8th IACS-APCTP-KIAS Joint Conference on Emergent Phenomena in Novel Oxide Materials and Low Dimensional Systems

APCTP Headquarters, Pohang, Korea

December 15-17, 2016

아시아태평양이론물리센터는 정부의 과학기술진흥기금 및 복권기금 지원으로 국민과 함께하고 있습니다.

VENUE

APCTP Headquarters, Pohang, Korea

Seminar room 512, Hogil Kim Memorial Hall, POSTECH

PERIOD

December 15 (Thu.) - December 17 (Sat.), 2016

OVERVIEW

Novel and emergent materials have attracted major interest in condensed matter research because of their wide ranging physical properties that are not only important for basic research but also for various applications. The major purpose of this conference is to present and discuss about cutting-edge theoretical work on novel and emergent materials that will include transition metal oxides, spin-orbit materials, topological insulators, novel iron based superconductors, and two-dimensional materials. In particular, Graphene and topological insulators constitute a novel class of materials in condensed matter physics whose low-energy quasiparticles obey Dirac-like, rather than Schrodinger like, equations. The main purpose of the present meeting will be to discuss about recent progresses in theory (both ab-initio as well as many-body approaches) to understand these novel materials. The conference will also have special talks by leading experimentalists in the Asia Pacific region working in the area mentioned above.

TOPICS

- Spin-orbit coupling materials
- Topological insulators
- Transition metal oxides
- Fe based superconductors
- Multiferroics

ORGANIZERS

- Jaejun Yu (Seoul National Univ., Korea | Chair)

- Kwon Park (KIAS, Korea | Co-chair)
- Indra Dasgupta (IACS, India | Co-Chair)
- Yunkyu Bang (Chonnam National Univ., Korea)
- D. D. Sarma (IISc, India)

INVITED SPEAKERS

- Yunkyu Bang (Chonnam National Univ., Korea)
- Aveek Bid (IISc, India)
- Subhro Bhattacharjee (TIFR, India)
- Debraj Choudhury (IIT, India)
- Indra Dasgupta (IACS, India)
- Myung Joon Han (KAIST, Korea)
- Sungdae Ji (POSTECH, Korea)
- Ji Young Jo (GIST, Korea)
- Changyoung Kim (Seoul National Univ., Korea)
- Kee Hoon Kim (Seoul National Univ., Korea)
- B.I. Min (POSTECH, Korea)
- Han-Jin Noh (Chonnam National Univ., Korea)
- Jae-Hoon Park (POSTECH, Korea)
- Kwon Park (KIAS, Korea)
- Tanusri Saha-Dasgupta (S.N. Bose Center, India)
- D. D. Sarma (IISc, India)
- Goutam Sheet (IISER, India)
- Young-Woo Son (KIAS, Korea)
- A. Sundaresan (JNCASR, India)

HOST INSTITUTES

- APCTP (Asia Pacific Center for Theoretical Physics)
- IACS (Indian Association for the Cultivation of Science)
- KIAS (Korea Institute for Advanced Study)

PROGRAM

DECEMBER 15 (THU)		
12:00 -13:00	**Registration** (with lunch)	
13:00 - 13:10	Opening	
Session A1 – Chair: Kwon Park		
13:10 - 13:50	**D. D. Sarma** (IISc, Bangalore)	"Electronic structure of the elusive metastable state in chemically exfoliated few layer MoS2"
13:50 - 14:30	**B.I. Min** (POSTECH)	"Electronic structures and excitation spectra in spin-orbit Mott insulators: Sr2IrO4 and Na2IrO3"
14:30 - 14:50	**Coffee Break & Discussion**	
14:50 - 15:30	**Indra Dasgupta** (IACS, Kolkata)	"On the Realization of Spin-Orbital Liquid States in Iridates"
15:30 - 16:10	**Myung Joon Han** (KAIST)	"Establishing Jeff =3/2 Ground State in a Lacunar Spinel GaTa4Se8"
16:10 - 16:30	**Coffee Break & Discussion**	
16:30 - 17:10	**Subhro Bhattacharjee** (TIFR, Bangalore)	"Quantum spin liquids on kagome XXZ antiferromagnets"
17:10 - 17:50	**Jae-Hoon Park** (POSTECH)	"Spin-orbit Coupled Isospin 1/2 Quantum Magnetism in Frustrated Magnets"
18:30 - 20:00	**Banquet**	

