites lightly doped by bismuth.

P-3-58

Influence of He^+ bombardment on compensation point of RE/TM ferrimagnetic multilayer

Ł. Frąckowiak,[1] P. Kuświk,[1] M. Matczak,[1] B. Szymański,[1] M. Schmidt,[1] J. Aleksiejew,[1] F. Stobiecki,[1] A. Tomita,[2] H. Huckfeldt,[2] and A. Ehresmann[2]

[1] *Institute of Molecular Physics, Polish Academy of Science, Poznań, Poland*

[2] *Institute of Physics and CINSaT, University of Kassel, Kassel, Germany*

Nowadays, magnetic materials based on RE/TM (Rare Earth-Transition Metal) alloys and multilayers (MLs) of those are widely studied because of their unique properties and possible future implementation in spintronic devices. The most important parameters of RE/TM MLs like the perpendicular magnetic anisotropy (PMA), the compensation point (magnetic moments from both sublattices RE and TM are compensated giving zero net magnetization), and the domination of one sublattice are mainly controlled by temperature and the ratio of RE/TM sublayer thicknesses (t_{RE} and t_{TM}, respectively). Here, we will show that using 10 keV-He^+ ion bombardment we were able to shift the compensation point to thicker RE sublayer compared to unbombarded MLs. Similarly, we found that PMA appears at higher t_{RE} after ion bombardment.

The work was financed by the National Science Centre Poland under SONATA BIS funding UMO-2015/18/E/ST3/00557

P-3-59

Influence of substitution and milling on structural and magnetic properties of $Sm(Ni_{1-x}Co_x)_3$ alloys

Marcin Sikora,[1,2] Dariusz Blachliński,[1,2] Anna Bajorek,[1,2] Krzysztof Ociepka,[1,2] Krystian Prusik,[2,3] and Grażyna Chełkowska[1,2]

[1] *Chełkowski Institute of Physics, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

[2] *Silesian Center for Education and Interdisciplinary Research, 75 Pułku Piechoty 1A, 41-500 Chorzów, Poland*

[3] *Institute of Materials Science, University of Silesia, 75 Pułku Piechoty 1A, 41-500 Chorzów, Poland*

The effect of the substitution of nickel by cobalt on the crystal structure and magnetic properties in the $Sm(Ni_{1-x}\ Co_x)_3$ has been investigated. The studied compounds have been obtained by arc melting. The XRD studies showed that all of them occur in single phase. The magnetic measurements have been performed using the SQUID for bulk samples with x=0.0, 0.1, 0.2 as well as for the sample with x=0.2 which was milled to nanoparticles form. The magnetocaloric effect was calculated from isotherms for $Sm(Ni_{0.8}Co_{0.2})_3$ in bulk form and nanopowder. The substitution of nickel by cobalt caused a decrease of the magnetocaloric effect. Reduction of this effect was even greater for nanoparticles.

P-3-60

Magnetocaloric Effect of Double Perovskite Manganite La0.8Ø0.6Ca1.6Mn2O7 having the Magnetostructural Transition

C.G. Ünlü,[1] A. Tekgül,[2] M. Acet,[3] and M. Farle[3]

[1] *Department of Biomedical Engineering, Pamukkale University, Denizli Turkey*

[2] *Department of Physics, Uludag University, Bursa, Turkey*

[3] *Faculty of Physics, Universität Duisburg-Essen, Duisburg, Germany*

The sintering of some perovskites was dominated by the diffusion of A-site cations during the densification, and A-site cation vacancies could assist the diffusion of A-site cations. Therefore, the porosities are created by this process. Furthermore, the magnetic properties and magnetocaloric effect of materials is controlling by porosity. We present a new approach introducing porosity in the bilayered Ruddlesden-Popper Perovskites $La_{1.4}Ca_{1.6}Mn_2O_7$ perovskite manganite. Here, A-site deficient is created by the evaporation of K^{1+} during the high temperature sintering and this evaporation supports the porosities of crystal structure of the material. It is shown that there is a structural transition associated with the ferromagnetic-paramagnetic transition. The results reveal that two phase transitions exist within the range from room temperature to 112 K: orthorhombic (O)-tetragonal (T)-rhombohedral (R).

P-3-61

Magnetic specific heat in perovskite oxides: $SrMnO_3$, $EuTiO_3$

D.M. Nalecz,[1,2] R.J. Radwanski,[1,2] S.S. Fedyk,[1,2] and Z. Ropka[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*

$EuTiO_3$ and $SrMnO_3$ are considered as prototype oxides with strong electron correlations, not well theoretically described so far. A theoretical problem is related with the role played by d or f electrons. In these oxides there are magnetically active ions, Mn and Eu, which have the incomplete $3d/4f$ shell. The Mn^{4+} and Eu^{2+} ions are quite similar in the respect that in the magnetic phase transition practically only the spin degree of freedom are released. Despite of the incomplete $3d/4f$ shell they are insulators. In standard LDA calculations d states in $SrMnO_3$ are obtained on the Fermi level pointing to their itinerant/metallic behavior. In this contribution we would like to compare the magnetic phase transitions in these two systems. We have calculated temperature dependence of the specific heat including the λ-type anomaly and the low-energy atomic-like electronic structure at the sub-meV energy scale. In the magnetic state there exists the discrete electronic structure at the 0.05 meV scale. The good description of c(T) indicates that the realized ionic valency is exactly the same as the formal valency and to a substantial physical adequacy of the crystal-field approach to compounds containing open $3d/4f$ shells where some number of d/f electrons are localized forming atomic-like strongly-correlated electronic systems.

P-3-62

Magnetic field induced switching of ferroelectric domains in GeMnTe/InP thin layers

H. Przybylińska,[1] V. Volobuiev,[2] A. Grochot,[1] A. Ney,[2] W Jantsch,[2] G. Bauer,[2] and G. Springholz[2]

[1] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *Institute of Semiconductor and Solid State Physics, Johannes Kepler University, Linz, Austria*

GeMnTe is one of the rare materials that are simultaneously ferroelectric (FE) and ferromagnetic (FM). The FE moment results from relative displacement of the cation and anion fcc sublattices along a <111> body diagonal, accompanied by transition from cubic to rhombohedral structure. While in the bulk all <111> directions are equally probable, in thin layers grown on (111) BaF_2 substrates biaxial strain leads to preferential orientation of the FE moment perpendicular to the layer surface. Here we present results of ferromagnetic resonance studies of GeMnTe layers grown by MBE on (111) InP substrates, showing that in this system the rhombohedral distortion occurs along <111> directions oblique to the surface normal. Moreover, the orientation of the FE moment switches from one oblique <111> axis to another when the direction of the applied magnetic field is changed.

The work is supported by National Science Centre under grant No. UMO-2014/15/B/ST3/03928

P-3-63

Fano resonances in side-coupled magnonic crystal/rectangular YIG-resonator system

S. Vysotsky,[1] Y. Khivintsev,[1] G. Dudko,[1] V. Sakharov,[1] Y. Filimonov,[1] N. Novitskii,[2] and A. Stognij[2]

[1] *Kotel'nikov IRE RAS (Saratov Branch), 38 Zelenaya str., 410019, Saratov, Russia*
[2] *SPMRC NAS of Belarus, 66 Independence Avenue, 220072, Minsk, Belarus*

MSSW propagation in the system consisting of 1D-magnonic crystal waveguide (MCW) and side-coupled rectangular YIG-resonator was studied. Such system can suuport Fano resonances [1]. On the other hand the considered structure can be viewed like MCW with side-coupled structural defect. We have shown that the MSSW transmitted characteristic (S_{21}) at YIG-resonator frequency f_R depends on position of this frequency with respect to frequency f_B of the Bragg resonances in MCW. If frequency f_R is located inside the magnonic gap ($f_R \approx f_B$) the $S_{21}(f_R)$ takes form corresponding to defect mode excitations – the amplitude of transmitted signal increase. Otherwise ($f_R \neq f_B$) the $S_{21}(f_R)$ characteristic takes the form of the resonance absorption.

References:

[1] A.E. Miroshnichenko, S. Flach, Y.S. Kivshar, Rev. Modern Phys., 82, 2257 (2010).

This work was supported by the Russian Science Foundation grant 17-19-01673 and performed in Kotel'nikov IRE RAS.

P-3-64

Ultrafast magnetization dynamics in epitaxial NiMnSn Heusler alloy thin film

A. Bonda,[1] S. Uba,[1] K. Załęski,[2] J. Dubowik,[3] and L. Uba[1]

[1] *Faculty of Mathematics and Informatics, University of Białystok, K. Ciołkowskiego 1M, PL-15-245 Białystok, Poland*

[2] *NanoBioMedical Centre, AMU, Umultowska 85, 61-614 Poznań, Poland*

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

The work is devoted to studies of ultrafast magnetization dynamics induced by femtosecond laser pulses in ferromagnetic NiMnSn shape memory Heusler alloy. We studied epitaxial thin $Ni_{54.3}Mn_{31.9}Sn_{13.8}$ film deposited on (001) MgO substrate. Spin precession in an external magnetic field was triggered and detected by the time-resolved magneto-optical Kerr effect (TRMOKE) using pump-probe technique in dual color scheme experiment. Measurements were performed as a function of magnetic field H and pulse fluence F. The measured TRMOKE signal is composed of oscillatory and background components, both decaying exponentially in a nanosecond time scale. Nonlinear dependence of the background contribution on the pump fluence was observed. The precession frequency was determined and found to be varying in the range of 1-10 GHz with H up to 3 kOe and decreasing linearly with F. The dependence of Gilbert damping parameter α on H and F was determined and discussed.

P-3-65

Motion of domain walls in pulsed magnetic fields in iron garnet crystal plates

L.A. Pamyatnykh,[1] M.S. Lysov,[1] L.Y. Agafonov,[1] D.S. Mekhonoshin,[1] S.E. Pamyatnykh,[1] and G.A. Shmatov[1]

[1] *Ural Federal University, Lenin Av. 51, Ekaterinburg, 620083, Russia*

Results of experimental study and numerical modelling of domain walls (DWs) motion in periodic alternating pulsed magnetic fields with frequencies 0,5-500 Hz are reported for uniaxial iron garnet plate $(TbErGd)_3(FeAl)_5O_{12}$ (thickness $L = 73\mu m$, saturation magnetization $M_S = 40Gs$, quality factor $Q = K_u/(2\pi M_S^2) = 0,55$) with stripe domain structure drift [1] observed at field amplitude H_{dr}. DWs reaction to pulsed magnetic fields was studied using stroboscopic technique. It was established experimentally that field impulses with amplitudes below H_{dr} result in larger shift of DWs from equilibrium in the direction of the drift in the plate than in the opposite direction. Numerical model takes anisotropy of attenuation into account. Simulations show that anisotropy of attenuation with respect to direction leads to DWs drift in harmonic and pulsed magnetic fields as well as to the difference in DW shifts in the direction of the drift and in the opposite direction.

References:

[1] Pamyatnykh L.A. et al., Acta Physica Polonica A, (2015), V. 127, l. 2, P. 388-390.

State assignment of the Russian Ministry of Education and Science (No 3.6121.2017).

P-3-66

Electronic propeties V:Ga-O:N center in GaN and GaInN: GGA+U approach

O. Volnianska[1]

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

Defect complex consisting of cation vacancy and substituting oxygen for N (VO) in GaN [1] is one of the most promising systems for the realization of qubits in semiconductors. Here we analyzed the electronic properties of charged VO in bulk wurtzite GaN and Ga1-xInxN for x ranging from 0 to 0.1 by GGA +U approach [2,3], including the Hubbard-like term +U applied on p(N) and p(O) orbitals. The VO is in high spin state with spins of 1/2, 1 and 3/2 for -1, 0 and +1 charge state, respectively, for both GaN and GaInN. Our calculations of transition levels of -2/-1 and -1/0 transitions in GaN amount to 1.5 and 1.1 eV relative to the VBM, respectively, which is in line with experiments [1]. Finally, we analyzed the possibility of using VO center in GaN and in GaInN in the context of spin qubit operation.

References:

[1] N. T. Son et al., Phys Rev B 80, 153202 (2009), A. Sedhain et al., Appl. Phys. Lett. 96, 151902 (2010).
[2] M. Cococcioni and S. de Gironcoli, Phys. Rev. B 71, 035105 (2005).
[3] P. Giannozzi et al. J. Phys.: Condens. Matter. 21, 395502 (2009).

The work was supported by the NSC (Poland) Grant No. 2015/17/D/ST3/00971. Calculations were done at ICM, University of Warsaw

P-3-67

MSSW nonreciprocity and focusing in YIG/ferromagnetic metal structure

G. Dudko,[1] Y. Khivintsev,[1,2] V. Sakharov,[1] N. Novitskii,[3] A. Stalmakhov,[2] and Y. Filimonov[1,2]

[1] *Kotelnikov SBIRE RAS, 38 Zelenaya str., 410019, Saratov, Russia*
[2] *Saratov State University, 83 Astrakhanskaya str., 410012, Saratov, Russia*
[3] *SPMRC NAS of Belarus, 66 Independence Avenue, 220072, Minsk, Belarus*

It is well known that magnetostatic surface wave (MSSW) spectrum in magnetic bi-layers is nonreciprocal. MSSW propagation and its spectrum were studied primarily for YIG films based structures with the magnetization $4\pi M$ of films in the range 400 $\leq 4\pi M_{1,2} \leq$ 1750 G. In this work, we discuss MSSW propagation and its focusing by curved antennas in layered structure YIG/ferromagnetic metal (Co, Fe) that have the difference of layers' magnetization $4\pi\Delta M \gg$ 1750 G and, thus, potentially very strong nonresiprocity of MSSW dispersion. We experimentally demonstrate strong nonreciprocity of MSSW propagation in YIG/Co structure. The results of micro-magnetic simulation of MSSW excitation by curved antenna and focusing effects in YIG/ferromagnetic metal structure were also discussed.

This work was partially supported by RFBR grants No.16-07-01092, 17-07-01452, 16-57-00153 Bel-a.

P-3-68

Universality of the magnetic irreversibility line in metglasses and superconductors

V. Sirenko,[1] and V. Eremenko[1]

[1] *B.Verkin Institute for Low Temperature Physics, Kharkov, Ukraine*

The measured temperature dependences of magnetization of metallic glasses and superconductor are analyzed. Their common feature is irreversibility of magnetization: below a certain temperature value T* the magnetization values measured at a fixed magnetic-field strength differ after cooling in a magnetic field (M_{fc}) and without it (M_{zfc}). It is shown, that for all of the samples the T*(H) is universal and fits well the theoretical dependence of de Almeida-Thouless ($T^* \sim H^{2/3}$) all over the measuring magnetic field range.

This work is based on the research provided by the grant support of the State Fund For Fundamental Research (project F-73/106)

P-3-69

Spin wave pulsed propagation in a magnonic crystal

César Leonardo Ordoñez Romero,[1] Zorayda Lazcano Ortiz,[1] Giuseppe Pirruccio,[1] Marco Osvaldo Vigueras Zúñiga,[2] Andrey Drozdovskii,[3] Boris Kalinikos,[3] Naser Qureshi,[4] Oleg Kolokoltsev,[4] and Guillermo Monsivais[1]

[1] *Instituto de Física, Universidad Nacional Autónoma de México, CU 04510, México*

[2] *St. Petersburg Electrotechnical University, 197376 St. Petersburg*

[3] *Facultad de Ingeniería, Universidad Veracruzana, Veracruz, México*

[4] *Centro de Ciencias Aplicadas y Desarrollo Tecnológico, UNAM, CU 04510, Mexico*

Magnonic crystals (MCs) have recently demonstrated an outstanding capability to connect fundamental physics with applications at microwave frequencies. Their characteristics have inspired multiple studies where detailed results on the behavior of the frequency-amplitude characteristic as a function of different structural parameters have been demonstrated. However, up to now, all the scientific reports deal exclusively with the resulting spin wave spectrum of the complete MC structure and little has been said about the behavior of the spin wave inside the magnonic crystal. Here, we present a detailed study of the propagation of surface spin waves pulses in a MC, the influence of the duration of the pulse in the formation and evolution of frequency bandgaps, and the spatial energy distribution as a function of frequency and position.

This work has been supported by UNAM-DGAPA grant 1N103915

P-3-70

Structural and magnetic properties of $Y_3Fe_5O_{12}$ thin films grown by Pulsed Laser Deposition

A. Krysztofik,[1] H. Głowiński,[1] P. Kuświk,[1,2] E. Coy,[3] S. Jurga,[3] and J. Dubowik[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Centre for Advanced Technologies, Poznań, Poland*
[3] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*

Yttrium Iron Garnet has recently attracted considerable attention because it is expected to find applications in novel electronic devices. Such applications require the fabrication of thin films with a high structural and magnetic quality. Here, we report on the properties of nanometer-thick YIG films grown by means of pulsed laser deposition. We show that PLD technique allows for the epitaxial growth of YIG films with low surface roughness and bulk-like magnetization. The damping parameter is of one order of magnitude lower than that of Permalloy or CoFeB thin films. Increased values of anisotropy fields, observed in our films, are attributed to a slight non-stoichiometry and consequent rhombohedral lattice distortion confirmed with X-ray diffraction.

This work was carried out within the Project NANOSPIN PSPB-045/2010 supported by a grant from Switzerland through the Swiss Contribution to the enlarged European Union.

P-3-71

Influence of anisotropy on spin wave propagation characteristics in PLD-grown YIG thin films

A. Krysztofik,[1] H. Głowiński,[1] P. Kuświk,[1] S. Ziętek,[2] E. Coy,[3] J. Rychły,[4] S. Jurga,[3] T. Stobiecki,[2] and J. Dubowik[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Department of Electronics, AGH University of Science and Technology*
[3] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[4] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

Spin wave (SW) propagation in thin films has become intensively investigated topic in recent years due to its promising applications in modern electronics. Nowadays, yttrium iron garnet (YIG), which serves as a medium for SWs, is a leading material due to the lowest attainable magnetization damping, thus SWs can propagate over large distances. Here, we report on SW propagation in the 82 nm thick YIG film over 150 μm range and discuss the influence of magnetic anisotropy fields on SW characteristics. We show that the anisotropy fields present in YIG films cause an increase in SW frequency and group velocity. Moreover, we elucidate that high anisotropy in PLD-grown films allows for faster information processing in SW circuits than in Liquid Phase Epitaxy films for which the values of anisotropy fields are smaller.

This work was supported by the Project NANOSPIN PSPB-045/2010 and the Horizon 2020 - GA No.644348 (MagIC)

P-3-72

Excitation of bulk spin waves by acoustic wave at the plane defect of a ferromagnet

Y. Gusieva,[1] P. Graczyk,[2] O. Gorobets,[1,3] and M. Krawczyk[2]

[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine*

[2] *Faculty of Physics, Adam Mickiewicz University in Poznan, Umultowska 85, Poznan, 61-614, Poland*

[3] *Institute of Magnetism, National Academy of Sciences of Ukraine, 36-b Vernadskogost., 03142, Kyiv, Ukraine*

Excitation of bulk spin waves by interface acoustic wave in the system of two ferromagnets was analytically and numerically investigated. We showed that besides magnetic oscillations forced by acoustic wave strain the resonance between Kosevich wave and bulk spin wave occurs. For the frequency of the Kosevich wave far below the resonance frequency the amplitude of dynamic magnetization is neglible. For the frequency above the resonance the acoustic wave excites bulk spin wave of the same frequency but different absolute value of the wave vector.

This work was supported by Horizon2020 - GA No. 644348(MagIC).

P-3-73

Electronic properties of $CeNiAl_4$ based on *ab initio* calculations and XPS measurements

M. Werwiński,[1] G. Chełkowska,[2] A. Szajek,[1] and A. Kowalczyk[1]

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

[2] *A. Chełkowski Institute of Physics, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

The $CeNiAl_4$ compound crystallizes in an orthorhombic $YNiAl_4$-type structure with a $P6/mmm$ space group. The earlier susceptibility data and X-ray photoelectron spectroscopy (XPS), suggested a localized character of the $4f$ states in CeNiAl4 with a valence state close to a Ce^{+3} ion.

In this work we present a combined theoretical and experimental study of the electronic structure for the Kondo dense system $CeNiAl_4$ based on the XPS data and *ab initio* calculations. Based on the band structure calculations the theoretical XPS valence band spectra are evaluate. Below the Fermi energy the total density of states contains mainly $3d$ states of Ni hybridized with Ce $4f$ states.

P-3-74

Electronic magnetic properties of $Ce_6Pd_{12}In_5$ and $La_6Pd_{12}In_5$ compounds based on *ab initio* calculations

M. Werwiński,[1] P. Leśniak,[1] W.L. Malinowski,[1] and A. Szajek[1]

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

Recently the novel heavy fermion Kondo lattice $Ce_6Pd_{12}In_5$ and its non-magnetic isostructural counterpart $La_6Pd_{12}In_5$ has been investigated in the framework of crystal structure, magnetic, thermodynamic and transport properties [1]. Both compounds crystallize in the same hexagonal crystal structure (space group $P6_3/mcm$) with a unique location of the rare earth atom. The aim of this work is to give insight into the electronic and magnetic structure of the $Ce_6Pd_{12}In_5$ and $La_6Pd_{12}In_5$ compounds based on the modern *ab-initio* spin polarized band structure calculations. The band structure calculations were performed based on the *full potential local-orbital minimum-basis* code (FPLO [2], version 14.00-49 in the fully relativistic mode).

References:

[1] M. Falkowski, A.M. Strydom, J. Alloys Compd. **613** (2014) 204.

[2] K. Koepernik, H. Eschrig, Phys. Rev. B **59** (1999) 1743.

P-4-01

Dynamics of a charge qubit encoded in a double quantum dot

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 the studies of the coherent dynamics of two coherently coupled quantum dots connected to external electrodes. For a single electron case the system can be used to encode a charge qubit [1], for which the dynamics and the read-out can be detected by current measurements. In the regime of sequential tunneling we use the full counting statistics [2] and the waiting time distribution [3] to investigate in details statistics of the tunneling events and their mutual correlations. In a short time regime the qubit dynamics, its coherent rotation on the Bloch sphere, can be directly seen in jump events when an electron is injected to and leave the system. We also consider a renewable effect which is important for qubit operations. The thermodynamics properties of the system, taking into account heat transfers and their correlations with charge currents, are studied as well.

References:

[1] K. D. Petersson, J. R. Petta, H. Lu, A.C Grossard, Phys. Rev. Lett. **105**, 246804 (2010).
[2] Y. V. Nazarov, Ann. Phys. **16**, 720 (2007).
[3] T. Brandes, Ann. Phys. (Berlin) **17**, 477 (2008).

The research was financed by the National Science Centre, Poland - project number 2016/21/B/ST3/02160

P-4-02

Ageing Phenomena in La-Sr Manganites with Divalent Substituents for Manganese

D. Merkulov,[1] A. Badelin,[1] S. Estemirova,[2] and V. Karpasyuk[1]

[1] *Astrakhan State University, 414056, Astrakhan, Russia*
[2] *Institute for Metallurgy UB RAS, 620016, Yekaterinburg, Russia*

Variations of electromagnetic and structural characteristics of $La_{1-c+x}Sr_{c-x}Mn_{1-x}Me_xO_{3+\gamma}$ manganites (Me=Zn,Ni) during storage time up to 30000 hours at room temperature and after frequentative thermal cycling in the 300–573 K range were investigated. Changes of magnetization of all samples were within the error of measurement. In most cases Curie point (T_c) showed irregular variations within the range of 20%, while zinc-substituted manganites with relatively high values of "c" exhibited some trend of T_c rise. The resistance of all samples increased during storage period, but changes of the magnetoresistance were different. The cell volume of single-phase manganites decreased over time, that may indicates an increase in oxygen content. However, the sample with the highest Ni content (x=0.125) at c=0.19 suffered phase transition "rhombohedral–orthorhombic structures", which cannot be explained by the oxygen absorption. Probably, this effect was due to the rearrangement of the ions and vacancies between crystal sublattices of manganite.

P-4-03

A magnetic phase-transition graphene transistor with tunable spin polarization

I. Hagymási,[1] P. Vancsó,[2] and L. Tapasztó[2]
[1] *Institute for Solid State Physics and Optics, MTA-WRCP, P.O. Box 49, H-1525 Budapest, Hungary*
[2] *Institute of Technical Physics and Materials Science, Centre for Energy Research, P.O. Box 49, H-1525 Budapest, Hungary*

Graphene nanoribbons with zigzag edge orientation (zGNRs) have an interaction induced gap and a magnetic insulating ground state with antiferromagnetic (AF) spin orientation between the two edges. We found that doping can alter the AF coupling to ferromagnetic (FM) between opposite edges. AF zGNRs display semiconducting, while FM ones exhibit metallic behavior in excellent agreement with our experimental findings [1]. This result can be exploited for a novel magnetically mediated switching mechanism in GNR based field-effect transistors. Instead of tuning the Fermi level in and out of a static bandgap, here the applied gate voltage can dynamically open and close an interaction gap, with only a minor shift of the Fermi level. The interplay of the band structure and edge spin configuration in zGNRs enables such transistors to carry spin polarized current without employing an external magnetic field [2].

References:

[1] G. Zs. Magda, X. Jin, I. Hagymási, *et al.*, Nature **514**, 608-611 (2014).
[2] P. Vancsó, I. Hagymási and L. Tapasztó, 2D Materials **4**, 024008 (2017).

P-4-04

Magnetic Quantum Oscillations of the Anomalous Hall Resistance in the Systems with Spontaneous Spin Polarization of Donor Electrons in Hybridized States

V.I. Okulov,[1,2] and E.A. Pamyatnykh[2]
[1] *Institute of Metal Physics UB RAS, Ekaterinburg, Russia*
[2] *Ural Federal University, Ekaterinburg, Russia*

The anomalous Hall effect observed in mercury selenide crystals with impurities of transitional elements[1] has been explained by the appearance of the magnetization current contribution $\sigma = c|e|(\partial M_0/\partial\zeta)$ into the Hall component of the conductivity tensor (M_0 is the spontaneous magnetization of the electron system, ζ is the chemical potential). At low temperatures and in high magnetic fields quantum oscillations of spontaneous magnetization are detected. In this report a calculation of oscillating dependence of $(\partial M_0/\partial\zeta)$ on magnetic field for a system of electrons in hybridized impurity states is presented. The oscillations have large amplitude and are described by the quantum oscillations of the density of states with the Fermi energy. The form of the oscillations was calculated taking into account the dependence of chemical potential and the energy level spin splitting on the magnetic field.

References:

[1] Lonchakov A.T., Okulov V.I., Govorkova T.E., Andriichuk M.D., Paranchich L.D., JETP Letters, 96, 405 (2012).

P-4-05

Structure and Magnetic Properties of Substitutional (Fe, Gd) co-doped In_2O_3

Marzook S. Alshammari,[1] Dhaifallah Almutairi,[1] Kadi Museery,[1] Ali AlAnzi,[1] Saleh Alssahally,[1] Mohammed Alkhunayfir,[1] and Raed Alhathlool[2]

[1] *King Abdulaziz City for Science and Technology, KACST, Saudi Arabia*

[2] *Al-Imam Mohammad Ibn Saud University, Saudi Arabia*

Diluted magnetic semiconductors (DMS) have attracted a great deal of attention due to their potential applications in Spintronics. Transition metals doped Indium Oxide (TM-dopedIn_2O_3) is nominated to be a promising DMS material. In_2O_3 is a transparent wide band gap, n-type semiconductor and crystallizes in a complex cubic bixbyite structure with 80 atoms in a unit cell. Therefore, compared to other host matrices, it would be a big challenge to achieve ferromagnetism in this matrix. In this research, the structure and magnetic properties of In_2O_3 powder co-doped with different impurity concentration of Iron (Fe) and Gadolinium (Gd) were investigated. These powders were prepared using solid state reaction method and the structural characterization was performed using X-ray diffraction (XRD). The magnetization was measured in a SQUID magnetometer. Room temperature ferromagnetism has been observed with distinctive coercive field of 1085Oe. The zero field cooled and the field cooled magnetization measurements (Zfc/Fc) show substitutional behaviors for all the samples and there is no sign for a formation of magnetic nanoparticles.

P-4-06

Transport through capacitively coupled embedded and T-shape quantum dots in the Kondo range

P. Florków,[1] M. Antkiewicz,[1] D. Krychowski,[1] and S. Lipiński[1]

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

The considered system consists of electrostatically coupled embedded (ED) and side attached dots (TD). TD is coupled to the wire via the open dot. Change of the gate voltage applied to the open dot allows tuning of the Fano interference asymmetry parameter q [1]. Using slave boson approach we discuss the interplay of interference and Kondo effect for different values of Fano parameter and different coupling of open and Kondo dots for strong intradot Coulomb interaction $\mathcal{U}$ in the limit of weak interdot Coulomb interaction $\mathcal{U}'$, $\mathcal{U}' \ll \mathcal{U}$, (broken SU(2) Kondo- Kondo Fano effect) and for strong interdot Coulomb coupling $\mathcal{U} = \mathcal{U}'$ (broken SU(4) Kondo- Kondo Fano effect).

References:

[1] I. Maruyama, N. Shibata, K. Ueda, J. Phys. Soc. Jpn. 73, 3239 (2004).

P-4-07

Giant magnetoresistance and Shubnikov–de Haas effect in LuSb

M. Kleinert,[1] O. Pavlosiuk,[1] P. Swatek,[1] D. Kaczorowski,[1] and P. Wiśniewski[1]

[1] *Institute of Low Temperature and Structure Research PAS - Wrocław; Poland*

Lanthanum monopnictides have recently been proposed as materials with non-trivial topology of their electronic structures [1,2]. Motivated by this conjecture and our previous work on YSb [3], we investigated single-crystals of another isostructural compound, viz. LuSb, by means of electrical resistivity, magnetoresistance and Hall effect measurements. We discovered giant magnetoresistance exceeding 3000 %, low-temperature resistivity plateau, and strongly angle-dependent Shubnikov–de Haas oscillations. The compound was characterized as a semimetal with nearly balanced contributions of electron and hole carriers to the magnetotransport properties. The experimental findings were supported by the results of our first-principle electronic structure calculations. We conclude that the magnetotransport in LuSb can be described in the scope of 3D multi-band Fermi surface model without topologically non-trivial electronic states.

— *Work supported by the National Science Centre (Poland); grant no. 2015/18/A/ST3/00057.* —

References:

[1] M. Zeng *et al.*, arXiv/1504.03492 (2015).
[2] J. Nayak, J. *et al.* Nat. Commun. **8**, 13942 (2017).
[3] O. Pavlosiuk, P. Swatek, P. Wiśniewski. Scientific Reports **6**, 38691 (2016).

P-4-08

Bismuth-based flexible magnetic sensors: from thin films to nanowires

Y. Zabila,[1] M. Marszałek,[1] M. Krupiński,[1] A. Zarzycki,[1] M. Perzanowski,[1] A. Maximenko,[1] and P. Horeglad[1,2]

[1] *Institute of Nuclear Physics, Polish Academy of Sciences, 31-342 Cracow*
[2] *Faculty of Physics, Astronomy and Appl. Computer Science, Jagiellonian Univeristy, 30-348 Cracow*

This contribution describes the modification of Bi structure and its influence on magnetotransport properties. Thin film samples deposited on Kapton substrates were vacuum annealed up to the melting point. There morphology and crystallographic structure were studied with scanning electron microscopy and X-ray diffraction while there transport properties (magnetoresistance MR and Hall effect) were studied with standard 4-point probe technique at fields up to 20 kOe. Low-temperature MR measurements were carried out at field up to 70kOe and temperature down to 5K. These results obtained for bismuth films have enabled us to optimise the magnetoresistive response of nanowires array embedded in the alumina matrix.

This work was supported by the National Centre for Research and Development within LIDER V program, Poland (project Nr.: LIDER/008/177/L-5/13/NCBR/2014).

P-4-09

Thickness and composition dependences of magnetic and magnetotransport properties of granular thin films Co_xAg_{100-x}

I. Shpetnyi,[1,2] S. Vorobiov,[1] I.Yu. Protsenko,[1] M. Matczak,[3] K. Załęski,[2] E. Coy,[2] G. Nowaczyk,[2] F. Stobiecki,[3] and S. Jurga[2]

[1]*Sumy State University, Rimsky-Korsakov Street 2, 40007 Sumy, Ukraine*

[2]*NanoBioMedical Centre, AMU, Umultowska 85, 61-614 Poznań, Poland*

[3]*Institute of Molecular Physics, PAS, Smoluchowskiego 17, 60-179 Poznań, Poland*

In this contribution we analyze the microstructure, magnetoresistive and magnetic properties of granular alloy films of Co_xAg_{100-x} as a function of sample thickness ($20 \leq d \leq 85$ nm) and composition ($15 \leq x \leq 90$ at.%). Samples with different thickness show a nonmonotonic dependence of magnetoresistance as a function of concentration $[\Delta R/R_S(x)]$. For low and high x the magnetoresistance is very weak ($\Delta R/R_S < 0.5\%$), however the origin of this effect is different. For the low concentration the distance between Co grains is large and the spin dependent transport is reduced. In contrary, for high x the threshold of structural percolation is exceeded and the Co grains are in direct contact. The Co concentration corresponding to the maximal values of $\Delta R/R_S$ increases with the decreasing thickness of the sample. For example, $\Delta R/R_S \approx 12\%$ and 4% were achieved for $d = 85$ nm, $x = 32$ at.% and $d = 35$ nm, $x = 40$ at.%, respectively.

