MSM 19

11th International Conference on

Magnetic and Superconducting Materials

August 17–24, 2019

GECE(#38), Seoul National University, Seoul, Korea

Program & Abstracts

Hosted by

The Korean Magnetics Society

Organized by

KIAS Korea Institute for Advanced Study

apctp 아시아태평양이론물리센터 asia pacific center for theoretical physics

Seoul National University Department of Physics & Astronomy

IAP Institute of Applied Physics Seoul National University

Supported by

KOFST Korean Federation of Science & Technology Societies

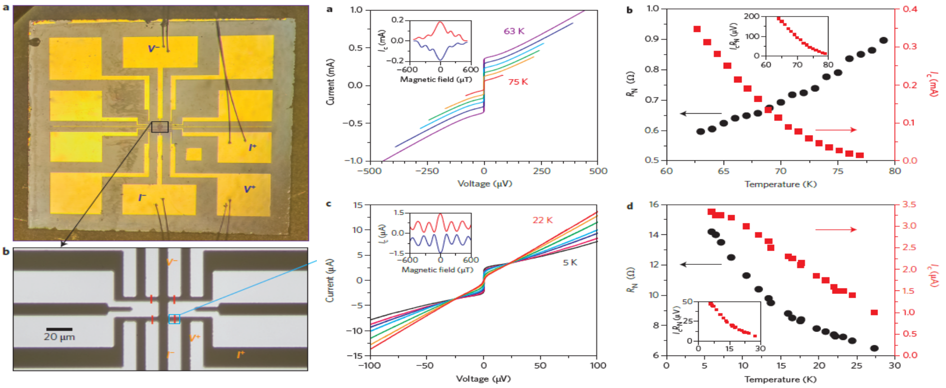
Korea Tourism Organization

SEOUL

ZEISS Helium Ion Microscope

Nano Josephson superconducting tunnel junctions in Y-Ba-Cu-O direct-patterned with a focused Helium Ion Beam

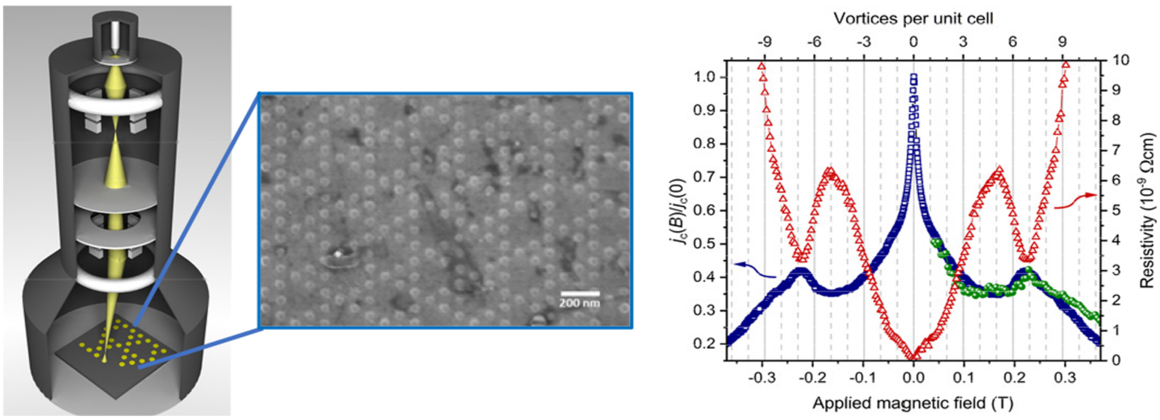
He Ion Irradiated Josephson Junctions   S.A. Cybart et. al., Nature Nanotechnology (2015)



- Josephson junctions on Yttrium barium copper oxide ($YBa_2Cu_3O_7$) films on sapphire.
- SNS and SIS Junctions fabricated at doses of 2 x 10^{16} ions/cm^2 and 6 x 10^{16} ions/cm^2

Ultradense trailored vortex pinning arrays in superconducting $YBa_2Cu_3O_{7-\delta}$ thin films created by focused He Ion beam irradiation for fluxonics applications

B.Aichner, B. Muller, M. Karrer, V.R.Misko, F.Limberger K.L. Mletschnig, M.Dosmailov, J.D.Pedarnig, F.Nori, R.Kleiner, D.Koelle and W.Lang   Applied Nano Materials (2019)



Using the focused beam of a helium ion microscope, they have fabricated periodic patterns of dense pinning centers with spacings as small as 70nm in thin films of the cuprate superconductor $YBa_2Cu_3O_{7-\delta}$.

