International Conference on

Magnetism and Magnetic Materials

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e-Posters

Magnetic Materials 2017

Low-temperature anomalies in thermal properties of YbB_{50} boride

Nikolay A Zhemoedov
Bryansk State University, Russia

Heat capacity and thermal expansion of YbB_{50} boride have been studied at 2-300 K. The sharp anomaly at about 5 K and smooth humps of the studied properties of boride at elevated temperatures was detected. The excess heat capacity and abnormal contribution to the thermal expansion of YbB_{50} have been determined by comparison with a paramagnetic LuB_{50} compound. Low-temperature anomalies of YbB_{50} thermal characteristics have been attributed to the magnetic phase transition to the antiferromagnetic state. The anomalies at 50-150 K temperature region were satisfactory described as results of the ground level splitting by the crystal an electric field (CEF). The scheme of CEF splitting was proposed.

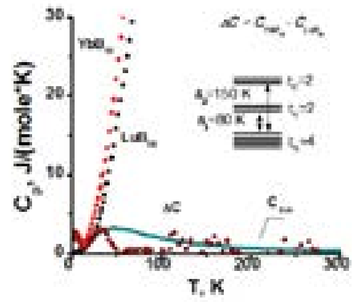


Figure 1: Heat capacity of YbB50 and LuB50. The excess heat capacity ΔC(T) and Schottky contribution CSch(T) to the ytterbium boride heat capacity. Insert: CEF-splitting scheme of the ground f-level Yb3+ ion.

Biography

Nikolay A Zhemoedov has completed from Bryansk State University at the age of 22 years. Now he is is a Post-graduate student at Bryansk State University. The field of his scientific interest is low-temperature physics of crystals, which are perspective in modern areas of technology. His research is supported by a grant from the Russian Science Foundation (Project "Development of new thermoelectric materials based on clathrates and clathrate-like substances", No. 16-12-00004, 2016-2018). He took part in some International conferences on the physics and chemistry of borides. He has four publications in reputed journals that have been cited 7 times and two presentations on international conferences. His h-index is two.

zhemoedov.nikolay@gmail.com

Notes:

Synthesis, structural and electrical characterization of soft Ni-Cr nanoferrites

Asghari Maqsood
Air University, Pakistan

Ferrites which are ferrimagnetic ceramic materials have different metal oxides converged with iron (Fe^{3+}) to form their core segment. Ferrites are of two kinds, soft and hard. Soft materials are used for electromagnets because they are simply magnetized and demagnetized. On the other hand, hard materials are hard to magnetize and demagnetize, so they are used for permanent magnets. The core properties of ferrites depend on composition, synthesis techniques, temperature, cation distribution and the particle size. Although iron and metallic alloys are scientifically useful as magnetic materials, these materials are impractical because of low resistivity at high frequency. Because of high electrical resistivity of these ferrites, these are superior at high frequencies. In this talk, the fabrication of Cr doped $Ni_{0.5}$-$Zn_{0.5}Cr_xFe_{2-x}O_4$ ($0.1 \leq x \leq 0.4$) is reported. The material was characterized by x-ray diffraction technique to get the information related to structure, average crystallite size, x-ray density, porosity, the specific surface area and surface to volume ratio as shown in the Fig. The variation of electrical parameters like DC electrical resistivity and mobility as a function of temperature was investigated in the range of 435 to 770 K. The activation energies of all the samples were calculated from the DC electrical resistivity data. The dielectric parameters such as dielectric constant (**ε**), dielectric loss (tanα) and AC conductivity (α_{ac}) are measured in the temperature range of 300 to 770 K. It was observed that the dielectric constant was found to increase with the Cr^{3+} concentration, while tanα and αac decreased. The results are explained on the basis of increase in interfacial and dipolar polarization in the samples. Transition temperatures obtained from dielectric constant are in agreement with Curie temperatures, obtained from resistivity plots.

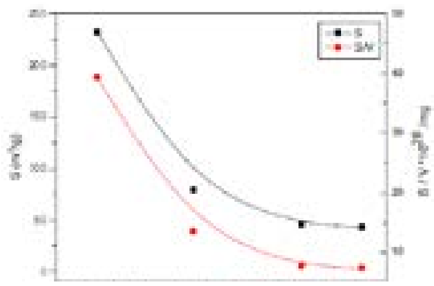


Figure 1: Variation of the specific surface area to volume ratio of Ni-Cr nanoferrites

Biography

Asghari Maqsood has her expertise in the fabrication and characterization of new materials. She prepared single crystals of rare-earth disilicates with the formula $R_2 Si_2O_7$ (R=Tm, Er, Ho, Dy). These materials were characterized through X-diffraction, magnetic, electrical and dielectric measurements. The results appeared in the ISI indexed journals, indicating the structural and importance of these materials from the application and academic interest. She also has the experience of dealing with high-temperature superconductors, thin-films of groups II-VI semiconductors and their application in solar cell technology. She developed a research laboratory namely Thermal Physics at Quaid-i-Azam University for post graduates, leading to MPhil and PhD degrees. The research group got involved in the synthesis of nanoferrites and their characterization almost a decade ago. The researchers have completed their research projects related to soft and hard nanoferrites for their PhD's under her supervision. The materials showed their applications in electronics, utility at high frequency, mechanical stiffness, etc. The systems $CoFe_2O_4$, Cu/Cd doped Mg-Zn; Cd doped Ni- ferrites are studied at length and the results are reported in publications.