P-4-10

Thermoelectric Generation Based on Spin Seebeck Effects: A Systematic Review

B. Guzowski,[1] R. Gozdur,[1] M. Lakomski,[1] and L. Bernacki[1]

[1]*Lodz University of Technology, Department of Semiconductor and Optoelectronics Devices, Wolczanska 211/215, 90-924 Lodz, Poland*

Thermoelectric generation based on spin Seebeck effect (SSE) has a great number of potential applications and therefore has become very attractive. One of such applications are thermoelectric generators. To have a well understanding of the recent progress in this area, an overview of the achieved Inverse Spin Hall Effect (ISHE) output voltage as a temperature ratio is given. Presented results can be a valuable source of reference for future research in this field.

P-4-11

The influence of thickness of YIG samples on generated Spin Seebeck voltage

L. Bernacki,[1] M. Lakomski,[1] R. Gozdur,[1] and B. Guzowski[1]

[1] *Lodz University of Technology, Department of Semiconductor and Optoelectronics Devices, Wolczanska 211/215, 90-924 Lodz, Poland*

Thermoelectric conversion, that converts wasted heat into electric power, due to spin Seebeck effect (SSE) seems to be very promising. Level of such harvested power should be as high as possible. In this paper the influence of magnetic insulator thickness on generated spin voltage is investigated. The bulk $Y_3Fe_5O_{12}$ (YIG) samples were investigated. It has been proven that the increasing of the dimensions of the tested samples provides a higher value of the obtained thermoelectric voltage in platinum interface. Obtained results confirm possible future SSE application in TEG large-scale devices.

P-4-12

Influence of intermixing at the Ta/CoFeB interface on spin Hall angle in Ta/CoFeB/MgO heterostructures

M. Cecot,[1] Ł. Karwacki,[2] W. Skowroński,[1] J. Kanak,[1] J. Wrona,[3] A. Żywczak,[4] L. Yao,[5] S. van Dijken,[5] J. Barnaś,[2] and T. Stobiecki[1]

[1] *AGH University, Department of Electronics*

[2] *Adam Mickiewicz University, Faculty of Physics*

[3] *Singulus Technologies AG*

[4] *AGH University, Academic Center of Materials and Nanotechnology*

[5] *Aalto University School of Science, Department of Applied Physics*

Spin-orbit interactions provides mechanisms of spin polarization induction even in non-magnetic metals. In adjacent ferromagnetic layer, the effective magnetic fields are generated, which can lead to magnetization switching or dynamics precession through spin-orbit-torque. Magnetic and structural measurements indicate that Ta/CoFeB interface can not be considered as a sharp transition. Fitting to the temperature dependence of damping-like and field-like torques were performed with an additional contribution from the Ta/CoFeB interface taken into account in the spin diffusion model. In this approach, the temperature variations of the spin Hall angle in the Ta underlayer and at the Ta/CoFeB interface are determined separately.

MC and WS acknowledge National Science Center, Poland, Grant No. 2015/17/D/ST3/00500, TS. acknowledges the statutory Grant 11.11.230.017.

P-4-13

Extreme magnetoresistance in the regular semimetal LuAs

J. Juraszek,[1] A. Rudenko,[1] Ł. Bochenek,[1] M. Daszkiewicz,[1] Z. Wang,[2] J. Wosnitza,[2] Z. Henkie,[1] M. Samsel-Czekała,[1] and T. Cichorek[1]

[1] *Institute of Low Temperature and Structure Research, PAS, Wroclaw, Poland*
[2] *Hochfeld Magnetlabor, Helmholtz-Zentrum Dresden-Rossendorf, Germany*

We report on a study of magnetotransport properties of a novel non-magnetic semimetal LuAs that crystallizes in a simple rock-salt structure. Through a set of transport experiments in transverse and longitudinal fields, we found that lutetium arsenide has similar magnetotransport characteristics as those of nearly compensated semimetals LaSb, LaBi, and YSb with the very same crystalline structure respecting inversion symmetry. This holds especially true for a near-quadratic extremely large magnetoresistance (XMR close to 400 000 % at 60 T and 5 K) without any sign of saturation and a field-induced up-turn in the resistivity followed by a plateau at low temperatures. In contrast to the aforementioned semimetals, the results of first principles calculations indicate that the band crossing between pnictogen p states and non-magnetic lanthanide d states near the X point is absent in LuAs. This narrows a number of possible scenarios proposed to explain a near-quadratic XMR behavior, specifically those based on nontrivial band topology appear to be inapplicable.

This work was supported by the Polish National Science Centre within Grant No. 2016/21/B/ST3/02361.

P-4-14

Optical interband transitions in a graphene nanoribbon with the Rashba spin-orbit interaction

M. Inglot,[1] and V.K. Dugaev[1]

[1] *Department of Physics and Medical Engineering, Rzeszów University of Technology, al. Powstańców Warszawy 6, 35-959 Rzeszów, Poland*

Optical properties of a single layer of graphene are well known now [1]: the absorption coefficient does not depends on frequency and is related to the fine-structure constant with value 1/137. Hence, the one-layer graphene absorbs only 2.3% of the incoming light. However, this property can be substantially modified by a substrate generating Rashba spin-orbit interaction [2]. In our consideration we include the spin-orbit interaction and discuss the relation between the size of graphene nanoribbon and the optical interband transitions. Additionally, we switch a weak in-plane magnetic field on and find a strong light-induced spin density and the charge and spin current generation. Spin and charge current manipulation by using electromagnetic field in graphene have a great potential to applications. Our calculations show that manipulating the nanoribbon size can strongly affect the optical properties of graphene[3].

References:

[1] M. I. Katsnelson, Graphene: Carbon in Two Dimensions (Cambridge Univ. Press, 2012).
[2] M. Inglot, V. K. Dugaev, E. Ya. Sherman, J. Barnaś. PRB 89, 155411 (2014).
[3] M. Inglot, V. K. Dugaev, E. Ya. Sherman, J. Barnaś. PRB 91, 195428 (2015).

P-4-15

Selected spin-orbit driven phenomena in 2DEG with Dresselhaus spin-orbit interaction

P. Majek,[1] and A. Dyrdał[1]

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

All-electrical control of magnetic moments in solids is possible due to spin-orbit interaction which is the origin of various spin and transport phenomena such as anomalous and spin Hall effects, current-induced spin polarization and spin-orbit torques.
We consider theoretically magnetized and nonmagnetized two-dimensional electron gas with Dresselhaus spin-orbit interaction that appears in semiconductor heterostructures when the growth direction of the quantum well is along the [100] crystallographic axis. Within the zero-temperature Green functions formalism and linear response theory we have obtained some analytical and numerical results describing the anomalous and spin Hall effects as well as the current-induced spin polarization. Our results are in agreement with those obtained earlier in the quasi-ballistic limit (extremely long relaxation time). However, they are more general as are applicable also for finite relaxation rate. We have also shown, among others, that the current-induced spin polarization in a nonmagnetic case is oriented in the plane of 2DEG and is aligned with the current flow direction.

P-4-16

Magnetic and magnetotransport properties of the hybrid anisotropy structures

A. Kolesnikov,[1] M. Stebliy,[1] A. Ognev,[1] A. Samardak,[1] L. Chebotkevich,[1] Hao Wu,[2] and Xiufeng Han[2]

[1] *Far Eastern Federal University, 8 Sukhanova St., Vladivostok 690950, Russia*
[2] *State Key Laboratory of Magnetism, Institute of Physics, Chinese Academy of Sciences, Beijing, China*

Nowadays, multilayers with different types of magnetic anisotropy (hybrid anisotropy structures (HAS)) are being actively investigated. These materials are important for practical use as spin-torque oscillators (STO) and medium for energy-assisted magnetization switching. The layers with perpendicular anisotropy allows to increase the switching speed, thermal stability, zero-field operation of STO, and layers with in-plane anisotropy, that break the axial symmetry of layers with PMA, can act as both a polarizer and a read-out layer.
In this paper, we investigated the magnetic and magnetoresistive properties of the hybrid multilayer structure with in-plane and out-plane anisotropies ($[Co/Ni]_{15}$ and $[Co/Pt]_4$, respectively) separated by a Cu interlayer. The effect of indirect exchange interaction on hysteresis, saturation fields, and magnetoresistance of HAS was investigated by experimentally techniques and micromagnetic simulation.

P-4-17

Correlation Between Magnetothermoelectric Power and GMR Effect in Layered NiFe/Co/Cu/Co Structures

T. Luciński[1]

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

We show the results of the magnetothermoelectric power (MTEP) and giant magnetoresistance (GMR) measurements of NiFe/Co/Cu/Co layered structures with different Co, Cu and NiFe thicknesses. The main purpose of the measurements was to examine the correlation between these two magnetic effects. Experimental data showed that the magnetic field (H) dependences of MTEP(H) and GMR(H) correlates quite strickingly. It has been shown that amplitudes of MTEP as well as GMR oscilates with both Cu and NiFe thicknesses. It was also shown that the magnetic field dependences of MTEP is inversly proportional to the GMR(H) dependence which is in agreement with theoretical model based on the spin dependent density of states at the Fermi level.

P-4-18

Magnetoresistive effects due to k-cubed Rashba spin-orbit interaction at the interfaces of oxides and semiconductors

A.Krzyżewska,[1] A. Dyrdał,[1] and J. Berakdar[2]

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

[2] *Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany*

Perovskite oxides heterointerfaces attract recently much attention from both experimental and theoretical sides, mainly due to their peculiar electronic properties like two-dimensional metallic conductivity, large magnetoresistance, metal-insulator transition, coexistence of superconductivity and ferromagnetism, and large spin-orbit interaction [1].

Within the Matsubara Green function formalism and linear response theory we consider some of the magnetoresistive phenomena (e.g. anomalous and planar Hall effects, anisotropic magnetoresistance) in a two-dimensional electron gas formed at the perovskite oxides interfaces. We assume the isotropic k-cubed form of Rashba interaction, that fits well to the reported experimental data [2] and is also widely used for modelling of spin-orbit phenomena in p-doped semiconductor heterostructures.

References:

[1] A. Brinkman, *et al.*, Nature Mater. **6**, 493 (2007); E. Lesne *et al.*, Nature Mater. **15**, 1261 (2016)

[2] H. Nakamura, *et al.*, Phys. Rev. Lett. **108**, 206601 (2012)

P-4-19

Current-induced spin polarization in 2DEG at perovskite oxides interfaces

Ł. Karwacki,[1] A. Dyrdał,[1] J. Berakdar,[2] and J. Barnaś[1]
[1] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*
[2] *Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany*

The two-dimensional electron gas (2DEG) at the interfaces of transition metal oxides reveals non-trivial electronic and spin properties, which are intriguing due to their fundamental theoretical aspects and promising applications in spintronics. Recently, very large spin-to-charge current conversion due to spin-orbit interaction in these structures has been reported [1]. We will discuss, within the Matsubara Green functions formalism, current-induced spin polarization due to isotropic k-cubed Rashba interaction. Such a form of the spin-orbit coupling at the interfaces is expected in some groups of oxide perovskites, and also effectively fits well to experimental data [2]. We have calculated the temperature dependence of the nonequilibrium spin polarization in nonmagnetic and magnetic cases. In the latter case we have also analysed behaviour of the spin-orbit torque.

References:

[1] E. Lesne et al., Nature Mater. **15**, 1261 (2016).
[2] H. Nakamura et al., Phys. Rev. Lett. **108**, 206601 (2012).

P-4-20

Seebeck effect in noncollinear double planar tunnel junctions with ferromagnetic electrodes and central layer separated by nonmagnetic barriers

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

The Seebeck effect is investigated in double planar tunnel junctions consisting of ferromagnetic electrodes and the central ferromagnetic layer separated by nonmagnetic barriers. It is assumed that the magnetic moments in the central layer can form the arbitrary angle with the magnetic moments in the external electrodes. The calculations are performed in the linear response theory using the free-electron model. The Seebeck coefficient is calculated as a function of the thickness of the central layer and the average temperature of the junction. The influence of the relative orientation of the magnetic moments in the external electrodes and the central layer on this coefficient is also analysed. It has been found that the Seebeck coefficient oscillates with thickness of the central layer and can be enhanced in the junction with special central layer thickness due to electron tunneling by resonant states. The form of the observed oscillations varies with the temperature of the junction. The change of the central layer thickness leads to modification of the dependence of the Seebeck coefficient on the angle between magnetic moments in the central layer and the external electrodes.

P-4-21

Transport and thermoelectric properties of magnetic organic structures

K. Zberecki,[1] and R. Swirkowicz[1]

[1] *Warsaw University of Technology, Faculty of Physics*

We analyze magnetic, transport and thermoelectric properties of narrow carbon polymers and magnetic organic chains, which are chemically functionalized with nitroxide (NO) groups. Numerical calculations of the electronic band structure and the corresponding transmission function are based on the Density Functional Theory. We predict that magnetic organic chains appear to be half-metallic ferromagnets with notable energy gap between spin-up and spin-down channels. This suggests that a device based on such structures could act as a very effective spin filter and its polarization may be changed with use of the gate voltage. Our calculations also predict very good thermoelectric performance of both types of organic structures, as the conventional and spin Seebeck coefficients are remarkably enhanced.
These results suggest that the studied magnetic organic structures would have a great potential for applications in spintronic devices.

P-4-22

Anomalous, spin and valley Hall effects in graphene-based structures

K. Florencki,[1] A. Dyrdał,[1] and J. Barnaś[1]

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

Hybrid graphene-based systems such as graphene deposited on various substrates (e.g. transition metal dichalcogenides or ferromagnetic thin films) as well as graphene decorated by adatoms are currently extensively studied both experimentally and theoretically [1-3]. This interest is mainly due to the possibility of using graphene as an active element of spintronics devices. Owing to the magnetic and spin-orbit proximity effects in hybrid graphene-based structures, enhanced spin-orbit interaction and magnetic moment in the graphene layer can be induced.
Within the linear response theory and Green function formalism we have studied anomalous, spin and valley Hall effects in graphene-based hybrid structures. To describe these phenomena theoretically we have used various forms of the low-energy effective Hamiltonians, which have been derived recently from *ab-initio* calculations (see e.g. [3,4]).

References:

[1] A. Avsar et al., Nature Communications 5, 4875 (2014); [2] J. Balakrishnan, Nature Communications 5, 4748 (2014); [3] M. Gmitra et al., Phys. Rev. Lett. 110, 246602 (2013); M. Gmitra and J. Fabian Phys. Rev. B 92, 155403 (2015); [4] Zollner et al., Phys. Rev. B 94, 155441 (2016).

P-4-23

Aharonov-Bohm and Aharonov-Casher effects of nonlocal and local Cooper pairs

D. Tomaszewski,[1] P. Busz,[1] R. López,[2] R. Žitko,[3] M. Lee,[4] and J. Martinek[1]

[1] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*

[2] *Institut de Física Interdisciplinària i Sistemes Complexos IFISC (CSIC-UIB), Spain*

[3] *Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia*

[4] *Department of Applied Physics, College of Applied Science, Korea*

Recent experiments show, that it is possible to generate a Josephson supercurrent form by split nonlocal Cooper pairs [1]. This new Josephson current required further studies especially its interference properties. While the behavior of single electrons under the influence of Aharonov-Bohm (AB) and Aharonov-Casher (AC) effects is well understood, it raises the question of the impact of these effects on nonlocal superconducting Cooper pairs which are in spin singlet state. We analyze a normal ring, where a single electron interference is possible and two parallel nanowires connected to two superconducting electrodes, where a single-electron interference can be absent but a cross Andreeev reflection is possible. At low transmission, we can link the AB effect only to local Cooper pairs and the AC effect to nonlocal Cooper pair transport.

References:

[1] R. S. Deacon, A. Oiwa, J. Sailer, S. Baba, Y. Kanai, K. Shibata, K. Hirakawa, and S. Tarucha, Nature Communications **(**6), 7446 (2015)

P-4-24

Spin Correlation and Entanglement Detection in Cooper Pair Splitters by Current Measurements Using Magnetic Detectors

P. Busz,[1] D. Tomaszewski,[1] and J. Martinek[1]

[1] *Institute of Molecular Physics, Polish Academy of Science, 60-179 Poznan, Poland*

Recently, there are significant breakthrough in experimental demonstrations of Cooper pair splitting (CPS) using the double quantum dot system [1-2]. The next important step, after successful splitting of Cooper pairs, would be experimental demonstration that the split electrons remain entangled. It occurs significantly more challenging since eight years after the first demonstration of the splitting there is still lack of the entanglement detection in this system. Therefore, we explore a general model of the CPS coupled to two ferromagnetic detectors converting spin information into charge information. We use perturbation theory taking into account of the spin dynamics and the exchange interaction between quantum dots and the ferromagnetic detectors. Despite of the complex spin precession in quantum dots [3] it is still possible to determine spin correlation by dc current measurements in this system. We propose an entanglement test based on the Bell inequalities and the entanglement witness approach.

References:

[1] L. Hofstetter et al., Nature **461**, 960 (2009)

[2] Z. B. Tan et al., Phys. Rev. Lett **114**, 096602 (2015)

[3] A. D. Crisan et al., Nature Communications **7**, 10451 (2016)

P-4-25

Efficiency of the Cooper pair splitter driven by the Zeeman effect and by spin-flip processes

K. Bocian,[1] W. Rudziński,[1] and I. Weymann[1]
[1] *Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

The Andreev reflection processes are investigated theoretically for mesoscopic systems based on a number of quantum dots coupled to ferromagnetic and superconducting external electrodes. The method of equation of motion for the nonequilibrium Green function is used to describe transport characteristics for the system. The influence of external magnetic field applied in the vicinity of quantum dots is examined in the context of the system working as the Cooper pair splitter. Consequently, phenomena due to splitting of the dots discrete levels involved by the Zeeman effect as well as by the spin-flip scattering processes are analyzed in detail. In particular, it is found that the presence of magnetic field may lead to enhancement of the efficiency of the Cooper pair splitting, which becomes crucial in case the considered system is designed to work as an effective source of electrons in entangled quantum states.

This work was supported by the Polish National Science Centre from funds awarded through the decision No. DEC-2013/10/E/ST3/00213.

P-4-26

Magnetic and transport properties of hexagonal graphene nanomeshes

Maciej Zwierzycki,[1] and Dmitry Ryndyk[2]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Bremen Center for Computational Materials Science, University of Bremen, Am Fallturm 1, 28359 Bremen, Germany*

Graphene nanomeshes are the nanostructures consisting of graphene flake with a regular pattern of antidots (holes) punched through it. Nanomesh-based transistors has been shown to offer improved I_{on}/I_{off} ratio of the collector current while supporting up to 100 larger driving currents that nanoribbon-based devices. In this paper we studied the electronic structure and magnetic and transport properties of graphene nanomeshes with hexagonally shaped antidots using denisty functional tight binding (DFTB) method. It has been found that the internal zigzag edges support magnetic moments and that lowest energy magnetic configuration is antiferromagnetic. The density of states (DOS) calculated for ground state configuration demonstrate the existence of the energy gap which furthermore can be substantially reduced upon switching (*e.g.* by external magnetic field) to ferromagnetic configuration. Based on this we predict that the structure will exhibit magnetoresistive effect, which makes graphene nanomeshes of this kind relevant for spintronic applications. The conclussions are further supported by transport calculations.

P-4-27

Current-induced magnetic switching in spin valves based on molecular magnets

Anna Plominska,[1] Maciej Misiorny,[1] and Ireneusz Weymann[1]
[1] *Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

Time-dependent transport through molecular spin valves based on single molecular magnets is considered theoretically by using the real-time diagrammatic technique. First, we show that it is possible to switch the magnetic moment of a molecule by applying spin-polarized current, and the switching process depends on the magnetic configuration of the device. Then, we analyze magnetic switching in a device consisting of two coupled molecular magnets. We demonstrate that the switching depends on the direction of the current flowing through the system; for one bias polarization magnetic moment is stabilized, while for the opposite bias magnetic switching occurs. This gives rise to a hysteresis loop of spins of molecules as a function of applied bias voltage, the size of which is determined by the switching time. We propose optimal parameters, for which the two molecules rotate their magnetic moments at different bias voltages.

This work is supported by the National Science Centre in Poland as the Project No. DEC-2013/10/E/ST3/00213.

P-4-28

Time-dependent numerical renormalization group study of quench dynamics in quantum dot systems

K. Wrześniewski,[1] and I. Weymann[1]
[1] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

We study the quench dynamics in quantum dots strongly coupled to normal and/or ferromagnetic contacts. The system is described by the single-impurity Anderson Hamiltonian, while its real-time evolution for arbitrary temperatures is calculated by means of time-dependent density-matrix numerical renormalization group method, implemented in the framework of matrix product states. We consider two general types of quantum quenches: the first one performed in the coupling strength between the dot and the leads, and the second one obtained by changing the position of the dot level. For these two cases we analyze the time-evolution of local observables, such as dot occupation and spin. We identify the relevant time scales associated with the emergence of Kondo correlations and an exchange field in the case of ferromagnetic leads.

This work was supported by the Polish National Science Centre from funds awarded through the decision No. DEC-2013/10/E/ST3/00213.

P-4-29

IrMn-based spin valve structures with low shunt current

B. KOCAMAN,[1] and N. AKDOGAN[1,2]

[1] *Department of Physics, Gebze Technical University, 41400 Kocaeli, Turkey*

[2] *Institute of Nanotechnology, Gebze Technical University, 41400 Kocaeli, Turkey*

We systematically studied the exchange bias field (H_{EB}) and the blocking temperature (T_B) in IrMn/Co/Cu/Py/Pt spin-valve multilayers. The blocking temperature of the spin-valve multilayers was significantly enhanced from 160 K to above 395 K by increasing annealing temperature of IrMn layer. This is attributed to the formation of (111) and (002) textures within the antiferromagnetic IrMn, which emerging progressively with increasing annealing temperature. We also investigated IrMn thickness dependence of H_{EB} and T_B. We realized exchange bias above room temperature by using 4 nm IrMn layer. Such thin IrMn layer is also important to reduce the shunt current which lowers the signal to noise ratio of the system. We have also shown that the thicker IrMn layer causes decreasing of the training effect.

P-4-30

Influence of the spin-orbit interaction on the electronic properties of the graphene with the Ni-adatoms - a DFT study

Małgorzata Wawrzyniak-Adamczewska,[1] and Anna Dyrdał[1]

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

The electronic properties of the free standing graphene layer with Ni-adatoms is studied with the density functional theory approach, taking into account the spin-orbit interaction. We focus on the case when the Ni-adatoms form the trigonal lattice that is established above the graphene. The three geometries are examined, namely the Ni-adatoms in ontop, bridge and hollow positions on the graphene. We show that the presence of the metallic magnetic layer strongly modifies the band structure of the graphene, as well as its magnetic state. In the vicinity of the K-point the graphene valence band states are drag down below the Fermi energy, while the graphene conduction band states are less affected. We show that deformation of the Dirac cone results from the hybridization of the Ni *3d* and C $2p_z$ valence states. The presence of the magnetic adatoms generates the magnetic moments on the graphene lattice.

This work has been supported by the Polish Ministry of Science and Higher Education through a research project "Iuventus Plus" in years 2015–2017 (Project No. 0083/IP3/2015/73). Calculations have been performed in the Cyfronet Computer Centre using Prometheus computer which is a part of the PL-Grid Infrastructure.

P-4-31

Non-collinear spin configurations and related magneto-transport effects in amorphous Fe-Gd thin films

A.E. Stanciu,[1,2] A. Kuncser,[1,2] A. Catrina,[1,3] A. Leca,[1,3] N. Iacob,[1] O. Crisan,[1] G. Schinteie,[1] and V. Kuncser[1]

[1] *National Institute for Materials Physics, Bucharest-Magurele, Romania*
[2] *Bucharest University, Faculty of Physics, Bucharest-Magurele, Romania*
[3] *Politehnica University of Bucharest, Faculty of Electronics, Telecommunications and Information Technology, Bucharest, Romania*

Understanding the fundaments of the wide variety of non-collinear spin structures that occur in amorphous rare-earth – transition metal alloy thin films and their suitable control are highly required for applications based on magneto-functional effects. The present work is focused on the magnetic features of amorphous Fe-Gd thin films of similar thickness, but with different Fe concentration crossing the magnetic compensation point of this compound with antiferromagnetic coupling between Fe and Gd. The films were obtained by co-evaporation from an Fe target and an Fe target enriched with 57Fe and covered with Gd platelets. Morpho-structural, magnetic, magneto-optic and local spin structure features were utterly investigated. The influence of the non-collinear spin structure with perpendicular spin components especially at the Fe side on the magneto-transport and magneto-optic phenomena was studied.

P-5-01

Magnetic skyrmion state stability in ultrathin cylindrical dots

G.R. Aranda,[1] O. Chubykalo-Fesenko,[2] J. Gonzalez,[1] and K.Y. Guslienko[1,3]

[1]*Depto. Fisica de Materiales, Universidad del Paıs Vasco, UPV/EHU, 20018 San Sebastian, Spain*

[2]*Instituto de Ciencia de Materiales de Madrid, CSIC, Cantoblanco, 28049 Madrid, Spain*

[3]*IKERBASQUE, the Basque Foundation for Science, 48013 Bilbao, Spain*

The stability of the skyrmion magnetization configurations in ultrathin circular magnetic dots is calculated analytically and simulated micromagnetically accounting realistic magnetic and geometrical dot parameters taken from recent experiments. The Dzyaloshinskii-Moriya exchange interaction (DMI) is accounted as an interface term. We simulated the Neel skyrmion stability in circular dots of radius R=50 nm and 250 nm and thickness of L=0.6 nm using the OOMMF code. The area of the Neel skyrmion stability/metastability, skyrmion magnetization profiles and the equilibrium skyrmion radius are found in the terms of the dot magnetic (perpendicular anisotropy constant, saturation magnetization, DMI strength etc.) and geometric parameters (R, L). It was shown that the Dzyaloshinskii criterion of the instability of ferromagnetic state in bulk ferromagnets should be essentially modified to describe stability of the magnetic skyrmions in 2D systems like ultrathin ferromagnetic films and dots.

P-5-02

Dependence of Kerr effect in two-layered F/N structures upon d-shell filling in normal metal

V. Skidanov[1]

[1]*Institute for Design Problems in Microelectronics RAS, 124365 Moscow, Russia*

Experimental investigation of Kerr effect in two-layered F/N and N/F film structures reveals non-monotonic dependence of magnetooptical signal upon nanoscale (0-200 nm) thickness of normal (N) transition metal layer with unfilled d-shell. It is shown that the presence of normal transition metal layer with thickness up to 200 nm atop ferromagnetic metal significantly modifies magnetooptical reply of the film structure including enhancement and inversion of Kerr effect instead of exponential reduction with normal metal thickness. The signal value was measured at the equal reflected white light intensity to avoid uncertainty caused by interference effects and different light absorption due to variety of samples thickness values. Investigations were made with a wide number of normal transition metals with different fillings of atomic shells 3d, 4d and 5d (Ti, Cr, Mo, Ta, Re, Pt, W). It was shown that the influence of normal metal layer rigorously depends upon filling of atomic d-shell of the metal. Inversed signal amplitude gradually reduced with d-shell filling. No signal inversion was observed for Cu and Au with filled 3d and 5d atomic shells. But two-fold enhancement of magnetooptical signal from Py film was found with Cu or Au layers underneath.

P-5-03

Effect of 1D ordering on magnetic properties of iron nanoparticles coated by silica shell

Adriana Zeleňáková,[1] Pavol Hrubovčák,[1] Vladimír Zeleňák,[2] and Jozef Kováč[3]
[1] *P.J. Šafárik University,Institute of Physics, Košice, Slovakia*
[2] *P.J. Šafárik University, Institute of Chemistry, Košice, Slovakia*
[3] *Institute of Experimental Physics, SAS, Košice, Slovakia*

In our work, we have studied the properties of iron nanoparticles (NPs) coated by silica layer, which were prepared by surface capping agents. Such designed silica layer prevents the oxidation of the iron cores and promotes the self-organization of NPs into the 1D chain structures. Magnetization study shows that prepared nanoparticles exhibit strong inter-particle magnetic interactions, which lead to long-range ordering of NPs magnetic moments. Magnetic properties show superferromagnetic behaviour. The low value of room temperature coercivity, the existence of electrical insulating silica layer and small size of Fe NPs favour studied material for potential usage in microelectronic devices designed for high voltage frequencies.

Acknowledgement: This work was supported by grants APVV-15-0115 and VEGA (No. 1/0377/16, No. 1/0745/17).

P-5-04

Investigation of entropy change in Co@Au nanoparticles via heat capacity measurements

O. Kapusta,[1] A. Zeleňáková,[1] R. Tarasenko,[1] R. Palková,[1] and V. Zeleňák[2]
[1] *P. J. Šafárik University, Institute of Physics, Košice, Slovakia*
[2] *P. J. Šafárik University, Institute of Chemistry, Košice, Slovakia*

In recent years, special intent has been devoted to a magnetocaloric effect (MCE) in nanoparticles. Magnetocaloric refrigeration is manifested in term of isothermal magnetic entropy change. One of the most used methods for the determination of entropy change is specific heat measurement as a function of temperature at constant magnetic field. In our work, we have investigated the magnetocaloric effect (MCE) of core-shell Co@Au nanoparticles by heat capacity measurements in temperature range 1.9 - 55 K under external magnetic field from range 0 – 9 T. The MCE was studied in terms of isothermal magnetic entropy change after subtraction of the lattice heat capacity. The maximum entropy change of 3,54 J K^{-1} kg^{-1} was obtained at $\sim$ 15 K when the field was changed from 0 to 9 T.

This work was supported by grants APVV-15-0115, APVV-14-0073, VEGA (No. 1/0377/16, No. 1/0745/17) and VVGS-PF-2016-72646.

P-5-05

Ion driven magnetic and structural modifications of ultrathin Co films with various covers

P. Mazalski,[1,2] R.P. Socha,[1] L. Ohnoutek,[3] L. Beran,[3] Z. Kurant,[2] A. Wawro,[4] J. Fassbender,[5] M. Veis,[3] and A. Maziewski[2]

[1] *Jerzy Haber Institute of Catalysis and Surface Chemistry of the Polish Academy of Sciences, Cracow, Poland*

[2] *Faculty of Physics, University of Bialystok, Bialystok, Poland*

[3] *Faculty of Mathematics and Physics, Charles University in Prague, Prague 2, Czech Republic*

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

[5] *Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*

Magnetic and chemical properties of Co ultrathin films covered with Pt or Au cap and buffer layers magnetized in the sample plane were modified by ion irradiation . A strong dependence of the interface type on magnetic properties in irradiated films was observed. Anisotropy modification but no out-of-plane magnetization component were found for Au, contrary to Pt adjacent layers. Magnetic properties were correlated with chemical changes with use of magnetooptical and X-ray photoemission spectroscopies. Experimental observations were supported by calculations (Tridyn package) of layered structure evolution with the ion fluence.

Supported by the NCN FUGA project (DEC-2015/16/S/ST3/00450).

P-5-06

Residual stress on $Cr_{99}Al_1$ polycrystalline thin films

Z.P. Mudau,[1] A.R.E. Prinsloo,[1] C.J. Sheppard,[1] A.M. Venter,[2] T.P. Ntsoane,[2] and E.E. Fullerton[3]

[1] *Physics, UJ, PO Box 524, Auckland Park, 2006, RSA*

[2] *RDD, Necsa, PO Box 582, Pretoria, 0001, RSA*

[3] *CMRR, UCSD, 9500 Gilman Dr., La Jolla, CA 92093-0401, USA*

The magnetic phase diagram of bulk $Cr_{100-x}Al_x$ shows interesting properties, including a possible quantum criticality at $x \approx 2$ [1]. As the magnetic properties of Cr is influenced by dimensionality, stress and strain [2], this study focusses on polycrystalline $Cr_{99}Al_1$ thin films. Samples were prepared on fused silica using sputtering techniques and varied in thickness (t) from 29 to 452nm. Resistance measurements in the range 2 to 400 K show no anomalies and it is presumed that the Néel temperatures exceed 400 K. In-plane stresses in these films were studied using the X-ray diffraction $sin^2\psi$-method, where ψ is the tilt angle of the sample [3]. The in-plane residual strain present in the coatings (ϵ) were determined, followed by the residual stress (σ). Results indicate that σ is influenced by dimensionality and increases with t reaching a maximum for t =110 nm, where after it decreases for the thicker samples.

References:

[1] C.J. Sheppard *et al.*, J. Alloys Compd. **595** 164 (2014)

[2] H. Zabel, J. Phys. Condens. Matter **11** 9303 (1999)

[3] I.C. Noyan, J.B. Cohen, Residual Stress Measurement by Diffraction and Interpretation (1987)

P-5-07

The shielding effectiveness of a magnetic fluid in radio frequency range

B. Dolník,[1] M. Rajňák,[1,2] R. Cimbala,[1] I. Kolcunová,[1] J. Kurimský,[1] J. Džmura,[1] J. Petráš,[1] J. Zbojovský,[1] P. Kopčanský,[2] and M. Timko[2]

[1]*Department of Electric Power Engineering, FEI, Technical University of Košice, Mäsiarska 74, 041 20 Košice, Slovakia*

[2]*Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 040 01, Košice, Slovakia*

This article builds on the previous work and describes the interaction of transformer oil-based magnetic fluid (MF) with the radio frequency (RF) magnetic near-field. Three prepared samples of the MF used as a barrier to magnetic near-field, consist of transformer oil and dispersed magnetite nanoparticles coated with oleic acid. We pay attention to the important area related to the electromagnetic field shielding by the MF. Such sample of the MF may be a good candidate for applications where it is necessary to simultaneously electrically isolate, remove the excess of heat and to shield electromagnetic interference (EMI). We present a method for the determination of shielding effectiveness (SE) of the MF under RF excitation conditions ranging from 500 MHz to 3 GHz. We report the effect of magnetic volume fraction in the MF and the effect of the sample thickness on the SE.