Contact Info. - ZEISS Korea

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Seeing beyond

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ORAL SESSION

POSTER SESSION

WELCOME MESSAGE

On behalf of the Committees for the 11th International Conference on Magnetic and Superconducting Materials, I am pleased to welcome you all to the MSM19 to be held in Seoul, Korea, from August 17 to 24, 2019.

As you are probably aware, the MSM has experienced significant growth over the last 20 years since the 1st MSM has been held in 1999 in Iran. Now the MSM has become one of the foremost international conferences in the fields of magnetism and superconductivity, affording participants a great opportunity to share and learn most recent research outcomes and technological trends.

The Organizing Committee is committed to hosting the scientific 'must-attend' event of 2019, with a broad range of plenary and invited lectures and oral & poster presentations. MSM19 opens discussions on latest advances in the fundamental and applied science of magnetism and superconductivity, and many other relevant topics.

The excellence of this year's program is derived from the hard works of the authors and presenters, and members of Organizing Committees.
I would like to deliver my special appreciation to all of them.

Seoul, the 600-year old capital of the Republic of Korea, is an ineffable international city where traditional and modern cultures coexist side-by-side in perfect harmony. Seoul is home to 266 cultural properties including five grand royal palaces and is also a proud center of the "Korean Wave" pop culture phenomenon that is beloved by global citizens across borders.

Please join the 11th MSM with your colleagues and friends. We are sure that you will have a memorable and informative conference. We look forward to having the pleasure of welcoming you all to Seoul!!

Kee Hoon Kim

MSM19 Conference Chair
Director, Center for Novel States of Complex Materials (CeNSCMR)
Professor, Dept. of Physics and Astronomy, Seoul National University

OVERVIEW

The MSM conference has started as a regional scientific conference on magnetism and superconductivity and their materials applications in 1999 with the objective of strengthening scientific relations among the scientists in the middle eastern region and with the advanced world scientific community. Ever since the first conference, which was dubbed as "a First World Conference in a Third World Country", a total of 10 subsequent MSM conferences have been organized in many countries spread in Asia, Africa, and Europe with the co-chairmanship of Prof. M. Akhavan. By having the first host in Seoul in this year of 2019, we expect that the MSM conference will further develop as one of the foremost international conferences on magnetism and superconductivity with high scientific quality and a historic tradition of binding truly international scholars together with scientific curiosity and researches on the subject. As original MSM conferences have envisioned, we hope that the MSM conference can bring together regional and international groups of researchers and technologists to fully discuss new results and current problems in the area of superconductivity and magnetism. Through the sharing of enchanting experiences with scientists around the world, we hope that we all could fully benefit from excellent natural and human resources across the whole globe.

1st	**MSM99**	Tehran, Iran September 27-30, 1999	**6th**	**MSM09**	Kolkata, India November 11-14, 2009
2nd	**MSM01**	Irbid, Jordan September 9-13, 2001	**7th**	**MSM11**	Selangor, Malaysia October 11-13, 2011
3rd	**MSM03**	Tunisia September 1-4, 2003	**8th**	**MSM13**	Sfax, Tunisia September 2-5, 2013
4th	**MSM05**	Morocco September 5-8, 2005	**9th**	**MSM15**	Antalya, Turkey April 30-May 3, 2015
5th	**MSM07**	Khiva, Uzbekistan September 25-30, 2007	**10th**	**MSM17**	Tehran, Iran September 18-21, 2017

Title	11th International Conference on Magnetic and Superconducting Materials (MSM19)
Date	August 17(Sat) - 24(Sat), 2019
Venue	Global Education Center for Engineers Convention (GECE #38) Seoul National University
Hosted by	The Korean Magnetics Society
Organized by	Korea Institute for Advanced Study Asia-Pacific Center for Theoretical Physics Department of Physics & Astronomy, Seoul National University Institute of Applied Physics
Website	www.msm19.org

COMMITTEE

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K. Shimizu	Osaka University	Japan