DECEMBER 16 (FRI)		
Session B1 – Chair: Yunkyu Bang		
9:00 - 9:40	**Kwon Park** (KIAS)	"Surface to bulk Fermi arcs via Weyl nodes as topological defects"
9:40 - 10:20	**Goutam Sheet** (IISER, Mohali)	"Tip-induced Superconductivity on the Weyl Semimetal TaAs"
10:20 - 10:40	**Coffee Break & Discussion**	

10:40 - 11:20	**Han-Jin Noh** (Chonnam Natl U)	"Angle-Resolved Photoemission Study of Conducting Delafossite PdMO2(M=Co, Cr)"
11:20 - 12:00	**Young-Woo Son** (KIAS)	"Stability and structural phase transition in transition metal dichalcogenides"
12:00 - 13:30	**Lunch**	
Session B2 – Chair: Indra Dasgupta		
13:30 - 14:10	**Changyoung Kim** (SNU)	"Electric field control of octahedra rotation on the surface of Sr2RuO4"
14:10 - 14:50	**Aveek Bid** (IISc, Bangalore)	"Correlated non-Gaussian phase fluctuations in LaAlO3/SrTiO3 heterointerfaces"
14:50 - 15:10	**Coffee Break & Discussion**	
15:10 - 15:50	**Ji Young Jo** (GIST)	"Oxygen octahedral tilting engineering of epitaxial thin films"
15:50 - 16:30	**Debraj Choudhury** (IIT, Kharagpur)	"Emergent transport and magnetic properties driven by electronic redistributions in some transition-metal oxide systems"
16:30 - 17:10	**Kee Hoon Kim** (SNU)	"Tailoring Direct and Converse Magnetoelectric Effects Toward Room Temperature in Hexaferrites"
17:10 - 18:30	**Poster Session (Dinner)**	

DECEMBER 17 (SAT)		
Session C1 – Chair: Jaejun Yu		
9:00 - 9:40	**A. Sundaresan** (JNCASR, Bangalore)	"On the nature of magnetic ground state in CoAl2O4: Magnetoelectric Study"
9:40 - 10:20	**Sungdae Ji** (POSTECH)	"Incarnation of Majorana fermions in Kitaev quantum spin lattice"
10:20 - 10:40	**Coffee Break & Discussion**	

10:40 - 11:20	**Tanusri Saha-Dasgupta** (S.N. Bose Center, Kolkata)	"Heterostructures of 3d-5d Double Perovskites: Potential Candidates for Confined Half-metallicity & High-T Quantum Anomalous Hall States"
11:20 - 12:00	**Yunkyu Bang** (Chonnam Natl U)	"Pairing Mechanism of the FeSe-monolayer and related Systems: Dynamical Tuning of Pairing Cutoff Energy"
12:00 -	**Closing Remarks**	

SESSION A1

SESSION A1

Electronic structure of the elusive metastable state in chemically exfoliated few layer MoS_2

D. D. Sarma
Solid State and Structural Chemistry Unit
Indian Institute of Science, Bengaluru 560012

An elusive metastable phase, existing only as small patches in chemically exfoliated few layer, thermodynamically stable 2H phase of MoS_2 is believed to influence critically properties of MoS_2 based devices. Its electronic structure is little understood in absence of any direct experimental data and conflicting claims from theoretical investigations. I shall present data[1] to resolve this issue based on probing the electronic structure of chemically exfoliated few layer systems using spatially resolved photoemission spectroscopy.
This work is carried out in collaboration with Banabir Pal, Anjali Singh, Sharada. G, Pratibha Mahale, Abhinav Kumar, S. Thirupathaiah, H. Sezen, M. Amati, Luca Gregoratti, and Umesh V. Waghmare.