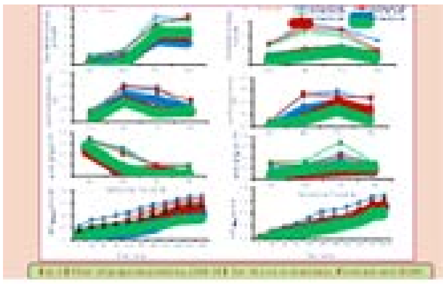
tpl.qau@usa.net

Notes:

Application of static magnetic field for alleviation of adverse effects of salt stress on germination and early growth characteristics in maize and soybean

Sunita Kataria[2] and **K N Guruprasad**[1]
[1]Shri Vaishnav Vidyapeeth Vishwavidyalaya, India
[2]DAVV, Indore, India

Maize and Soybean seeds were pre-treated with static magnetic field (SMF) of 200 mT for 1 h to evaluate the effect of static magnetic field for alleviation of adverse effects of salt stress on germination and early growth characteristics. The adverse effect of NaCl induced salt stress was found on percentage germination and germination related parameters. Enhanced percentage germination and early seedling growth parameters (root and shoot length, and vigour indices) under different salinity levels (0 to 100 mM NaCl) indicated that magneto priming was more effective in alleviating salinity stress at early seedling stage of both maize and soybean as compared to untreated seeds. α- amylase and protease activities were also higher in SMF treated seeds under both non-saline and saline conditions. This could have resulted in faster hydration of enzymes in SMF treated seeds leading to higher rate of germination. Increased levels of superoxide radical and hydrogen peroxide was found in germinating magnetoprimed seeds of maize and soybean, under both the growing conditions. Enhancement in seed germination and seedling vigour under both the growing conditions by SMF treatment may be due to the combined effect of enhanced α- amylase and protease activities and enhanced levels of free radicals in the seeds. Consequently, SMF pre-treatment effectively mitigated adverse effects of NaCl on both maize and soybean.



Biography

Sunita Kataria has completed her Ph.D. in 1999 from School of Life Sciences, Devi Ahilya University and Postdoctoral studies from School of Life Sciences, Devi Ahilya University. She has 15 years of research experience and worked as CSIR Research associate, CSIR Pool Scientists and DST-Women Scientists in School of Life Sciences, DAVV, Indore. She has published more than 40 papers in reputed journals and 03 book chapters.

sunita_kataria@yahoomail.com

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Accepted Abstracts

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New frontiers of magnetic materials for regenerative medicine

Ugo D'Amora, Teresa Russo, Antonio Gloria, Roberto De Santis and **Luigi Ambrosio**
Institute of Polymers, Composites and Biomaterials, Italy

Over the past years, the fundamentals of magnetism and magnetic materials have been widely employed in medicine (such as, in drug and gene delivery and hyperthermia treatment of tumors). The possibility to apply these principles to tissue engineering has opened an interesting wide research area of interest. Tissue engineering aims to develop multi-disciplinary approaches for the repair/regeneration of damaged tissues. The main goal is to reconstruct tissues using three-dimensional biodegradable and biomimetic "scaffolds" as a template for cell growth and extracellular matrix deposition. In the design of scaffolds with magnetic properties, the main driving idea was to obtain structures able to be manipulated through magnetic force gradients attracting bio-aggregates, linked to magnetic carriers (i.e. vascular endothelial growth factors) and stimulating angiogenesis and bone regeneration. Furthermore, they can also be used as hyperthermia agents for delivering thermal energy to targeted bodies. Great attention has been focused on the manufacturing process, the material and scaffold features including morphological, chemical-physical, mechanical and mass transport performances through a suitable topological optimization. In particular, fully biodegradable and magnetic nanocomposite scaffolds were produced through additive manufacturing. The properties of the scaffolds were assessed through experimental/theoretical *in vitro* investigations and *in vivo* tests. Morphological studies were performed with Micro-Tomography and Scanning Electron Microscopy. Micro-, Macro- and Nano-mechanical analyses were also carried out. A magnetic analysis was performed in order to assess the behavior of these materials, highlighting their ability to be magnetized at 37°C with an external magnetic field. Human mesenchymal stem cell adhesion and viability were assessed by means of Confocal Laser Scanning microscopy and Alamar Blue assay, whilst cell differentiation was evaluated by the measurement of ALP activity. Furthermore, the influence of a time-dependent magnetic field on cell-laden constructs was also studied. In conclusion, this work suggested these materials as suitable candidates for bone regeneration.

ugo.damora@unina.it

3D Euler deconvolution of aeromagnetic data and pseudogravity transforms for mapping of structures and mineralized zones in Osi NE, Southwestern Nigeria

Olawuyi Ayodele Kehinde
University of Ilorin, Nigeria

3D Euler deconvolution of aeromagnetic data and pseudo-gravity transforms over Osi NE, Southwestern Nigeria was carried out. It was aimed at identification of the structures and the prospective mineralized zones in the area. This work involved the qualitative and quantitative analysis of aeromagnetic data, pseudo-gravity transforms and geological information using Oasis Montaj™ and Rockwork15™ software. The 3-D Euler Deconvolution of the acquired potential field data and the information obtained from geological maps was employed in the interpretation work. The identified faults and lineament features generally coincide with the river channels which indicate a structural control of the drainage system in the study area. The rose diagram of the extracted faults and lineament features showed a predominance of NE-SW and NW-SE trends typical of the post-Pan African lineaments while the other identified structures and prospective mineralized zones explain the reasons for artesian mining in the study area.

gideonola2001@yahoo.com

Magnetism of impurities in 3D topological semimetal α-Cd_3As_2

Yu V Goryunov[1] and **A N Nateprov**[2]
[1]E K Zavoisky Kazan Physical-Technical Institute of the RAS, Russia
[2]Institute of Applied Physics, Academy of Science of Moldova, Republic of Moldova