P-5-09

Influence of electric field on AC magnetic susceptibility of a mineral oil based ferrofluid

M. Rajnak,[1,2] B. Dolnik,[2] T. Tobias,[1] K. Paulovicova,[1] J. Kurimsky,[2] R. Cimbala,[2] P. Kopcansky,[1] and M. Timko[1]

[1]*Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 040 01, Košice, Slovakia*

[2]*Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, 04200 Košice, Slovakia*

In a ferrofluid the magnetic susceptibility is sensitive to the size and shape of magnetic nanoparticles and their concentration. In this paper we report on the AC magnetic susceptibility of a ferrofluid based on a mineral oil and iron oxide nanoparticles of various concentrations. As this type of ferrofluid is of increasing interest for electrical engineering applications, we investigate the effect of an external electric field and an electric current on the AC magnetic susceptibility at ambient conditions. It is known that the electric field can induce the particle assembling. Then, the structural changes may affect the magnetic susceptibility of the ferrofluid. We observed that the ferrofluid's magnetic susceptibility decreases with increasing electric field. However, a heating effect with increasing electric field was observed too. Hence, it is concluded that besides the structural changes the Joule heating has an impact on the magnetic susceptibility of the ferrofluid in the external electric field.

P-5-10

Effect of Fe substitution on structural and magnetic properties of $NiCr_2O_4$

P. Mohanty,[1] A.R.E. Prinsloo,[1] C.J. Sheppard,[1] and W.D. Roos[2]

[1] *Physics, UJ, PO Box 524, Auckland Park, 2006, RSA*

[2] *Physics, UFS, PO Box 339, Bloemfontein, 9300, RSA*

At room temperature, the normal oxide spinel $NiCr_2O_4$ is tetragonally distorted and crystallizes in the $I4_1/amd$ space group due to cooperative Jahn-Teller ordering driven by the orbital degeneracy of tetrahedral Ni^{2+}. The ferrimagnetic Curie temperature (T_C) for $NiCr_2O_4$ is 74 K. The magnetic moments of $NiCr_2O_4$ are composed of a ferrimagnetic (longitudinal) and an antiferromagnetic (transverse) component. Exchange interaction between the magnetic cations influences the overall magnetic properties of the compound. Present work focuses on the modification of structural and magnetic properties upon substituting Fe at Cr sites in $NiCr_2O_4$ with the motivation of changing the magnetic exchange interaction. In order to do so, single phase $Ni(Cr_{0.5}Fe_{0.5})_2O_4$ samples were prepared by co-precipitation techniques with controlling *p*H of precipitation. Upon Fe substitution, crystal structure was not affected much contrary to the earlier reports. The oxidation state of each element was determined using X-ray photoelectron spectroscopy (XPS). T_C was found to increase dramatically above 300 K, confirmed both from temperature and field dependent dc-magnetization studies.

P-5-11

Dual-cantilever magnetometry

K. Sečianska,[1] J. Šoltýs,[1] M. Mruczkiewicz,[1] J. Tóbik,[1] and V. Cambel[1]

[1] *Institute of Electrical Engineering, Slovak Academy of Sciences, Dúbravská cesta 9, 841 04 Bratislava, Slovakia*

We have designed and realized dual-cantilever magnetometry system, in which coupling magnetic forces between the two cantilevers can be switched on/off by external magnetic field. The coupling is realized by two ferromagnetic ellipses, located each one on one of the cantilevers. One of the ellipses is "narrow", and shows only single-domain magnetic state independently on the external field applied; the second one is "wide", and shows also closure-domain state. In such configuration, the interacting force between the cantilevers can be attractive, repulsive, or is switched off when the closure domain state appears in the wide ellipse. The coupling between the ellipses directly corresponds to the phase-shift of the vibrating cantilevers. In this sense, the phase- shift of the dual-cantilever can be used to read the magnetic state of the ellipses. In this work we present the fabrication of the dual-cantilever magnetometer, micromagnetic simulations of the magnetic state of the ellipses, and we interpret the experimental results achieved.

P-5-12

Substrate-dependent modifications of ultrathin cobalt films driven by femtosecond laser pulses

J. Kisielewski,[1] Z. Kurant,[1] I. Sveklo,[1] A. Stupakiewicz,[1] D. Mitin,[2] M. Albrecht,[2] M. Krupiński,[3] M. Marszałek,[3] A. Wawro,[4] and A. Maziewski[1]

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

[2] *Institute of Physics, University of Augsburg, Germany*

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

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

Magnetic properties of ultrathin Co sandwiched between Pt or Pd films deposited on various substrates (Al_2O_3, Si/SiO_2) were irreversibly modified by femtosecond laser pulses, similarly as in [J. Kisielewski *et al.*, J.Appl.Phys. **119**, 193901 (2016)]. Formation of out-of-plane magnetization phases is strongly dependent on the type of substrate. Dynamic pump-probe studies were carried out in the low pump pulse energy regime, where the light-heating process is reversible. A cooling rate of hundreds of picoseconds was also substrate-dependent, which can be related to its heat conductivity. The results are supported by calculations of temperature dynamics during the pulse irradiation. Irreversible laser-induced modifications can be used to pattern out-of-plane magnetic structures, which we demonstrate with interference lithography.

Partially sponsored by Harmonia project, NCN DEC-2012/06/M/ST3/00475.

P-5-13

Variation of magnetic fluid deformation related to nanoparticle concentration in steady electric field

M. Kosterec,[1] R. Cimbala,[1] Z. Čonka,[1] M. Špes,[1] J. Kurimský,[1] M. Rajňák,[1,2] K. Paulovičová,[2] M. Timko,[2] and P. Kopčanský[2]

[1] *Technical University of Kosice, Mäsiarska 74, 041 20 Košice, Slovakia*

[2] *Institute of Experimental Physics SAS, Watsonová 47, 040 01 Košice, Slovakia*

Today, it is important to know the behaviour of magnetic fluids applied in the power electrical machines, when exposed to an electric field. The structure of such magnetic fluids is easily controllable by external magnetic fields. However, less attention has been paid to structural phenomena in magnetic fluids induced by electric fields. The core of this paper is dedicated to the experimental observation of a magnetic fluid droplet deformation in a steady electric field. The mutual relation between the deformation parameter and magnetic nanoparticles concentration is analysed. Spatio-temporal analysis of the droplet shape is presented in the paper. The phenomena of the droplet deformation was recorded by a camera. The detailed experimental procedure is presented. The method of deformation parameter calculation based on linear pixel as the smallest-size unit in digital image is written. Finally, the relation between the deformation parameter and the nanoparticle volume concentration, as well as the time and magnitude of the DC field application is thoroughly evaluated.

P-5-14

Glass-crystall materials with participation of $Bi_{12}TiO_{20}$ and $Bi_4Ti_3O_{12}$ phases, obtained by free cooled melts in Bi_2O_3-TiO_2-SiO_2-Nd_2O_3 system

S. Slavov,[1] and Z. Jiao[2]

[1] *Department of Physics, University of Chemical Technology and Metallurgy, 8 Kl. Ohridski Blvd., 1756 Sofia, BULGARIA*

[2] *School of Environmental and Chemical Engineering, Shanghai University, Huanhua Building, 333 Nanchen Road Shanghai 200444, P.R. CHINA*

Synthesis of selected samples in the system Bi_2O_3-TiO_2-SiO_2-Nd_2O_3 was made using two successive procedures: starting oxide homogenization in 15 min and melting at temperature of 1450^{o}C and 1100^{o}C, in depend on composition. The phase composition is determined by X-ray diffraction (XRD) analysis. The microstructure is observed by scanning electron microscopy (SEM). Through initial amount control of the start compositions leads to formation of polyphase glass-ceramics with participation of following phases: $Bi_{12}TiO_{20}$ and $Bi_4Ti_3O_{12}$. The glass phase quantity, siulica oxide and titanium oxide contents in volume, influence on the formation of separate phase areas varying in sizes and number.

Acknowledgments : *The study was performed with financial support of Swap and Transfer, Erasmus Mundus Action 2 Mobility Lot 12, Grant ID number* **SAT_2542**

P-5-15

Electrodeposition of Pt-Ni nanowires using various alumina templates and characterization of their magnetic properties

D. Hložná,[1] O. Shylenko,[1] E. Čižmár,[1] A. Kovalčíková,[2] and V. Komanický[1]

[1] *Institute of Physics, P. J. Šafárik University, Košice, Slovakia*

[2] *Institute of Materials Research, Slovak Academy of Sciences, Košice, Slovakia*

High aspect ratio porous aluminum oxide membranes of various pore diameter and interpore distance were used as templates for the synthesis of electrodeposited magnetic Pt-Ni nanowire arrays. The pulsed electrodeposition potential sequence consisted of 1000 cycles comprising deposition, discharge and rest pulse, which results in $PtNi_3$ nanowire composition and length of around 1 μm. The morphology and composition of Pt–Ni nanowires were determined by scanning electron microscopy and energy dispersive X–ray spectroscopy. The temperature dependence of susceptibility was measured in zero–field cooled (ZFC) and field–cooled (FC) mode in the temperature range from 2 K to 300 K. The position of maximum in ZFC magnetic moment was taken as the blocking temperature $T_B \sim 5$ K.

This work has been supported by Slovak research and development agency grant APVV-14-0073.

P-5-16

Physical properties of epitaxially-grown $Cr_{100-x}Co_x$ alloy films

C.J. Sheppard,[1] A.R.E. Prinsloo,[1] E.E. Fullerton,[2] D. Dekadjevi,[3] P. Elies,[3] and J. Richy[3]

[1] *Physics, UJ, PO Box 524, Auckland Park, 2006, RSA*
[2] *CMRR, UCSD, 500 Gilman Dr., La Jolla, CA 92093-0401, USA*
[3] *Physics, UBO, 29285 Brest Cedex 3, France*

In $Cr_{100-x}Co_x$ alloys the Co local moment is strongly coupled to the spin-density-wave (SDW). It is therefore expected that dimensionality should more strongly influence the SDW, and thus the various properties of this system, than in the case of pure Cr. In order to probe this, the present study extends investigations to include epitaxial $Cr_{100-x}Co_x$ thin films, with $0< x <8$ and thickness 200 nm. Samples were prepared on MgO(100) substrates using DC magnetron co-sputtering. The magnetic phase diagram for these samples indicates a decrease in Néel temperatures (T_N) up to a triple point concentration of x_L=2.6, where after the T_N values increase and peak at $x \approx 5$. Hall coefficients determined at 2 K, R_H^{2K}, as function of x shows a peak at $x \approx 4$. XRD analyses indicate that for samples with $x \approx x_L$ the crystal coherence length in growth direction (100) is a maximum, while the mosaicity is a minimum. AFM studies indicate roughness is a minimum at x_L, where cubical structures are observed. Structures for $x < x_L$ are small and elongated, while for $x > x_L$ large tilted cubic structures are formed.

P-5-17

Anisotropy dependent magnetic microstructure in perpendicular magnetized $L1_0$ FePt thin films

J. Zehner,[1] S. Fähler,[1] R. Schäfer,[1] C. Damm,[1] K. Nielsch,[1] and K. Leistner[1]

[1] *Leibniz-Institute for Solid State and Materials Research IFW Dresden, Institute of Metallic Materials, PO 270116, 01171 Dresden, Germany*

The understanding and control of magnetic domains in thin films with perpendicular magnetic anisotropy is of fundamental interest for emerging spintronic, magnetic data storage, and magnetoelectric devices. We study the magnetic domains in 4 nm thin continuous $L1_0$ ordered FePt (001) films prepared on Pt/Cr/MgO(001) substrates by pulsed laser deposition. Kerr microscopy revealed a fundamental change in the magnetic domain pattern when varying the degree of $L1_0$ order by thermal activation. Large magnetic domains with fractal boundaries and non-equilibrium character are present at high $L1_0$ order, while small and stable dot like domains are found in films exhibiting lower $L1_0$ order. A roughness-induced contribution could be excluded by in-depth morphological and microstructural analysis (XRD, TEM, AFM). The evolution of the domain patterns can be directly explained by the change of the intrinsic uniaxial magnetocrystalline anisotropy (MCA). At high $L1_0$ order, because of the large uniaxial MCA, reverse domains only nucleate at a magnetic field exceeding the pinning field. At a lower $L1_0$ order and associated MCA, domain nucleation takes place at lower reverse magnetic fields, at which domain wall pinning is still effective.

P-5-18

Magnetic properties of hybrid composites base on gold and magnetite nanoparticles

O. Moscoso Londo no,[1] D. Muraca,[1,2] P. Tancredi,[3] L. Souza da Costa,[2] D. Zanchet,[4] L. Socolovsky,[3] and M. Knobel[1]

[1]*Institute of Physics Gleb Wataghin, University of Campinas , Campinas, Sao Pablo, Brazil.*

[2]*Brazilian Nanotechnology National Laboratory , Campinas, Sao Pablo, Brazil*

[3]*Engineering Faculty, University of Buenos Aires, Buenos Aire, Argentina.*

[4]*Institute of Chemistry, University of Campinas, Campinas, Sao Pablo, Brazil.*

Hybrid entities composed by gold and iron oxide nanoparticles reveals properties not found in the individual components, that could emerge from new phenomena at interfacial region. In this work we study the structural and magnetic properties of diverse nanoparticles morphologies (core@shell, dumbell-like and flower-like) conformed by gold and iron oxide nanoparticles. According to ours results, by means of XRD, XANES, TEM and *dc* magnetization measures, for the magnetic response of the gold/Fe-oxide, the coupled interfacial area plays an essential role on the magnetization behavior. For example, when the gold and magnetite nanoparticles are in a dimer or flower-like configuration a conventional, and already reported, exchange bias was observed, whereas if the architecture is core@shell, the field cooled hysteresis loop becomes narrower in approximately 60 Oe respect to the conventional ones.

P-5-19

Influence of He^+ ion bombardment on domain nucleation in Co based perpendicular magnetic anisotropy multilayers

A. Jarosz,[1] A. Gaul,[2] M. Urbaniak,[1] A. Ehresmann,[2] and F. Stobiecki[1]

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

[2]*Department of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel, Germany*

The influence of He^+ ion bombardment (IB) on domains nucleation in Co/Au, Co/Pt, and Co/Pd sputter-deposited multilayers (MLs) with perpendicular magnetic anisotropy was investigated. The MLs were patterned, using electron lithography and a lift-off process, into grids of squares of 32 to 512 μm size and bombarded with different ion fluences. The magnetization reversal was investigated using Kerr microscopy to determine the influence of IB on the effectivity of domain nucleation centers (DNCs). The analysis of the Kerr images allowed us to estimate the DNCs' densities for each material as a function of ion fluence. An Arrhenius-type model of the DNCs and micromagnetic simulations were used to approximate the observed behavior. Preliminary results indicate that the near-edge DNCs are less susceptible to the influence of IB than those within the area of the sample.

Funded by National Science Centre Poland (NCN): DEC-2013/08/M/ST3/00960.

P-5-20

Infulence of surface morphology on perpendicular magnetic anisotropy of nanoporous Co/Pd multilayers and CoPd alloy thin films

J. Chojenka,[1] A. Maximenko,[1] A. Zarzycki,[1] Y. Zabila,[1] and M. Marszałek[1]
[1] *Institute of Nuclear Physics Polish Academy of Sciences, PL-31342 Krakow, Poland*

Nanoporous magnetic thin films exhibit very different properties from those of continuous films. The present work is focused on the magnetic Co/Pd multilayers (ML) deposited on nanoporous Al_2O_3 templates with different pore diameters (10 – 35 nm). The studies concern the properties of as deposited and annealed in vacuum at 300°C. To determine the contribution of pore morphology to magnetic properties of the system, Co/Pd ML on flat Si substrate was also prepared. SEM imaging confirmed nanoporous morphology of the films before and after annealing. All nanoporous films preserved perpendicular magnetic anisotropy with $K_{eff} \approx 0.5 - 1.0 \cdot 10^6 \ \frac{erg}{cc}$. However, after annealing a twofold decrease of coercive field was detected. MFM imaging of antidots before and after annealing showed complicated magnetic contrast with small magnetic domains. We also observed the areas with magnetic moments distortion from perpendicular direction connected with complex distribution of magnetic material on developed surface of antidots.

The support from the NCN grant 2014/13/N/ST8/00731 is acknowledged.

P-5-21

Perpendicular magnetic anisotropy of nanoporous Co/Pd multilayers

A. Maximenko,[1,2] J. Kasiuk,[2] A. Zarzycki,[1] J. Fedotova,[2] and M. Marszałek[1]
[1] *Institute of Nuclear Physics Polish Academy of Science*
[2] *Institute for Nuclear Problems of Belarusian State University*

The present work is focused on the magnetism of nanoporous films produced by deposition of Co/Pd multilayers with high perpendicular magnetic anisotropy (PMA) on porous TiO_2 templates with almost flat interpore surface morphology, and on Al_2O_3 where the pores are located in the middle of 3D hexagonal packed hemispherical deepenings. The pore diameters and interpore distances were varied in the range 10–180 nm and 20–420 nm, respectively. All nanoporous films conserve PMA with effective magnetic anisotropy constant (K_{eff}) around $2 \cdot 10^6 \ \frac{erg}{cc}$ despite of their microstructure and morphology changes. The isotropic growth of crystallites in films on porous templates was determined in contrast to highly (111) textured continuous film. The transition of magnetization reversal mechanism from domain wall motion for the continuous film to coherent rotation mode, described by Stoner-Wolharth model (SW), was found for nanostructured films. The effective anisotropy constant K_{eff} for nanoporous films was determined using SW model and the obtained values correlate well with values determined directly from the hysteresis loops.

The support from the NCN grant 2014/13/N/ST8/00731 is gratefully acknowledged.

P-5-22

The surface magnetism of the single-digit explosive nanodiamonds

A. Krupska,[1] R. Strzelczyk,[1] J. Karpeta-Kaczmarek,[2] M. Augustyniak,[2] and M.A. Augustyniak-Jabłokow[1]

[1] *Institute of Molecular Physics of Polish Academy of Sciences, Poznań, Poland*
[2] *Department of Animal Physiology and Ecotoxicology, University of Silesia, Katowice, Poland*

WITHDRAWN

P-5-23

Magnetic clusters on a surface of the partly hydrogenated graphene and chemically reduced graphene oxide

M.A. Augustyniak-Jabłokow,[1] R. Strzelczyk,[1] and M. Maćkowiak[1]

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

Both, partly hydrogenated graphene and chemically reduced graphene oxide exhibit ferromagnetic response, but of different origin. Our study revealed that the FMR signals, corresponding to ferromagnetic properties, are accompanied by the narrow EPR line with g$\sim$2. This signal is characterized by very strong temperature dependence of intensity. The intensity of the EPR signal corresponds to the magnetic susceptibility and decreases 540 times with temperature increase from 4.2 to 300 K. As the temperature dependence of the inverse susceptibility is not linear, the observed dependencies do not indicate ferromagnetic transition in the regions of low hydrogen density. The studied signals are of Lorentzian lineshape and their linewidth depends on the spin concentration, which gradually decreases with time. These features suggest that EPR signals in the studied materials are due to magnetic clusters created by absorption of hydrogen atoms. This interpretation is in accordance with the theoretical results showing instability of the sites with the single hydrogen atom absorbed.

We gratefully acknowledge the research grant from the Polish National Science Center: UMO-2016/21/D/ST3/00975.

P-5-24

Formation of ordered FePd $L1_0$ phase in Fe/Pd multilayers deposited on nanoporous templates

M. Hajdyła,[1] A. Maximenko,[1] A. Zarzycki,[1] Y. Zabila,[1] and M. Marszałek[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences, PL-31342 Krakow, Poland*

Nanoporous oxide materials are used as substrates for nanostructuring of magnetic thin films to modify their magnetic properties. FePd alloys with ordered $L1_0$ structure possess high coercive field (H_C) and effective magnetic anisotropy constant (K_{eff}). To obtain the ordered $L1_0$ phase, annealing or impulse heating is required. In present work, Fe/Pd multilayers deposited on flat Si and on nanoporous TiO_2 and Al_2O_3 templates were annealed in vacuum at temperatures $450 - 600°C$ to form alloy with $L1_0$ structure. The changes of the morphology, magnetic properties and ordering degree of FePd alloys as a function of annealin temperature were investigated. It was shown, that annealing at temperatures above 530°C resulted in the formation of $L1_0$ phase with in – plane magnetic anisotropy for all types of templates. The relationship between the degree of $L1_0$ phase order and substrate morphology was observed. The template topograph also influences coercivity and shape of the hysteresis loop of FePd films but did not affect effective magnetic anisotropy constant, which maintains the level of $10^6 \frac{erg}{cc}$.

The support from the NCN grant 2014/13/N/ST8/00731 is acknowledged.

P-5-25

Influence of local structure on magnetic anisotropy in Co/Pd thin film

A. Zarzycki,[1] A. Maximenko,[1] Y. Zabila,[1] and M. Marszałek[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Kraków*

We present the magnetic and structure properties of Co/Pd thin films where the influence of intermixing at the interfaces is addressed. The series of $Si/[Co_{0.3}/Pd_t]_{10}$ multilayers were prepared with Pd layer thickness $t = 0.6$ and 1.0 *nm*. Next the samples were annealed in vacuum at 300^0C for 15 min to enhance the mixing. The structure was studied with XRD measurements and with EXAFS spectroscopy measured at Pd and Co *K*-edge. For annealed alloys with different amount of Pd XRD showed a small differences of lattice constants for both systems while the Pd layer thickness has almost no influence on the Co and Pd interatomic distances obtained from EXAFS measurements. The interatomic distances of Co-Co and Pd-Pd atoms for the as-prepared Co/Pd multilayers were close to the bulk values suggesting a small intermixing at the interfaces and partial preservation of multilayered structure. A presence of PMA in both as-prepared and annealed samples indicates strong influence of magnetocrystalline anisotropy.

This work was supported with Polish National Science Center grant no. 2014/13/N/ST8/00731.

P-5-26

Magnetic excitations in inhomogeneous magnetic layered composites

A. Urbaniak-Kucharczyk[1]

[1] *Chair of Solid State Physics, Faculty of Physics and Applied Computer Sciene, University of Łódź, Pomorska149/153, 90 236 Łódź, Poland*

The knowledge of properties of elementary magnetic excitations in magnetic layered composites is important to minimize their disturbing influence or make use of them in logic devices. Spin waves patterns for a ferromagnetic layered composite with spatial distribution of anisotropy across magnetic layers have been calculated. Temperature dependence of anisotropy parameters has been also taken into account. As a result the characteristics of spin wave spectrum have been obtained for systems deposited on substrate characterized by parameters corresponding to GaAs for the case of uniform anisotropy parameter and for non-uniform distribution of this parameter. The effects of damping due spin-spin interaction leading to non-zero line-width of ferromagnetic resonance peaks have been additionally taken into account. As a result the dependence of the resonance lines profiles and the low-temperature magnetisation behaviour on parameters characterizing system under consideration were obtained for the case of uniform anisotropy parameter and for exponential distribution of this parameter in magnetic layers, respectively.

P-5-27

DFT+U vs. many-body model approach for a model of metalorganic switch

T. Kostyrko,[1] and T. Ślusarski[1]

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

We consider a metalorganic system with valence tautomeric properties[1] as a molecular switch. The molecule includes a delocalized spin of the organic subunit coupled with the localized spin centered on copper atom with its co-ligands and may appear in the several spin and charge states[2].

We use the results of the DFT calculations to compute the parameters of a many-body model of the system. To obtain the correct hierarchy of magnetic states a multi-orbital two-center Hamiltonian is proposed. The model is subsequently studied within an effective field approach and the exact diagonalization method. On this basis we indicate the limitations of the effective field description and stress the importance of accurate treatment of the Coulomb correlations for a detailed explanation of the switching behaviour.

References:

[1] C.G. Pierpont, Coord. Chem. Rev. 216-217, 99 (2001).

[2] T. Kostyrko, T. Ślusarski, Appl. Surf. Sci. 373, 19 (2016).

Prof. Bogdan Bułka is gratefully acknowledged for helpful discussions. This work has been supported by the National Science Centre under the contract DEC-2012/07/B/ST3/03412. The computations were performed at the Poznań's Supercomputing and Networking Center.

P-5-28

Large scale arrays of $Fe_{60}Al_{40}$ nanomagnets generated by ion irradiation

M. Krupiński,[1] R. Bali,[2] D. Mitin,[3] A. Zarzycki,[1] A. Semisalova,[2] K. Potzger,[2] M. Albrecht,[3] and M. Marszałek[1]

[1] *Institute of Nuclear Physics, Polish Academy of Sciences, Poland*
[2] *Helmholtz-Zentrum Dresden-Rossendorf, Germany*
[3] *Institute of Physics, University of Augsburg, Germany*

Large-scale periodic arrays of trigonal ferromagnetic islands embedded in a paramagnetic matrix have been fabricated by deposition of polystyrene nanospheres on 40 nm thick B2-$Fe_{60}Al_{40}$ thin films. Subsequently, the system was irradiated by Ne^+ ions in 30 – 130 keV range at $6x10^{14}$ cm^{-2} fluence, which induced chemical disorder and thus a ferromagnetic phase in the uncovered $Fe_{60}Al_{40}$.
Changes in coercive field, saturation magnetization, and magnetic anisotropy constant have been determined in a temperature range of 5 K – 350 K and correlated with the radiation damage obtained from simulations. The domains and the switching behaviour were studied by SMRM. The results demonstrated that the proposed approach can be used to produce large-area magnetic arrays embedded within a flat surface with magnetic properties tuneable by temperature and patterning period.

This work was supported by The German Academic Exchange Service (DAAD) with contract No. PPP-PL 57214850.

P-5-29

Exchange bias in oxygen-implanted Co/Au thin film heterostructures

M. Perzanowski,[1] J. Gregor-Pawłowski,[1] A. Zarzycki,[1] R. Böttger,[2] R. Hübner,[2] K. Potzger,[2] and M. Marszałek[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Kraków, Poland*
[2] *Institue of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany*

Magnetic systems exhibiting exchange bias effect are being considered as functional parts of modern data storage devices. A model system for the investigation of this effect is an antiferromagnetic-ferromagnetic CoO/Co interface. In this paper we present the studies of magnetic properties of Co-CoO/Au multilayers where the cobalt oxide was formed by oxygen ion beam implantation. Special emphasis is given to the role of the oxygen concentration profile in the magnetic properties. By properly designed the implantation conditions (ion beam energy and fluence) it is possible to fabricate a system revealing controlled stepwise magnetization reversal process. This underlines the great potential of this approach to tailor the magnetic properties through modification of implantation profiles.

This work was supported by DAAD Service with contract No. PPP-PL 57214850 „Magnetic anisotropies in cobalt heterostructures induced by oxidation".

P-5-30

Some structural and substructural properties of nanocrystalline CZTS films obtained by chemical techniques

P. Danilchenko,[1] O. Dobrozhan,[1] I. Shpetnyi,[1,2] and A. Opanasyuk[1]

[1] *Sumy State University, Rymskogo-Korsakova St. 2, Sumy, Ukraine*

[2] *Adam Mickiewicz University, NanoBioMedical Centre, ul. Umultowska 85, 61-614 Poznań, Poland*

Cu_2ZnSnS_4 (CZTS) thin films were obtained onto the glass substrates at T_s = 523 K using a colloidal nanocrystal ink deposited by pulsed spray pyrolysis method, followed by two mild temperature annealing regimes ($T_a const$ = 723 K, t = 2-5 min, δ = 1 min; T_a = 523-673 K, $tconst$ = 3 min, δ = 50 K). It is well-known that CZTS films possess the high degree of the secondary phases, complex defects and structural inhomogeneity, thus, the main goal of this work was to investigate the structural and substructural properties of the obtained films. X-ray diffraction analysis revealed that the films were polycrystalline with a tetragonal phase and had the minimum amount of the secondary phases at T_a = 723 K and t = 2 min. These films showed the texture growth in the [112] direction. The average CSD sizes were $L_{(112)}$ = 31.9 nm and $L_{(220)}$ = 11.3 nm. The values of the lattice parameters were a = (0.5420-0.5444) nm, c = (1.0650-1.0849) nm, c/a = (1.965-1.993) nm with a weak dependence on the regimes. The optimal conditions for the almost single phase films were found. *Acknowledgments: MES of Ukraine (G.N. 0116U002619, 0115U000665c, 0116U006813)*

P-5-31

Magneto-optical spectroscopy of Pt/Co/Pt trilayers irradiated with single pulse of soft X-Rays emitted from laser

L. Ohnoutek,[1] I. Sveklo,[2] L. Beran,[1] Z. Kurant,[2] T. Burian,[3] L. Juha,[3] I. Yatsyna,[4] R. Sobierajski,[4] A. Wawro,[4] A. Bartnik,[5] P. Wachulak,[5] A. Maziewski,[2] and M. Veis[1]

[1] *MFF, Charles University, Prague, Czech Republic*

[2] *Faculty of Physics, University of Bialystok, Bialystok, Poland*

[3] *Institute of Physics, Czech Academy of Sciences, Prague, Czech Republic*

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

[5] *Institute of Optoelectronics, Military University of Technology, Warsaw, Poland*

Magnetic and magnetooptical properties of Pt/Co/Pt epitaxial trilayers were irreversibly modified by single pulse irradiation at Prague Asterix Laser System. A transition between in-plane magnetization state into perpendicular state was observed. Polar magneto-optical Kerr effect magnetometry together with magnetic force microscopy were used to control magnetic properties, while magneto-optical spectroscopy sensitive to intermixing at the interfaces [1] was used for simulation of depth concentration profiles.

References:

[1] E. Jakubisova-Liskova, et al., J. Appl. Phys. 115, 17C106 (2014).

Sponsored by Harmonia project, NCN DEC-2012/06/M/ST3/00475

P-5-32

Lysozyme amyloid fibrils doped by carbon nanotubes

J. Majorosova[1]

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

Production of new composites for the creation of modern materials with desired properties is the key feature of nanotechnology. Despite the well known advantages of magnetic nanoparticles, the aim of the present study was syntetised lysozyme amyloid fibrils from hen egg white and subsequently dopped this solution by superparamagnetic magnetite nanoparticles Fe3O4 and feromagnetic single wall carbon nanotubes (SWCNT). Transmision electron microscopy was used to obtain the structural and dimensional information of samples. The structural changes of prepared solutions in applied external magnetic field were investigated by Polarization Microscopy. The charge was measured by Zeta Sizer Nano ZS. Presented results indicate the possibility to explore the interaction of feromagnetic nanotubes with fibrils by applying of external magnetic field.

This work was supported by Ministry of Education Agency for Structural Funds of EU in frame of project 26210120012.

P-5-33

SWR studies of higher-order surface anisotropy terms in (Ga,Mn)As thin films

H. Puszkarski,[1] P. Tomczak,[1] and H.T. Diep[2]

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

[2] *Lab. de Physique Théorique et Modélisation, U. de Cergy-Pontoise, France*

We have recently [1] extended the theory of spin-wave resonance (SWR) by deriving a new formula representing the surface pinning parameter $A = A(\varphi, \vartheta)$ as a series of contributions from anisotropies assumed to occur in (Ga,Mn)As thin films (see Eq. (3.13) in [1]). The pinning coefficients in this equation corespond to different anisotropies: a_{c1}, a_{c2} and a_{c3} are related to the first-, second- and third-order cubic anisotropies, respectively; $a_{[001]_1}$ and $a_{[001]_2}$ to the first- and second-order perpendicular uniaxial anisotropies, respectively; $a_{[100]}$ and $a_{[110]}$ to the respective in-plane uniaxial anisotropies; ϑ and φ denote the spherical magnetization angles. Here, we compare the theoretical predictions with the experimental data obtained in the SWR study of (Ga,Mn)As films reported in [2], to find that, except for the $a_{[100]}$ uniaxial anisotropy, all the anisotropies taken into account in [1] indeed occur on the surface of a (Ga,Mn)As thin film. To our best knowledge this is the first report of the existence of higher-order surface anisotropy fields in this material.

References:

[1] H. Puszkarski, P. Tomczak and H. T. Diep, Phys. Rev. B **94**. 195303 (2016).

[2] X. Liu, Y.-Y. Zhou, and J. K. Furdyna, Phys. Rev. B **75**, 195220 (2007).

P-5-35

Structural and magnetic properties of Co_2FeSi and Co_2MnSb Heusler alloys thin films grown on HOPG

Karol Załęski,[1] Emerson Coy,[1] Mateusz Kempiński,[1] and Feliks Stobiecki[1,2]
[1] *NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[2] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

Graphene is a promising material for a spin channel in spintronic devices because of the large electron mobility and the long spin diffusion length [1]. Half-metallic Heusler alloys are the best materials for spin injectors and detectors due to the 100% spin-polarisation of electrons at the Fermi level [2]. Combination of these materials can lead to the improvement of performance of the spintronic devices [3]. However, the growth of the Heusler alloys on the graphene was not studied before.
Herein, we present the influence of the growth temperature on structural and magnetic properties of Co_2FeSi and Co_2MnSb Heusler alloys thin films deposited on HOPG (whose surface is similar to graphene) substrates by magnetron sputtering. In particular, the difference in the growth mode between the two alloys will be discussed.