References:
1. Banabir Pal *et al*., Unpublished results.

SESSION A1

Electronic structures and excitation spectra in spin-orbit Mott insulators: Sr_2IrO_4 and Na_2IrO_3

B. I. Min*, Beom Hyun Kim, Minjae Kim, Bongjae Kim, Kyoo Kim
Department of Physics, POSTECH, Pohang, 37673, Korea

Sr_2IrO_4 and Na_2IrO_3 are referred to as $J_{eff} = 1/2$ Mott insulators, in which the strong spin-orbit (SO) coupling and the Coulomb correlation interaction stabilize the insulating states by splitting $5d^5$ shell into half-filled $J_{eff} = 1/2$ and fully-occupied $J_{eff} = 3/2$ states. The strong SO couplings in these systems induce intriguing physical properties, which do not appear in conventional 3d Mott insulators, such as SO exciton peaks in the resonant inelastic scattering (RIXS) spectra. Furthermore, they exhibit a bit different low energy excitation feature from each other. The optical spectrum $\sigma(\omega)$ in Sr_2IrO_4 shows two peaks, while $\sigma(\omega)$ in Na_2IrO_3 shows a single broad peak. We have investigated their optical and RIXS spectra using the model multiplet-structure calculations as well as the density-functional theory (DFT) band calculations. We have also addressed their insulating nature, Slater-type or Mott-type, by examining their temperature-dependent electronic structures on the basis of a combined scheme of the DFT and the dynamical mean-field theory (DMFT). We have shown that the insulating state for Na_2IrO_3 persists even above the N´eel temperature, which reveals the Mott-type insulating nature.

SESSION A1

On the Realization of Spin-Orbital Liquid States in Iridates

Indra Dasgupta*
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The search for quantum spin (-orbital) liquids (QSL) -materials where local moments are well formed but continue to fluctuate quantum mechanically down to zero temperature still remains a fundamental challenge in condensed matter physics. In this talk we shall show that the electronic structure of 6H perovskite type quaternary iridates Ba3MIr2O9, have all the necessary ingredients to host QSL state. In Ba3MIr2O9, Ir ions form structural dimers and non magnetic M provides a knob to tailor the valence of Ir leading to emergent quantum phases. As a first example [1], we shall consider the pentavalent (d4) 6H perovskite iridate Ba3ZnIr2O9 and argue that the ground state of this system is a realization of novel spin-orbital liquid state. Our results reveal that such a system provides a very close realization of the elusive J=0 state where Ir local moments are spontaneously generated due to the comparable energy scales of the singlet-triplet splitting driven by spin-orbit coupling (SOC) and the super-exchange interaction mediated by strong intra-dimer hopping. While the Ir ions within the structural Ir2O9 dimer prefers to form a spin-orbit singlet states(SOS) with no resultant moment, however substantial frustrated inter-dimer exchange interactions induce quantum fluctuations in the SOS states favoring spin-orbital liquid phase at low enough temperature. As a second example [2] we shall consider the d4.5 insulator Ba3YIr2O9 and explain the origin of the pressure induced magnetic transition to a spin-orbital liquid state in this system. Finally we shall discuss the importance of Kitaev interactions in the realization QSL phases for the d5 members of the same family [3].

• Work done in collaboration with S. Bhowal, S.K. Panda, S. Ganguly, Y Li, R Valenti, L Nordstrom, A. Nag and S Ray

[1] Origin of the spin-orbital liquid state in a nearly J=0 iridate Ba3ZnIr2O9.
A. Nag et. al. Phys. Rev. Lett. 116, 375501 2016
[2] Electronic structure and spin-orbit driven magnetism in d4.5 insulator Ba3YIr2O9
S.K. Panda, S. Bhowal, Ying Li, S. Ganguly, Roser Valenti, L. Nordstrom, and I. Dasgupta
Physical Review B 92, 180403 (Rapid Communication), 2015.
[3] S. Bhowal, S. Ganguly and I. Dasgupta (To be published)

SESSION A1

Establishing J_{eff} =3/2 Ground State in a Lacunar Spinel $GaTa_4Se_8$

Myung Joon Han[1]