The electron spin resonance (ESR) for Eu^{2+}, magnetic and conductive properties of the 3D Dirac topological semimetal α-Cd_3As_2 doped with a small amount of europium impurity was first studied. At present, it has been established that α-Cd_3As_2 is a topological semimetal, a 3D analog of graphene. The conduction band and the valence band of the α-Cd_3As_2 have linear dispersion law and touch each other in the 3D Brillouin zone in Dirac nodes. In the presence of time reversibility and inversion symmetry, the Dirac nodes are twice degenerate. The break of any symmetry leads to the splitting of the Dirac node into two Weyl nodes, separated either by the energy interval (see the right insert in the figure) or separated in momentum space. Thus, the presence of a magnetic field or magnetic impurities in the Dirac semimetal (DSM) transforms it into a Weyl semimetal (WSM) and leads to a number of unusual phenomena. Here we assume that we have discovered an unusual type of diamagnetically ordering of magnetic impurity. Data on the magnetic susceptibility (see figure) and ESR showed the presence of an Eu^{2+} ions additional phase magnetized oppositely to the external field and ordered at T_{AFM} ~ 124 K. Measurements of ESR, carried out at high temperatures, allow us to conclude that this phase (g- factor is near 4.4) consists of the Eu^{2+} ions located in interstices positions - tetrahedral vacancies in fluorite type cell (see left insert in figure). Whereas the main phase (g ~ 2.2) consists of the Eu^{2+} ions in the positions substitution of the Cd^{2+} ions. These positions differ in the degree of chemical compression of the Eu^{2+} ions. Due to the proximity of the size of the Cd^{2+} ion to the size of the nonmagnetic Eu^{3+} ion, this leads to the fact that the magnetic moment of ions in the interstitial positions effectively decreases. About 10% of all Eu^{2+} ions places in this position. When doping in an amount of about 0.1 at. %Eu, the electron concentration increases from ne = 6•10^{17} $см^{-3}$ for α-Cd_3As_2 to ne = 2,2•10^{19} $см^{-3}$ for the doped sample and is temperature independent. The last value is more the Eu impurity content and this requires accurate consideration of question about distribution of the Eu between valence and conduction zones. The ESR data show anomalous large values of the g - factor of the Eu^{2+} ions, which in its turn indicates very large values of the g factor of the conduction electrons (g ~ 16-18). This indicates very interest interplay between Eu^{2+}, Eu^{3+} ions and their "free" electrons. We believe that selectively ordering of the Eu^{2+} ions located in tetrahedral vacancies oppositely to the external field is the result of the splitting of twice degenerate Dirac nodes on two Weyl nodes with different energies, on a similarity to splitting of electronic states with different spin directions.

gorjunov@kfti.knc.ru

Synthesis and properties of aluminum doped ZnO nanostructures for device applications

Sirikanjana Thongmee
Kasetsart University, Thailand

Al-doped ZnO nanorods (NR's) having Al concentration up to 10 mol% were grown by the hydrothermal method. XRD measurements showed that the Al substituted ZnO NR's maintained the hexagonal wurtzite structure for all levels of Al substitution. EDX measurements of the ZnO: Al NR's indicated that the Al substitution created additional Zn vacancies in the wurtzite structure which are reflected in the enhanced photoluminescence emission in the visible light spectra between 450 to 550 nm of the more heavily doped ZnO: Al NR's. SEM images of the heavier doped ZnO: Al nanorods showed nano nodules being formed on the surface of the hexagonal shaped NR's. The saturation magnetization of the ZnO: Al NR's as measured by a SQUID magnetometer increased to 10.66 × 10-4 emu/g as more Al was substituted in. The hysteresis loops for the ZnO: Al NR's began to exhibit novel effects, such as horizontal shift (exchange bias field 0.0382 kOe for the 9 mol % NR) and butterfly shapes.

fscisjn@ku.ac.th

Influence of carbon impurity on the magnetic properties of the EuB_6

T S Altshuler, Yu V Goryunov, A N Levchenko[1] and **V B Filippov**[1]
Kazan E K Zavoisky Physical-Technical Institute, Russia
[1]Institute of Applied Physics, Academy of Science of Moldova, Republic of Moldova

EuB_6 is a well-known compound with a colossal magnetoresistance. Its electronic and magnetic properties depend on each other. The influence of carbon doping in the anion sublattice $EuB_{6-x}C_x$ on the magnetic properties of this compound was studied by electron spin resonance (ESR) and by electron transport (ET). The ESR measurements were performed at 9.3 GHz in the temperature range T = 10-300 K, and ET measurements in the temperature range 80-300 K. According to the ESR data, magnetic phase separation is observed for all the samples. The observed two ESR lines correspond to two types of polarons, in which there is a Kondo and an anti-Kondo coupling of the magnetic moments of Eu^{2+} with the magnetic moments of the charge carriers. At x= 0.02 the splitting of the ESR line is observed at 40K as well as EuB_6. However, in $EuB_{5.93}C_{0.07}$ the ESR line splits already at 130 K. At high temperatures, we observe linear resistance R (T) temperature dependencies for all samples that are characteristic for metals. The concentration dependence of the residual resistance R0 is shown in the figure. For a sample with x=0.07 at temperatures below 130 K, R(T) acquires a semiconductor character, which is probably related to the opening of a gap in the spectrum of electronic excitations due to either stronger localization of electrons or changes in the Fermi surface. The dependence R (T) resembles the temperature dependence of the width of the ESR line of this sample. This similarity suggests that both dependencies are due to the same dissipative processes in the systems of localized magnetic moments and current carriers. It is obvious that the tetravalent carbon, penetrating the sub lattice of the trivalent boron, must be an electron donor. In accordance with this, it must increase the concentration of electrons in the sample and, of course, its conductivity. However, the opposite result is observed. Perhaps this is due to the increase in the number of scattering centers in the boron sublattice. A key role in the relaxation of the electronic subsystems of $EuB_{6-x}C_x$ can be due to specific mechanisms associated, for example, with s-f Hubbard-Mott scattering and s-f super-exchange of localized f-electrons through the valence band electrons.