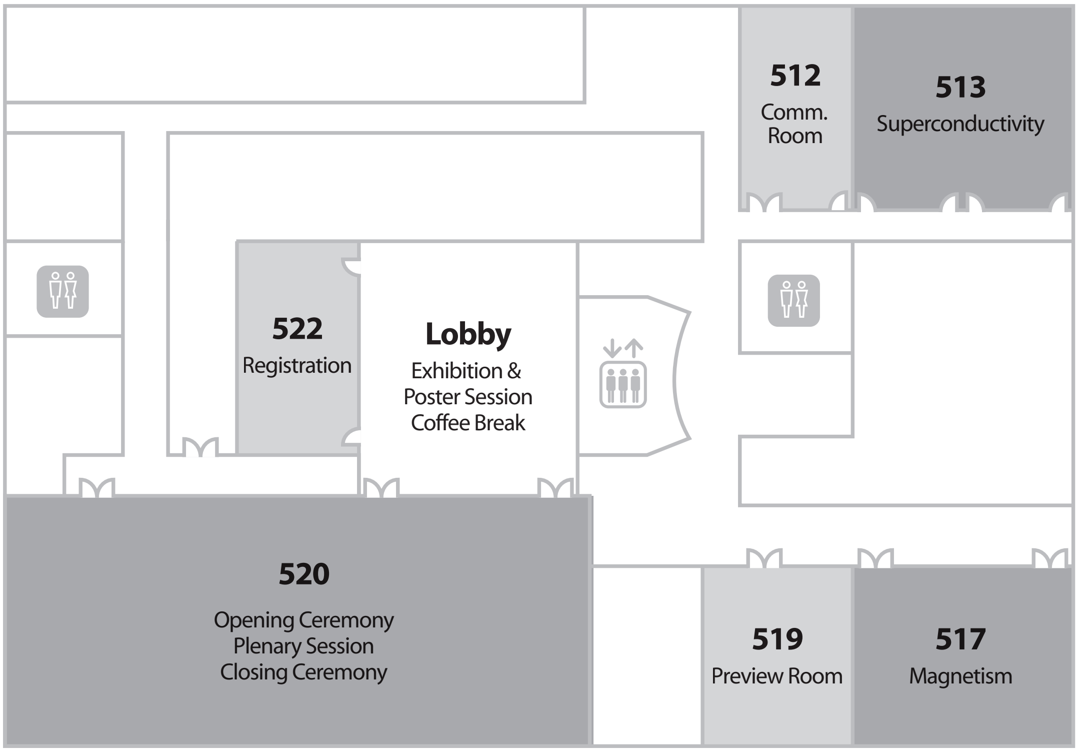
PROGRAM AT A GLANCE

	SATURDAY Aug 17	SUNDAY Aug 18		MONDAY Aug 19		TUESDAY Aug 20	
		513	517	513	517	513	517
AM		**Registration** *<Room 522>*		**Opening Ceremony Plenary Session** 08:30-09:50 *< Room 520 >*		**Superconductivity** 09:00-10:30	**Magnetism** 09:00-10:30
				Superconductivity 10:00-10:30	**Magnetism** 10:00-10:30		
				Coffee Break 10:30-10:50			
				Superconductivity 10:50-12:20	**Magnetism** 10:50-12:20	**Superconductivity** 10:50-12:20	**Magnetism** 10:50-12:20
PM		**Tutorial Session**		**Lunch** 12:20-14:00 *Move to the building(#75-1) across the street (outside)*			
	Registration *<Room 522>*	**I. Eremin** 12:30-15:30	**M. Farle** 12:30-15:30	**Superconductivity** 14:00-16:30	**Magnetism** 14:00-16:45	**Superconductivity** 14:00-15:30	**Magnetism** 14:00-15:30
		Coffee Break 15:30-16:00				**Coffee Break** 15:30-15:50	
		S.-Q. Shen 16:00-19:00	**H.-W. Lee** 16:00-19:00	**Poster Session** 16:30-18:00 *< Lobby - 5F >*		**Superconductivity** 15:50-17:50	**Magnetism** 15:50-17:50
		Beer Party 19:00-20:00 *< BBQ Cafe - 1F >*		**Reception** 18:00-19:30 *< BBQ Café - 1F >*		**Night Tour** 18:00-22:00 *< Meeting Point - 1F >*	