References:

[1] W. Han et al., Nat. Nanotechnol. 9, 794 (2014)
[2] T. Kimura et al., NPG Asia Mater. 4, e9 (2012)
[3] T. Yamaguchi et al., Appl. Phys. Express 9, 063006 (2016)

This work has been supported by the National Science Center under the contract DEC-2014/15/B/ST3/02927.

P-5-36

Effect of disorder on the properties of ensembles of interacting, ferromagnetic nanoparticles with cubic magnetocrystalline anisotropy: A Monte Carlo study

M. Marchwiany,[1] A. Majhofer,[2] J. Szczytko,[2] and A. Twardowski[2]
[1] *Interdisciplinary Centre for Mathematical and Computational Modelling, University of Warsaw, ul. Prosta 69, 00-838 Warsaw, Poland*
[2] *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, ul. L. Pasteura 5, 02-093 Warsaw, Poland*

We investigate an ensemble of 216 ferromagnetic single-domain nanoparticles with cubic magnetocrystalline anisotropy. Particles are spherical in shape and identical in size. The Hamiltonian contains: the anisotropy energy, interactions with the external field and long-range dipole-dipole interactions. We use the Monte Carlo method to simulate zero-field-cooled and field-cooled experiments to estimate blocking temperatures. We apply periodic boundary conditions and the Ewald summation techniques to get rasults relevant for infinite systems. We compare systems with particles distributed randomly and forming the simple cubic lattice and additionally compare cases with parallel anisotropy axes with the ones where axes are oriented randomly.

The work was partly supported by the ICM Grant No. G56-32.

P-5-37

Magneto-rheological and thermal transport characteristics of a transformer oil based ferrofluid

K. Paulovičová,[1] J. Tóthová,[2] M. Rajňák,[1,2] Z. Wu,[3] B. Sundén,[3] L. Wadsö,[4] T. Tobiáš,[1] P. Kopčanský,[1] M. Timko,[1] and V. Lisý[2]

[1]*Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 040 01, Košice, Slovakia*

[2]*Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, 04200 Košice, Slovakia*

[3]*Department of Energy Sciences, Lund University, 22100 Lund, Sweden*

[4]*Division of Building Materials, Lund University, 22100 Lund, Sweden*

Ferrofluids constitute a potential substitute of liquid dielectric in high voltage technologies. Hence, the flow and thermal transport characteristics of a ferrofluid based on transformer oil were investigated. The magneto-rheological behavior of the ferrofluid was studied in the shear rate range from 1 to 1000/s and magnetic field up to 1 T. The thermal conductivity, specific heat and thermal diffusivity were obtained for the studied oil and ferrofluid. The Newtonian character of the ferrofluid changed to a non-Newtonian by application of the magnetic field. The magneto-viscous effect has been observed at low shear rates. Doping of the oil by 3 wt% of the nanoparticles resulted in enhancement of the thermal conductivity by about 3.2 %.

P-5-38

EPR of graphene oxide and reduced graphene oxide under adsorption conditions

M. Kempiński,[1,2] P. Florczak,[2] and W. Kempiński[3]

[1]*Faculty of Physics, AMU, Umultowska 85, 61-614 Poznań, Poland*

[2]*NanoBioMedical Centre, AMU, Umultowska 85, 61-614 Poznań, Poland*

[3]*Institute of Molecular Physics, PAS, Smoluchowskiego 17, 60-179 Poznań, Poland*

We report the observation of Electron Paramagnetic Resonance (EPR) in graphene oxide and reduced graphene oxide. Both materials were subjected to the procedure of purification under vacuum conditions and subsequent immersion in various media i.e. air, helium and water. Strong changes in EPR spectra appeared as a result of host-guest interaction between the adsorbed molecules and the surface of graphene sheets. The role of defects and oxygen functionalities in the spin localization phenomena within the graphene-based materials will be discussed.

This work was supported by the National Center of Science, Grants No: DEC-2013/09/B/ST4/03711 and DEC-2014/15/B/ST3/02927

P-5-39

Structure and heating efficiency of the porous silica coated magnetite nanoparticles

P. Pawlik,[1] Ł. Laskowski,[2] M. Pruba,[1] and K. Pawlik[1]

[1] *Institute of Physics, Częstochowa University of Technology, Al. Armii Krajowej 19, Częstochowa, Poland*

[2] *Department of Microelectronics and Nanotechnology, Częstochowa University of Technology, Al. Armii Krajowej 36, Częstochowa, Poland*

In the present studies the microstructure and heating efficiency of the porous silica coated magnetite nanoparticles were investigated. The Fe_3O_4 samples were obtained by the co-precipitation process that involves a synthesis of the iron-oxide particles from the aqueous solutions of the Fe (II) and Fe (III) salts. The magnetite nanoparticles coated with the porous silica were produced by the modified Stöber process. The microstructure of both the silica-coated and non-coated powders was studied using the high resolution transmission electron microscopy. Furthermore, the XRD studies as well as the Mössbauer and Raman spectroscopies were used to analyze the phase constitution of the investigated samples. The XRD measurements were supported by the Rietveld refinement to determine the unit cell parameters and the average grain sizes of produced samples. The magnetic hyperthermia studies allowed to compare the specific loss power (SLP) for non-coated and silica-coated magnetite nanoparticles.

P-5-40

Superparamagnetic behavior in well dispersible magnetite core-shell Fe_3O_4@SiO_2 nanoparticles

K. Chybczyńska,[1] K. Tadyszak,[2] E. Coy,[2] and A. Kertmenc[3]

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

[2] *NanoBioMedical Centre, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznań, Poland*

[3] *Department of Pharmaceutical Technology and Biochemistry, Faculty of Chemistry, Gdańsk University of Technology, Narutowicza 11/12, 80-233 Gdańsk, Poland*

Magnetic properties of core-shell Fe_3O_4@SiO_2 nanoparticles were measured with use of AC and DC magnetometry. Particles were in form of crystalline magnetic core of 11.5 nm and an amorphous silica shell. The magnetic measurements confirmed superparamagnetic nature of particles. Hysteresis loops exhibit typical temperature dependence of coercivity Hc, with lowering temperature Hc increases. Moreover hysteresis loops does not saturate at any temperature confirming that Fe_3O_4 surface spins are highly disordered due to high surface anisotropy.

A.K. was financed by UMO-2015/17/N/NZ7/01087, K.T. was financed by 2016/21/D/ST3/00975.

P-5-41

DFT augmented symmetry approach applications to simulations of the chromium-based rings: cross-validation using the PBE and B3LYP functionals

Michał Wojciechowski,[1] Bartosz Brzostowski,[1] and Grzegorz Kamieniarz[2]
[1] *Institute of Physics, University of Zielona Góra, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

The DFT estimates of magnetic couplings in molecular nanomagnets are computationally demanding and their values have not achieved the satisfactory accuracy in spite of a lot of effort. We concentrate here on comprehensive convergence and accuracy tests for predictions of the augmented symmetry approach aiming at reducing the computational complexity of the DFT calculations for molecular rings which is particularly important for the Wien2k code. Using both the PBE and the B3LYP functionals, we demonstrate the numerical stability of magnetic couplings, magnetic moments and the HOMO-LUMO gaps, changing the size of the basic parameters RKM, the number of k-points and types of the unit cells as well as some symmetry constraints. We reach the significant gain in the computing time without a loss in the accuracy of the final results with respect to those obtained by the standard approaches which paves the way to application of the hybrid functionals within Wien2k. We conclude that the value RKM = 3.0 and a single k-point in the irreducible Brillouin zone are enough for estimation of magnetic couplings.

P-5-42

Propagating spin waves in 1D quasiperiodic magnonic crystals

F. Lisiecki,[1] J. Gräfe,[2] J. Rychły,[3] P. Kuświk,[1] H. Głowiński,[1] M. Krawczyk,[3] and J. Dubowik[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Max Planck Institute for Intelligent Systems, Stuttgart, Germany*
[3] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

In this work we report on fabrication and spin waves (SWs) dynamics in one-dimensional quasiperiodic magnonic crystals consisted of $Ni_{80}Fe_{20}$ nanowires arranged using Fibonacci inflation rule. Magnetic dynamic properties were investigated using ferromagnetic resonance with vector network analyzer and scanning x-ray microscopy with x-ray circular dichroism contrast with which propagating SWs were imaged for quasiperiodic and reference periodic structure. Gradual variation of the phase along the propagation direction is visible which indicates propagating character of the SWs in the structure. Significant jumps of the phase value between wide and narrow nanowires are also observed, which means that the oscillations in both type of nanowires are out-of-phase. It may suggest that the optical modes were excited. The outcomes of numerical calculations were used for the interpretation of the experimental results.

The study has received funding from European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie GA No644348 (MagIC).

P-5-43

Electron energy spectrum in 2D quantum dot

S. Wolski,[1] V. Dugaev,[1] J. Barnaś,[2] E. Sherman,[3,4] M. Inglot,[1] and P. Kwaśnicki[5]

[1] *Department of Physics and Medical Engineering, Rzeszów University of Technology, Poland*

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

[3] *Department of Physical Chemistry, The University of the Basque Country UPV/EHU, Bilbao, Spain*

[4] *IKERBASQUE Basque Foundation for Science, Bilbao, Spain*

[5] *Research and Development Centre for Photovoltaics, ML System S.A Zaczernie, Poland*

Semiconductor quantum dots introduced into the photoelectric material are currently a very important and effective way to increase the efficiency of photoelectric devices and photovoltaic cells. This is related to the appearance of additional energy levels in the system, and it expands the range of absorption frequencies toward the infrared. This work contains the theory and numerical calculation of energy levels in quantum dots in perovskite solids. The model of the structure includes a semiconductor quantum dot shaped in nanodisk which is surrounded by another semiconductor. The calculations of the energy levels as functions of the dot radius and various types of semiconductors materials are performed.

P-5-44

AFM-FM phase transition in ultrathin FeRh and in FeRh/FM (Fe, Co) bilayers on W(110) substrate

P. Dróżdż,[1] M. Ślęzak,[1] K. Matlak,[1] J. Korecki,[1,2] and T. Ślęzak[1]

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

[2] *Jerzy Haber Institute of Catalysis and Surface Chemistry PAS, Kraków, Poland*

Low dimensional FeRh films exhibiting AFM-FM transition are promising materials for the heat assisted storage media applications [1]. Ultrathin FeRh layers with the thickness of 33, 50 and 100Å were grown on the W(110) substrate. The magnetic properties were studied in-situ using longitudinal magnetooptical Kerr effect. The AFM-FM phase transition was observed for all the investigated thicknesses, but with clearly different temperature characteristics. The transition temperature decreases with decreasing thickness when heating from the AFM to FM phase while, on its cooling branch transition becomes smeared and wider for the thinnest film as compared to the thicker ones. In addition, we show that deposition of 5 Å Co capping layers on FeRh surface shifts the transition temperature downward relative to the uncoated FeRh. Finally, the in-plane anisotropy of the cobalt film can be programmed with use of AFM-FM phase transition in FeRh.

References:

[1] J. Cao, N.T. Nam, S. Inoue, H.Y.Y. Ko, N.N. Phuoc, and T. Suzuki, J. Appl. Phys. 103, 07F501 (2008).

P-5-45

On the adsorption of magnetite nanoparticles on lysozyme amyloid fibrils

J. Majorošová[1]

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

An adsorption of magnetic nanoparticles (MNP) from aqueous ferrofluids on amyloid fibrils of hen egg white lysozyme (HEWL) in 2 mg/mL acidic dispersions have been detected for three different MNP concentrations. The mixture of the MNP with amyloid fibrils has been characterized by transmission electron microscopy (TEM), small-angle X-ray scattering (SAXS) and magneto-optical measurements. It has been observed that the scope of adsorption is determined by the MNP concentration. With increasing the MNP concentration, the aggregates of magnetic particles are formed and they repeat the general rod-like structure of the fibrils. The observed phenomenon is also discussed with respect to potential applications for ordering lysozyme amyloid fibrils in a liquid crystal phase under external magnetic fields.

This work was supported by the projects of the Slovak Scientific Grant Agency VEGA (No. 0041, 0045, 0181), the Slovak Research and Development Agency APVV 0171-10, the European Structural Funds, No. 26220220005, No. 26110230061 and 26220120021,No. 26110230097, PROMATECH No. 26220220186, APVV 0171-10 and M-ERA. NET MACOSYS. A part of the work was done with the support of RFBR, grant no. 14-22-01054 ofi-m. We gratefully acknowledge the technical support from Clement Blanchet (EMBL) at the P12 BioSAXS beamline (EMBL/DESY, PETRA III).

P-5-46

Perpendicular magnetic anisotropy in Au/CoFeB/Au system – static and dynamic characterization

Hubert Głowiński,[1] Piotr Kuświk,[1] and Janusz Dubowik[1]

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

Magnetic thin film systems with perpendicular magnetic anisotropy (PMA) constantly attract attention due to their scientific and application potential. Nowadays the CoFeB layers characterized by PMA are extensively studied as a magnetic thin film system for magnetic random access memory. In CoFeB films PMA can be achieved by a contact with MgO layer and annealing or without annealing with noble metals, like Pd or Pt. Here we present novel layered system (Au/CoFeB/Au) which exhibits PMA without annealing. Using polar magnetooptical Kerr effect and vector network analyzer ferromagnetic resonance (VNA-FMR) measurements we found that spin reorientation transition from out-of-plane to in-plane anisotropy occurs at CoFeB thickness (t_{CoFeB}) of 1.1 nm. Additionally, from VNA-FMR we determined that g-factor of Au/CoFeB/Au system measured in the in-plane (out-of-plane) configuration decreases (increases) with decreasing t_{CoFeB}. We observed a linear dependence of g-factor on $1/t_{\mathrm{CoFeB}}$, what suggests that the effect is interfacial in origin. The g-factor can be explained in terms of the s-d hybridization at CoFeB/Au interfaces.

The work was financed by the National Science Centre Poland under SONATA BIS funding UMO 2015/18/E/ST3/00557

P-5-47

Non-collinear Magnetic Configuration on Multilayered Thin Films

Taner Kalaycı,[1] Caner Değer,[1] Şahin Aktaş,[1] and Fikret Yıldız[2]

[1] *Marmara University, Department of Physics, İstanbul, 34722, Turkey*

[2] *Gebze Technical University, Department of Physics, Kocaeli, 41400, Turkey*

Non-collinear magnetization configuration of ferromagnetic layers, due to the competition between interlayer coupling energy and magnetic anisotropies of coupled layers, is potential candidate for spintronic applications such as magnetic recording and sensor technologies [1]. In this study, we have revealed the effects of non-magnetic (NM) spacer and Co reference layer thickness in $[Co/Pt]_6$/NM/Co multilayer to tailor magnetization directions in non-collinear configuration. Magnetic properties of samples have been investigated by using Magnetooptic Kerr effect and ferromagnetic resonance technique. A micromagnetic simulation based on Metropolis algorithm was employed to determine bilinear coupling between $[Co/Pt]_6$ and Co layers and anisotropy constants. It is revealed that controlling of non-collinear states in such systems is possible by variation of thickness of spacer and reference layers and $[Co/Pt]_6/t_{NM}/t_{Co}$ trilayer system can be used in multilayered magnetic systems.

References:

[1] F. Yildiz *et al.*, Phys. Rev. Lett., **103** (2009) 147203

P-5-48

He+ ion bombardment modification of magnetic properties of Co layers sandwiched between Pd and/or Au

M. Matczak,[1] B. Szymański,[1] A. Jarosz,[1] M. Urbaniak,[1] P. Kuświk,[1] M. Schmidt,[1] J. Aleksiejew,[1] A. Ehresmann,[2] and F. Stobiecki[1]

[1] *Institute of Molecular Physics, Polish Academy of Science, Poznan, Poland*

[2] *Institute of Physics and CINSaT, University of Kassel, Kassel, Germany*

Ion bombardment (IB) is a very efficient method for post-deposition modification of magnetic properties of multilayers (ML_s). In this contribution the influence of He^+ (10 keV) IB on the coercive field (H_C) and hysteresis loop squareness (M_R/M_S, M_R and M_S are saturation and remanence magnetization, respectively) of Pd/Co/Pd, Au/Co/Pd, Pd/Co/Au, and Au/Co/Au ML_s was systematically studied. For Au/Co/Au and Pd/Co/Au ML_s, in full fluence of the He^+ ions (D) range, H_C decreases until M_R/M_S=0. However, for Pd/Co/Pd and Au/Co/Pd systems in a certain range of D and the thicknesses of Co sublayer (t_{Co}), H_C and M_R/M_S increase which indicates that perpendicular magnetic anisotropy (PMA) is enhanced or induced. Considering these properties and taking into account a strong increased or induced PMA of Au/Co/Pd films, this system seems to be a good candidate for magnetically patterned media.

P-5-49

Josephson effect in graphene based-junctions

R.J. Wojciechowski,[1] and L. Kowalewski[1]
[1] *Faculty of Physics, Adam Mickiewicz University*
ul. Umultowska 85, 61-614 Poznań (Poland)

We study the Josephson effect in graphene based junctions where superconductivity in graphene is induced by the proximity effect from external contacts. The junction considered is described by the Dirac-Bogoliubov-de-Gennes equation with appropriate boundary conditions imposed on the normal metal-superconductor (SN) interface [1]. We calculated the Josephson current taking into account two types of reflections with the electron-hole conversion, which occur at the graphen-based SN interface, namely, the specular Andreev and retro Andreev reflections. In addition, we discuss the influence of the chiral nature of the quasiparticle in graphene on the Josephson supercurrent. We claculate the Josephson supercurrent, in the diffusive and ballistic limits [2,3], and show that the supercurrent is determined both by the width and length of a graphene strip as well as by the different types of graphene edges.

References:

[1] M. Titov and C. W. J. Beenakker, Pys.Rev. **B74**, 041401R (2006).
[2] V. E. Calado, S. Goswami, G. Nanda, M. Diez, A. R. Akhmerov, K. Watanabe, T. Taniguchi, T. M. Klapwijk, and L. M. K. Vandersypen, Nature Nanotechnology **10**, 761 (2015).
[3] A.G. Moghaddam and M. Zareyan, Phys.Rev **B74**, 241403R (2006).

P-5-50

Modulation of magnetic anisotropy through self-assembled surface nanoclusters: evolution of morphology and magnetism in Co-Pd alloy films

Wen-Chin Lin[1]
[1] *Department of Physics, National Taiwan Normal University, Taipei 11677, Taiwan*

In this study, the self-assembly of surface nanoclusters on 10-20-nm-thick $Co_{50}Pd_{50}$ (Co-Pd) alloy thin films deposited on the $Al_2O_3(0001)$ substrate was systematically investigated. When the Co-Pd alloy films were stored in an ambient environment, small nanodots gradually gathered to form large nanoclusters. Approximately 30 days after growth, a nanocluster array formed with an average lateral size of 100 $\pm$ 20 nm and average height of 10 $\pm$ 3 nm. After 100 days, the average lateral size and average height had increased to 140 $\pm$ 20 and 25 $\pm$ 5 nm, respectively. Cross-sectional investigation through transmission electron microscopy coupled with energy dispersive spectroscopy showed that the nanoclusters were mostly composed of Co oxide. A uniform Pd-rich underlayer had ben maintained underneath the self-assembled Co-oxide nanoclusters. With the formation of a Co-oxide nanocluster array, the magnetic easy axis of the Co-Pd film gradually altered its direction from the pristine perpendicular to in-plane direction. The hydrogenation-induced spin-reorientation transition was also suppressed with the evolution of the surface Co-oxide nanoclusters.

P-5-51

Andreev transport through a magnetic molecule

F. Pawlicki,[1] and I. Weymann[1]

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

The Andreev transport through a single molecular magnet coupled to two external ferromagnetic leads and one superconducting lead is studied theoretically by means of the real-time diagrammatic technique. The calculations are performed by including the sequential tunneling processes between the molecule and ferromagnetic leads, while the coupling to superconductor can be arbitrary. We analyze the dependence of the Andreev current, differential conductance and tunnel magnetoresistance on various intrinsic parameters of the molecule. The interplay between superconducting proximity effect and the possibility of tunneling through excited states of the molecule gives rise to the splitting of Andreev bound states. Moreover, by studying the behavior of the tunnel magnetoresistance, which quantifies the amount of crossed Andreev reflection compared to direct Andreev tunneling, we discuss the possibility of using magnetic molecules for Cooper pair splitting.

This work was supported by the Polish National Science Centre from funds awarded through the decision No. DEC-2013/10/E/ST3/00213.

P-5-52

Interlayer exchange coupling in Nb/Fe multilayers

A. Marczyńska,[1] M. Pugaczowa-Michalska,[1] B. Szymański,[1] and L. Smardz[1]

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

The (110) oriented Nb/Fe multilayers (MLs) with constant Fe (2 nm) and variable Nb sublayer thicknesses were prepared at room temperature using UHV magnetron sputtering. Growth of the Nb-Fe bilayers were studied in-situ by X-ray photoelectron spectroscopy (XPS). From the exponential variation of the XPS Fe-2p and Nb-3d integral intensities with increasing layer thickness we conclude that the Fe and Nb sublayers grow homogeneously in the planar mode. The artificial periodicity was revealed by intense satellite peaks in the low - and high - angle X-ray diffraction patterns. Magnetic hysteresis loop measurements at 5 K revealed antiferromagnetic (AFM) exchange coupling peak of the Fe sublayers near Nb spacer thickness of about 3, 5, 8 and 10 monolayers. Furthermore, above 200 K we have observed additional AFM peaks near Nb spacer thickness of about 13 and 15 monolayers. The Nb spacer thicknesses corresponding to the positions of the local AFM peaks slightly increase at 300 K. In general, the experimentally determined positions of AFM peaks at 5 K are in good agreement with ab-initio calculations with localized spin density and a generalized gradient approximations of exchange-correlation potential.

P-5-53

Modification of exchange coupling in Fe/Nb/Fe/Pd layered structures using hydrogen

M. Wachowiak,[1,2] A. Marczyńska,[1] A. Rogowska,[1,2] H. Dawczak-Dębicki,[1,3] S. Pacanowski,[1] M. Pugaczowa-Michalska,[1] and L. Smardz[1]

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

[2] *Faculty of Technical Physics, Poznań University of Technology, Poznań, Poland*

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

3 nm Fe/d-Nb/3 nm Fe trilayers were prepared at room temperature using UHV magnetron sputtering. A capping layer of 5 nm Pd was used to catalyse hydrogen absorption and to avoid oxidation of the top Fe layer. The magnetic characterisation of the samples was performed using a vibrating sample magnetometer at 295 K. Calculations of the interlayer exchange coupling energy were carried out using ab-initio method with localized spin density and generalized gradient approximations of exchange-correlation potential. The bottom and top Fe layers were deposited in different deposition conditions to obtain relatively high difference in their coercive fields. The interlayer exchange coupling energy was determined from a shift of the minor hysteresis loop from the origin. Results showed clear antiferromagnetic (AFM) coupling maxima near 3, 6, 9, and 12 monolayers of Nb spacer. The above result was in good agreement with ab-initio calculations. Furthermore, the position of the AFM peaks and coupling energy values could be modified using hydrogen.

P-5-54

Growth of Mn doped Germanium Nanowires on Silicon (111) Substrate By Molecular Beam Epitaxy

I. GUNDUZ AYKAC,[1,2] A. ONEL,[1] O. MERCAN,[1] and L. COLAKEROL ARSLAN[1]

[1] *GEBZE TECHNICAL UNIVERSITY, Department of Physics, Kocaeli* 41400*, Turkey*

[2] *ISTANBUL MEDENIYET UNIVERSITY, Department of Physics Engineering, Istanbul* 34000*, Turkey*

In this study, the germanium NWs were grown by MBE on Si(111) substrates from gold seeds using the so-called VLS process. We performed ex-situ HF etching and in-situ annealing steps until we obtained the 7x7 reconstruction on Si substrate. Then 1 nm thick gold film was deposited at room temperature. After that, thermal annealing was carried out inside the UHV chamber and following this, well ordered gold nanostructures placed on Ge pedestal were formed. After cooling the substrate, the Ge nanowire growth was carried out. After the growth of nanowires, a thin Mn layer growth was performed at room temperature and annealed at different temperatures. The grown nanowires were characterized by the XRD to optimize the growth rate and improve quality of the crystal. Electron microscopy (SEM,EDX) studies were carried out to determine the structure of the Au – Ge nano systems.

P-5-55

Exchange coupling effects in naturally oxidised ultrathin iron films

A. Rogowska,[1,2] A. Marczyńska,[1] H. Dawczak-Dębicki,[1,3] M. Wachowiak,[1,2] M. Nowicki,[2] S. Pacanowski,[1] B. Jabłoński,[1,2] W. Kowalski,[1] J. Grembowski,[1] T. Bilski,[1] R. Czajka,[2] and L. Smardz[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Faculty of Technical Physics, Poznań University of Technology, Poznań, Poland*
[3] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

Oxidation process of Fe films under atmospheric conditions is depth limited such that an oxide covering layer with a well-defined thickness is formed by which the underlying metal is prevented from further oxidation. Iron thin films were deposited onto 1.6 nm – V(110) buffer layer using UHV magnetron sputtering. The chemical compositions of natural Fe oxides were studied by X-ray and ultraviolet photoelectron spectroscopy. The planar growth of Fe oxides was revealed by atomic force microscopy. Furthermore, magnetic measurements of Fe films with an initial thickness lower than 5 nm revealed an exchange anisotropy which is imposed to the metallic rest. As a result, we have observed a shift and broadening of the hysteresis loops due to the exchange interaction at the metal – oxide interface. The blocking temperature increases with time reaching 260 K after 650 days of oxidation.

P-5-56

Hydrogen absorption in Gd thin films

A. Marczyńska,[1] S. Pacanowski,[1] B. Szymański,[1] and L. Smardz[1]

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

Rare earth metals are of great scientific interest because of unusual electronic and magnetic properties which arise from their highly localized 4f electrons. Adsorbates can significantly alter the electronic structure of the underlying substrate and are additionally of great importance in technological processes, e.g., heterogeneous catalysis. In this contribution we have studied in-situ an initial hydrogen absorption in Gd thin films using X-ray photoelectron spectroscopy (XPS). As an initial hydrogen absorption indicator we have used broadening of the Gd-4f peak. The Gd thin films with a thickness from 50 nm to 200 nm were deposited at room temperature (RT) using UHV RF magnetron sputtering. As a substrate we have used naturally oxidised Si(100) wafers with and without Pd buffer layer. Results showed, that due to Gd-Pd alloy formation near interface the initial hydrogen absorption is greater for the Gd samples deposited directly on the Si substrate without Pd buffer layer. Furthermore, hydrogen absorption and desorption kinetics up to 1000 mbar in Pd covered 200 nm – Gd thin films were studied at RT using four-point resistivity measurements and X-ray diffraction. Magnetic susceptibility measurements revealed Gd-Pd alloy formation for "as prepared" samples and a magnetisation decreasing for hydrogenated thin films.

P-5-57

Magnetic properties of hydrogenated Mg/Ni multilayers

S. Pacanowski,[1] A. Marczyńska,[1] H. Dawczak-Dębicki,[1,2] B. Jabłoński,[1,3] B. Szymański,[1] and L. Smardz[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[3] *Faculty of Technical Physics, Poznań University of Technology, Poznań, Poland*

Magnesium hydride is both relatively cheap and abundant and together with its high gravimetric and volumetric hydrogen storage capacity that makes it a favoured material for practical applications. In this contribution we have studied magnetic properties of Mg/Ni multilayers (MLs) before and after hydrogen absorption using VSM. The structure was characterised by standard X-ray diffraction. The MLs were deposited by UHV magnetron sputtering onto naturally oxidised Si(100) substrates. Results showed, that due to MgNi alloy formation near interfaces the magnetisation of MLs was strongly reduced. Effective MgNi alloy thickness strongly depends on Mg sublayer thickness. Furthermore, hydrogen absorption and desorption kinetics up to 1000 mbar was studied at RT in Pd covered Mg/Ni MLs using four-point resistivity measurements. The kinetics also strongly depends on both magnesium and nickel sublayer thicknesses.

Work of the first author (S. P.) was financially supported within the research project "Diamond grant", 2015-19, No. DI2014010344.

P-5-58

Combination of magnetic and semiconductor properties in (Ga,Mn)(Bi,As) nanostructured thin films

K. Levchenko,[1] T. Andrearczyk,[1] J. Sadowski,[1,2] E. Lusakowska,[1] J.Z. Domagala,[1] M. Trzyna,[3] R. Jakiela,[1] I. Radelytskyi,[1] T. Figielski,[1] and T. Wosinski[1]

[1] *Institute of Physics, Polish Academy of Sciences, PL-02668 Warsaw, Poland*
[2] *MAX-IV Laboratory, Lund University, SE-22100 Lund, Sweden*
[3] *University of Rzeszów, PL-35310 Rzeszów, Poland*

Driven by the high requirements for modern technologies, we combined miniaturization and state of the art concepts development within spintronic nanostructures made from thin films of the (Ga,Mn)(Bi,As) quaternary alloy [1]. We will present nanostructures of cross-like and ring-shape geometries, tailored using electron-beam lithography patterning and chemical etching from 10-nm thick (Ga,Mn)(Bi,As) epitaxial layers with 6% Mn and 1% Bi contents. A specific interplay between the anisotropies arousing in the structures creates a resistance difference between contact pairs, providing its utility for memory units, that can be driven by an applied low magnetic field or a spin-polarized current and increased as a result of enhanced spin-orbit coupling by bismuth incorporation.

References:

[1] K. Levchenko et al., J. Supercond. Nov. Magn. 30, 825 (2017)

P-5-59

Structure of FeO(111) islands on Ru(0001) annealed in ultra-high vacuum

N. Michalak,[1,2] Z. Miłosz,[2] S. Jurga,[2] and M. Lewandowski[2]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smulochowskiego 17, 60-179 Poznań, Poland*
[2] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

Ultrathin iron oxide films epitaxially grown on metal single crystal supports exhibit interesting electronic, catalytic and magnetic properties [1]. On Ru(0001), FeO(111) islands and films can be grown by iron deposition in ultra-high vacuum (UHV) and subsequent oxidation in 1 x 10^{-6} mbar O_2 at 900-1000 K [2]. We prepared FeO(111) islands on Ru(0001) and annealed them in UHV at temperatures ranging from 900 to 1050 K. Scanning tunneling microscopy (STM), low energy electron diffraction (LEED) and x-ray photoelectron spectroscopy (XPS) results revealed significant structural differences between pristine and UHV-annealed islands.

References:

[1] G.S. Parkinson, Surf. Sci. Rep. 71 (2016) 272.
[2] G. Ketteler and W. Ranke, J. Phys. Chem. B 107 (2003) 4320.

This work was financially supported by the National Science Centre of Poland (PRELUDIUM project No. 2016/21/N/ST4/00302)

P-5-61

Structural and magnetic properties of Ni nanofilms on Ge(001) by molecular beam epitaxy

Amelia Elena Bocirnea,[1,2] Ruxandra Maria Costescu,[1] Iuliana Pasuk,[1] George Adrian Lungu,[1] and Cristian Mihail Teodorescu[1]
[1] *National Institute of Materials Physics, Atomistilor 405A, Magurele Ilfov 077125, Romania*
[2] *University of Bucharest, Faculty of Physics, Atomistilor 405, Magurele Ilfov 077125, Romania*

Ni films of 20 nm nominal thickness were grown on Ge(001) substrates by molecular beam epitaxy at several different temperatures from room temperature up to 400 °C. Their structure and their magnetic properties were determined with in-situ and ex-situ techniques. XRD and XPS reveal the nucleation of Ni-Ge compounds (NiGe, Ni_2Ge, Ni_5Ge_2) as well as a departure from the *fcc* Ni structure exhibited by the films at and beyond a temperature of 100 °C. The Ni 2p binding energy increases, while the Ge 2p binding energy is not strongly affected by the metal deposition. Ni diffuses further into the germanium with higher substrate temperature, forming increasingly Ni-rich Ni-Ge compounds diluted into the Ge matrix (such that LEED patterns of Germanium are still visible after growth on 300 and 400 °C substrates). MOKE measurements show the magnetic character of hexagonal Ni_5Ge_2 (which is determined here for the first time to be a room-temperature ferromagnetic phase).

P-5-62

Preparation and characterisation of Ce/Fe multilayers

H. Dawczak-Dębicki,[1,2] A. Marczyńska,[1] S. Pacanowski,[1] Ł. Majchrzycki,[3] B. Szymański,[1] and L. Smardz[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[3] *WCZT, Adam Mickiewicz University, Poznań, Poland*

Ce/Fe multilayers (MLs) with constant Fe (2 nm) and variable Ce sublayer thickness were prepared onto naturally oxidised Si(100) substrates using UHV magnetron sputtering. Chemical purity of the sublayers was revealed in-situ by X-ray photoelectron spectroscopy (XPS). The structure of the samples was studied by standard low- and high-angle X-ray diffraction (XRD). Surface morphology of the samples was examined by atomic force microscopy. Magnetic properties of the MLs were studied in the temperature range between 5 and 350 K using a vibrating sample magnetometer in a magnetic field up to 9 T. Furthermore, hydrogen absorption and desorption kinetics up to 1000 mbar was studied at room temperature (RT) in Pd covered MLs using four-point resistivity measurements. The solid state amorphisation reactions have been confirmed by XRD and magnetic measurements in the "as-deposited" Ce/Fe MLs. The absence of satellite peaks in the low-angle XRD patterns revealed no artificial layered structure. The above results show that interdiffusion of cerium and iron atoms is extremely fast at RT.