[1]*Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 305-701, Korea*

$GaTa_4Se_8$ has been known as a 'paramagnetic Mott' insulator and exhibits superconducting transition under pressure. Its low temperature behaviors found in susceptibility and specific heat have not yet been clearly understood. The important first step to study these phases and the relationship between them is to identify the electronic structure and the nature of its magnetic moment if there is any. By using first-principles band structure calculation and resonant inelastic x-ray scattering technique, we show that $GaTa_4Se_8$ is a novel 'J_{eff}=3/2 Mott' insulator in which spin-orbit interaction plays a key role to form a gap together with electronic correlation. Based on this new picture, we will revisit and discuss the intriguing behaviors previously reported in this material and will compare with other related materials.

SESSION A1

Quantum spin liquids on kagome XXZ antiferromagnets

Subhro Bhattacharjee
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The nearest neighbour S=1/2 Heisenberg antiferromagnet on Kagome lattice is a good candidate for a quantum spin liquid ground state. Recent numerics for a class of S=1/2 XXZ antiferromagnets shows a rich structure of the phase diagram that includes the isotropic Heisenberg point. In this talk, I shall use the connection between the XXZ model, as seen in the numerics, to discuss about the possible spin liquid ground states of such models, with particular emphasis on a chiral spin liquid state, which we obtain by gauging a U(1) symmetry protected phase of bosons.

SESSION A1

Spin-orbit Coupled Isospin 1/2 Quantum Magnetism in Frustrated Magnets

Jae-Hoon Park
Max Plank POSTECH Center for Complex Phase Materials
Department of Physics & Division of Advanced Materials Science, POSTECH

In cooperation with the crystal field, large spin-orbit coupling introduces the Kramers doublet, and the magnetism is described with the so-called spin-orbit coupled isospin 1/2, and the system often displays novel quantum magnetism behaviors. In this talk, I will discuss recent results of spin-orbit coupled isospin quantum magnetism in a geometrical frustrated pyrochlore $Ba_3Yb_2Zn_5O_{11}$ and a layered Kitaev lattice α-$RuCl_3$.

SESSION B1

SESSION B1

Surface to bulk Fermi arcs via Weyl nodes as topological defects

Kwon Park
KIAS

A hallmark of Weyl semimetal is the existence of surface Fermi arcs. An intriguing question is what determines the connectivity of surface Fermi arcs, when multiple pairs of Weyl nodes are present. To answer this question, we show that the locations of surface Fermi arcs are predominantly determined by the condition that the Zak phase integrated along the normal-to-surface direction is π. The Zak phase can reveal the peculiar topological structure of Weyl semimetal directly in the bulk. Here, we show that the winding of the Zak phase around each projected Weyl node manifests itself as a topological defect of the Wannier-Stark ladder, energy eigenstates under an electric field. Remarkably, this leads to bulk Fermi arcs, open line segments in the bulk spectra. Bulk Fermi arcs should exist in conjunction with surface counterparts to conserve the Weyl fermion number under an electric field, which is supported by explicit numerical evidence.

[Ref.] K. W. Kim, W.-R. Lee, Y. B. Kim, and K. Park, *Nat. Commun.* **7**, 13489 doi: 10.1038/ncomms13489 (2016).

SESSION B1

Tip-induced Superconductivity on the Weyl Semimetal TaAs

Leena Aggarwal [1*], Sirshendu Gayen [1*], Shekhar Das [1*], Ritesh Kumar [1*], Vicky Suß [2], Chandra Shekhar [2], Claudia Felser [2], and **Goutam Sheet** [1*]

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ABSTRACT

A Weyl semimetal is a topologically non-trivial phase of matter that hosts mass-less Weyl fermions, the particles that remained elusive since their theoretical discovery in 1929. The Weyl semimetals exhibit unique transport properties and remarkably high surface spin polarization. These materials are also known to exist near topological phase boundaries and consequently, it is expected that new exotic phases of matter can be realized on them. In this talk, I will discussed the emergence of a unique superconducting phase at mesoscopic point contacts between elemental normal metals and high quality single crystals of the Weyl semimetal TaAs, where neither TaAs nor the metals are superconductors. The critical temperature (Tc) of such superconducting point contacts is found to be more than 7 K. Andreev reflection spectroscopy of the point contacts reveals a superconducting gap of 1.2 meV that coexists with a high transport spin polarization of 60 %. This indicates that a highly spin polarized supercurrent may flow through mesoscopic point contacts on TaAs. Therefore, the Weyl semimetals might find application in spintronic devices.