WEDNESDAY Aug 21		THURSDAY Aug 22		FRIDAY Aug 23		SATURDAY Aug 24
513	517	513	517	513	517	
Superconductivity 09:00-10:30	**Magnetism** 09:00-10:30	**Superconductivity** 09:00-10:30	**Magnetism** 09:00-10:30	**Superconductivity** 09:00-10:30	**Magnetism** 09:00-10:30	**Free Discussion**
Coffee Break 10:30-10:50						
Superconductivity 10:50-12:20	**Magnetism** 10:50-12:20	**Superconductivity** 10:50-12:20	**Magnetism** 10:50-12:20	**Superconductivity** 10:50-12:20	**Magnetism** 10:50-12:20	
Lunch 12:20-14:00 *Move to the building(#75-1) across the street (outside)*						
DMZ Tour 13:00- 19:30 *< Meeting Point - 1F >*		**Superconductivity** 14:00-16:45	**Magnetism** 14:00-16:45	**Superconductivity** 14:00-16:30	**Magnetism** 14:00-16:30	
		Poster Session 16:30-18:00 *< Lobby - 5F >*		**Closing** 16:30-17:30 *< Room 520 >*		
		Gala Dinner 18:00-20:00 *< Restaurant - B1>*				

VENUE

Global Education Center for Engineers Convention (GECE #38)
Seoul National University



GECE
글로벌공학교육센터
Global Education Center for Engineers

PLENARY & TUTORIAL SPEAKERS

Plenary Speaker

"The Quest for Majorana Fermions"

Anthony J. Leggett

University of Illinois at Urbana-Champaign, USA

WHEN 09:00-09:50, August 19 (Mon)

WHERE Rm 520, GECE #38

Tutorial Speakers

"Theory of Unconventional Superconductors: Multiband Aspects"

Ilya Eremin

Ruhr-University Bochum, Germany

WHEN 12:30-15:30, August 18 (Sun)

WHERE Rm 513, GECE #38

"Magnetic Excitations and Exciting Magnetism at the Nanoscale"

Michael Farle

University Duisburg-Essen, Germany

WHEN 12:30-15:30, August 18 (Sun)

WHERE Rm 517, GECE #38

"Introduction to Topological Insulators and Semimetals"

Shun-Qing Shen

The University of Hong Kong, Hong Kong

WHEN 16:00-19:00, August 18 (Sun)

WHERE Rm 513, GECE #38

"Spintronics: Spin Current and Magnetization Dynamics"

Hyun-Woo Lee

Pohang University of Science and Technology, Korea

WHEN 16:00-19:00, August 18 (Sun)

WHERE Rm 517, GECE #38

REGISTRATION

Registration Desk

Rm 522, Global Education Center for Engineers Convention (GECE #38)

SAT	August 17	15:00-18:00
SUN MON TUE	August 18, 19, 20	08:00-18:00
WED	August 21	08:00-14:00
THU	August 22	08:00-18:00
FRI	August 23	08:00-17:00

Onsite Registration Fee

Regular	USD 600 | KRW 600,000
Student	USD 400 | KRW 400,000
Accompanying Person	USD 150 | KRW 150,000

Registration Fee Includes

Regular	Tutorial, Technical Sessions, Lunch, Beer Party, Reception, Night Tour, Gala Dinner ★ Optional: DMZ Tour (USD 50)
Student	Tutorial, Technical Sessions, Lunch, Beer Party, Reception, Gala Dinner ★ Optional: Night Tour (USD 30) | DMZ Tour (USD 50)
Accompanying Person	Lunch, Beer Party, Reception, Gala Dinner ★ Optional: Night Tour (USD 30) | DMZ Tour (USD 50)

Name Badge

01 For security purposes, badge is required to be admitted to all areas during the conference.

Coupons

02
- Beverage (Beer Time only)
- Souvenir
- Gala Dinner (applicant only)

Receipt & Certificate

03 Registration receipt and a certificate of attendance are provided.

Program & Abstract Book

04 Useful information and abstracts of MSM19

USEFUL TIPS

Lunch

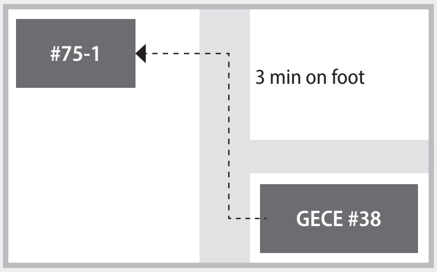
Don't forget to bring your name badge.

WHEN

MON-FRI Aug 19-23 12:20-14:00

WHERE

#75-1 (Outside: the building across the street)



REMARK

Please collect your lunch coupon at the entry of the lunch place. (Lunch coupon will be distributed only during the lunchtime.)

Doughnut Time

Doughnut & coffee will be provided every morning.

WHEN

MON	Aug 19	08:00-08:20
TUE-FRI	Aug 20-23	08:30-08:50

WHERE

5F Lobby, GECE #38

Wi-Fi Access

NETWORK convention

PASSWORD snusnu38

Mobile Charging Service

Mobile device charging is available at the registration desk.