P-5-63

Graphene growth on "technical" supports: Ni(111)/Si(111) and Ni(111)/Al_2O_3(0001)

Z. Miłosz,[1] S. Mielcarek,[2] S. Jurga,[1] F. Stobiecki,[1] and M. Lewandowski[1]

[1] *NanoBioMedical Centre, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*
[2] *Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*

Epitaxial graphene can be grown on various metal single crystal supports, however, high cost of these substrates limits their applicability in electronic devices. We deposited nickel onto "technical" Si(111)-(7x7) and Al_2O_3(0001) supports and annealed at high temperatures trying to obtain epitaxial nickel films that could mimic single-crystalline Ni(111). As fabricated substrates were then annealed in ethylene (C_2H_4) gas in order to obtain epitaxial graphene. Preliminary ***in situ*** scanning tunneling microscopy (STM) and ***ex situ*** Raman spectroscopy results confirmed the presence of graphene and/or graphite on both supports.

This work was financially supported by the National Science Centre of Poland (grant No. 2014/15/B/ST3/02927).

P-5-64

Influence of synthesis on Fe^{2+} relative content in $(Fe^{3+})[Fe^{2+}_{1-3\delta}Fe^{3+}_{1+2\delta}\square_{\delta}]O_4$ particles of various mean diameter

D. Kubániová,[1] J. Kohout,[1] and O. Kaman[2]

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

[2] *Institute of Physics ASCR, v.v.i., Na Slovance 2, 182 21 Praha 8, Czech Republic*

The effect of synthesis route on the stoichiometry of Fe_3O_4 with spinel structure and its ^{57}Fe hyperfine parameters was investigated by means of low temperature Mössbauer spectroscopy (MS) in fields up to 6 Tesla. While magnetite structure is stable for bulk samples, high specific surface of nanoparticles allows quick oxidation during the synthesis and/or after exposure to oxygen-rich environment, thus yielding mixed maghemite/magnetite (non-stoichiometric) samples. The nanoparticles (NPs) in this study were synthetized by thermal decomposition in high-boiling point solvents. The particles' morphology and size distribution as observed via TEM corresponded well to the log-normal distribution with mean diameter d_0=11.3 nm. As-prepared (in oil) and purified NPs showed differences in MS spectra. The comparison with the spectra of ~50-100nm and polycrystalline microscopic particles suggested that the protective oily environment stabilized the magnetite NPs for prolonged period.

The financial support under the grant GAČR 16-04340S is gratefully acknowledged.

P-5-65

XPS and UPS valence band studies of nano- and polycrystalline Ni-Ti alloy thin films

S. Pacanowski,[1] J. Skoryna,[1] A. Szajek,[1] A. Marczyńska,[1] H. Dawczak-Dębicki,[1,2] M. Werwiński,[1] Ł. Majchrzycki,[3] and L. Smardz[1]

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

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

[3] *WCZT, Adam Mickiewicz University, Poznań, Poland*

It is well known that modifications of the valence bands of the nanocrystalline alloys could significantly influence on their hydrogenation properties. In this contribution we study valence bands of in-situ prepared nano- and polycrystalline Ni-Ti alloy thin films using X-ray (XPS) and ultraviolet (UPS) photoelectron spectroscopy. Additionally, theoretical valence bands were calculated using ab initio methods. The structure and morphology of the samples have been studied by X-ray diffraction and atomic force microscopy, respectively. Furthermore, hydrogen absorption and desorption kinetics up to 1000 mbar were studied in Pd covered alloy samples using four-point resistivity measurements. Results showed that the valence bands of the nanocrystalline Ni-Ti alloy thin films are considerably broader compared to those measured for the polycrystalline samples with the same compositions.

Work partially (S.P.) supported within the research project "Diamond grant", 2015-19, No. DI2014010344.

P-5-66

Influence of valence band modifications on hydrogen absorption in Zr-Pd alloy thin films

B. Jabłoński,[1,2] S. Pacanowski,[1] M. Werwiński,[1] A. Marczyńska,[1]
H. Dawczak-Dębicki,[1,3] A. Szajek,[1] and L. Smardz[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Faculty of Technical Physics, Poznań University of Technology, Poznań, Poland*
[3] *Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*

Intermetallic compounds based on hydrogen absorbing elements usually form stable hydrides. This is the case of $PdZr_2$ alloy. On the other hand, a similar compound, $ZrPd_2$, does not absorb hydrogen, although it has the same crystal structure and satisfy the empirical geometrical criteria for hydride formation. The above behaviour was explained as a purely electronic effect. In this contribution we study valence bands modifications of in-situ prepared nanocrystalline $PdZr_2$ and $ZrPd_2$ thin films using X-ray and ultraviolet photoelectron spectroscopy. Results were compared with valence bands calculated by ab initio methods. Furthermore, hydrogen absorption and desorption kinetics up to 1000 mbar were studied in Pd covered samples. Results showed that modifications of the valence bands of the nanocrystalline alloy thin films could significantly influence on their hydrogenation properties.

Work partially (S.P.) supported within the research project "Diamond grant", 2015-19, No. DI2014010344.

P-5-67

Phase and structure formation in the layered $[Fe_{50}Pt_{50}/Cu/Fe_{50}Pt_{50}]_n$ (n=1, 2) films

R.A. Shkarban,[1] O.V. Fihurna,[1] A.Yu. Chernysh,[1] and Yu.N. Makogon[1]
[1] *National Technical University of Ukraine*
«Igor Sikorsky Kyiv Polytechnic Institute»,
03056, Prospect Peremogy 37, Kyiv, Ukraine

The use of additional layers of alloying element such as Cu in $Fe_{50}Pt_{50}$ films can accelerate ordering processes by changing the stress state in FePt layer and leads to reduction of $L1_0$ phase formation temperature. The effect of annealing atmosphere and adding of Cu on $L1_0$ phase formation in $[Fe_{50}Pt_{50}/Cu(7{,}5\ nm)/Fe_{50}Pt_{50}]_n$ films, where n=1, 2 was investigated. The films were deposited by magnetron sputtering on $SiO_2/Si(001)$ substrate. Annealing of samples in temperature range of 5000°C-8000°C for 30 s was carried out in vacuum and hydrogen atmosphere. The phase transition from the disordered $A1$-FePt phase into the ordered $L1_0$ phase in film with n=1 begins after annealing in vacuum at 500°C. In film with n=2 film ordering temperature rises up to 700°C. At annealing in hydrogen independently from quantity Cu interlayers $L1_0$-FeCuPt forms at 500°C. The annealing in hydrogen accelerates of ordering processes.

P-5-68

Influence of annealing atmosphere on formation of nanoscale films Co-Sb – functional elements thermoelectric

R.A. Shkarban,[1] Yu.N. Makogon,[1] and S.I. Sidorenko[1]

[1] *National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», 03056, Prospect Peremogy 37, Kyiv, Ukraine*

The effect of substrate temperature and annealing atmosphere (vacuum or a nitrogen atmosphere) for forming the phase composition and structure in a nanoscale $CoSb_x$ films (30 nm) at a concentration from 65 at.% to 81 at.% Sb is investigated.
It is established that $CoSb_3$ films are thermally stable up to ∼300°C. The annealings of Co-Sb films both in vacuum and in nitrogen atmosphere, at temperatures higher 300°C lead to a sublimation as to over antimony and antimony with $CoSb_3$ crystal phase. It is shown that the influence of the annealing atmosphere in Co-Sb films displayed more intense sublimation of the antimony at the annealing in vacuum. It is established that a more intensive process of Sb sublimation at annealing of X-ray amorphous films in both a vacuum and a nitrogen atmosphere, connected with lower activation energy of Sb sublimation in comparison with crystalline films.

The authors would like to thank Prof. M. Albrecht and Dr. G. Beddies and workers from Chemnitz University of Technology (Germany) for sample preparation, assistance in conduction of investigations and discussion of results. This work was financially supported by the Deutsche Akademischer Austauschdienst (DAAD) in the frame of the Leonard-Euler-Program (Grant No. 08/01145 and No. 50744282).

P-5-69

Influence of top Ag layer on ordered $L1_0$ FePt phase formation in thin Ag(0; 7,5 nm)/$Fe_{50}Pt_{50}$(15 nm) films on SiO_2/Si(001) substrates

R.A. Shkarban,[1] M.N. Shamis,[1] and Iu.N. Makogon[1]

[1] *National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», 03056, Prospect Peremogy 37, Kyiv, Ukraine*

The promising material for use in magnetic recording with high density is films based on $L1_0$ FePt phase due to large magnetocrystalline anisotropy (7×106 J/m^3).
The effect of an additional top Ag layer with low surface energy on diffusion processes of $L1_0$ FePt phase formation and its structural and magnetic properties in Ag (0; 7,5 nm)/$Fe_{50}Pt_{50}$(15 nm) films on SiO_2(100 nm)/Si(001) substrates were studied. It was established, that in as-deposited films disordered A1 FePt phase was formed. In $Fe_{50}Pt_{50}$ (15 nm) film the ordered $L1_0$ FePt phase was formed after annealing at temperature of 700°C. This process is accompanied by sharp coercivity increase. With increasing of annealing temperature the coercivity also rises.
It was found, that the initial compressive stresses in films affect on ordered $L1_0$ FePt phase formation. Compressive stress reduction caused by additional top Ag layer lead to increase of $A1$ FePt→$L1_0$ FePt phase transformation temperature to 800°C, wich is 100°C higher than in $Fe_{50}Pt_{50}$ film. The texture in the [001] direction, which is perpendicular to the substrate, increases. The compressive stress relaxation occurs with $L1_0$ FePt phase formation in films.

P-6-01

Influence of partial substitution of Fe by Mn on thermomagnetic properties of magnetocaloric $LaFe_{11.2}Co_{0.7}Si_{1.1}$ alloy

P. Gebara,[1] and J. Marcin[2]

[1] *Institute of Physics, Czestochowa University of Technology, Armii Krajowej 19 Av., 42-200 Czestochowa, Poland*

[2] *Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47 St., 040 01 Kosice, Slovakia*

The aim of the present work was to study the influence of partial substitution Fe by Mn in the $LaFe_{11.2-x}Mn_xCo_{0.7}Si_{1.1}$ (where x=0.1, 0.2 and 0.3) alloys. The master alloys were prepared by arc-melting of the high purity of constituent elements under low pressure of Ar. The obtained specimens were annealed in at 1323K for 15 days in sealed quartz tubes under low pressure of protective Ar gas. Magnetic properties of prepared samples were measured in the wide range of temperatures by Quantum Design MPMS-XL 5 equiped with 5T superconducting magnet. Measurements revealed that systematic increase of Mn in alloy composition resulted in decrease of the Curie temperature, which was correlated with of lattice parameter of the $La(Fe,Si)_{13}$- type phase. For samples corresponding to Mn content x=0.1 and 0.2 decrease of magnetic entropy change was observed. However in the case of sample with x=0.3 the increase of magnetic entropy change was detected.

Acknowledgements: P.G. thanks SAIA and prof. R. Szczęśniak for financial support.

P-6-02

Open source implementation of different variants of Jiles-Atherton model of magnetic hysteresis loops

Roman Szewczyk,[1] and Peng Cheng[2]

[1] *Industrial Research Institute for Automation and Measurements PIAP, Poland*

[2] *Department of Electronics Design, Mid Sweden University, Sweden*

Jiles-Atherton model is one of the most advanced and most popular model of magnetic hysteresis loop [1]. Since its introduction in 1984 this model was developed considering different physical phenomena and computational issues. As a result, cross-validation of the results of modelling performed by different authors became difficult.

To overcome this problem, open-source MATLAB/OCTAVE based implementation of Jiles-Atherton model is presented. Developed implementation covers isotropic model of magnetic hysteresis loops as well as uniaxial and cubic anisotropy. Moreover, the correction proposed by Venkataraman together with different approaches to derivative of the anhysteretic magnetization are considered.

Developed library is freely available to commercial and scientific use. As a result, it can be the base for further development of Jiles-Atherton model for better understanding of magnetization process as well as modelling the inductive components.

References:

[1] D. C. Jiles, D. L. Atherton, Journal of Magnetism Magnetic Materials 61 (1986) 48-60.

P-6-03

Magnetization processes in Fe-based soft magnetic composites

Z. Birčáková,[1] P. Kollár,[1] J. Füzer,[1] R. Bureš,[2] and M. Fáberová[2]

[1] *Institute of Physics, Faculty of Science, Pavol Jozef Šafárik University, Park Angelinum 9, 04154 Košice, Slovakia*

[2] *Institute of Materials Research, Slovak Academy of Sciences, Watsonova 47, 04001 Košice, Slovakia*

Soft magnetic composites represent a specific class of materials with still expanding application range for various ac and dc electromagnetic applications such as cores with three dimensional isotropic ferromagnetic behaviors for transformers, electromotors, sensors, and actuators. In this work the relations for irreversible permeability at initial magnetization curve were derived and verified on selected type of Fe-based composites. The derivation was based on the Steinmetz law and the linear functions approximation for DC energy losses. The verification of the relationship was based on the comparison of experimental and calculated dependences of the irreversible permeability vs. magnetic induction, where the empirical coefficients in relations were found.

This work was realized within the frame of the project ITMS 26220220105 supported by Operational Program "Research and Development" financed through European Regional Development Fund; further by Slovak Research and Development Agency under contract APVV-15-0115.

P-6-04

Low frequency core losses components of FeNiMo powder compacted materials

D. Olekšáková,[1] P. Kollár,[2] and J. Füzer[2]

[1] *Faculty of Mechanical Engineering, Technical University in Košice, Letná 9, 042 00 Košice, Slovakia*

[2] *Institute of Physics, Faculty of Science, P. J. Šafárik University, Park Angelinum 9, 04154 Košice, Slovakia*

The aim of this work was to investigate dc and low frequency ac magnetic properties of the bulk FeNiMo samples prepared by a hot compaction of the powder with two particle size. The Fe16Ni79Mo5 (wt. %) swarfs were prepared from the ingot of the same chemical composition and then milled using a RETSCH PM4000 planetary ball mill for 1 hour and for 100 hours.

The relations of core losses with the frequency as well as with the maximum induction of FeNiMo alloys were investigated. The usual three-component concept of separation of core losses, consisting of hysteresis, eddy current and anomalous losses, was used to explain the influence of the powder particle size on core loss frequency dependences.

This work was realized within the frame of the project ITMS 26220120035 supported by Operational Program "Research and Development" financed through European Regional Development Fund and also by the Slovak Research and Development Agency under contract No. APVV-15-0115.

P-6-05

Magnetic hardening induced in RCo_5 (R = Y, Gd, Sm) by short HEBM

P. Łopadczak,[1,2] A. Bajorek,[1,2] K. Prusik,[2,3] M. Zubko,[2,3] and G. Chełkowska[1,2]
[1] *A. Chełkowski Institute of Physics, University of Silesia in Katowice, Poland*
[2] *SMCEBI, University of Silesia in Katowice, Chorzów, Poland*
[3] *Institute of Materials Science, University of Silesia in Katowice, Chorzów, Poland*

The paper is focused on the magnetic and structural properties of RCo_5 (R = Y, Gd, Sm) intermetallics fabricated by high energy ball - milling (HEBM). The investigated samples were first produced by arc-melting as bulk materials and then were milled for 1h in dimethylformamide with balls to powder ratio 10:1. The influence of the HEBM parameters on the microstructure was investigated by a variety of complementary measurement methods. The Rietveld refinement was performed to estimate the dependence of crystallite size and microstrain on type of sample. The hysteresis loops were recorded by SQUID magnetometer at 2 K and 300 K and at magnetic field up to $\mu_0 H = 7$ T. The impact of short HEBM process is visible as the enhancement of coercivity and simultaneous reduction of the saturation magnetization.

P-6-06

An improvement of magnetic flux-linkage in electrical generator using the novel permanent magnet arrangement

Warat Sriwannarat,[1] Pirat Khunkitti,[1] Akraphon Janon,[2]
Sathiraporn Pornnimitra,[1] and Apirat Siritaratiwat[1]
[1] *Department of Electrical Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand*
[2] *Department of Mechanical Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand*

The partitioned stator permanent magnet generator (PS-PMG) is widely used as electrical generator due to its high flux-linkage, electromotive force (EMF), however the limitation of increasing flux-linkage of conventional PS-PMG is being reached due to the restricted area of flux-linkage circulation. Then, we proposed 2 novel structures of PS-PMG by using the dual rotor with co-axial core to improve the flux-linkage and EMF of the PS-PMG. It was found that the flux-linkage produced by the proposed structure is 18% higher than that of conventional PS-PMG existing in the literatures. The position of additional permanent magnets of the stator was found to be the reason for flux-linkage improvement since the flux-linkage is increasingly circulated through both armature windings. This flux-linkage enhancement causes 21% increment of EMF compared to the conventional PS-PMG under the same condition. The EMF produced by the proposed structure is classified in the high-value range of PMG.

P-6-07

Size effect of hard magnetic properties of Fe-Nb-B-Tb milled alloys

K. Granek,[1] G. Ziółkowski,[1] and A. Chrobak[1]

[1] *August Chełkowski Institute of Physics, Univeristy of Silesia*

Magnetic materials are very important in nowadays technologies. Recently we have reported ultra-high coercivity of Fe-Nb-B-RE (6 at. % of Nb) bulk nanocrystalline alloys produced by the vacuum suction casting technique, i.e. more than 7 T at the room temperature and after some field annealing [1]. Such type of materials have a potential to be a base for a new type of spring-exchange composites with magnetic characteristics better than conventional Nd-based permanent magnets. This work refers to size effect of hard magnetic properties of $(Fe_{78}Nb_8B_{14})_{0.88}Tb_{0.12}$ alloy prepared by a vacuum suction casting technique and milled in a low-energy ball mill. Finally, a set of powders with different pulverization degree was obtained. In the presented paper selected magnetic and structural properties as a function of mean grain size are shown. The discussion is focused on application possibility of the obtained hard magnetic powders in designing of new magnetic composites containing ultra-hard magnetic phases.

References:

[1] A. Chrobak, G. Ziółkowski, N. Randrianantoandro, J. Klimontko, D. Chrobak, K. Prusik, J. Rak, Ultra-high coercivity of (Fe 86-x Nb x B 14) 0.88 Tb 0.12 bulk nanocrystalline magnets, Acta Materialia 98 (2015) 318–326.

P-6-08

The effect of annealing temperature on the magnetic properties of Pr-(Fe,Co)-(Zr,Nb)-B ribbons

K. Pawlik[1]

[1] *Institute of Physics, Częstochowa University of Technology, Al. Armii Krajowej 19, 42-200 Częstochowa, Poland*

The properties of the rapidly solidified ribbons of $Pr_9Fe_{50+x}Co_{13}Zr_1Nb_4B_{23-x}$ (where x = 0, 2, 5, 8) alloys annealed at temperatures ranging from 923 K to 1033 K were investigated. The heat treatment of the fully amorphous as-cast ribbons led to the simultaneous crystallization of the hard magnetic $Pr_2(Fe,Co)_{14}B$, the soft magnetic α-Fe and the paramagnetic $Pr_{1+x}Fe_4B_4$ phases. However, the crystallization of the α-Fe phase took place as the second crystallization event at higher temperatures for x = 0 and 8 alloys. Using Rietveld refinement of the X-ray diffraction patterns, the crystallite sizes of constituent phases were calculated. Additionally, using the PONKCS method the weight fractions of the crystalline and amorphous components were quantified. For all alloy compositions the temperature dependencies of magnetic parameters were determined from the hysteresis loops. The measurement of recoil curves allowed to determine the switching field distributions. Furthermore, the intergrain exchange interactions were analyzed based on δM plots.

P-6-09

Magnetoelastic Villari Effect in Structural Steel Magnetized in the Rayleigh Region

M. Kachniarz,[1] K. Kołakowska,[1] R. Szewczyk,[1] and P. Nowak[2]

[1] *Institute of Metrology and Biomedical Engineering, Warsaw University of Technology, sw. Andrzeja Boboli 8, 02-525 Warsaw, Poland*

[2] *Industrial Research Institute for Automation and Measurements PIAP, al. Jerozolimskie 202, 02-486 Warsaw, Poland*

Studies on the magnetomechanical effects are important aspects of modern physical science connected with magnetism. For the structural steel, it is possible to utilize the magnetoelastic Villari effect for stress assessment. However, previous studies in this area were performed for high magnetizing fields from the saturation region. The following paper is focused on the magnetoelastic effect in low magnetizing fields corresponding to the so-called Rayleigh region. Special experimental setup allowing to apply mechanical stress and measure magnetic characteristics of the investigated structural steels was utilized during the experiment. Obtained results indicate significant correlation between applied mechanical stress and magnetic properties of the investigated materials.

This work was partially suported by statutory funds of Institute of Metrology and Biomedical Engineering, Warsaw University of Technology (Poland).

P-6-10

Multitechnique characterization of selected R - T magnetic nanomaterials synthesized by HEBM

Anna Bajorek,[1,2] Paweł Łopadczak,[1,2] Krystian Prusik,[2,3] Maciej Zubko,[2,3] Marcin Wojtyniak,[1,2] and Grażyna Chełkowska[1,2]

[1] *A. Chełkowski Institute of Physics, University of Silesia in Katowice, Uniwersytecka 4, 40-007 Katowice, Poland*

[2] *Silesian Center for Education and Interdisciplinary Research, University of Silesia in Katowice, 75 Pułku Piechoty 1A, 41-500 Chorzów, Poland*

[3] *Institute of Materials Science, University of Silesia in Katowice, 75 Pułku Piechoty 1A, 41-500 Chorzów, Poland*

Nowadays rare earth based magnetic nanopowders prepared by high energy ball milling (HEBM) are widely studied. A variety of applied HEBM parameters lead to the modification of microstructure and magnetic properties simultaneously. Multitechnique characterization of selected R - T magnetic nanopowders synthesized by HEBM with comparison to their bulk parent compounds will be presented. The significant influence of milling duration on the final size and shape of as-milled crystallites/particles as well as the evident enhancement of coercivity and its variation over applied milling time will be demonstrated.

P-6-11

Magnetization processes of hard magnetic composites – Monte Carlo studies

G. Ziółkowski,[1] K. Granek,[1] and A. Chrobak[1]

[1] *Institute of Physics, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

Magnetic materials are very important in nowadays technologies. New and continuously increasing requirements can be fulfilled by modern nanostructured magnetic composites containing phases characterized by different magnetic properties. Recently, we reported ultra-high coercivity (> 7 T) in Fe-Nb-B-Tb type of bulk nanocrystalline alloys. It was shown that in such materials the interactions between soft and hard magnetic phases with specific irregular branches are especially important and can lead to an appearing of new and unique properties. A better understanding the interactions in such systems is interesting form scientific and application point of view.

In the present work we performed some simulated annealing plus Monte Carlo studies concerning a spherical particles embedded into ferromagnetic matrix as well as irregular branches of soft and hard magnetic phases. Magnetization process of such system depends on exchange interactions of soft and hard magnetic object and interface between them. Especially interesting is the comparison of interactions in systems with different, regular and irregular geometry. Moreover, the influence of different kind of anisotropy is also widely discussed.

P-6-12

Microstructure and Magnetic Properties of CeFeB Powder Prepared by High-energy Ball Milling

M. Grigoras,[1] G. Stoian,[1] L. Budeanu,[1] A. Damian,[1] H. Chiriac,[1] N. Lupu,[1] and M. Lostun[1]

[1] *National Institute of Research and Development for Technical Physics, Iasi, Romania*

The cost and availability pressure of rare-earth (RE), especially for Nd and Dy that are essential for high performance of $Nd_2Fe_{14}B$-type permanent magnets (PM), have forced the research on more economically materials. In this sense Ce is of interest given that it is the most abundant RE element. In powder technology, which is the preferred method of PM preparation, keeping of hard magnetic properties unaltered during the milling process, it is a challenge. Considering these aspects, the aim of our work is to investigate the effect of the milling environment on the microstructure and magnetic properties of Ce–Fe–B powders prepared by high-energy ball milling starting from $Ce_{10+x}Fe_{84-x}B_6$ (x=0-6) ribbons. By controlling the parameters of milling, we have managed to obtain powders with Hc=5.95 kOe, Mr=7.56 kG, and (BH)max=8.16 MGOe, values are almost identical to those of the precursors.

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS - UEFISCDI, project number PN-II-RU-TE-2014-4-1431

P-6-13

Effect of particle magnetic moment distribution on magnetic properties of maghemite nanoparticles

C. Rani,[1] and S.D. Tiwari[1]

[1] *School of Physics and Materials Science, Thapar University, Patiala 147004, India*

Magnetic properties of nanoparticles depend on several factors. These factors include their size, morphology, distribution in size and many more. Effect of particle size distribution has been studied by many authors in detail, but the effect of particle magnetic moment distribution on magnetic properties of maghemite nanoparticles has never been studied. Nanoparticles of maghemite, with ferrimagnetic ordering, are stable oxides of iron. Pure phase of this material is synthesized by following the procedure described elsewhere [1]. Structural characterization of this sample is done with x-ray diffraction and transmission electron microscopy. Magnetization of samples as function of temperature and applied magnetic field are measured using a SQUID magnetometer. We study the effect of particle magnetic moment distribution on maghemite nanoparticles using modified Langevin function, first without considering the distribution and then with considering the distribution. It is found that this distribution plays an important role in magnetic nanoparticles.

References:

[1] T. Hyeon, S.S. Le, J. Park, Y. Chung, H.B. Na, J.Am. Chem. Soc. **12798**, 123 (2001)

P-6-15

Magnetization reversal and magnetic domain structure in Ne ion irradiated Co/Mo/Co coupled thin film structures

M. Tekielak,[1] Z. Kurant,[1] M. Jakubowski,[2] R. Boettger,[3] A. Maziewski,[1] and A. Wawro[2]

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

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

[3] *Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany*

The Co(3 nm)/Mo wedge (d_{Mo}: 0–3 nm)/Co(3 nm) structure exhibits two-fold in-plane magnetic anisotropy and magnetization of the Co layers parallel (P) or antiparallel (AP) coupled. AP coupling occurs in 0.5 nm$<d_{Mo}<$1 nm range and P coupling beyond this range. Magnetic properties are modified by irradiation with 17 keV Ne ions. The magnetization reversal processes and magnetic domain structure were studied using magnetooptical Kerr magnetometry and microscopy. In the region of AP coupling the independent magnetization reversal of the Co layers is observed. For $d_{Co}<0.5$ nm simultaneous magnetization reversal both Co layers by a domain wall movement towards the higher coercivity region occurs. For $d_{Co}>1$ nm reversal process by domain nucleation with the preferential orientation of domain walls was observed.

Supported by the National Science Centre in Poland under the project 2014/13/B/ST5/01834.

P-6-16

The influence of severe plastic deformation on magnetic properties of ferromagnetic 4-f elements: Tb and Dy

S. Taskaev,[1] M. Ulyanov,[1] K. Skokov,[1] A. Pellenen,[2] D. Bataev,[1] and V. Khovaylo[3]
[1] *Chelyabinsk State University, Chelyabinsk, 454001, Russia*
[2] *National Research South Ural State University, Chelyabinsk, 454080, Russia*
[3] *National University of Science and Technology "MISIS", Moscow, 119049, Russia*

In this work we continue our previous investigations of the severe plastic deformation (SPD) on the magnetic properties of 4-f elements, with special accent on magnetic anisotropy and magnetic transformations. Severe plastic deformation has a great effect on magnetic properties of 4-f elements [1]. For instance, in Gd a significant increase of the magnetocrystalline anisotropy (up to 2 orders of magnitude) has been observed. The aim of this work is to investigate other important for permanent magnets industry ferromagnetic elements Tb and Dy for a change in physical properties.

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 Russian Science Foundation grant 15-12-10008 for financing this work.

P-6-17

Magnetic properties of high pressure torsion ferromagnetic 4-f elements: Er and Ho

S. Taskaev,[1] K. Skokov,[1] V. Khovaylo,[2] M. Ulyanov,[1] and D. Bataev[1]
[1] *Chelyabinsk State University, Chelyabinsk, 454001, Russia*
[2] *National University of Science and Technology "MISIS", Moscow, 119049, Russia*

As it shown in [1], severe plastic deformation has a great effect on magnetic properties of 4-f elements. In this work we report the influence of high pressure torsion on magnetic, structural and thermodynamic properties of Er and Ho samples treated with the help of HPT technique. High pressure torsion was performed under 5 GPa with 5 complete turns at room temperature. This feature is helpful for designing novel magnetic materials (especially hard magnetic materials). Special accent is made for modifying magnetic anisotropy of the HPT treated Er and Ho metals.

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 Russian Science Foundation grant 15-12-10008 for financing this work.

P-6-18

A composite soft magnetic material and products on its basis

G. Govor,[1] M. Przybylski,[2] A. Vecher,[1] J. Zukrowski,[2] and K. Yanushkevich[1]

[1] *Scientific and Practical Center for Materials NASB, P.Brovki 19, Minsk 220076, Belarus*

[2] *ACMiN, Kawiory 30, Krakow 30-055, Poland*

The experimental-industrial technology for producing a soft magnetic material based on iron powder ASC100.29, covered with a layer of nanometer magnetic insulator is developed. The magnetic characteristics of the materials in the frequency range up to 1 MHz was investigated. As a result shown, that the saturation magnetic flux density is B_m = 2,1 Tesla and the maximal permeability μ_m = 800 -1000. The prototypes of power supplies for various purposes, generators, motors, chokes, and other devices are developed with using the soft magnetic composite material.

P-6-19

Magnetic properties of rapidly solidified $Fe_{61}Co_{10}B_{20}Y_{8-x}W_yPt_x$ (x = 1, 2; y = 0, 1) bulk alloy

P. Pietrusiewicz[1]

[1] *Institute of Physics, Faculty of Production Engineering and Materials Technology, Częstochowa University of Technology, al. Armii Krajowej 19, 42-200 Częstochowa, Poland*

In the literature there can be found reports for the rapidly cooled alloy consisting of Pt mainly in the form of thin ribbons. In this work, we present the effect a small quantity additive of W and Pt for the magnetic properties of massive two-phase alloys in the form of plates with a thickness of 0.5 mm. The observed phases in the alloys were: amorphous and crystalline, which participation depending on the alloy additives. Generally, it is assumed that alloys with the addition of Pt are characterized by a relatively high saturation magnetization and magnetocrystalline anisotropy, which is mainly influenced by the presence of crystalline phases FePt, Fe_3Pt, $FePt_3$. For the investigated alloys it was noted that the gradual introduction of W and Pt in place of the Y to alloy $Fe_{61}Co_{10}B_{20}Y_{8-x}W_yPt_x$ increased the value of saturation magnetization ($\mu_0 M_s$) and on the reduction of the coercive field (H_c). On the basis of the XRD patterns analysis, it was found that the sample with the greatest content of the platinum, there are crystallites of the smallest size and the share of the α-Fe crystalline phase is much greater than for the other studied samples.

P-6-20

Assessment of the magnetostrictive properties of the S235JR structural steel under tensile and compressive stresses

A. Juś,[1] M. Kachniarz,[2] R. Szewczyk,[1] and S. Puchalski[2]

[1] *Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, Warsaw University of Technology, Andrzeja Boboli 8, 02-525 Warsaw, Poland*

[2] *Industrial Research Institute for Automation and Measurements, Al. Jerozolimskie 202, 02-486 Warsaw, Poland*

WITHDRAWN

P-6-21

Structural and magnetic behavior of the LPT MnBi phase

R. Hirian,[1] T.-L. Biter,[1] A. Boiciuc,[1] O. Isnard,[2,3] and V. Pop[1]

[1] *Faculty of Physics, Babeş-Bolyai University, Cluj-Napoca, RO-400084 Romania*

[2] *University Grenoble Alpes, Institut NÉEL, 25 rue des Martyrs, F-38042 Grenoble, France*

[3] *CNRS, Institut NÉEL, 25 rue des Martyrs, F-38042 Grenoble, France*

The Low Temparature (LTP) MnBi phase is very attractive as a permanent magnet, due to its large magnetocrystalline anisotropy (K of 107 erg/cm^3), relatively high magnetization and most of all due to its positive temperature coefficient of coercivity. The synthesis of the (LTP) MnBi single phase has proven to be a difficult task. In our study the MnBi ingot was prepared by arc melting under a purified Ar atmosphere and annealing at 400 °C for 10 to 72 hours. X-ray diffraction patterns showed that the resulting samples had a high concentration (more than 80%) of LTP MnBi phase. Some traces of Mn and Bi were also visible in XRD. Magnetic measurements at 300 K indicate that the coercivity is highly dependent on the microstructure of the samples, as the coercive field (H_c) increases from 0.03 T (in the bulk samples) to 0.3 T in ground samples.