taltshuler@yandexl.ru

Spin-Filtering in superconducting junction with the manganite interlayer

Gennady A Ovsyannikov
Kotel'nikov Institute of Radio Engineering and Electronics RAS, Russia

The tunnel current flowing through the ferromagnetic layer between two non-magnetic electrodes becomes spin-polarized due to exchange splitting of the ferromagnetic insulator conduction band with the states with the spin up and spin down. Electronic and spin transport in superconducting mesa-structures made of epitaxial cuprate superconductor YBa_2Cu_3Ox(YBCO) and niobium thin films with an insulating manganite $LaMnO_3$ (LMO) thin film as interlayer were investigated. Ferromagnetic resonance measurements of heterostructure Au/LMO/YBCO shows ferromagnetic state at temperatures below 150 K, as in the case of reference LMO film grown on the neodymium gallate substrate. Spin current in the mesa structure was studied. The heights of the tunneling barrier in mesa structure Au/LMO/YBCO evaluated from resistive characteristics of mesa-structures at different thickness of interlayer showed an exponential decrease approximately from 30 mV down to 5 mV with increase of manganite interlayer thickness. Temperature dependence of the conductivity of mesa-structures could be described taking into account d-wave superconductivity in YBCO and a spin filtering of the electron transport. Spin filtering is supported also by measurements of magneto-resistance and the high sensitivity of mesa-structure conductivity to weak magnetic fields. Varying the external weak magnetic field $|H|<10$ Oe and dc bias current the microwave generation with a line-width of order 50 MHz was observed in GHz frequency band using low noise microwave amplifier. The frequency of generation could be tuned by biasing current with a rate 10^{13} Hz/A. The impact of spin filtering on charge current and manipulation of spin-dependent switching from oscillating to non-oscillating states are discussed taking into account the asymmetry of oscillation amplitudes over applied H-field.

gena@hitech.cplire.ru

Probing the electronic and magnetic properties of magnetic oxides using resonant photoemission study

R J Choudhary
UGC DAE Consortium for Scientific Research, India

The electrical and magnetic properties of any transition metal oxide are related to its electronic structure. Resonant photoemission spectroscopy (RPES) is a novel technique to understand the valence band structure of any transition metal based oxide material. In the present talk, I shall discuss the results of different classes of magnetic oxide materials. These materials are grown in thin film form using pulsed laser deposition. X-ray photoelectron spectroscopy, and RPES measurements have been performed at AIPES beamline at Indus-1, RRCAT, Indore. For over a decade, TM doped semiconducting oxides based dilute magnetic semiconductors (DMS) have attracted a huge attention of condensed matter community owing to its prospects in spintronic applications. To better understand the effect of TM doping or presence of defects on the electrical and magnetic properties, it is crucial to realize modification in the host semiconducting oxide's electronic properties. We have investigated the electronic and magnetic properties of the pulsed laser deposited epitaxial thin films of Fe doped (4 at. %) and undoped anatase TiO2-d by resonant photoemission, resistivity, magnetization measurements and ab-initio band structure calculations. Our study reveals the formation of local magnetic moment and finite density of states at the Fermi level indicating its metallic (degenerate semiconducting) behaviour in both the films, leading to magnetic ordering at room temperature and a Kondo minimum in resistivity behaviour. Present work suggests that there is a competition between magnetic ordering mechanism by JRKKY and moment screening mechanism by JKondo. In the light of this result the role of carrier density is also discussed in achieving the magnetic ordering in DMS materials either by defect engineering or by transition metal doping.

ram@csr.res.in

From inception to completion, magnetism was the attraction

Bello Sambo
University of Huddersfield, UK

From the early stage of being an ingenuously scientifically curious minded individual (creating a small electromagnet yourself by connecting the ends of a copper wire to the positive and negative ends of a cell battery), down to the more conscious decisions of personally developing the skills and tools to learn one or more of the many engineering fields of study, there exist direct and constant contact with the interesting phenomenon exhibited by magnetic materials. Faraday's Law of Induction dominates almost every aspect of our domestic and industrial environment, ranging from electric fans, microwave ovens, air conditioners, food processors, washing machines, and heavy equipment driven by motors. The interaction between magnetic materials on the magnetic flux lines has virtually found relevance in most engineering applications. Computer systems are essential for processing data at the competitive speed and accuracy in this time and age, equally important is an inexpensive means for storing the processed data. This is mostly an application of magnetizing tiny magnetic domains on the disc as in the case of using floppy disks, magnetic tape, and hard disk drives. In addition to storage, the transmission of data from one device to the other is also a function of electromagnetic radiation e.g. Bluetooth technology. Recent advances in research and development have led to the realization a "proof of concept" for magnetic field human body communication system which uses the body as a vehicle to deliver magnetic energy between electronic devices in the absence of a power boost typically used to overcome the signal obstruction. This technology offers 10 million times lower energy level compared to those associated with Bluetooth radios. At the undergraduate level, I was exposed to the concept of antenna theory, which not only borders on telecommunication transmitter-receiver applications, but also biomedical imaging such as MRI. Further postgraduate studies in Engineering Control Systems and Instrumentation brought out in the open the significance of electromagnetic induction based actuators in experimental and model-based projects. The relevance of magnetic materials and magnetism became even more pronounced in doctoral research project work related to railway research. The application of magnetism in railway industry has indeed proven to be successful in condition monitoring by means of magnetic flux leakage (MFL) inspection technique, which focuses on magnetizing the rail and then correlating exit points (poles) to the presence, severity, and location surface defects on rails. More revolutionary to the conventional train track interaction is the utilization of the behavior of similar and opposite poles for propulsion/levitation of the train on the track (maglev train). The combination of a large electrical power source, metal coils lining a track, and large guidance magnets attached to the underside of the train enables Maglev trains to attain speeds above the threshold 1000 [km/h] and a levitation of between 1 and 10 [cm] above the track. The novelty of the maglev technology lies in the substitution of fossil fuels, which is replaced by the magnetic field created by the electrified coils in the track and underside of the vehicle which combine to propel the train in the direction of motion. As a direct consequence of my personal experience with magnetism related works, it is safe to say that it is not only the different polarity of magnetic materials that experience attraction but also the science and engineering world is bound to the field of electromagnetism.