References:

1. Leena Aggarwal , Sirshendu Gayen , Shekhar Das , Ritesh Kumar ,Vicky S uß , Chandra Shekhar , Claudia Felser, and Goutam Sheet, arXiv: 1607:05131.(to appear, Nature Communications)

2. Leena Aggarwal, Abhishek Gaurav, Gohil S. Thakur, Zeba Haque, Ashok K. Ganguli & Goutam Sheet, Nature Materials 15 (2016), 32".

SESSION B1

Angle-Resolved Photoemission Study of Conducting Delafossite $PdMO_2$ (M=Co, Cr)

Han-Jin Noh[1]
[1]*Department of Physics, Chonnam National University*

Conducting delafossites $PdMO_2$ (M: trivalent transition metal ions) provide an interesting playground for the study of the interaction between conduction electrons and other degrees of freedom. Due to the quasi-two-dimensionality of the crystal structure, they show a highly anisotropic behavior in the electric conductivity. In addition, their in-plane conductivities are the highest among conducting oxides and are even higher than that of Pd metal in spite of the presence of correlated insulating MO_2 layers. Further, when the trivalent metal ions have a local magnetic moment as in the case of Cr^{3+}, more plentiful physical phenomena are expected to appear not only from the spin interactions on two-dimensional triangular lattices but also from the interactions between the conduction electrons and the local spins. In this talk, we take $PdCoO_2$ and $PdCrO_2$ as a prototypical example for non-magnetic/magnetic conducting delafossite, respectively, and present our experimental and theoretical data to understand their electronic/magnetic properties.

[1] Noh *et al.*, Phys. Rev. Lett. 102, 256404 (2009).
[2] Noh *et al.*, Phys. Rev. B 80, 073104 (2009).
[3] Ok *et al.*, Phys. Rev. Lett. 111, 176405 (2013).
[4] Noh *et al,* Scientific Reports 4, 3680 (2014).
[5] Glamazda *et al*., Phys. Rev. B 90, 045122 (2014)

SESSION B1

Stability and structural phase transition in transition metal dichalcogenides

Young-Woo Son
Korea Institute for Advanced Study, Seoul, Korea

Since the successful exfoliation of two dimensional (2D) crystals in 2005, the physical properties of many layered materials in their single layer as well as bulk forms have been attracted serious attentions owing to their versatile electronic properties. Among them, the transition metal dichalcogenides (TMDs) are interesting for their bulk and few layers electronic properties, such as non-saturating extremely large magnetoresistance, existence of type-II Weyl semi metallic (WSM) phase in the bulk and quantum spin Hall phase in their few layers form. In this talk, I present a theoretical study showing that $MoTe_2$ and WTe_2 have different structural phase transition behaviors owing to different valence configuration in Mo and W. To calculate the structures correctly, we use an advanced self-consistent van der Waals density functional method with the spin-orbit interaction. It is found that the both compounds favor the orthorhombic-phase over the monoclinic-phase as their ground configuration, showing the best agreement with the available experimentally determined crystal structures. We demonstrate that the $MoTe_2$ has a noticeable transition energy barrier between the two phases while the energy barrier does not exist in the phase transition of WTe_2, thus demonstrating an energetic evidence for the observed phase transitions behavior. With our calculation scheme and the structural parameters without any experimental input, we show that $MoTe_2$ is a robust type II WSM while WTe_2 is not, highlighting a subtle relationship between the topological semimetal phase and atomic structures in TMDs. We expect that our calculation scheme may provide a more concrete theoretical basis for future development in discovering topological phase in layered materials.