Financial support of Romanian Ministry of Education and Research, grant PN-II-RU-TE-2014-4-2360

P-6-22

Realization of Negative magnetization and Asymmetric magnetoresistance in $GdFe_4MnAl_7$ intermetallic alloy

Venkatesh Chandragiri,[1] and Wei Ren[1]

[1] *ICQMS, Department of Physics, Shanghai University, 99 Shangda Road, Shanghai 200444, P. R. China*

The magnetization of the $GdFe_5Al_7$ do not show magnetic compensation as $M_R < M_{Fe}$ [1, 2]. The *Mn* doped alloy shows following significant points: (*i*). Although, the parent compound, $GdFe_5Al_7$ does not show negative magnetization and T_{comp}, the *Mn* doped alloys show negative magnetization associated with the magnetic compensation at T_{comp} = 20 K. (*ii*). The magnetic ordering (T_c) was seen in parent compound at T = 255 K, while doping of *Mn* leads to T_c value 175 K, indicating that the exchange interactions induced by the *Mn* doping are act opposite to the Fe sub-lattice interactions (according to the mean field theory). (*iii*). M-H loops are weakly hysteresis well below T_{comp} and no hysteresis similar to soft ferromagnetic nature were seen between the T_c and T_{comp} which is noticed for $GdFe_5Al_7$ at T = 2 K. Further, meta-magnetic transition like features were found in the M-H loops nearby T_{comp} which was typically seen for magnetic compensated analogues.

References:

[1] D.I. Gorbunov, S. Yasin, A.V. Andreev, Y. Skourski, N.V. Mushnikov, E.V. Rosenfeld, S. Zherlitsyn, J. Wosnitza, J. Magn. Magn. Mater., **383** (2015) 208-214.

[2] V. Chandragiri, K.K. Iyer, E.V. Sampathkumaran, Phys. Rev. B, **92** (2015) 014407.

P-6-23

GMI effect in nanocrystalline $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ bilayer and trilayer ribbons

F. Andrejka,[1] L. González-Legarreta,[1] J. Marcin,[1] J. Kováč,[1] P. Švec,[2] P.Švec Sr. ,[2] and I. Škorvánek[1]

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

[2] *Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia*

A modified double-nozzle and triple-nozzle planar flow casting method was used for preparation of amorphous $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ bilayer and trilayer ribbons. This method offers a possibility to prepare amorphous ribbons with increased thickness. The single-layer ribbon was also prepared for the sake of comparison. In order to modify soft magnetic characteristics, all ribbons were nanocrystallized at 823 K in presence of longitudinal (LF) or transverse (TF) magnetic field. The impedance measurements were performed over a frequency range 0.1-100 MHz. The position of GMI maxima ratio was progressively moved to lower frequency with an increase of sample thickness. The highest percentage change of magnetoimpedance of about 177 % and sensitivity of 65 %/Oe was achieved for bilayer ribbon after TF-annealing. These GMI characteristics are of potential interest for applications in sensing elements.

This work was supported by the projects ITMS: 26220220037, APVV-15-0621 and VEGA 2/0173/16.

P-6-24

FORC analysis of soft/semi-hard magnetic $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9/Co_{72.5}Si_{12.5}B_{15}$ bilayer ribbons

B. Kunca,[1] I. Matko,[2] P. Švec,[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 45, Slovakia*

Hysteresis behavior and interphase interactions were studied in soft/semi-hard magnetic bilayer $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9/Co_{72.5}Si_{12.5}B_{15}$. Rapidly solidified amorphous ribbons were prepared by modified double-nozzle planar flow casting method. Subsequently, specimens were isothermally annealed for 180 seconds at 843K in the vacuum furnace, leading to formation of nano/microcrystalline structure. Interphase interactions were characterized using the First Order Reversal Curves (FORC) analysis. Switching field distribution (SFD), calculated from the individual FORCs, showed correlation between intensity of the interaction fields and magnetic state of the semi-hard phase at various reversal fields. FORC distribution unveiled positive coupling within semi-hard magnetic microcrystalline grains of $Co_{72.5}Si_{12.5}B_{15}$ layer. The effects of the magnetostatic interaction between semi-hard and soft magnetic layers will be discussed.

This work was supported by the projects ITMS: 26220220037, APVV-15-0621 and VEGA 2/0173/16.

P-6-25

Magnetocaloric effect in amorphous and partially crystallized $Fe_{80}Zr_7Cr_6Nb_2Cu_1B_4$ alloy

Agnieszka Łukiewska,[1] Jacek Olszewski,[1] Mariusz Hasiak,[2] and Piotr Gębara[1]

[1] *Institute of Physics, Częstochowa University of Technology, Armii Krajowej 19, 42-200 Częstochowa Poland*

[2] *Wrocław University of Science and Technology, Smoluchowskiego 25, 50-370 Wrocław, Poland*

In the present work the microstructure and thermomagnetic properties of $Fe_{80}Zr_7Cr_6Nb_2Cu_1B_4$ ribbon in the as-quenched state and after the accumulative annealing in the temperature range 600 K – 800 K for 10 min were studied using vibrating sample magnetometry and Mössbauer spectroscopy. The second order phase transition from ferro- to paramagnetic state is observed and the Curie temperatures are placed just below 273 K. The maximum value of the magnetic entropy change (ΔS_M) observed in the vicinity of the Curie point is equal to 0.85J/(kg K) for the alloy in the as-quenched state. The second, low intensity maximum noticeable near 180 K could be related to supplementary magnetic phase transition. It was confirmed by Mössbauer studies and magnetic measurements performed for zero-field-cooled (ZFC) and field-cooled (FC) regimes.

P-6-26

Effect of Nd^{3+} doping on magnetic and dielectric properties of $SrFe_{12}O_{19}$ hexaferrite synthesized by coprecipitation method

A. Hilczer,[1] K. Pasińska,[2] E. Markiewicz,[1] A. Pietraszko,[2] and B. Andrzejewski[1]

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

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

Magnetic and dielectric properties of hexagonal ferrites important for applications in microwave absorbers are strongly determined by the processing conditions. We studied the dielectric and magnetic response of $Sr_{1-x}Nd_xFe_{12}O_{19}$ (x=0, 0.03, 0.05, 0.07, 0.09) solid solutions obtained by coprecipitation method. The structure of the samples was controlled by X-ray diffraction and scanning electron microscope images revealed that the average size of plate-like shaped crystallites decreases with increasing x (from ∼200 nm to 80 nm) and for x=0.09 the crystallites are oval. Nd^{3+} doping was found to result in an increase in the coercive field which we would like to relate to the domain wall pinning. The doping-induced changes were found to be monotonous with x up to 0.07. The observed dispersion in dielectric permittivity was found to be correlated with the frequency behavior of electric conductivity of the samples.

P-6-27

DFT and Monte Carlo study of the magnetization versus temperature dependence of the $Zr(Fe_{1-x}Co_x)_2$ system

Wojciech Marciniak,[1] Bartosz Wasilewski,[2] and Mirosław Werwiński[2]

[1] *Faculty of Technical Physics, Poznan University of Technology, Pl. M. Skłodowskiej-Curie 5, 60-965 Poznan, Poland*

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

Self-consistent field calculations for the $Zr(Fe_{1-x}Co_x)_2$ system were performed using the Korringa-Kohn-Rostoker method (SPR-KRR implementation). Following that the exchange integrals were obtained from the potential. KKR has been also used to obtain magnetic moments, out of which, using the Uppsala atomistic spin dynamics (UppASD), magnetization and susceptibility dependences on temperature were calculated for a whole range of concentrations. Utilised code allows for Monte Carlo simulations of the Heisenberg Hamiltonian. The lattice constants were optimized using the FPLO code. For both the SPR-KKR and FPLO codes the calculations were done using the GGA. The chemical disorder was treated using the coherent potential approximation (CPA).

The authors acknowledge the financial support from the Foundation of Polish Science grant HOMING. The HOMING programme is co-financed by the European Union under the European Regional Development Fund.

P-6-28

Impact of ion-irradiation upon microstructure and magnetic properties of NANOPERM-type $Fe_{81}Mo_8Cu_1B_{10}$ metallic glass

M. Hasiak,[1] and M. Miglierini[2,3]

[1] *Wrocław University of Science and Technology, Smoluchowskiego 25, 50-370 Wrocław, Poland*

[2] *Slovak University of Technology in Bratislava, Ilkovičova 3, 812 19 Bratislava, Slovakia*

[3] *Czech Technical University in Prague, V Holešovičkách 2, 180 00 Prague 8, Czech Republic*

NANOPERM-type $Fe_{81}Mo_8Cu_1B_{10}$ soft magnetic metallic glass (MG) was exposed to bombardment with 130 keV nitrogen ions. The evolution of structural arrangement as well as magnetic properties is inspected. Surface sensitive techniques of Mössbauer spectrometry as Conversion Electron Mössbauer Spectrometry (CEMS) and Conversion X-Ray Mössbauer Spectrometry (CXMS) were employed. Structural modifications demonstrate themselves also via macroscopic magnetic parameters such as temperature dependence of magnetization, Curie temperature, and hysteresis loops. CEMS/CXMS experiments have revealed that this is caused by a presence of bcc-Fe and Fe_3O_4 crystallites that were formed during the production of this MG.

This work was supported by the research grant VEGA 1/0182/16.

P-6-29

Role of Pr addition on structure, thermomagnetic properties and magnetocaloric effect of GdGeSi alloy

M. Hasiak[1]

[1] *Wrocław University of Science and Technology, Department of Mechanics and Materials Science, Smoluchowskiego 25, 50-370 Wrocław, Poland*

Materials exhibiting a large magnetocaloric effect in the vicinity of room temperature for potential applications in cooling technology belong to the group of materials, which are intensively studied in recent years. These materials used in refrigeration promise energy saving as well as application of an environmentally friendly technology. In this paper author investigates the role of RE (Rare Earth) addition to $Gd_{80}Ge_{15}Si_5$ (wt.%) on microstructure, topography, magnetocaloric effect and other thermomagnetic properties i.e. magnetization, hysteresis loops, heat capacity, AC/DC susceptibility, in wide range of temperature and external magnetic field. Moreover, magnetocaloric effect as magnetic entropy changes in the vicinity of room temperature is also investigated.

P-6-30

Mössbauer study of the some intermetallic compounds $Fe_{80-x}Ni_xB_{20}$ (x = 0, 8, 16, 24, 28)

M. Kądziołka-Gaweł,[1] A. Chrobak,[1] and R. Babilas[2]

[1] *Institute of Physics, University of Silesia, Uniwersytecka 4, 40-007 Katowice, Poland*

[2] *Institute of Engineering Materials and Biomaterials, Silesian University of Technology, S. Konarskiego 18a, 44-100 Gliwice, Poland*

Fe-based amorphous and nano-crystalline alloys were prepared by the melt-spinning technique and characterized by X-ray diffraction, magnetostatic and Mössbauer effect methods. The Mössbauer spectroscopy allows to study the local environments of the Fe atoms in the investigated $Fe_{80-x}Ni_xB_{20}$ (x = 0, 8, 16, 24, 28) compounds and showing the changes in the structure due to the changing of Ni addition. Combination of X-ray diffraction and Mössbauer spectroscopy results confirm formation of different phase complex including the α-Fe-Ni, γ-Fe-Ni, Fe_2B and Fe_3B in investigated materials. Magnetostatic measurements indicate on structural transformation around 700°C in compounds with x = 8 and 16.

P-6-31

Influence of eddy current thermal annealing on soft amorphous alloys

J. Salach,[1] and M. Kachniarz[2]

[1] *Institute of Metrology and Biomedical Engineering, Warsaw University of Technology*

[2] *Industrial Research Institute for Automation and Measurements*

The following paper presents the results of investigation on the influence of eddy current thermal annealing on magnetic properties of soft amorphous alloys based on iron and iron-nickel. Thermal annealing is a method of material treatment utilized to reduce the mechanical stress within the material and improve its magnetic properties [1]. Traditional methods of thermal annealing include long-term annealing of the material in high temperature. The proposed method is based on conductive properties of amorphous alloys. Eddy currents induced within the material by inductive heating are utilized to rapidly increase the temperature of the material, which results in much less period of time necessary to conduct the treatment. The results obtained with proposed method will be compared to the results of traditional thermal treatment.

References:

[1] J. Salach [et al], The Influence of Thermomagnetic Treatment on the Magnetoelastic Characteristics of Fe61Co19Si5B15 Amorphous Alloys, Act. Phys. Pol. A, vol. **127**, pp. 617-619, 2015

This work was partially supported by statutory funds of Institute of Metrology and Biomedical Engineering, Warsaw University of Technology (Poland).

P-6-32

Electronic structure of $Sm(Ni_{1-x}Co_x)_3$ alloys – XPS and *ab initio* study

A. Majtyka,[1] M. Sikora,[2] D. Blachliński,[2] G. Chełkowska,[2] and J. Deniszczyk[1]

[1] *Institute of Materials Science, University of Silesia in Katowice, 75 Pułku Piechoty 1A, 41-500 Chorzów, Poland*

[2] *A. Chełkowski Institute of Physics, University of Silesia in Katowice, Uniwersytecka 4, 40-007 Katowice, Poland*

The complex band structure investigations for $Sm(Ni_{1-x}Co_x)_3$ alloys were performed using the X-ray photoelectron spectroscopy (XPS) and an *ab initio* calculations. The aim of the study was to determine how the electronic structure changes with concentration in these compounds. Experimental XPS spectra indicated that the Ni/Co substitution results in a reconstruction of the valence band (VB), especially the intensity near the Fermi level decreases with Co content. The *ab initio* based simulated XPS valence band spectra agree qualitatively with experimental ones apart from the structure of Sm-4f sub-spectra where the multiplet decomposition is observed. Analysis of the calculated electronic structure of $Sm(Ni_{1-x}Co_x)_3$ alloys confirmed the VB reconstruction and showed that the valence of Sm ions and the location of Sm-4f band with respect to Fermi level depend on the local atomic environment of Sm ions.

P-6-33

Thermal effects on structural and magnetic properties of $Fe_{78}B_{13}Si_9$ amorphous ribbon

M.L. Soltani,[1] A. Touares,[1] J.G. Gasser,[2] and T.A. Aboki[3]

[1] *LPS, Dpt. of Physics -Annaba University, Annaba, Algérie*

[2] *LCP –A3LCP –A2MC , Université de Lorraine, 57078, Metz, France*

[3] *GMS-LPCS UMR 7045, Chimie Paristech, Paris Cedex 05, France*

The Differential Scanning Calorimetry (DSC), Resistivity (ρ) and Absolute thermoelectric Power (ATP) measurements are carried out to study the thermal effect on structural and magnetic evolution of soft magnetic $Fe_{78}B_{13}Si_9$ amorphous ribbons. In DSC of as-quenched sample, two clearly separated exothermic peaks are observed at 807 K and 820 K with $5\frac{K}{min}$. The kinetics of the crystallization give the values of the apparent activation energy $Ea_1 = 384\frac{kJ}{mole}$ and $Ea_2 = 308\frac{kJ}{mole}$ and agrees with a kinetic evaluation of the peak temperatures according to Kissinger and Auguis-Bennet's models.Resistivity and ATP are very accurate probes of the state of matter, the informations are the same than those obtained by DSC at the same heating rates. Some characteristic values from hysteresis loops for maximum applied magnetic field $H_max = 1$ kOe give magnetization $M_s = 116.89\ \frac{emu}{g}$ and hysteresis loops up to 27000 $\frac{A}{m}$ (about 300 Oe) give the coercive field Hc= 22 $\frac{A}{m}$.

P-6-34

Normal and inverse magnetocaloric effect in the melt-spun $Y_{1-x}Tb_xCo_2$ ($0 \leqslant x \leqslant 1$) alloys

N. Pierunek,[1] Z. Śniadecki,[1] V. Franco,[2] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*

[2] *Condensed Matter Physics Department, Sevilla University, Spain*

YCo_2 compound is an exchange-enhanced Pauli paramagnet on the verge of being a magnet. Ferromagnetic long-range ordering can be induced by topological or chemical disorder. The influence of Tb substitution on the magnetic properties of $Y_{1-x}Tb_xCo_2$ ($0 \leqslant x \leqslant 1$) compounds are studied by means of X-ray diffraction and vibrating sample magnetometry. Magnetic properties depend on the introduced structural disorder and may differ from the properties of structurally stable counterparts [1]. The system investigated crystallizes in $MgCu_2$-type Laves phase (Fdm space group). Magnetic entropy changes $\Delta S_M(T, \mu_0 H)$ and refrigerant capacity RC are determined on the basis of $M(H)$ curves to characterize magnetocaloric effect (MCE). For $Tb_{0.6}Y_{0.4}Co_2$ compound ($T_C = 156$ K) in as-quenched state the ΔS_{Mpk}, δT_{fwhm} and RC are equal to 5.95 J/kgK, 49 K and 104 J/kg, respectively (magnetic field changes from 0 to 5 T). The temperature dependence of real and imaginary components of AC susceptibility and heat capacity measurements suggest the presence of parimagnetic ordering above the Curie temperature. Structural disorder broadens the magnetic transition and the temperature-dependent magnetic entropy changes in the compounds investigated and moreover is the prerequisite of the parimagnetic ordering [2].

References:

[1] A.F. Pasquevich, *et al.*, Physica B **354** (2004) 357.

[2] C.M. Bonilla, *et al.*, J. Phys.: Condens. Matter **26** (2014) 156001.

P-6-35

Magnetocaloric effect in amorphous $Gd_{65}Fe_{15-y}Co_{5+y}Al_{10}X_5$ (y = 0, 5, 10; X = Al, Si, B) ribbons

N. Pierunek,[1] Z. Śniadecki,[1] J. Marcin,[2] I. Škorvánek,[2] and B. Idzikowski[1]

[1] *Institute of Molecular Physics, PAS, Poznań, Poland*

[2] *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 temperature and magnetic field. We focus our attention on MCE in $Gd_{65}Fe_{15-y}Co_{5+y}Al_{10}X_5$ (y = 0, 5, 10; X = Al, Si, B) alloys. The synthesized melt-spun materials have amorphous structure, confirmed by XRD. The T_C, determined from $M(T)$ curves by the inflection method ranges from 145 K to 195 K. The values of μ_{eff} for all analyzed samples are equal to about 6 μ_B/atom and are smaller than the magnetic moment of Gd^{3+} free ion, which is equal to 7.94 μ_B, mainly due to the presence of $3d$ elements. The maximum value of magnetic entropy changes (change in the magnetic field from 0 to 5 T) is 7.1 $Jkg^{-1}K^{-1}$ for $Gd_{65}Fe_{10}Co_{10}Al_{10}B_5$. The related refrigeration capacity is equal to 748 Jkg^{-1}. All ribbons exhibit second order phase transition, which is confirmed on the basis of the universal curve and field dependent critical exponent n analysis [1].

References:

[1] V. Franco, J.S. Blázquez, A. Conde, Appl. Phys. Lett. **89** (2006) 222512

P-6-36

Optimization of magnetic properties of $Hf_2Co_{11}B$ alloys by high pressure torsion or annealing

A. Musiał,[1] Z. Śniadecki,[1] Yu. Ivanisenko,[2] D. Wang,[2] and B. Idzikowski[1]

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

[2] *Institute of Nanotechnology, KIT, Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany*

Modifications of microstructure play an important role in ongoing investigation of the new permanent magnet materials. Depending on the particular system and conditions, high pressure torsion (HPT) [1] can lead to amorphization, comminution of grains or to crystallization. Heat treatment and plastic deformation were used to modify the crystalline structure and investigate its influence on the magnetic properties of $Hf_2Co_{11}B$ ribbons. X-ray diffraction (XRD) and differential scanning calorimetry (DSC) confirmed that plastic deformation of partially crystalline alloy led to its amorphization. The coercive field H_c of the annealed sample after HPT was reduced from 0.7 to 0.2 kOe, while the subsequent reannealing of the deformed sample enhanced H_c up to 1.3 kOe. The coercivity value was doubled, thus revealing that the existing nuclei of the hard magnetic phase facilitates its further growth.

References:

[1] B. Straumal, A. Korneva, P. Zieba, Arch. Civ. Mech. Eng. 14 (2014) 242–249

P-6-37

Thermal stability and glass forming ability of (Hf,Cr)-Co-B alloys

A. Musiał,[1] Z. Śniadecki,[1] and A.R. Klimametov[2]

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

[2] *Institute of Nanotechnology KIT, Eggenstein-Leopoldshafen, Germany*

Cr substitution causes the refinement of grains and can increase magnetic anisotropy and hard magnetic properties of $Hf_2Co_{11}B$ alloy. Experimental analysis of $Hf_{2-x}Cr_xCo_{11}B$ ($0 \leq x \leq 2$) melt-spun alloys was performed (x-ray diffraction, differential scanning calorimetry) and compared with the results of semi-empirical calculations (Miedema model). Amorphous ribbons were obtained for high Hf content ($0 \leq x \leq 1$) while for $1.5 \leq x \leq 2$, formation of crystalline phases is reported. Moreover, Hf-rich alloys are characterized by higher thermal stability. Formation enthalpy of $Hf_2Co_{11}B$ amorphous alloy is equal to -20.6 kJ/mol and along with other parameters indicate moderate glass forming ability (GFA). Similar atomic radii of Cr and Co and smaller interfacial enthalpy of Cr-Co than of Hf-Co pair, results in low GFA for the alloys with high Cr content.

P-7-01

Conception, fabrication and test of AMR-based magnetic gradiometers for navigation applications

A. Jouy,[1,2,3] H. Jaffres,[2] and M. Mansour[3]

[1] *Unité mixte de physique, CNRS, Thales, Palaiseau*

[2] *Laboratoire de Physique des Plasmas, Palaiseau, France*

[3] *Sysnav, 57 Rue de Montigny, 27200 Vernon, France*

In this talk, we will present the design and performances of a micronic magnetic gradient sensor based on AMR technology. The sensing parts of the gradiometer are made of a thin 200 um long ellipsoid-shaped Py AMR element covered by a thick Au barberpole with maximized sensitivity. The sensing magnetoresistances are placed at each part of a 5mmx5mm Si/SiO2 substrate and are included in a Wheatstone bridge balanced in a way that the transverse voltage is proportional to the field gradient. CoZrNb flux concentrators have been designed to provide optimal gain for gradiometer application i.e. maximize the amplification of a field gradient and minimized the amplification of a uniform field. Innovant solutions for low consumption anisotropy switching and offset compensations are being experimented using spin-hall-effect and spin-transfer coupling with adjacent Pt and AuW layers. We will compare sensors performances in terms of linearity, reversibility, and magnetic detectivity ($T/\sqrt{Hz}$) from 0.1Hz to few KHz frequency range.

P-7-02

Discrete inverse transformation for eddy current tomography

P. Nowak,[1] M. Urbański,[1] P. Raback,[2] J. Ruokolainen,[2] M. Kachniarz,[3] and R. Szewczyk[1]

[1] *Institute of Metrology and Biomedical Engineering, Warsaw University of Technology*

[2] *CSC – IT Center for Science*

[3] *Industrial Research Institute for Automation and Measurements PIAP*

Paper presents results of a discrete inverse tomography transformation on exemplary results from eddy current tomography setup. Eddy current phenomena is highly non-linear and measurement results are ill-posed function of distribution of physical properties of the matter (mostly electrical conductivity and magnetic permeability). Thus the inverse transformation (reconstruction of objects' shape) is based on an optimization algorithm in which objects' model is described as a discrete array. With the usage of Finite Element Method (FEM) tomography measurement process is reconstructed and modelling results are compared with the measurement.

P-7-03

Magnetocaloric and magnetotransport properties of metamagnetic $Dy_6Fe_2Si_3$ compound

Arun K,[1] Rashid T P,[1] Ivan Curlik,[2] Sergej Ilkovic,[2] Marian Reiffers,[2] and Nagalakshmi R[1]

[1] *Department of Physics, National Institute of Technology, Tiruchirappalli 620 0015, India*

[2] *Faculty of Humanities and Natural Sciences, Presov University, Presov, Slovakia*

We investigated the structural, thermodynamic, magnetic, and magnetotransport properties of novel $Dy_6Fe_2Si_3$ compound. This compound crystallizes in two different phases(Dy_5Si_3 and $DyFe_2$) having metamagnetic transition below T_c (∼49 K) from antiferromagnetic (AFM) to ferromagnetic (FM) around a field of 1 T. The isothermal magnetization curve for T = 2 K reveals the presence of two field induced metamagnetic transitions at H_{c1} = 0.5 T and H_{c2} = 6 T. A large negative magnetoresistance (MR) of 28 % at 2 K for 9 T is observed and this may be attributed to the Kondo effect. The magnetic entropy change, $\triangle S_m$, computed from the isothermal magnetization data shows a maximum $\triangle S_m$ of -7.5 J/kg.K (for a field change, $\triangle$H = 20 kOe) and 2.39 J/kg.K (for $\triangle$H = 70 kOe) at 4 K and 49 K respectively. Large magnetocaloric effects and large MR suggest that this material is interesting for magnetic cooling and sensing applications.

P-7-04

Magnetocaloric effect in antiferromagnetic half-Heusler alloy DyNiSb

K. Synoradzki,[1] K. Ciesielski,[1] and D. Kaczorowski[1]

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

The low-temperature magnetic, thermal and magnetocaloric properties of the half-Heusler compound DyNiSb were studied on polycrystalline samples. The temperature variations of the magnetization and the heat capacity reveal a phase transition from paramagnetic to antiferromagnetic state at the Néel temperature $T_N \approx 3.1$ K. The compound exhibits normal and inverse magnetocaloric effect with the isothermal magnetic entropy change reaching 5.2 J/kg K at 4.5 K for a magnetic field change of 30 kOe. The estimated refrigerant capacity is about 58 J/kg.

This work was supported by the National Science Centre under research grant no. 2015/18/A/ST3/00057.

P-7-05

Magnetocaloric properties of the Fe_2MnGa Heusler alloy

K. Synoradzki,[1,2] J. Dubowik,[2] and Y.V. Kudryavtsev[3]

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

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

[3] *Institute of Metal Physics NAS of Ukraine, Kiev, Ukraine*

Magnetocaloric effect in $Fe_{46}Mn_{24}Ga_{30}$ Heusler alloy (HA) was investigated. This alloy exhibits martensitic transformation accompanied with paramagnetic to ferromagnetic transition with a huge increase in magnetization at martensite start temperature $M_S = 166$ K. M_S is shifted up to 190 K by the external magnetic field of $\mu_0 H = 5$ T. Significant isothermal entropy change $\Delta S_M = 13.4$ J/K kg and refrigerant capacity $\mathrm{RC}(\Delta\mu_0 H = 5\mathrm{T}) = 208$ J/kg make this HA perspective for practical applications.

P-7-06

Terbium aluminum borate as promising material for magnetic refrigeration

V.A. Bedarev,[1] M.I. Pashchenko,[1] D.M. Merenkov,[1] O.M. Bludov,[1] V.O. Pashchenko,[1] S.M. Poperezhai,[1] S.L. Gnatchenko,[1] T. Zajarniuk,[2] and A. Szewczyk[2]

[1] *B. Verkin Institute for Low Temperature Physics and Engineering, National Academy of Sciences of Ukraine, 61103 Kharkov, Ukraine*

[2] *Institute of Physcis, Polish Academy of Sciences, Warsaw, Poland*

Rotational magnetocaloric effect in $TbAl_3(BO_3)_4$ single crystal was studied by using measurements of the field dependences of magnetization and the temperature dependence of heat capacity. This effect has been modeled within the quasidublet approximation. The changes of isothermal entropy caused by rotation of the crystal in constant magnetic field from an easy axis to a hard axis of magnetization were estimated. The maximum value of entropy changes was about 12.12 J/(mol·K) at temperature 5 K and magnetic field 5T. The field dependence of refrigerant capacity (RC) was calculated and the value of RC was 221 J/kg at magnetic field 5T. The rotational magnetocaloric effect was determined for various magnetic fields at different temperatures. The maximum effect value was about 12 K in magnetic field ≈ 2 T at initial temperature of the crystal 13.2 K. It was shown that the terbium aluminum borate can be the perspective material for magnetic cooling at low temperatures.

P-7-07

Improvement of Rotating Magnetocaloric Effect in 2D Mn(II)-Nb(IV) Molecular Ferrimagnet

P. Konieczny,[1] Łukasz Michalski,[1,2] Robert Podgajny,[3] Szymon Chorąży,[3] Robert Pełka,[1] Dominik Czernia,[1,2] Szymon Buda,[3] Jacek Mlynarski,[3] Barbara Sieklucka,[3] and Tadeusz Wasiutyński[1]

[1] *Institute of Nuclear Physics PAN, Kraków, Poland*

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

[3] *Faculty of Chemistry, Jagiellonian University, Kraków, Poland*

Magnetic and magnetocaloric properties of a 2D Mn(II)-Nb(IV) ferrimagnet on single crystals were investigated. A sizable anisotropy of magnetocaloric effect between the easy plane and hard axis in low fields was used to study the rotating magnetocaloric effect. We demonstrate that the inverse part of magnetocaloric effect can be used to improve the rotating magnetic entropy change up to 51%. This finding is of key importance for searching efficient materials for RMCE.

References:

[1] P. Konieczny, Ł. Michalski, R. Podgajny, S. Chorąży, R. Pełka, D. Czernia, S. Buda, J. Młynarski, B. Sieklucka, T. Wasiutyński, Inorg. Chem., **56** (2017) 2777-2783

This work was supported by the Polish National Science Center (Grant No. DEC-2013/11/N/ST8/01267)

P-7-08

NDE and SHM of Critical Parts Using Magnetic and Electromagnetic Methods

M. Witoś,[1] M. Zieja,[1] N. Fallahi,[2] Z.H. Żurek,[3] and J. Kwaśniewski[4]

[1] *Air Force Institute of Technology, Warsaw, Poland*

[2] *I & T Nardoni Institute, Brescia, Italy*

[3] *Silesian University of Technology, Katowice, Poland*

[4] *AGH University of Science and Technology, Cracow, Poland*

The paper has been intended to introduce a complex research problem, that is present in aviation, power engineering, mining and transport, with regard to assurance of operational safety for ageing technology, which is exposed to different form of material degradation. Theoretical reasons of non-destructive evaluation (NDE), structural health monitoring (SHM) and active control of material fatigue have been outlined. The magnetic and electromagnetic methods of NDE and SHM such as metal magnetic memory, low frequency eddy current spectroscopy, Barkhausen noise and 3MA have also been presented [1-3]. The topic has been illustrated by means of practical examples.

References:

[1] Open Acces Database of NDT and SHM, http://www.ndt.net/search/docs.php3.

[2] *Electromagnetic Nondestructive Evaluation (XVII)*, ed. K. Capova, L. Udpa, L. Janosek, (IOP Press 2014).

[3] G. Dobmann, Non-destructive Testing for Ageing Management of Nuclear Components, *Nuclear Power-Control, Reliability and Human Factors*, ed. P. Tsvetkov, (INTECH, 2011).

P-7-09

Production and theoretical simulation of performance of metal-bonded La(Fe,Mn,Si)$_{13}$H$_x$ composite material

D. Karpenkov,[1,2] I. Radulov,[1] T. Braun,[1] A. Karpenkov,[3] K. Skokov,[1] and O. Gutfleisch[1,4]

[1] *Institut fur Materialwissenschaft, TU Darmstadt, 64287 Darmstadt, Germany*

[2] *NUST MISiS, Leninskiy pr.4, 119991 Moscow, Russia*

[3] *Chelyabinsk State University, Faculty of Physics, 45400 Chelyabinsk, Russia*

[4] *Fraunhofer ISC, IWKS Group Materials, Recycling and Resource Strategy, 63457 Hanau, Germany*

Hydrogenated La(Fe,Mn,Si)$_{13}$ based alloys have excellent magnetocaloric properties but poor mechanical and chemical stability. In this work we show how machinability and corrosion protection of the particles can be improved by a hot-dip coating. The metal coated particles were used to build two different types of heat exchangers: stacked flat plate and packed bed of spherical particles. Further a theoretical comparative investigation of the performance of two heat exchangers geometries, using the similarity theory, combined with unsteady heat transfer approach, is presented.

This work was supported by DFG (Grant No. SPP 1599), European Community 7th Framework Program (Grant No. 310748 DRREAM), the Grant of NUST MISiS (K4-2015-013) and RSF grant (N15-12-10008).

P-7-10

Magnetic and Lattice Contributions to the Magnetocaloric Effect in the First Order Phase Transition Materials

A.M. Aliev,[1] A.B. Batdalov,[1] L.N. Khanov,[1] and A.R. Kaul[2]

[1] *Amirkhanov Institute of Physics of Daghestan Scientific Center RAS, 367003 Makhachkala, Russia*

[2] *Moscow State University, 119991 Moscow, Russia*

Materials with magnetostructural phase transitions are considered as the most promising for the magnetic refrigeration technology. In addition to a magnetic entropy change in these materials a lattice entropy change can be observed due to a large magnetostricition. But to date there is no suitable and generally accepted procedure to evaluate the contributions to the magnetocaloric effect (MCE). In this report a method to estimate the lattice and magnetic contributions to the magnetocaloric effect is proposed. The method is based on the analisys of the field dependences of the MCE and magnetostriction, measured under identical conditions in cyclic magnetic fields. Two assumptions are used for that: the lattice contribution is proportional to the magnetostriction and the field dependence of the magnetic contribution obeys $\Delta T_{\mathrm{m}} = aH^n$ relation. The results of estimation of contributions in the different families of magnetocaloric materials are reported.

P-7-11

The plastic deformation of Heusler alloys by the multiple isothermal forging

I. Musabirov,[1] I. Safarov,[1] R. Galeev,[1] and R. Mulyukov[1]
[1] *Institute for Metals Superplasticity Problems of RAS, 39 Stepan Khalturin, Ufa, 450001, Russia*

Heusler alloys belong to a class of promising functional materials. The ferromagnetic shape memory and magnetocaloric effects are observed in materials. The main disadvantage is degradation during heating and cooling through the martensitic transformation. One of the ways to improve the stability of the functional properties of these materials is the plastic deformation by the different methods. The results of the influence of the plastic deformation by the multiple isothermal forging on the functional properties are presented in the paper. The study of the dilatometry, magnetic and electrical properties of Ni_2MnGa alloy after plastic deformation by forging is shown.