bello.sambo@hud.ac.uk

Spin super fluids: From DC and AC transport to topological hydrodynamics

So Takei
Queens College, City University of New York, USA

In this talk, I will discuss various aspects of spin superfluidity (long-ranged, dissipationless transport of spin angular momentum) in magnetic insulators that make it distinct from the familiar mass and charge super fluids. I first propose the simplest realization of the phenomenon using a spin Hall-facilitated two-terminal device. Various U (1)-symmetry breaking effects that lead to the suppression and the eventual destruction of the superfluid state are introduced and discussed. I then present ways in which superfluid-like behavior can be restored in the presence of such detrimental effects by considering spin transport in the AC regime and via topological magnetic solitons.

stakei@qc.cuny.edu

Preparation of painting material of Li-Ni ferrite

Emad K Al-Shakarchi
Nahrain University, Iraq

The Li-Ni Nano ferrite samples with the structure $Li_{0.5-0.5x}Ni_xFe_{2.5-0.5x}O_4$ was prepared by hydrothermal method. They prepared two sets, from metal chlorides, and ferrous sulfate with NaOH. In each set, the variation of (x) was 0, 0.1, 0.3, to 1.0. The samples were without and with adding Fe^{+2}. The ratio of Fe^{+3}/Fe^{+2} was kept at 1.7. The preparation temperature was 155^0C and pH-value was equal to 11. The samples showed spinel ferrite structure beyond x=0.3 for set one and pure phase in 0.3 by using Fe^{+2}. Lattice constant of set two was a little lower than set one and both were little lower than theoretical. The crystallite size gets minimum at x=0.5 for set one and roughly maximum at x=0 for set two. FTIR spectrums tetrahedral showed peak shift to higher frequency with increasing Ni^{+2} concentration. Particles shapes were: rods (often hematite) average diameter 40 nm, spherical (nanocube ferrite in origin) sizing around 20 nm. M-H Loops had S-shape like to superparamagnetic one. Generally, the prepared samples have lower coercivety, higher saturation magnetization. Both sets gave maximum susceptibility at x=0.5. These results explained based on composition, cations distribution, cation interactions and particle size. Resonance microwave absorption by using FMR test showed that the maximum imaginary susceptibility χ" is at x=0.5 for set one besides high values of 0.7 and 0.9, with largest line width of about 950 G at x=0.7. Set two showed maximum absorption (χ") and line width at x=0.9. The powder mixed with Novalac epoxy by 7.93% wt. The FMR test with no field showed that high absorption to microwave field for frequencies larger than 19 GHz. The explanation of that set two samples has larger absorption than the set one that based on hopping conductivity and magnetic parameters (Ms and Hc) variation. Transmission line method by using VNA in X-band and Ku-band showed that return (reflection) RL loss got minimum at x=0.3 in for set one in X-band whereas that happen at x=0.3 and x=0.5 for set two. Adding Fe^{+2} lowered the minimum by a factor of more than 1.5. The insertion losses IL in X-band ranging from -4.5 to -7 dB, RL and IL in Ku-band have same behavior but their values were lower. RL got minimum at x=0.5 with value of about near to -18dB whereas it was around -12dB by adding Fe^{+2}, the average IL in Ku-band was about -6dB.

eks2000@hotmail.com

Multifunctional molecule-based magnets

Cynthia L M Pereira
Federal University of Minas Gerais, Brazil

In this contribution, it will be described about some examples of molecule-based magnets involving flexible and rigid organic ligands based on oxamate groups. Flexible organic ligands can be understood as entities that can change their chemical conformations such as syn and anti- forms depending on external stimuli such as pH variation, for instance; rigid ligands are not capable to change their chemical conformations by an external stimulus. To illustrate this, it will be presented about some compounds based on H_4edpba (*N*, *N*'-2,2'ethylenediphenylenebis (oxamic acid)) and H_4opba (*N*, *N*'-1,2-phenylenebis (oxamic acid)) ligands. These ligands were used on the synthesis of the molecule-based magnets. The relation between (metallo) supramolecular structures and magnetic properties will be presented as well as other interesting properties such as catalytic activity for decomposition of organic pollutants.