SESSION B2

SESSION B2

Electric field control of octahedra rotation on the surface of Sr_2RuO_4

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[2]*Department of Physics and Astronomy, Seoul National University, Seoul, Korea*

MO_6 octahedron is the building block of many transition metal oxides and contributes to the electronic states near the Fermi energy. As a result, MO_6 dominantly determines the electronic properties. MO_6 octahedra in these materials are quite often rotated. The octahedra rotation was found to greatly affect the electronic structure, causing exotic phenomena such as metal insulator transition. Therefore, controlling the octahedra rotation would be interesting in both fundamental science and application point of views.

The RuO_6 octahedra in the surface layer of Sr_2RuO_4 are known to be rotated. By using alkali metal dosing method and angle resolved photoemission, we show that we can control the rotation of the surface RuO_6 octahedra. We find the RuO_6 octahedra rotation angle decreases as K is dosed on the surface of Sr_2RuO_4, resulting in disappearance of the folded bands. We also investigated the phenomenon by using the low energy electron diffraction and provide a direct evidence for the reduction in the rotation angle. The origin of the reduced octahedra rotation will be discussed in conjunction with density functional calculation study.

SESSION B2

Correlated non-Gaussian phase fluctuations in LaAlO3/SrTiO3 heterointerfaces

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We probe the existence of large, correlated non-Gaussian phase fluctuations in the vicinity of the superconducting phase transition in the conducting layer residing at the interface of $LaAlO_3/SrTiO_3$ heterostructures. The non-Gaussian fluctuations appear between the Berezinskii-Kosterlitz-Thouless transition temperature T_{BKT} and the mean-field transition temperature T_C. Subsequent theoretical analysis reveals that non-Gaussianity arises predominantly due to the percolative transition of a Josephson coupled network of superconductors. Our results confirm that the superconductivity in this system is confined to two dimensions. Our analysis suggests that the non-Gaussian components in resistance fluctuation is a generic feature of two-dimensional inhomogeneous superconductors close to the transition temperature and provides a novel means to explore the BKT transition in two-dimensional inhomogeneous superconductors.

SESSION B2

Oxygen octahedral tilting engineering of epitaxial thin films

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For ABO_3 perovskite oxides consisting of oxygen octahedra and two kinds of positive ions (A and B), a tilt of oxygen octahedra can be critical to determine electrical or magnetic properties behaviors. Especially, both an angle and a direction of tilt involve changes in a bonding length and an angle of B-O-B via an overlap among *d* orbitals and localized charge carriers. We controlled oxygen octahedral tilt angle inside the $BiFeO_3$ thin films via oxygen octahedral coupling with $SrRuO_3$ bottom layers depending on growth condition, especially oxygen partial pressure. We found that the crystallographic structure and oxygen octahedral tilting pattern of $BiFeO_3$ layers can be equivalent to those of $SrRuO_3$ layers. At the room temperature, the positive piezoresponse of tetragonal $BiFeO_3$ film is 1.6 times larger by than that of tilted $BiFeO_3$ film while the saturation magnetization of non-tilted $BiFeO_3$ film is 2.5 times smaller by than that of tilted $BiFeO_3$ film.

Keywords: oxygen octahedral tilting, ferroelectric thin film, time-resolved X-ray microdiffraction

SESSION B2

Emergent transport and magnetic properties driven by electronic redistributions in some transition-metal oxide systems

Debraj Choudhury
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Charge-transfer processes often lead to novel physical properties. Using examples of some transition metal oxide systems, like in bulk $KCuO_2$ as well as in thin-film $LaTiO_3/LaNiO_3$ and $YTiO_3/CaTiO_3$ hetero-interfaces, emergent physical properties which include the uncorrelated covalent-insulating and diamagnetic state in bulk $KCuO_2$, the engineered Mott ground state in $LaTiO_3/LaNiO_3$ superlattice and interface driven metallicity in $YTiO_3/CaTiO_3$ hetero-interfaces will be discussed. In all the above cases, the nature and importance of electronic redistributions either within a bulk unit-cell or across interfaces will be discussed.