The study was supported by a grant RFBR No. 16-32-60159 mol-a-dk

P-7-12

Direct studies of giant magnetocaloric effect in Mn(As,P) in cyclic magnetic fields

A.M. Aliev,[1] A.G. Gamzatov,[1] A.B. Batdalov,[1] G.A. Govor,[2] K.I. Yanushkevich,[2] and A.I. Galias[2]
[1] *Amirkhanov Institute of Physics, DSC of RAS, 367003, Makhachkala, Russia*
[2] *Scientific-Practical Materials Research Centre of the National Academy of Sciences of Belarus, 220072 Minsk, Republic of Belarus*

First order phase transition materials are considered as the most promising for magnetic refrigeration technology. In these materials both magnetic and lattice subsystems contribute to the overall magnetocaloric effect (MCE) and giant value of MCE can be observed. These materials include MnAs in which one of the highest MCE near room temperature was discovered. In this report we present results of the direct measurements of the adiabatic temperature change in MnAs compound as well as in doped $MnAs_xP_{1-x}$ (x=0.02, 0.025, 0.03) ones in cyclic magnetic fields up to 8 T. The substitution of As by P results in a slight shift of the Curie temperature and change in width of the temperature hysteresis and more pronounce change in the MCE value. The investigations show giant MCE in all studied $MnAs_xP_{1-x}$ and the existence of the critical magnetic field that induces reversible MCE in cyclic magnetic fields.

P-7-13

The magnetic trackers and calibration modules implemented in the helmet-mounted cueing systems for Polish military helicopters

A. Szelmanowski,[1] S. Michalak,[1] A. Pazur,[1] P. Janik,[1] and W. Paterek[1]

[1] *Air Force Institute of Technology, ul. Ks. Bolesława 6, 01-494 Warsaw, Poland*

In the paper there are presented selected magnetic phenomena implementations in the scope of helmet attitude and heading tracking systems relatively to the aircraft body (magnetic trackers) and magnetic heading errors compensation systems (magnetic deviation) utilized in the helmet-mounted cueing systems.

References:

[1] Z. Gosiewski, A. Ortyl - Inertial systems alghorithms for space orientation of moving objects, Institute of Aviation, Warsaw (1999)

[2] A. Szelmanowski, A. Pazur, P. Janik, Helmet mounted display systems from the optoelectric surveillance systems for civil and military SAR/CSAR helicopters, AFIT works nr 369/43/16 (2016).

[3] Rush C., Helmet display in aviation. Helmet mounted display. Design issues for rotary-wing aircraft, USA, Fort Rucker (2009).

This work was supported by the project no. 0-5599-43 in research@developed works realised in Department dor Avionics of the Air Force Institute of Technology in 2016.

P-7-14

Passive magnetic suspension for UAV magnetic runway

K. Falkowski,[1] K. Sibilski,[2] Anna Sibilska-Mroziewicz,[3] and Edyta Ładyżyńska-Kordaś[3]

[1] *Military University of Technology*

[2] *Air Force Institute of Technology*

[3] *Warsaw University of Technology*

The launchers are used to take–off small UAV. Frequently launchers use elastic energy of rubber or powder cartridge to launch UAV. The modern launchers use linear electric drivers to running of UAV. The UAV is located on the sledge. The sledge has linear driver which ensures speed of sledge with UAV. The sledge moves above two linear passive magnetic guides [1]. In the article are presented passive magnetic system with superconductors. The system was designed for take-off and landing UAV with take-off weight about 2 kg. The sledge has four passive magnetic suspensions. Four pieces of superconductor YBCO sink in nitrogen. The magnetic array is used in construction of magnetic runway. The arrangement of magnets shapes magnitude and distribution magnetic field in the suspension.

References:

[1] K. Falkowski "Pasive magnetic suspensions", Military University of Technology, Warsawa 2016 (in Polish)

P-7-15

Magnetic-Induced Deformation of NiMnGa Alloy With Shape Memory Effect

D. Kuchin,[1] V. Koledov,[1] Yu. Koshkid'ko,[2] and A. Kamantsev[1]

[1] *The Kotel'nikov Institute of Radio-engineering and Electronics (IRE) of Russian Academy of Sciences. Moscow, Russia.*

[2] *The International Laboratory of High Magnetic Fields and Low Temperatures. Wroclaw, Poland.*

The experimental setup for studying thermomechanical properties [1,2] of ribbon samples or plates was placed in the field of the Beater magnet. For the sample of Ni2.16Mn0.84Ga alloy, the bending deformation versus temperature in different magnetic fields up to 10 T was measured. The martensite transformation temperatures shift was approximately 0.5 C/T. Also, the deformation dependencies on the magnetic field were obtained for various constant temperatures. It is established that for a given alloy sample there is almost complete transition back and forth from the austenite to martensitic phase at 41 C when the magnetic field 10 T is switched on and off.

References:

[1] Bruno, Nickolaus M., et al. "High-field magneto-thermo-mechanical testing system for characterizing multiferroic bulk alloys." Review of Scientific Instruments 86.11 (2015): 113902.

[2] Shelyakov, A. V., et al. "Melt-spun thin ribbons of shape memory TiNiCu alloy for micromechanical applications." International Journal of Smart and Nano Materials 2.2 (2011): 68-77.

P-7-16

Investigation on Structural, Transport, Microstructure, Magnetic and Magneto caloric properties of Cu substitution in CoMnGe alloys

U. Devarajan,[1] and Sunil Nair[1,2]

[1] *Department of Physics, Indian Institute of Science Education and Research, Dr. Homi Bhabha Road, Pune 411008, India*

[2] *Centre for Energy Science, Indian Institute of Science Education and Research, Dr. Homi Bhabha Road, Pune 411008, India*

We are investigating structure, transport, nature of magnetic transitions and magnetocaloric effect in $CoMn_{1-x}Cu_xGe$ (x = 0, 0.3, 0.7) intermetallics alloys. The non-magnetic (Cu) element are positioned at Mn site of the alloys which make drastic change in structures (Orthorhombic-Hexagonal) and exhibits metallic behavior.The magneto-structural transition reduce drastically and changes the order (First (AFM-FM) Second (FM-PM)) of transition. Giant MCE is observed near RT (307 K) for stoichimetric sample and decrease towards LT's for Cu doped samples.The change in magnetic entropy (ΔS_M) is decreasing with effect of Cu doping. Refrigeration capacity (RC) are linearly increased with magnetic field for all samples and decreased with Cu doping.

The authors acknowledge to SERB- National Post Doctoral fellowship (PDF/2016/000412)

P-7-17

Preparation and characterization of magnetic nanoparticles

I. Khmara,[1,2] M. Kubovcikova,[1] M. Koneracka,[1] B. Kalska-Szostko,[3] V. Zavisova,[1] I. Antal,[1] and P. Kopcansky[1]

[1] *Institute of Experimental Physics SAS, Kosice, Slovakia*

[2] *Institute of Physics, P.J. Safarik University, Kosice, Slovakia*

[3] *University of Bialystok, Institute of Chemistry, Bialystok, Poland*

The magnetic nanoparticles (MNPs) with core diameter 10 nm have been modified by poly-L-lysine to bind antibody for cancer cell detection. Prepared biocompatible magnetic fluids (MFPLL) were characterized by dynamic light scattering method to obtain the particle size distribution. The microstructure of the MNPs and MFPLL samples has been studied by transmission electron microscopy, X-ray diffraction and Mössbauer spectroscopy. Magnetic properties of the samples were measured by SQUID magnetometer and superparamagnetic behavior of the samples was confirmed.

P-7-18

Hydrogenation-Induced Reversible Spin Reorientation Transition in $Co_{50}Pd_{50}$ Alloy Thin Films

Wen-Chin Lin[1]

[1] *Department of Physics, National Taiwan Normal University, Taipei 11677, Taiwan*

Because of the Pd-catalyzed hydrogen dissociation and absorption, magnetic Pd-alloys provide a model system for the investigation of the critical hydrogenation effect on magnetism. In this study, $Co_{50}Pd_{50}$ (CoPd) alloy thin films were fabricated by e-beam-heated co-evaporation on $Al_2O_3(0001)$ substrates. These films exhibited a thickness-dependent spin reorientation transition (SRT) from perpendicular direction to in-plane direction with increase of thickness. For 10-30 nm-thick CoPd alloy films with perpendicular magnetic anisotropy (PMA), hydrogenation triggered a SRT to an in-plane anisotropy. The reversibility of SRT was demonstrated by cyclicly changing the hydrogen gas pressure. Furthermore, hydrogenation-induced SRT randomized the magnetic domain orientation. In comparison with a bare CoPd film , a stronger PMA and a less pronounced hydrogenation-induced SRT were observed in a Pd-capped CoPd film. These observations suggest that the hydrogen content in CoPd alloy films can drastically and reversibly modify PMA, inferring the possible hydrogenation-induced charge transfer and modulation of electronic structure in CoPd.

References:

[1] Po-Chun Chang, Yu-Chuan Chen, Chuan-Che Hsu, Hsiang-Chih Chiu, and Wen-Chin Lin, J. Alloys Comp 710, 37-46 (2017).

P-7-19

Magnetic anisotropy of bulk and rod shape amorphous silica

M. Hiroata,[1] and C. Uyeda[1]

[1] *Graduate School of Science, Osaka University, Japan*

In a microgravity experiment, it was generally difficult to release a small sample a diffuse area because of various attractive forces. The enormously enhanced anisotropy observed at the silica surface is not solved as yet. In order to solve this problem, a structural anisotropy at atomic scale should be experimentally identified. We therefore performed Electron Spin Resonance ESR in the above sample plates, and angular dependence with uni-axial symmetry was obtained with its principle axis nearly normal to the silica surface. Angular dependence of the ESR spectra was observed in these samples, and existence of structural anisotropy at atomic level in the surface area. This can be the cause of the large anisotropy value. It is natural to assume that the observed anisotropy originate from the ferrous ion isolated in the material. Structural anisotropy at atomic scale produces by the process of rapid cooling. As performed in the present report, comparison between the anisotropy data and the ESR spectrum will provide useful information to study the cause of the observed anisotropy. Further information will be obtained by changing the experimental conditions in synthesizing the samples.

P-7-20

Magnetic separation and identification of volatile diamagnetic solids in low magnetic field

W. Yamaguchi,[1] C. Uyeda,[1] and K. Hisayoshi[1]

[1] *Graduate School of Science, Osaka University, Osaka Japan*

The separation occurred because the magnetic potential of grain at initial position was completely converted into kinetic energy at the collecting plate, and the terminal velocity of the grains there was uniquely determined by the field intensity at initial sample position and susceptibility. Here we report that the separation is extended to volatile solid such as ice Ih and solid carbon dioxide. Further more, the concentration silicate particle included in an ice grains are identified by their magnetic susceptibility that was determined from translating velocity. The method is applicable in collecting/separating the ice grains in an on-site mission to the icy rings and satellites. Both magnetic fields and dust particles are omnipresent in various regions in space. Although the field intensity is low, the cosmological time scale in space might allow specific translations of solid particles, causing chemical fractionation in the primitive materials.

References:

[1] Hisayoshi *et al.* Sci Reps. 2010.

P-7-21

Rating impact of laser padding on the top layer steel by magnetic methods

W. Napadłek,[1] M. Witoś,[2] and T. Prusik[2]

[1] *Military University of Technology in Warsaw, Warsaw, Poland*

[2] *Air Force Institute of Technology, Warsaw, Poland*

The article presents the problem of quality control the paramagnetic material of weld overlays laser made on X22CrMoV12-1 steel samples [1-3]. To assess the quality of the paramagnetic material and the effect of overheating, in addition to laboratory tests on the Keyence optical microscope, measures of existing magnetization (magnetic field distribution) and electromagnetic properties were used. Examples of research results are presented. It has been found, that is expedient use magnetic methods to assess the quality the microstructure of laser pad welded surface layer (Influence of heat generation, microstructure changes, chemical composition and own stresses).

References:

[1] Craik D.J., Wood M.J. Magnetization changes induced by stress in a constant applied field, Journal of Applied Physics D: Applied Physics, 3, pp. 1009-1016 (1970).

[2] The Web's Largest Open Access Database of Nondestructive Testing (NDT), http://www.ndt.net/search/docs.php3.

[3] M. Witos, M. Zieja, B. Kurzyk, IT SUPPORT OF NDE AND SHM WITH APPLICATION OF THE METAL MAGNETIC MEMORY METHOD, The e-Journal of Nondestructive Testing, Vol.21 No.05, (2015). www.ndt.net/article/aero2015/papers/We_4_A_3_Witos1.pdf.

P-8-01

Stress monitoring in steel elements via detection of AC magnetic permeability changes

T. Szumiata,[1] K. Hibner,[1] K. Dziewiecki,[2] Z. Mazur,[2] A. Gockiewicz,[1] M. Gzik-Szumiata,[1] B. Górka,[1] and M. Witoś[3]

[1] *Department of Physics, University of Technology and Humanities in Radom, Krasickiego 54, 26-600 Radom, Poland*

[2] *Institute of Applied Mechanics and Power Engineering, University of Technology and Humanities in Radom, Krasickiego 54, 26-600 Radom, Poland*

[3] *Air Force Institute of Technology, Księcia Bolesława 6, 01-494 Warsaw, Poland*

The influence of mechanical stress on low frequency AC magnetic permeability was studied. The cold-drawn bars with C45 steel were subjected to investigation. The tensile stress was applied by means of material testing machine. The registered changes of magnetic permeability of the stretched rods were almost frequency-independent in low frequency limit. A significant mechanomagnetic hysteresis was observed slightly evolving from cycle to cycle with tendency of stabilization. The extension of basic Stoner–Wohlfarth model of magnetic permeability allowed to fit the data in the range of the increasing tensile stress and to estimate the change of the internal stress due to the relaxation effect.

P-8-02

Impact of microstructure on the thermoelectric properties of the ternary compound $Ce_3Cu_3Sb_4$

P. Witas,[1] J. Goraus,[1] P. Zajdel,[1] K. Balin,[1] J. Koperski,[1] J. Lelątko,[2] and A. Ślebarski[1]

[1] *Institute of Physics, University of Silesia*

[2] *Institute of Materials Science, University of Silesia*

We present detailed structural and thermoelectric studies of the ternary compound $Ce_3Cu_3Sb_4$. This material is of interest due to considerable thermopower above room temperature ($\sim$ 100 μV/K) and low thermal conductivity (2 W/(m K)). We have used X-ray diffraction, scanning electron microscopy (SEM), and secondary ion mass spectrometry (TOF-SIMS) for microstructural characterization to study variation of thermoelectric data across the samples. The thermoelectric properties were examined using a PPMS measurement system. We analyze the impact of the sample quality on the thermoelectric properties. The properties variability is mainly due to structural defects caused by stresses during material preparation and also due to formation of foreign phases $CeCuSb_2$ and CeSb. The figure of merit ZT is also strongly dependent on the quality of the sample. The largest value ZT $\approx$ 0.15 at 400 K is determined for the almost stoichiometric sample with small amounts of a impurity phases.

References:

[1] P. Witas et al., Mater. Charact. 123, 256–263 (2017)

P-8-03

Modelling of spin-dependent mechanical friction at atomic level

M. Gzik-Szumiata,[1] T. Szumiata,[1] and D. Morozow[2]

[1] *Department of Physics, University of Technology and Humanities in Radom, Krasickiego 54, 26-600 Radom, Poland*

[2] *Institute of Machinery Engineering, University of Technology and Humanities in Radom, 54 Krasickiego Str., 26-600 Radom, Poland*

Though magnetic coupling is considered to be noticeably weaker than chemical, electronic interactions, it has been recently shown by Wolter and co-workers [1] that spin-spin exchange energy can considerably influence the friction between magnetic materials. In our work a simple 2D model of pseudostatic friction at atomic level has been prepared, in the frame of which both Lennard-Jones potential and spin-dependent term of exchange interaction has been included. It has been demonstrated, that for iron both average lateral and normal forces between atoms of "base" and "slider" in the tribological node are altered through the change of relative direction of spins, by over a dozen of percent, when the interatomic distance is comparable to the lattice constant. Spin-dependent correction of friction coefficient has been estimated.

References:

[1] B. Wolter, Y. Yoshida, A. Kubetzka, S.-W. Hla, K. von Bergmann, R. Wiesendanger, "Spin friction observed on the atomic scale", Physical Review Letters **109** (2012) 116102-1 - 116102-5.

P-8-04

Magneto-optical study toward discrimination of iron mineral in human tissues

M. Koralewski,[1] J. Żurawski,[2] Ch. Langkammer,[3] and J. Karoń[2]

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

[2] *K. Marcinkowski University of Medical Sciences, Poznań, Poland*

[3] *Department of Neurology, Medical University of Graz, Graz, Austria*

Our work presents experimental studies of magnetic optical rotatory dispersion (MORD) for thin slices (about 5 micrometers on quartz glass) of tissues obtained from white matter of the brain and spleen and their comparison to thin film of composite made from akaganeite mineral and PVA as well as ferritin and their mimetics aqueous suspensions. MORD data were correlated with respective absorption UV-VIS spectra and optical microscopy examination of tissues. The MORD measurements were performed at room temperature using an upgraded polarimeter P200 (Jasco), and static magnetic field, switchable from –3 to +3 kOe. In the investigated samples we do not observe saturation of Faraday rotation and MORD spectra do not show feature related with non-heme ferrous (Fe(II)). We observe a good correlation between MORD spectra for akaganeite composite film and ferritin and their mimetics aqueous suspensions with spectra of thin slices of both human tissue, which suggest a contribution from Fe (III). Magnetically induced rotation of the light polarization plane seems to be a promising method to study magnetic properties of human tissues in vitro.

P-8-05

Dependence of ultrasonic and magnetic hyperthermia on the concentration of magnetic nanoparticles

K. Kaczmarek,[1] T. Hornowski,[1] R. Bielas,[1] D. Żak,[1] and A. Józefczak[1]

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

Hyperthermia treatment is the heating of tumor tissue up to temperatures between 41°C and 45°C, which trigger several physiological reactions in the body. Hyperthermia within tissue can be applied through various mechanisms. One of them is magnetic hyperthermia which uses superparamagnetic iron oxide nanoparticles (SPION) heated by an externally applied magnetic field. SPIONs can also be used as sonosensitizers in ultrasound hyperthermia increasing acoustic wave attenuation. The impact of SPION concentration on thermal effect during ultrasonic and magnetic hyperthermia was investigated in agar-gel phantom with added magnetite nanoparticles. The presence of nanoparticles in the tissue-mimicking phantom increases the thermal losses of ultrasound energy and temperature of the phantom.

This work was supported by a Polish National Science Centre grant, no DEC-2015/17/B/ST7/03566.

P-8-06

Active LR integrator circuit for drift-free magnetoelastic transducers

Piotr Gazda,[1] Michał Nowicki,[1] and Maciej Kachniarz[2]

[1] *Institute of Metrology and Biomedical Engineering, Warsaw University of Technology, Andrzeja Boboli 8, 02-525 Warsaw, Poland*

[2] *Industrial Research Institute for Automation and Measurements PIAP, Al. Jerozolimskie 202, 02-486 Warsaw, Poland*

Current integrator systems usually use active RC integrator circuits. Crucial difficulty associated with this analog system is the integrator drift. The following paper presents the idea of the active integrator circuit based on inductive and resistive components. This concept allows to eliminate the time drift of the circuit, which is undesired phenomena resulting from capacitive components working in the traditional negative feedback loop.The SPICE simulations were performed to validate the presented idea. Then, prototype circuit with discrete components was tested. Inductors were based on nanocrystalline and air cores. The developed solution was tested as magnetoelastic sensors transducer, to confirm the ability for long-term, continuous, drift-free, integrator circuit operation. The results were compared with traditional, RC circuit with automatic drift compensation.

P-8-07

Detection of biogenic magnetic nanoparticles in human's aortic aneurysms

S. Gorobets,[1] O. Gorobets,[1] Y. Darmenko,[1] I. Sharau,[2] and O. Lazarenko[3]

[1] *Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine*

[2] *Institute of Magnetism NASU and MES of Ukraine , Kyiv, Ukraine*

[3] *State Scientific Institution "SPCPCM", Kyiv, Ukraine*

The presence of biogenic magnetic nanoparticles (BMNs) in aortic aneurysm is detected using magnetic force microscopy. The presence of BMNs (single BMN and their chains) in aortic aneurysm may cause magneto-dipole interactions of these BMNs with BMNs of microorganisms - pathogens of heart and with artificial magnetic nanoparticles in the drug delivery systems. The accumulation of BMNs in the human heart can be attributed not only to the process of biomineralization BMNs directly in the tissues of heart but due to the accumulation of microorganisms – pathogens of heart that are natural producers of BMNs.

References:

[1] Gorobets S.V.,Gorobets O.Yu.,Chyzh Yu.M.,Sivenok D.V.(2013). Magnetic dipole interaction of endogenous magnetic nanoparticles with magnetoliposomes for targeted drug delivery. Biophysics, 379—384.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348 (MagIC).

P-8-08

Magnetic force microscopy of the ethmoid bones of migratory and non-migratory fishes

S. Gorobets,[1] O. Gorobets,[1] M. Bulaievska,[1] and I. Sharau[2]

[1] *Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine*

[2] *Institute of Magnetism NAS of Ukraine and MESYS of Ukraine, Kyiv, Ukraine*

For a long time it was believed that the biogenic magnetic nanoparticles (BMNs) in the ethmoid bones of fishes and birds are associated with navigation in the geomagnetic field. However, it was proven that BMNs don't affect the ability of migratory birds to orient in the Earth's magnetic field. It is relevant to check the presence of BMNs in organs of migratory and non-migratory fishes. The presence of BMNs was investigated in the samples of ethmoid bones of salmon, pike and silver carp by the method of magnetic force microscopy. As a result, the biological material of ethmoid bones of migratory and non-migratory fishes contain both separate BMNs and their chains, so BMNs in the ethmoid bone of fishes are not related to their ability to migrate in the geomagnetic field.

References:

[1] Ritz T, Thalau P, Phillips J B, Wiltschko R, Wiltschko W (2004) Nature 429: 177-180.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348 (MagIC).

P-8-09

The role of magnetic nanoparticles in vesicular transport in eukaryotes

S. Gorobets,[1] O. Gorobets,[1] and A. Mikeshyna[1]
[1] *National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine*

A model is considered to calculate the forces of interaction of magnetic nanoparticles (BMNs) (ranging in size from 50 to 250 nm bounded to the cell membrane separately or gathered in chains) with the vesicle inside the cell (in size from 100 to 800 nm). In this model, the order of magnitude of the gradient magnetic forces of interaction of BMNs with an effectively paramagnetic or paramagnetic vesicle is 1,0e-11 N, the interaction forces of BMNs with a magnetoliposomeresulted in an order of magnitude 1,0e-9 N. The forces of the magnetic dipole interaction of chains of BMNs with vesicles do not depend on a number of BMNs in the chain for sufficiently long chains of about 20 nanoparticles. So magnetodipole forces can significantly affect on vesicular transport.

References:

[1] Gorobets S.V., Gorobets O.Yu., Chyzh Yu.M., Sivenok D.V. 2013 Biophysics 58(3) 379

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 644348 (MagIC).

P-8-10

The influece of the chemical disorder in the FeCo system on the magnetic properties - a combined ab initio and Monte Carlo study

Bartosz Wasilewski,[1] Wojciech Marciniak,[2] and Mirosław Werwiński[1]
[1] *Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznań, Poland.*
[2] *Faculty of Technical Physics, Poznan University of Technology, Pl. M. Skłodowskiej-Curie 5, 60-965 Poznan, Poland*

Having performed the self-consistent field calculations for the $Fe_{1-x}Co_x$ system. using the Korringa-Kohn-Rostoker method implemented in Munich (SPR-KRR) code, we obtained the exchange integrals from the resultant potential. We then used the obtained magnetic moments and exchange integrals to calculate, using the Uppsala atomistic spin dynamics (UppASD) code, the magnetization and susceptibility dependency on temperature for the whole range of concentrations. The UppASD code allows for Monte Carlo (MC). We treated the chemical disorder using the coherent potential approximation (CPA). The lattice constants were optimized using the FPLO code. The calculations were done using the GGA for both the SPR-KKR and FPLO codes.

The authors acknowledge the financial support from the Foundation of Polish Science grant HOMING. The HOMING programme is co-financed by the European Union under the European Regional Development Fund.

P-8-11

EMR of high-spin Mn(III) ions in porphyrinic complexes

Krzysztof Tadyszak,[1] Czesław Rudowicz,[2,3] Hitoshi Ohta,[4,5] and Takahiro Sakurai[5]

[1] *NanoBioMedical Centre, AMU Poznań, Poland*

[2] *Faculty of Chemistry, AMU, Poznań, Poland*

[3] *Institute of Physics, West Pomeranian University of Technology Szczecin, Poland*

[4] *Graduate School of Science, Kobe University, Nada, Kobe, Japan*

[5] *Center for Supports to Research and Education Activities, Kobe University, Japan*

We have have performed semiempirical modeling of the spin Hamiltonian (SH) parameters aimed at the elucidation of the intrinsic magnetic nature of high-spin (S = 2) manganese (III) $3d^4$ ions at tetragonal symmetry sites in tetraphenyl - porphyrinato manganese (III) chloride (MnTPPCl) and related complexes. This modeling utilizes the microscopic spin Hamiltonians (MSH) approach developed for the $3d^4$ and $3d^6$ ions with spin S = 2 at orthorhombic and tetragonal symmetry sites in crystals, which exhibit an orbital singlet ground state arising from the ground ^{5}D multiplet.

We gratefully acknowledge the research grants from the Polish National Science Center: DEC-2012/04/M/ST3/00817 (CZR) and UMO-2016/21/D/ST3/00975 (KT).

P-8-12

ThRhSi: a non-centrosymmetric superconductor

Krzysztof Domieracki,[1] and Dariusz Kaczorowski[1]

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

The superconducting silicide ThRhSi crystallizes with a non-centrosymmetric crystal structure of the LaPtSi-type (space group $I4_1md$) [1]. The absence of inversion centre in a system with strong spin-orbit coupling implies a possibility of identifying sizeable contribution of spin-triplet component in the Cooper pairs condensate. Motivated by this prospect, we carried out detailed investigations of the superconducting state in ThRhSi by means of electrical resistivity, magnetic susceptibility and heat capacity measurements, performed down to 0.35 K in magnetic fields up to 5 T. The experimental data revealed bulk superconductivity with the critical temperature $T_c = 5.7$ K and the upper critical field $H_{c2}(0) = 2$ T. A set of superconducting parameters was derived, compared with those in a few related compounds, and discussed in terms of the alleged unconventional character of the superconducting state.

References:

[1] P. Lejay, B. Chevalier, J. Etourneau, J. M. Tarascon, P. Hagenmuller, *Mat. Res. Bull.* **18**, 67 (1983).

P-8-13

The satellites orientation method using a torque magnetic drive

Igor Korobiichuk,[1] Borys Samotokin,[2] Dmytro Shostachuk,[2] Maciej Kachniarz,[1] and Michał Nowicki[3]

[1] *Industrial Research Institute for Automation and Measurements PIAP*
[2] *Zhytomyr State Technological University*
[3] *Warsaw University of Technology, Warsaw, Poland*

Small values of external perturbation forces made it possible to use a torque magnetic drive (TMD) as a control system. Today, satellite orientation systems use pulsed-type algorithm for discharge of an angular momentum accumulator. The feasibility of using other algorithms (continuous, continuous-pulsed and algorithm of TMD operation using 'forecast' models of accumulated angular momentum and geomagnetic field) is not covered and not examined, although each has certain advantages for certain types of satellites and their conditions of operation in space. The article highlights satellites operating conditions in space, considers satellites orientation method using a torque magnetic drive and substantiates the necessity of satellite motion simulation with further establishing a technique for evaluation of orientation system given the effect of permanent magnetic and gravitational fields, the type of discharge of accumulated angular momentum, the height of trajectory and the nature of random perturbations.

P-8-14

Electronic structure of Th_7Ru_3

M. Sahakyan,[1] and V.H. Tran[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, PO. Box 1410, 50-422 Wrocław, Poland*

Physical properties of non-centrosymmetric Th_7T_3 (T= Co, Fe, Rh, Os, Ir, Ru), were studied by Matthias et al. [1]. The authors showed that expect for Th_7Ru_3, the remaining compounds have superconducting transition at approximately 1.5 - 2 K. Owing to the aspect of non-centrosymmetric superconductivity, there is a need to perform an investigation of electronic band structures. Such studies have recently been presented by us for Th_7Co_3 [2] and Th_7Fe_3 [3]. In this contribution, we report the results of scalar and fully relativistic calculations for Th_7Ru_3, using the full potential linearized-muffin-thin-orbital method. The obtained data reveal that effect of asymmetric spin-orbit coupling with splitting energy of 10 - 40 meV is much weaker, and simultaneously the van Hove singularity-like peak locates at -2.1 eV with respect to the Fermi level, is much deeper as compared to those of Fe-, Co-based superconductors. The findings can explain the existing difference between the studied Th_7T_3.

References:

[1] B. Matthias et. al. J. Phys. Chem. Solids 19(1-2) 014516 (1967)
[2] M. Sahakyan and V. H. Tran, J. Phys.: Condens. Matter 28, 205701 (2016)
[3] M. Sahakyan and V. H. Tran, Phil. Mag 97, 957 (2017)

Financial support from the project 2016/21/B/ST3/01366 NSC of Poland.

P-8-15

Crystal structure and magnetic properties of $EuNi_{6.9}Si_{6.1}$

N. Klymentiy,[1] S. Pukas,[1] B. Belan,[1] R. Gladyshevskii,[1] and D. Kaczorowski[2]

[1]*Department of Inorganic Chemistry, Ivan Franko National University of Lviv, Kyryla i Mefodiya St. 6, 79005 Lviv, Ukraine*

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

The existence of the europium nickel silicide $EuNi_{7.8-6.7}Si_{5.2-6.3}$ [O.I. Bodak, E.I. Gladyshevskii, *Dopov. Akad. Nauk Ukr. RSR, Ser. A* (1969) 1125] was confirmed. Its crystal structure was refined by the Rietveld method, using the X-ray pattern of a single-phase alloy of composition $EuNi_{6.9}Si_{6.1}$. The structure is tetragonal (a = 7.8491(9), c = 11.279(1) Å), and the structure type $CeNi_{8.5}Si_{4.5}$ ($I4/mcm$), which is one of the tetragonal derivatives of the cubic type $NaZn_{13}$, was chosen as starting model for the refinement. Differently from $CeNi_{8.5}Si_{4.5}$, in $EuNi_{6.9}Si_{6.1}$ the Ni and Si atoms were found to form statistical mixtures in all of the positions not occupied by Eu. The results of the investigation of the magnetic properties indicated Curie-Weiss paramagnetism due to stable magnetic moments on divalent europium ions. The inverse magnetic susceptibility follows the Cure-Weiss law with an effective magnetic moment of μ_{eff} = 7.66 μ_B and a paramagnetic Curie temperature of θ_p = -9.5 K.

P-8-17

Use of MRI to measure whole brain atrophy in MS Patients

P. Mazgaj,[1] Z. Drzazga,[1] I. Karpiel,[1] A. Giec-Lorenz,[2] and E. Krzystanek[3]

[1]*Department of Medical Physics, Institute of Physics, University of Silesia, Katowice, Poland*

[2]*Helimed Diagnostic Imaging Sp. z o.o., Laboratory of Magnetic Resonance Imaging, Katowice, Poland*

[3]*Department of Neurology, Medical University of Silesia in Katowice, Katowice, Poland*

Magnetic resonance imaging is used for anatomical assessment of human brain structures in neurodegenerative disorders causing brain atrophy. It can be described in terms of change in the brain parenchymal fraction (BPF). In brain MRI, segmentation of brain tissues is an important step for numerical application. In this work we investigate the impact of segmentation method in SPM12 and additional segmentation in Computational Anatomy Toolbox (CAT12) for BPF determination. Dependence of brain atrophy on age of the studied patients and disease duration compared with healthy individuals is discussed.

P-8-18

Optimization of fMRI analysis of speech areas in pre- and postoperative diagnostics

Ilona Karpiel,[1] Zofia Drzazga,[1] Patrycja Mazgaj,[1] Mirosław Drzazga,[2] and Aldona Gietz Lorenc[3]

[1] *Department of Medical Physics, Institute of Physics, University of Silesia, Katowice, Poland*

[2] *Institute of Computer Science, University of Silesia, Sosnowiec, Poland*

[3] *Helimed Diagnostic Imaging SP. z o.o., Laboratory of Magnetic Resonance Imaging, Katowice, Poland*

Mapping brain activity by means non-invasive method functional magnetic resonance imaging (fMRI) is possible due to changes in hemoglobin forms in blood vessels. This method gives a possibility to characterize relevant functional areas adjacent to the tumor what has important implications for surgical intervention. In this work we focus on optimization of the parameters (Gaussian kernel, significance level and cluster-level extent threshold) used in SPM analysis for the activity of Broca and Wernicke areas responsible for production and understanding the speech which are very important from the point of view patients quality life. Controlling the familywise error rate (FWE) is also discussed for the studied patients.