cynthialopes@ufmg.br
lopescynthia@yahoo.com.br

Magnetic materials for wireless actuation in biomedicine

Arianna Menciassi
The BioRobotics Institute, Scuola Superiore Sant'Anna, Italy

This talk introduces the key aspects of magnetic actuation for medical devices in the miniature scale, based on the author experience on robotics for minimally invasive intervention, targeted therapy, personalized medicine and bionic artificial organs. The quest for miniaturization and natural access to the targeted pathologies led to the development of diagnostic and therapeutic tools to be delivered with an endoluminal and transluminal approach - such as endoscopic capsules - and to be controlled and propelled by remote operation schemes from outside. The quest for targeted therapy has recently opened new opportunities for robotic technologies, which are used more and more as controllers for the delivery of drugs embedded in nanobiotech vectors and as solutions for making therapy really localized in the area of interest, thus enabling on-demand release kinetics and eliminating (or strongly limiting) side effects. After a description of magnetic solutions developed by the authors' group for actuating, locomoting and triggering mechanisms to be employed in medical devices, the talk will focus on recent applications of magnetic control. Examples range from magnetic control and triggering for drug delivery capsules to be used in the spine, to magnetic activation mechanisms for artificial organs (i.e. urinary sphincters or artificial pancreas), and magnetic microfilms manipulation for personalized therapy and lab-on-chip technologies.

arianna.menciassi@santannapisa.it

Magnetostructural coupling and giant magnetocaloric effect in MnCoGe-based compounds

Santosh Pal
Institute for Energy Technology, Norway

Serious environmental consequences of the traditional vapor-compression cooling techniques have turned the research efforts towards the development of alternative cooling techniques, and the search for materials showing large caloric effect. Magnetic cooling technology is a rapidly growing technology with a potential of becoming more economical, energy efficient and environmentally friendly cooling technology. The search of new or improving the existing magnetic materials exhibiting large magnetocaloric effect near room temperature but with the use of none or negligibly small number of critical/toxic elements is a field of intense research for magnetic cooling technology. The magnetocaloric effect of a material can be significantly improved by combining the lattice degree of freedom with the magnetic one. This produces a first-order magnetostructural transition which in turn leads to a gigantic magnetocaloric effect. Intermetallic alloy MnCoGe is an interesting compound which experiences a martensitic structural transformation and a magnetic transition separated by around 100 K. Both of the transitions can be tuned via physical and/or chemical pressure which can lead to a magnetostructural coupling resulting in a first-order transition and thus a giant magnetocaloric effect. In this presentation, magnetostructural coupling and giant magnetocaloric effect via tuning of the structural and magnetic transitions of MnCoGe compound through partial substitution of Co and Mn by Cu will be discussed. A giant maximum isothermal entropy change of ~40 $JKg^{-1}K^{-1}$ (for $\Delta H = 5$ T) has been obtained for 10 at %Mn substitution by Cu. The Mn-substituted samples show a normal paramagnetic to ferromagnetic transitions. Interestingly, in addition to paramagnetic to ferromagnetic transitions, the Co-substituted samples show ferromagnetic to antiferromagnetic (FM to AFM) and then AFM to FM transitions with decreasing the temperature. The presence of antiferromagnetic phase and complex magnetic transitions can be possible due to the varying Mn-Mn distances during the martensitic transition. A comparative study of the Mn- and Co-substituted samples and a correlation of the magnetic and structural properties will be presented and discussed.

Santosh.kumar.pal@ife.no
pal.santosh07@gmail.com

Nanoscale cascade dynamic effects and ion beam treatment of soft magnetic materials

Vladimir V Ovchinnikov
Institute of Electrophysics, UD, RAS, Russia

Classical radiation physics describes well several known phenomena (radiation embrittlement, swelling, radiation creep) based on relatively slow processes of thermo- and radiation-enhanced diffusion. Mechanisms based on the description of the defects migration processes cannot however, explain the small-dose effect under neutron and low-dose long-range effect under ion irradiation. In fact, in both cases we are talking about instant structural-phase rearrangements, at large distances with an insignificant number of displacements per atom (sometimes<0.001). The author and his colleagues found many arguments in favor of the decisive role of nanoscale dynamic effects in explaining the effect of cascade-forming radiation on matter. The presentation takes a brief look at the model considering the explosive energy release in the regions of the dense cascades of atomic displacements and the emission of powerful post-cascade solitary waves that initiate structural-phase transformations at their front in metastable media, theoretically, at unlimited distances (in practice at least up to several millimeters under ion irradiation, at $R_p < 1$ μM; Rp is the projected ion range). The application part of the report contains an overview of more than a dozen of articles of the author and his colleagues and the latest results on the effect of ion beams on the phase composition, atomic distribution, the grain and magnetic domain structure, as well as the magnetic properties of soft magnetic materials such as transformer steel (bands 0.1-0.35 mm thick), fine met (25 μM), perm alloy, and carbonyl iron powders. Mossbauer, X-ray diffraction, and TEM data are used.

viae05@rambler.ru

Magnetic phase diagram of spatially anisotropic frustrated two-dimensional antiferromagnet

Vladimir Ilkovic
Bogoliubov Laboratory of Theoretical Physics JINR, Russian Federation

The new magnetic materials such as the layered oxide high-temperature superconductor can be well described by the Heisenberg spin model with nearest-neighbor (NN) antiferromagnetic coupling J_1 and next-nearest-neighbor (NNN) antiferromagnetic coupling J_2. It is now well accepted that the model J_1--J_2 exhibits two phases displaying magnetic order at small J_2, separated by an intermediate paramagnetic phase in the interval $J_{c1}<J_2<J_{c2}$. The ground state for $J_2<J_{c1}$ exhibits Neél magnetic order, whereas for $J_2>J_{c1}$ it exhibits collinear stripe order. A generalization of the frustrated J_1-J_2 model is the J_1^x--J_1^y--J_2 model where J_1^y is the directional anisotropy parameter. The nearest-neighbor bonds have different strength J_1^x and J_1^y in the x and y directions, respectively. The effect of the coupling J_1^y on the Neél and stripe states is investigated. Our aim here is to further the study of this model by using the quantum many-body Green function method. It has been applied successfully to calculate with high accuracy the properties of many lattice quantum spin systems.