SESSION B2

Tailoring Direct and Converse Magnetoelectric Effects Toward Room Temperature in Hexaferrites

Kee Hoon Kim

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Despite its technical and fundamental importance, large variation of macroscopic magnetization by an electric field (E) (converse magnetoelectric, ME, effects) has rarely been achieved in bulk materials and remains a considerable challenge. Here, we present recent progresses of the subject in multiferroic ferrites with the hexagonal structure; room temperature modulation and large reversal of magnetization (M) by E have been realized in the Co_2Y-type and Zn_2Y-type hexaferrites, respectively. In those systems, a transverse conical spin state and a competing alternating longitudinal spin state play a major role in exhibiting remanent M and electric polarization. In the Zn_2Y-type, upon sweeping E through the range of ±2 MV m^{-1}, M varied quasi-linearly in the range of ±2 μ_B per f.u., resulting in the reversal of M. Moreover, the remanent M exhibited non-volatile changes of ±0.15 μ_B per f.u., depending on the history of the applied electric fields. The strong modulation and non-volatile two-states of M at zero magnetic field were observable up to ~150 K. We also present how one can increase such large converse ME effect toward room temperature by tailoring spin properties in the Co_2Y-type hexaferrites. Based on the above progresses, we suggest that soft ferrimagnetism with small magnetic anisotropy and the related transverse conical state with high ordering temperature are key ingredients to achieve the giant converse magnetoelectric effect at room temperature [1-4]. In close collaboration with Changbae Park, Kwangwoo Shin, Saehwan Chun, Yisheng Chai, Sangil Kwon, Shoonchil Lee, Jae Ho Chung, and Jae Hoon Park.

Reference:

[1] C. B. Park et al., preprint; [2] Y. S. Chai et al., Nature comm. 5, 4208 (2014); [3] Sae Hwan Chun *et al*., Phys. Rev. Lett. 108, 177201 (2012); *ibid,* 104, 037204 (2010)

SESSION C1

SESSION C1

On the nature of magnetic ground state in $CoAl_2O_4$: Magnetoelectric Study

A. Sundaresan
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Magnetic ions located at tetrahedrally coordinated *A*-site of a normal spinel, AB_2X_4 can be frustrated, because of a competition between the nearest-neighbor (J_1) and next-nearest-neighbor (J_2) exchange interactions. In the limit of $J_2 < J_1/8$, a collinear antiferromagnetic ordering is expected, while a spiral spin liquid state appears for $J_2 > J_1/8$. For example, Co_3O_4 and $MnAl_2O_4$ with $J_2/J_1 \sim 0.019$ and 0.09, respectively, exhibit a well-defined long range collinear antiferromagnetic ordering, while $MnSc_2S_4$ has $J_2/J_1 \sim 0.85$ and exhibits a spiral spin liquid ground state. The ground state of the A-site magnetic spinel, $CoAl_2O_4$, has been reported to be a collinear antiferromagnetic ordering or a spiral spin liquid state, because of the competing exchange interactions with $J_2/J_1 \sim 1/8$ and inversion between A and B-site cations. In this talk, I will present magnetoelectric properties $CoAl_2O_4$ with varying anti site disorder or inversion and address the nature of ground state.

SESSION C1

Incarnation of Majorana fermions in Kitaev quantum spin lattice

Seung-Hwan Do[1,2], Sang-Youn Park[1], Junki Yoshitake[3], Joji Nasu[4], Yukitoshi Motome[3], Y. S. Kwon[5], D. T. Adroja[6], D. Voneshen[6], Kyoo Kim[1], T.-H. Jang[1], J.-H. Park[1,7,8*], Kwang-Yong Choi[2*] and **Sungdae Ji[1,7*]**