P-8-20

Ferroelectric Organic Layers on Graphene for Photovoltaics

Małgorzata Wawrzyniak-Adamczewska,[1] Paweł Masiak,[2] Juan José Meléndez,[3] and Małgorzata Wierzbowska[4]

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

[2] *Institut of Physics, Polish Academy of Sciences, Warszawa, Poland*

[3] *Department of Physics and Institute for Advanced Scientific Computing of Extremadura, University of Extremadura, Badajoz, Spain*

[4] *Institute of High Pressure Physics, Polish Academy of Sciences, Sokołowska 29/37, 01-142 Warsaw, Poland*

The electronic and optical properties of the aromatic molecules terminated with the dipole groups are studied within the DFT approach. The systems are simultaneously of donor and acceptor type. The path-separation for the electrons and holes is observed and the carrier mobilities are very high, as for the organic crystals. The band gap and the absorption spectrum can be tuned by changing a number of the aromatic rings. The physisorption process on the grephene causes the molecular distortions, and this leads to articulated change of the optical spectra.

This work has been supported by The National Science Centre of Poland by the Project DEC-2012/07/B/ST3/03412. Calculations have been performed in the PL-Grid Infrastructure

P-8-21

Adaptive modulation amplitude in 2D spectral-spatial EPR imaging

T. Czechowski,[1,2] M. Baranowski,[1,3,2] A. Boś-Liedke,[1,4] and K. Tadyszak[1,5]
[1]*NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland*
[2]*noviLET, Poznań, Poland*
[3]*Department of Physics, Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[4]*Department of Medical Physics, Faculty of Physics, Adam Mickiewicz University, Poznań, Poland*
[5]*Institute of Molecular Physics Polish Academy of Sciences, Poznań, Poland*

A study concerning the image quality in Electron Paramagnetic Resonance Imaging (EPRI) in 2D spectral-spatial (2D SSI) experiments is presented. The aim of the measurements is to improve the signal to noise ratio (SNR) of the projections by applying a more consciously selected modulation amplitude parameter. The study demonstrates the advantages of the adaptive method, which involves selecting different and dependent on cosine function modulation amplitudes for each projection.

Financial support from the National Science Centre (UMO-2014/15/B/ST4/04946), National Cohesion Strategy from Innovative Economy (POIG.01.03.01-30-150/09) and Smart Growth (POIR.01.01.01-00-0025/15) is gratefully acknowledged.

P-8-22

Investigation of the Antiferromagnetic Coupling between Chromium(III) Ions Mediated by -O-Nb^{V}-O- Bridges

F. Torić,[1] D. Pajić,[1] M. Jurić,[2] L. Androš Dubraja,[2] A. Zorko,[3] A. Ozarowski,[4] V. Despoja,[1] W. Lafargue-Dit-Hauret,[5] and X. Rocquefelte[5]
[1]*Department of Physics, Faculty of Science, University of Zagreb, 10000 Zagreb, Croatia*
[2]*Ruđer Bošković Institute, 10000 Zagreb, Croatia*
[3]*Jožef Stefan Institute, 1000 Ljubljana, Slovenia*
[4]*National High Magnetic Field Laboratory, Florida State University, Tallahassee, Florida 32310, USA*
[5]*Institut des Sciences Chimiques de Rennes, UMR 6226 CNRS, Université de Rennes 1, Rennes, France*

Magnetic behavior of novel heterotetranuclear compound $[Cr_2(bpy)_4(\mu\text{-}O)_4Nb_2(C_2O_4)_4]\cdot 3H_2O$ (1; bpy = 2,2'-bipyridine) was investigated by magnetization measurements, EPR (X-, Q-band and and high-field) spectroscopy and DFT calculations. Results of $M(T)$ measurements show antiferromagnetic interaction of Cr^{III} ions through two diamagnetic bridges -O-Nb^{V}-O- with parameter of interaction $J = -12.77cm^{-1}$ and ZFS parameter $D = -0.17cm^{-1}$. The EPR spectra simulations and DFT calculations reveal the presence of a single-ion anisotropy that is close to being uniaxial, $D = -0.31cm^{-1}$ and $E = 0.024cm^{-1}$.

P-8-23

Magnetic properties of the R_2MgCo_9 (R = Y, Nd, Tb) compounds and $Nd_2MgCo_9H_{11.4}$ hydride

V. Shtender,[1] V. Paul-Boncour,[2] R. Denys,[1] and I. Zavaliy[1]

[1] *Karpenko Physico-Mechanical Institute, NASU, Lviv, Ukraine*

[2] *Université Paris-Est, ICMPE, CNRS, UPEC, Thiais, France*

New R_2MgCo_9 (R = Y, Nd, Tb) compounds have been synthesized by powder sintering method and corresponding hydrides have been prepared by solid gas method. Their crystal structure and magnetic properties have been systematically studied. X-ray diffraction analysis showed that all R_2MgCo_9 compounds belong to the $PuNi_3$-type structure. The $Nd_2MgCo_9H_{11.4}$ hydride preserves $PuNi_3$-type structure with hydrogen-induced volume expansion 16.7 %. The influence of the R element on the magnetic properties of R_2MgCo_9 compounds have shown that R_2MgCo_9 (R = Y, Nd) compounds are ferromagnetic (ferrimagnetic for Tb) with high Curie temperature T_C = 612, 635 and 525 K respectively. A spin reorientation at 407 and 225 K have been observed for R_2MgCo_9 (R = Y, Nd) respectively. Hydrogenation of Nd_2MgCo_9 causes the decrease of the transition temperatures due to a weakening of the magnetic interactions and probably a change of magnetic order (to antiferromagnetic with T_N = 265 K) and various spin reorientations at lower temperatures [1].

References:

[1] V.V. Shtender, R.V. Denys, V. Paul-Boncour *et al.*, J. Alloy. Compd. 695 (2017) 1426–1435.

INDEX OF AUTHORS

SCIENTIFIC EXHIBITORS

scia Systems is a full range supplier of advanced ion beam and plasma processing equipment. The systems are applicable for coating and etching processes in the production of microelectronics, MEMS and precision optical components, in both, high volume production as well as research and development environments.

Due to their flexible and modular design, the systems can be configured according to customer specific requirements. Amongst others by combining several vacuum process chambers into cluster or in-line solutions. Together with our worldwide service partners, we offer comprehensive service and superior technology support.

scia Mill 150
for ion beam etching (IBE)

Technology Portfolio

- Ion Beam Trimming (IBT)
- Ion Beam Etching and Milling (IBE/IBM)
- Dual Ion Beam Deposition (DIBD)
- Plasma Enhanced Chemical Vapor Deposition (PECVD)
- Reactive Ion Etching (RIE)
- Magnetron Sputtering
- Plasma Cleaning

scia Coat 200
for dual ion beam deposition (DIBD)

Contact information

scia Systems GmbH
Annaberger Str. 240
09125 Chemnitz | Germany
info@scia-systems.com | www.scia-systems.com

Sales Partner in Poland

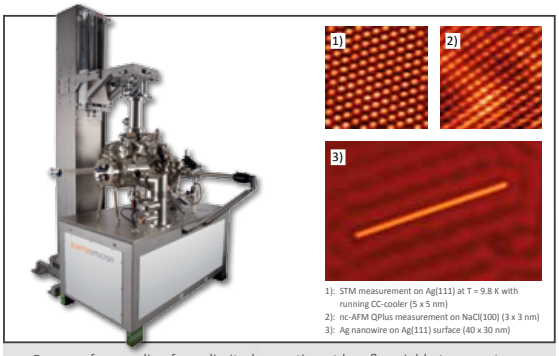
APVACUUM Sp. z o.o.
ul. Klonowa 24
62-002 Suchy Las k. Poznania | Poland
biuro@apvacuum.com | www.apvacuum.com

scientaomicron

Three new SPM Systems

Fermi DryCool™ SPM

Infinite Measurement Time & Convenient Cooling below T = 10K

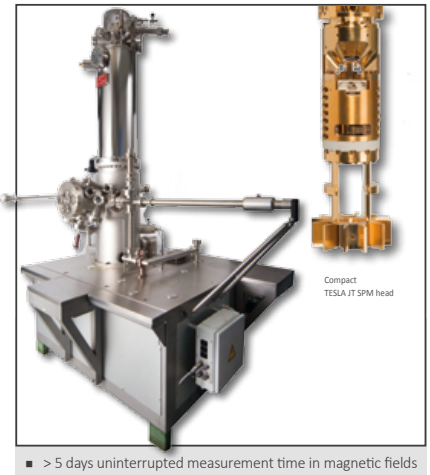


1): STM measurement on Ag(111) at T = 9.8 K with running CC-cooler (5 x 5 nm)
2): nc-AFM QPlus measurement on NaCl(100) (3 x 3 nm)
3): Ag nanowire on Ag(111) surface (40 x 30 nm)

- Cryogen-free cooling for unlimited operation at low & variable temperatures
- Independent tip & sample temperature control from LT to above RT
- Ultra-low noise level below 1 pm with active cooling
- Superior drift performance
- Scienta Omicron's leading QPlus AFM technology

Tesla JT SPM

STM & QPlus AFM in High Magnetic Fields at T < 1.4 K

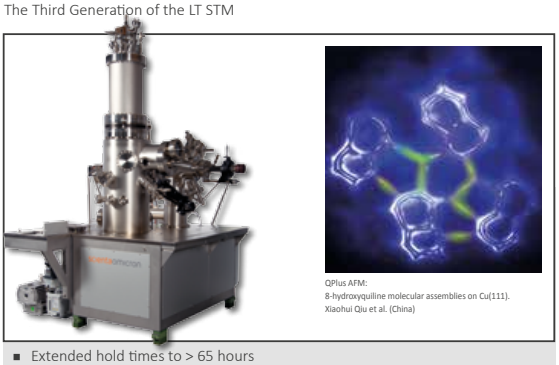


Compact
TESLA JT SPM head

- > 5 days uninterrupted measurement time in magnetic fields
- Base temperature T < 1.4 K with 4He
- Dry UHV magnet Bz > 3 T
- Optical access & ease of use
- STM and advanced spectroscopy and leading QPlus AFM

LT STM III

The Third Generation of the LT STM



QPlus AFM:
8-hydroxyquiline molecular assemblies on Cu(111).
Xiaohui Qiu et al. (China)

- Extended hold times to > 65 hours
- STS with ΔE < 1 meV
- New cabling for GHz signals for improved time resolution
- Scienta Omicron's leading QPlus AFM technology

www.ScientaOmicron.com

Our instruments for your research

LOT QuantumDesign

Benefit from our expertise

- **Cryogenics**
  Helium liquefiers, cryostats and cryogenic control systems
- **Electron microscopy**
  Desktop SEM, in-situ stages for EM/TEM/CT, sample preparation, detectors and accessories
- **Imaging**
  Imaging systems and scientific cameras from X-ray to IR
- **Light & lasers**
  Scientific light sources and light power measurement devices
- **Life sciences**
  Systems and components to study magnetic, mechanical, optical and thermal biophysical phenomena
- **Materials science**
  Systems to characterize magnetic, mechanical, optical and thermal material properties
- **Optics**
  Broadest range of optical filters and components
- **Spectroscopy**
  Spectrometers, modular optical spectroscopy and components

Visit us at: www.lot-qd.com

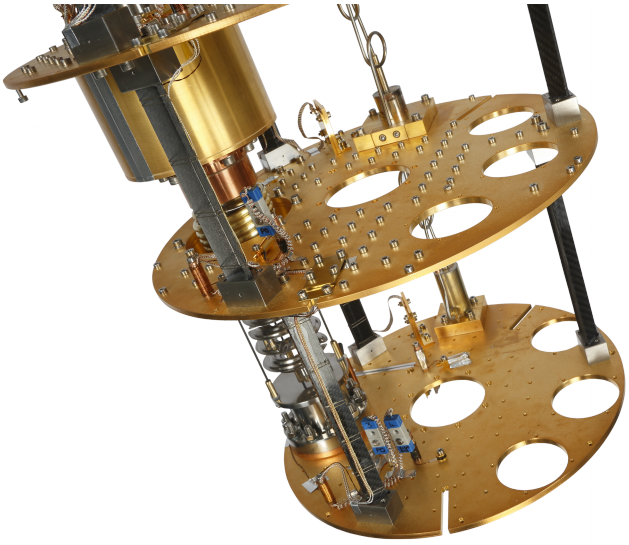
LOT-QuantumDesign Polska
ul. Gliwicka 147, 43-190 Mikołów
Tel.: +48 73 050 71 94
E-mail: pdluzewski@lot-qd.com

lub
ul. Sztygarska 12/3 41-500 Chorzow
Tel.: 32 248 20 48,
Kom.: 515 166 893, E-mail: kowalczyk@lot-qd.pl

LABIS to nowoczesna firma z siedzibą w Warszawie, która prowadzi działalność handlową i produkcyjną skoncentrowaną wokół innowacyjnych dziedzin technicznych, w szczególności nanotechnologia, optoelektronika i kriogenika. Dostarczamy narzędzia i systemy aparatury badawczej dla uczelni wyższych i instytutów naukowych, głównie dla jednostek fizyki i chemii eksperymentalnej.

Jesteśmy oficjalnym partnerem firmy **Oxford Instruments Nanoscience, UK**, która jest wiodącym na świecie producentem narzędzi naukowych do charakteryzacji i odkrywania nowych materiałów w fizyce kwantowej. Umożliwiamy badania w skali atomowej oferując platformę do pracy w ultra niskich temperaturach, silnym polu magnetycznym połączoną z zaawansowaną aparaturą pomiarową. Nasza kriogeniczna aparatura laboratoryjna jest obecna we wszystkich ośrodkach naukowych w Polsce i obejmuje następujące kategorie:

- Optyczne kriostaty azotowe — 5 dostarczonych systemów.
- Optyczne kriostaty helowe — 7 dostarczonych systemów.
- Kriostaty i magnesy suche — 6 dostarczonych systemów.
- Chłodziarki rozcieńczalnikowe — 2 systemy suche i jeden mokry.
- Chłodziarki 3He — 1 dostarczony system.
- Magnesy nadprzewodzące — 11 dostarczonych systemów.
- Części kriogeniczne i elektronika — Kilkadziesiąt systemów.



LABIS
Zwycięzców 40/122
03-938 Warszawa
tel. +48 22 205 09 24
e-mail labis@labis.pl
www.labis.pl

LABIS Nanotechnology Tools and Systems

OXFORD INSTRUMENTS The Business of Science®

NOTES

NOTES

NOTES

NOTES

NOTES

VENUE

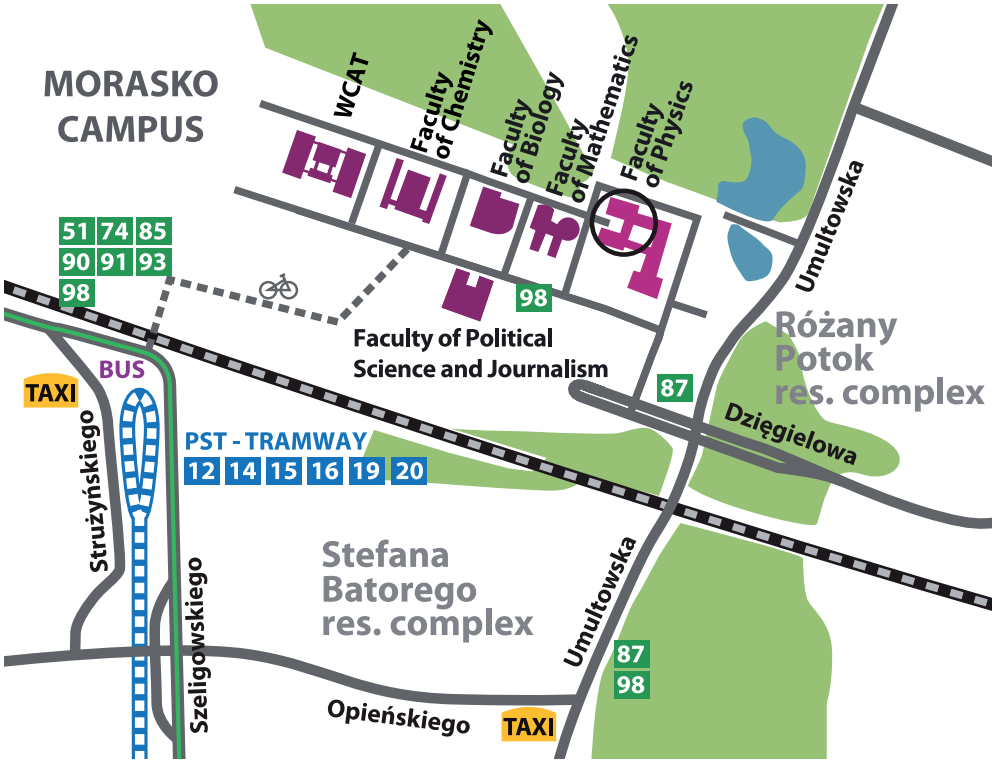
The European Conference

PHYSICS OF MAGNETISM 2017

June 26 - 30, 2017, Poznań, Poland

Adam Mickiewicz University, Poznań
Faculty of Physics
Umultowska 85
61-614 Poznań

GPS coordinates
52º28'03'' N
16º55'45'' E

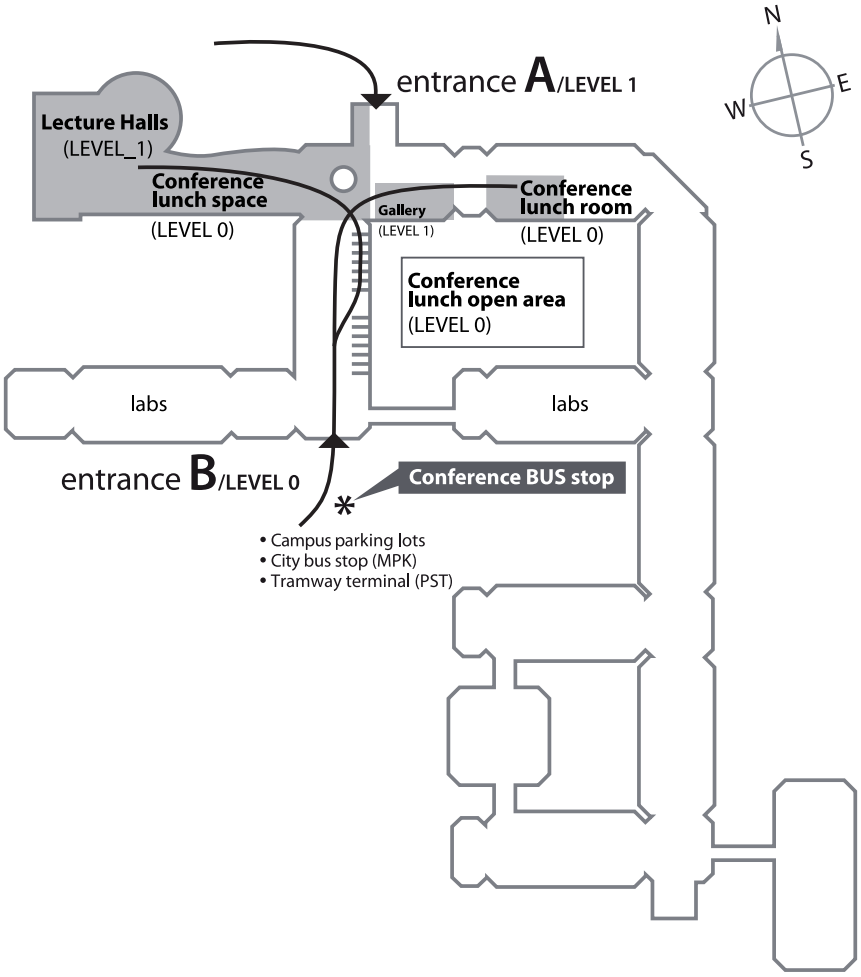


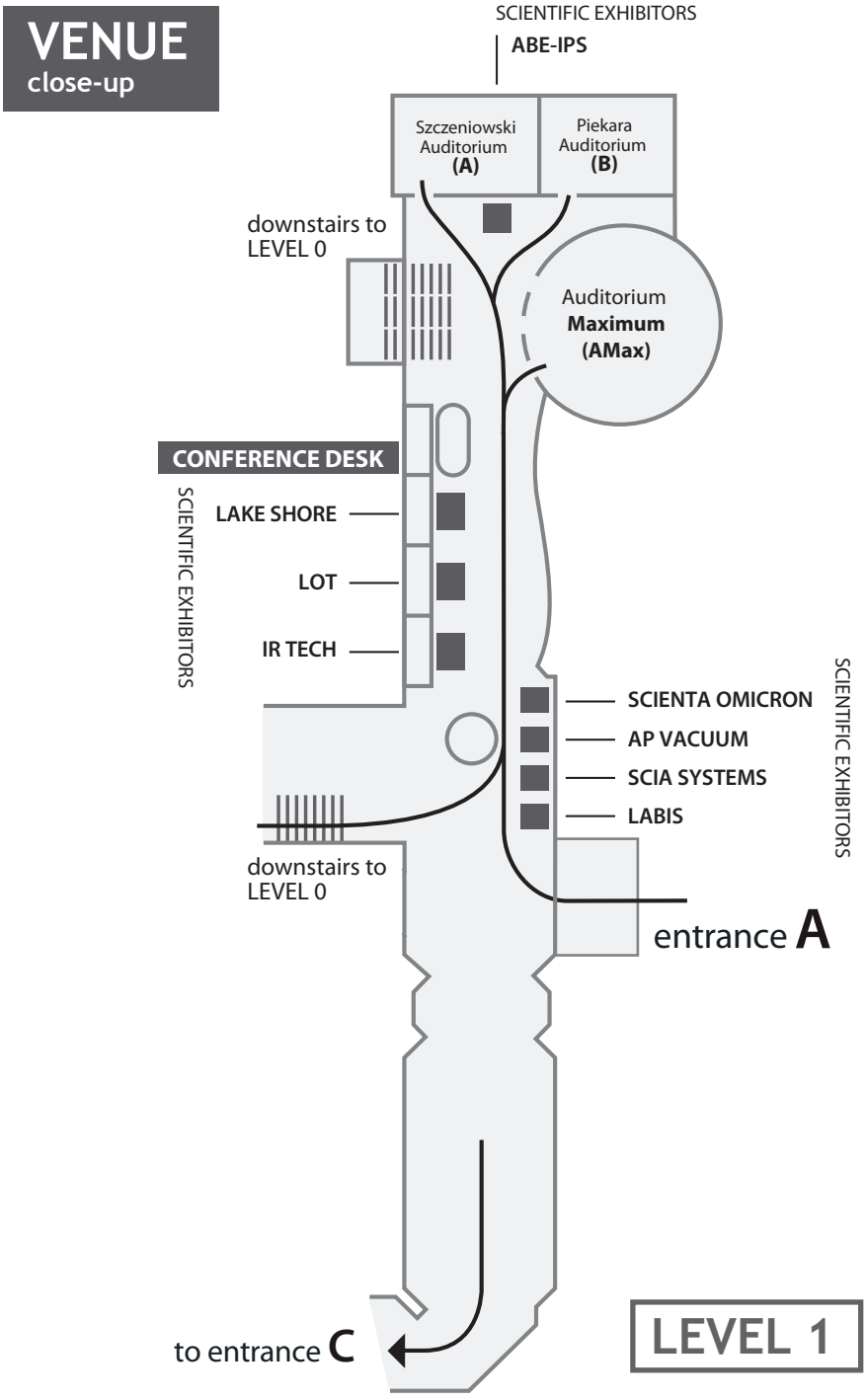
VENUE

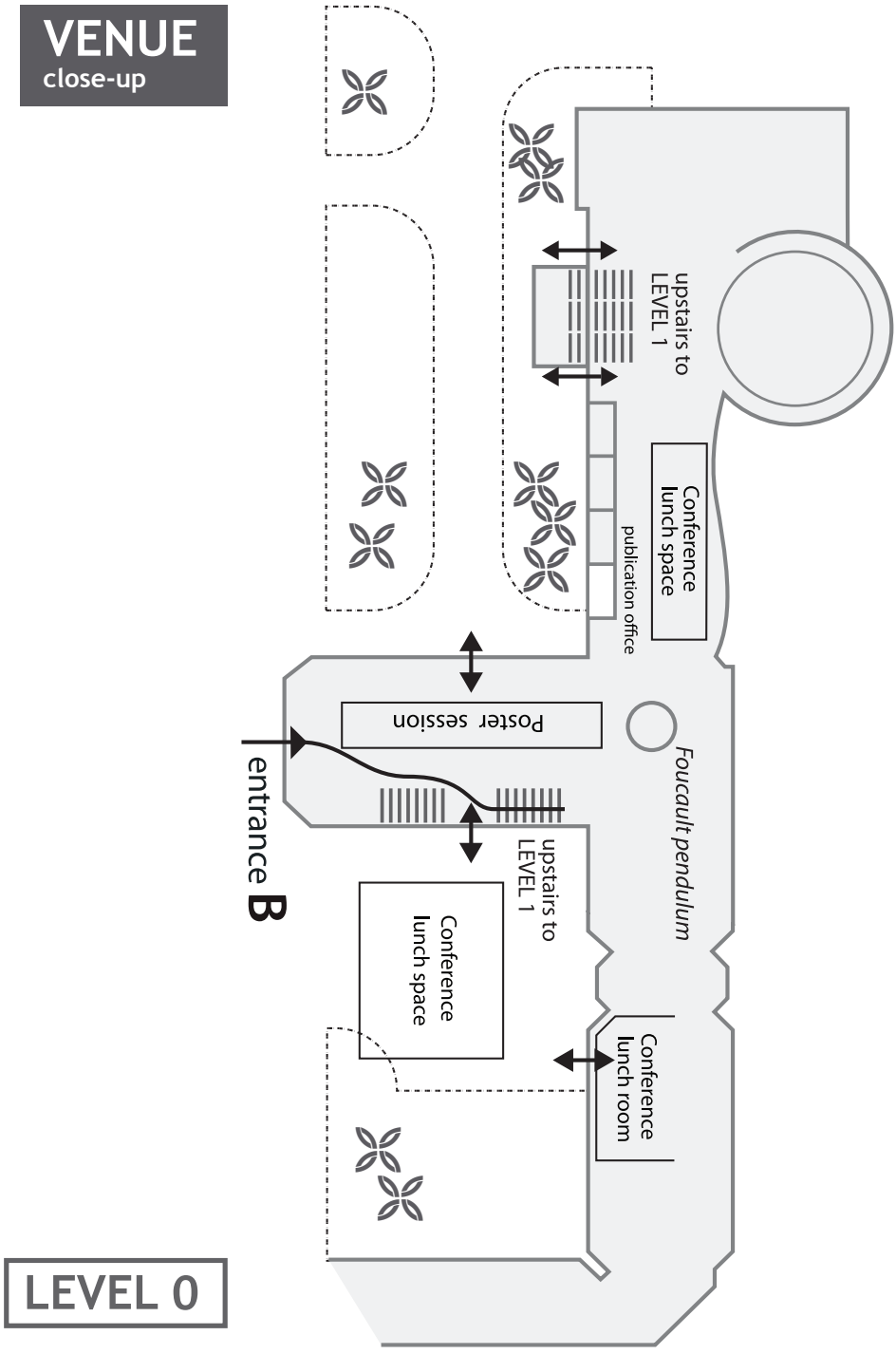
The European Conference

PHYSICS OF MAGNETISM 2017

June 26 - 30, 2017, Poznań, Poland




VENUE
close-up
SCIENTIFIC EXHIBITORS
ABE-IPS
Szczeniowski Auditorium (A)
Piekara Auditorium (B)
downstairs to LEVEL 0
Auditorium Maximum (AMax)
CONFERENCE DESK
SCIENTIFIC EXHIBITORS
LAKE SHORE
LOT
IR TECH
SCIENTIFIC EXHIBITORS
SCIENTA OMICRON
AP VACUUM
SCIA SYSTEMS
LABIS
downstairs to LEVEL 0
entrance A
to entrance C
LEVEL 1


VENUE
close-up
upstairs to LEVEL 1
Conference lunch space
publication office
Poster session
Foucault pendulum
entrance B
upstairs to LEVEL 1
Conference lunch space
Conference lunch room
LEVEL 0

Wireless Connection

How to connect to wireless network?

- wireless network name: **pm17**
- password **Physmag2017**

or

- wireless network name: **NetworkForGuests**
- password **is not** required

or

- **EduRoam access**

www.ifmpan.poznan.pl/pm17

PM'17 book of abstracts

The European Conference PHYSICS OF MAGNETISM 2017 (PM'17)

	Monday, June 26	Tuesday, June 27	Wednesday, June 28	Thursday, June 29	Friday, June 30	
$8^{30} - 9^{00}$	***REGISTRATION*** ***$8^{30} - 10^{45}$***	**I. Affleck**	**A. Bansil**	**G. Lonzarich**	**B. Hjörvarsson**	$8^{30} - 9^{00}$
$9^{00} - 9^{30}$		**M. Lewenstein**	**T. Fischer**	**F. Steglich**	**H. Szymczak**	$9^{00} - 9^{30}$
$9^{30} - 10^{00}$		**P. Prelovšek**	**R. Frésard**	**P. Wiśniewski**	**R. Skomski**	$9^{30} - 10^{00}$
$10^{00} - 10^{30}$		*coffee break*	*conference photo*	*coffee break*	*coffee break*	$10^{00} - 10^{30}$
$10^{30} - 11^{00}$	***OPENING***	***POSTER SESSION I*** ***$10^{45} - 12^{45}$*** *categories: 3, 8*	*coffee break*	***POSTER SESSION III*** ***$10^{45} - 12^{45}$*** *categories: 1, 4, 6*	**G. Tatara**	$10^{30} - 11^{00}$
$11^{00} - 11^{30}$	**S.S.P. Parkin**		***POSTER SESSION II*** ***$11^{00} - 13^{00}$*** *categories: 2, 5, 7*		**M. Krawczyk**	$11^{00} - 11^{30}$
$11^{30} - 12^{00}$					**P. Bortolotti**	$11^{30} - 12^{00}$
$12^{00} - 12^{30}$	**T. Dietl**				**F. Mila**	$12^{00} - 12^{30}$
$12^{30} - 13^{00}$	**W.E. Pickett**	*lunch*	*lunch*	*lunch*	***AWARDS, SUMMARY CLOSING***	$12^{30} - 13^{00}$
$13^{00} - 13^{30}$	*lunch*	**J.M. Tranquada**				$13^{00} - 13^{30}$
$13^{30} - 14^{00}$		**J.E. Hirsch**				$13^{30} - 14^{00}$
$14^{00} - 14^{30}$	O-1-03 | **R. Oszwałdowski** | O-3-08	**J. Spałek**	O-3-01 | **V. Zabłotskii** | O-1-08	**J. Rusz** | O-2-06 | O-5-01	*lunch*	$14^{00} - 14^{30}$
$14^{30} - 15^{00}$	O-1-11 | O-3-07		O-1-04 | O-1-14	O-7-01 | O-4-15 | O-5-13		$14^{30} - 15^{00}$
$15^{00} - 15^{30}$	O-1-20 | O-4-09 | O-3-12	*coffee break*	O-1-06 | O-5-03 | O-1-19	O-6-01 | O-3-05 | O-5-15		$15^{00} - 15^{30}$
$15^{30} - 16^{00}$	O-2-01 | O-5-02 | O-4-04	**K. Bedell** | O-3-03 | O-1-01	O-1-13 | O-2-03 | O-3-13	O-6-04 | O-4-08		$15^{30} - 16^{00}$
$16^{00} - 16^{30}$	O-2-04 | O-5-04 | O-4-10	O-3-11 | O-1-02	O-1-09 | O-4-02 | O-6-05	*$15^{30} - 15^{45}$ transportation to Ostrów Tumski*		$16^{00} - 16^{30}$
$16^{30} - 17^{00}$	*coffee break*	O-4-13 | O-3-06 | O-1-05	O-5-09 | O-5-12 | O-5-18			$16^{30} - 17^{00}$
$17^{00} - 17^{30}$	**A. Bianconi**	O-4-06 | O-3-09 | O-1-15	O-4-01 | O-5-10 | O-6-03	*Sightseeing of Ostrów Tumski*		$17^{00} - 17^{30}$
$17^{30} - 18^{00}$	**B. Dąbrowski**	O-4-07 | O-3-10 | O-4-05	*coffee break*			$17^{30} - 18^{00}$
$18^{00} - 18^{30}$	**M. Urbaniak**	*coffee break*	**ERC presentation O. Limaj & Session of Scientific Exhibitors**	*$18^{00} - \ldots$ concert in Archcathedral Basilica*		$18^{00} - 18^{30}$
$18^{30} - 19^{00}$	*coffee break*	**B. Tsukerblat** | O-4-14 | O-8-01	*$18^{00} - 18^{15}$ transportation to the concert hall*			$18^{30} - 19^{00}$
$19^{00} - 19^{30}$	**S. Eisebitt** | O-1-10 | O-2-05	O-1-17 | O-8-02		*$19^{00} - \ldots$ banquet*		$19^{00} - 19^{30}$
$19^{30} - \ldots$	O-1-12 | O-1-07	O-4-11 | O-5-14 | O-6-02	*$19^{00} - \ldots$ concert*			$19^{30} - \ldots$
	O-5-16 | O-1-16 | O-1-18	O-5-07 | O-5-11 | O-3-02				
	O-5-17 | O-2-02 | O-4-12	O-5-08 | O-5-19 | O-3-04				
	O-5-06 | O-2-07					
	19^{30} - … welcome party					

ISBN 978-83-933663-4-7