vilko@theor.jinr.ru

Magnetic structures and excitations of 3D nanoparticles

Jean-Claude S Levy
Paris Diderot University, France

Magnetic nanoparticles are produced for memory applications as well as for biomedical applications since they can be driven or stirred by external magnetic fields. Networks of nanoparticles evidenced interesting spectra of excitations opening the way to materials with a low index such as metamaterials. The magnetic structures and excitations of 3D nanoparticles are rather badly known because of the occurrence of long ranged coupling such as dipolar interaction which competes with local interactions such as an exchange. The goal of this paper is to introduce a systematic view of these magnetic structures and excitations for different materials and samples. The characteristic parameter is the ratio between dipolar interaction and exchange. This effective ratio evolves with both materials and sample size. The results of Langevin numerical analysis of both structures and excitations of a 64*64*64 cube show a set of transitions from a uniform domain structure to a final multidomain structure where singularity lines design a full 3D network as shown in the figure, a snapshot of an actual movie. Among the steps: a single vortex (or antivortex) line, the occurrence of a 2D network of vortex lines. As expected in such small samples super-paramagnetism occurs and there is a rather slow dancing collective motion of these singularity lines. These rather localized collective motions generalize the gyrotropic vortex motion of a 2D nanoparticle. The low-frequency excitations are directly obtained from Langevin simulations while higher energy excitations are derived from the dynamical matrix approximation, evidencing gaps in the spectrum. The low energy spectrum shows a critical behavior of the super-paramagnetism blocking time. These behaviors would be modulated by the addition of extra interactions such as anisotropy and Dzyaloshinskii-Moriya interaction for instance with the introduction of skyrmions

Jean-claude.levy@univ-paris-diderot.fr

The behavior of diamagnetic macromolecules in a magnetic field

S A Vshivkov
Ural Federal University, Russia

The effect of a magnetic field on the phase transitions, structure, and rheological properties has been studied for the liquid crystalline cellulose derivative – solvent systems: hydroxyethyl cellulose – water, hydroxyethyl cellulose - DMAA, hydroxyethyl cellulose - DMF, hydroxypropyl cellulose - water, hydroxypropyl cellulose - DMF, hydroxypropyl cellulose – DMAA, hydroxypropyl cellulose – ethanol, ethyl cellulose – DMAA, cyanoethyl cellulose – DMAA, cyanoethyl cellulose – DMF, Na-carboxymethyl cellulose–water. Phase diagrams are constructed and the regions of existence of isotropic and anisotropic phases and the dimensions of macromolecules and supramacromolecular particles in a wide composition range are determined. Under application of magnetic field, the domain structure is formed in solutions and the temperature–concentration region of the liquid crystalline phase widens. The studied systems are found to possess memory: after the magnetic field is switched off, the orientation of macromolecules and the increased temperature of phase transitions are preserved for many hours. As the molecular mass of the polymer is increased, the ability of macromolecules to orient themselves in the magnetic field declines. The concentration dependence of supramolecular particle radius in the presence of the magnetic field is described by a curve with maxima. The threshold mechanism governing the effect of magnetic field on liquid crystalline transitions in polymer solutions has been discovered. The critical value of magnetic intensity that brings about a shift in boundary curves is consistent with the critical value of Hcr necessary for the cholesteric liquid crystal – nematic liquid crystal phase transition. Application of a magnetic field is shown to be accompanied by an increase in the viscosity of these systems by a factor of 1.3 – 4. The concentration dependence of viscosity in the presence of a magnetic field is described by curves with an extremum.

sergey.vshivkov@urfu.ru

Effect of a strain on the magnetotransport properties of Bi wires

Elena P Condrea
Institute of Electronic Engineering and Nanotechnologies, Academy of Science of Moldova, Republic of Moldova

The presented investigations of the magnetotransport measurements of Bi wires complement the series of recently published experimental results on bulk Bi in high magnetic field. The design of measurements in the magnetic field was diversified by using uniaxial strain directed along the wire axis. By combining high magnetic field and strain, the electronic structure of the bismuth wires was modified; as a result, the quantum limit for light and heavy electrons could be changed in different ways. Measurements of the longitudinal magnetoresistance in the magnetic field of up to 35 T oriented along the bisector axis of Bi wires have revealed an anomaly in a magnetic field far above the quantum limit of the electrons: a sharp peak of MR at 33T (figure 1). Investigation of magnetoresistance under uniaxial strain has revealed that the sharp peak of the magnetoresistance at 33 T is reproduced in lower magnetic fields at 28 T according to a decrease in the light electron concentration under strain. Thus, a correlation between the exit of the last Landau level of light electrons and the Lifshitz Transition has been found. The result is that the critical magnetic field of the Electronic Topological Transition has decreased; thereby, the magnetic field range of the occurrence of magnetic-field-induced instabilities associated with the last Landau level of electrons has been extended. It should also be noted that a decrease in the resistance in higher fields with the apparent metallization of bismuth indicates possible changes in the mechanism of carrier scattering associated also with the Lifshitz Transition and with the substructure of the last Landau level of electrons.

condrea@nano.asm.md

Influence of Ce^{+3} co-substitution on the structure and electric properties of $Zn_{0.5}Mn_{0.43}Cd_{0.07}Fe_{2-y}Ce_yO_4$ ferrites