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The seminal work of Anderson triggered a great deal of theoretical and experimental efforts to search for the novel quantum spin liquid (QSL) states in matters, and it has become one of central issues in contemporary condensed matter physics. The QSL state, a long-range quantum entangled state, is represented by a topological order and fractionalization of constituent magnetic moments. While the most QSL states have been described by deconfined spinons as an elementary excitation in frustrated magnets, Kitaev's QSL state is exactly derived by fractionalizing the spin excitation into Majorana fermions in a perfect 2-dimensional honeycomb lattice, the so-called Kitaev lattice, with the ansatz of bond dependent Ising-like spin interaction. In the past decade, experimental realization of the fascinating Kitaev model has been eagerly pursued. In this talk, I will present the experimental evidences of fractionalized Majorana fermions in a high quality α-$RuCl_3$ single crystal. Extensive thermodynamic and neutron spectroscopic measurements directly proved fractionalized Majorana fermion excitations as a result of thermal fractionalization of J_{eff} = ½ pseudospins.

SESSION C1

Heterostructures of 3d-5d Double Perovskites: Potential Candidates for Confined Half-metallicity & High-T Quantum Anomalous Hall States

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Considering the specific case of double perovskite (DP) compound Ba_2FeReO_6 (BFRO) made out of 3d transition metal (TM) ion Fe and 5d transition metal ion Re, we show that by embedding the BFRO in the band insulator $BaTiO_3$ (BTO) in a heterostructure quantum well geometry, the electrons of the DP can be confined to two dimensions due to potential energy mismatch created between the TM ions in the DP and in the insulating oxide. The 2D confinement achieved in the BTO/BFRO/BTO quantum well structures provides significant improvement over that in polar catastrophe-driven LAO/STO in terms of (i) 2D confinement length is an order of magnitude smaller, (ii) complete spin polarization of the 2D electron gas (2DEG), (iii) polarity control of the 2DEG, suggestive of magnetoelectric coupling, and (iv) realization of ultrathin half metals with topological bands.

Extending on the idea of driving topologically non-trivial features, we further find that BFRO/BTO geometry with termination at Fe layer, leads to formation of a C=1 quantum anomalous hall insulator (QAHI) state with a large topological gap $\sim$100meV and an estimated FM $T_c \sim$ 315K. The large gap and high T_c should enable practical use of our proposal. Our study identifies three key ingredients for the formation of this QAHI, which should be broadly applicable to other t_{2g} physics dominated 3*d*-5*d* or 3*d*-4*d* half-metallic DPs like Sr_2FeMoO_6 and Sr_2CrWO_6.

Work done in collaboration with Santu Baidya, Arun Paramekanti and Umesh Waghmare.

[1] Santu Baidya, Umesh V. Waghmare, Arun Paramekanti, and Tanusri Saha-Dasgupta, Phys. Rev. B **92**, 161106(R) (2015).

[2] Santu Baidya, Umesh V. Waghmare, Arun Paramekanti, and Tanusri Saha-Dasgupta, Phys. Rev. B **94**, 155405 (2016).

SESSION C1

Pairing Mechanism of the FeSe-monolayer and related Systems: Dynamical Tuning of Pairing Cutoff Energy.

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Since the discovery of the Fe-based superconductors 8 years ago, still the pairing mechanism of this new family of superconducting material is under debate. More recently, the discovery of the FeSe/SrTiO3 monolayer system (Tc~60-100K) and other heavily electron-doped iron selenide (HEDIS) compounds such as $A_xFe_{2-y}Se_2$ (A=K, Rb,Cs, Tl, etc.) (Tc~30-40K), $(Li_{1-x}Fe_xOH)FeSe$ (Tc~40K) , and pressurized bulk FeSe (Tc~37K) are posing a serious challenge to our understanding of the Iron-based superconductors (IBS). The most puzzling common feature of the HEDIS compounds is that they are missing the hole Fermi surfaces.
In this talk, I will propose a unified pairing mechanism for all these compounds with introducing a new concept: namely, dynamical tuning of pairing cutoff energy. I will show how the RG process actively tune the original pairing scale ω_{sf} down to the incipient band energy ε_b, and then form the s^{++}-wave gap state only with the electron pockets. In this way, the system can achieve the maximum T_c, potentially reserved in the systems and becomes robust against the impurity scattering.

Ref. Y. Bang, arXiv:1605.01509 (in press in NJP)

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