Muhammad Imran Arshad
Government College University, Faisalabad, Pakistan

The separation techniques are uniquely physical in nature and operate without the usage of heat and thus utilizing least energy as compared to the orthodox thermal separation methods. In this research work we have analyzed the role of substitution of Ce on the electric behavior and structure properties of Cadmium doped Mn Zn ferrites. Series of $Zn_{0.5}Mn_{0.43}Cd_{0.07}Fe_{2-y}Ce_y O_4$ (x=0.0, 0.1, 0.2, 0.3, 0.4, 0.7) was synthesized by coprecipitation technique. The synthesized particles were sintered at 900^{0}C. XRD analysis showed that particles have cubic spinel structure. Crystallite size lied in the range 46.4 nm-53.5 nm calculated by the Scherrer formula. Crystallite size, lattice constant and x-ray density were found directly affected by concentration of RE^{3+}. By using two probe method IV properties were studied at different temperatures. It was observed that resistivity of synthesized nanoparticle increases by increasing concentration of Ce and temperature. The value of electrical resistivity lied in the range ~10^9 Ω cm to ~10^{10} Ω cm. Activation energy of these nanomaterials lies in the range of 1.04 - 2.73. Activation energy decreases with the increase in concentration of x. These characteristics made these particles promising candidates for high frequency applications.

miarshadgcuf@gmail.com

Phase diagram for the O(n) model with defects of “random local field” type and verity of the Imry-Ma theorem

A S Sigov
Moscow Technological University, Russian Federation

After the publication in 1975 the classical paper by Imry and Ma, the viewpoint was firmly established in the literature that at space dimensions d<4 the introduction of an arbitrarily small concentration of defects of the "random local field" type in a system with continuous symmetry of the *n*-component vector order parameter (O*(n)* model) leads to the long-range order collapse and to the occurrence of a disordered state, which in what follows will be designated as the Imry-Ma state and the statement given above will be named the Imry-Ma theorem. An anisotropic distribution of the directions of defect-induced random local fields in the order parameter *n*-dimensional space gives rise to the effective anisotropy in the system. Evaluation of the effective anisotropy constant K_{eff} for strong anisotropic distributions in the order of magnitude gives the value K_{eff} ~ *x(hl)*^2 / JS^2, where *x* is the defect concentration, h_l is the local field induced by l^{th} defect, J is the exchange interaction constant between neighboring spins and the brackets denote averaging over defects. The Imry-Ma theorem breaks down due to existence of the “easy axis” anisotropy induced by the defects designed initially for breaking down the long-range order. In the case of slightly anisotropic distribution of the fields, there exists a critical concentration of defects, if exceeded the Imry-Ma inhomogeneous state can exist as an equilibrium one. In the case of strongly anisotropic distribution of the fields, the Imry-Ma inhomogeneous state is completely suppressed and the state with the long-range ordering is realized at any defect concentration.

assigov@yandex.ru

Magnetism in rutile-type oxides

Dorj Odkhuu[1], **Tumurbaatar Tsevelmaa**[2] and **Purev Taivansaikhan**[1]
[1]Incheon National University, Republic of Korea
[2]University of Ulsan, Republic of Korea

While rutile-type transition metal oxides (TMO_2) have been widely used in a variety of important applications such as an active catalyst, supercapacitors, batteries, and fuel cells, an existence of intrinsic magnetism in RuO_2 has recently drawn much attention in spintronics. In this study, we have performed the density-functional theory plus U (DFT+U) calculations on magnetism and magnetic anisotropy energies (MAE) of RuO_2 and OsO_2. These oxides are identified to favor an antiferromagnetic phase, which is a result of mutual mechanisms of Kramer-Anderson superexchange interaction and Jahn-Teller effects. More remarkably, we found very large MAE up to an order of 10 meV per transition metal atom in bulk, which are four orders of magnitude greater than those of the conventional transition metals. This anisotropic phenomenon further exhibits a persistently increasing dependence of film thickness, which is very uncommon in thin film materials.

Biography

Dorj Odkhuu has completed his PhD in Physics from University of Ulsan in 2014 and Postdoctoral studies from Ulsan National Institute of Science and Technology and California State University Northridge. He is currently an Assistant Professor at Incheon National University, South Korea. His research focuses on first-principles calculations of magnetic and magnetoelectric materials and he has published more than 40 papers in peer-reviewed journals.

odkhuu@inu.ac.kr

The effect of alkali concentration on the structural and magnetic properties of Mn-ferrite nanoparticles prepared via the co-precipitation method

Somayeh Pourbafarani
Isfahan University, Iran

Chemistry plays an important role in the development of novel nano-structural materials, and a simple control of solution chemistry can lead to specific changes in crystallite properties. One of the chemical techniques in the synthesis of nanoparticles is co-precipitation. The advantages of using this method are that the structural and morphological properties of nanoparticles can be varied by controlling the chemical and physical parameters of the reaction medium such as the alkali concentration, reaction temperature, molar ratio of salts, ionic strength of aqueous medium, and reaction time. In this work, $MnFe_2O_4$ nano particles were synthesized using the co-precipitation method under two different NaOH concentration settings as reaction agents at 355 K (82°C). Structural and morphological properties of the nanoparticles were examined using X-ray diffraction and a scanning electron microscope. The decrease of NaOH concentration led to the increase of particle size, more crystallinity and a narrower particle size distribution. The results were evaluated from a chemical point of view and were based on the supersaturation level, which was influenced by alkali concentration. It was concluded that the higher NaOH concentration led to a more rapid nucleation and more random cation distribution. The magnetic properties of the nanoparticles were consistent with the structural and morphological properties of the particles.

s.pourbafarani@chmail.ir