Coffee

Fresh coffee and tea will be served during the break times.

WHEN

SUN	Aug 18	15:30-16:00
MON-FRI	Aug 19-23	10:30-10:50
TUE	Aug 20	15:30-15:50

WHERE

5F Lobby, GECE #38

Preview Room

Internet and printing service are available.

WHEN

SUN	Aug 18	11:00-18:00
MON-FRI	Aug 19-23	08:00-18:00

WHERE

Rm 519, GECE #38

Message Board

Message board will be set up at the conference room lobby (5F) so that participants can get useful information.

Parking

Parking ticket will be provided at the registration desk to the MSM19 participants during the conference.

Abstract e-Book

You can download your abstract from the website. www.msm19.org

Shuttle Bus Service

Complimentary shuttle bus service will be offered to/from all **MSM19 official hotels**. Travel time from hotel boarding areas to Seoul National University, including waiting, is approximately 10-55 minutes. Peak traffic time is expected to be 8:00 AM – 9:30 AM and 6:00 PM – 7:00 PM.

HOTEL → VENUE	Shilla Stay Guro → Tran Blue Hotel → Venue	Hoam Faculty House → Gwanak Residence → Venue
18 (SUN)	11:00 → 11:25 → 11:55	11:30 → 11:35 → 11:40
19 (MON)	07:10 → 07:35 → 08:05	07:50 → 07:55 → 08:00
20 (TUE)	07:40 → 08:05 → 08:35	08:20 → 08:25 → 08:30
21 (WED)	07:40 → 08:05 → 08:35	08:20 → 08:25 → 08:30
HOTEL → VENUE	**Shilla Stay Guro → Tran Blue Hotel → Venue**	**Gwanak Residence → Venue**
22 (THU)	07:40 → 08:05 → 08:35	08:25 → 08:30
23 (FRI)	07:40 → 08:05 → 08:35	08:25 → 08:30
VENUE → HOTEL	**Venue → Tran Blue Hotel → Shilla Stay Guro**	**Venue → Gwanak Residence → Hoam Faculty House**
18 (SUN)	20:20	20:20
19 (MON)	19:45	19:45
20 (TUE)	18:15 (Gwanak Residence → Hoam Faculty House → Tran Blue Hotel → Shilla Stay Guro)	
21 (WED)	14:00 (Gwanak Residence → Tran Blue Hotel → Shilla Stay Guro)	
VENUE → HOTEL	**Venue → Tran Blue Hotel → Shilla Stay Guro**	**Venue → Gwanak Residence**
22 (THU)	20:10	20:10
23 (FRI)	17:45	17:45

SOCIAL PROGRAMS

Beer Party

The welcome reception will be an excellent chance to make new friends and expand partnerships. Come and join this entertaining icebreaker of MSM19.

WHEN 19:00-20:00, August 18 (Sun)

WHERE 1F BBQ Café, GECE #38

Opening Ceremony

The opening ceremony will mark the official beginning of conference and all participants are cordially invited. Be a part of the official opening celebration.

- Opening Address by MSM19 Conference Co-Chair
- Welcoming Addresses by President of Seoul National University & President of the Korean Magnetics Society

WHEN 08:30-08:50, August 19 (Mon)

WHERE Rm 520, GECE #38

Reception

The welcome reception will celebrate the role of the 11th MSM19 as a major networking platform of global magnetic and superconducting materials community. Join us for our fresh food, Korean traditional champagne and socializing whilst.

WHEN	18:00-19:30, August 19 (Mon)
WHERE	1F BBQ Café, GECE #38

Night Tour

Regular participants can join this program for free of charge. Student participants & Accompanying persons may purchase a tour ticket (USD 30). Do not miss this chance to enjoy the entire city of Seoul at N Seoul Tower!

WHEN	18:00-22:00, August 20 (Tue)
WHERE	Deoksugung Palace → N Seoul Tower
REMARK	• Please come to the designated meeting point (1F) on time. • On-site conference tour reservation needs to be made one day prior to the scheduled tour. • A sandwich meal is included in the night tour.

Sponsored by KOREA TOURISM ORGANIZATION

DMZ Tour

Regular & Student participants and Accompanying persons may purchase a tour ticket (USD 50) to join DMZ tour ranked 1st on a tourist preference.

WHEN	13:00-19:30, August 21 (Wed)
WHERE	Imjingak Park → The Unification Bridge → DMZ Theater and Exhibition Hall → The 3rd Infiltration Tunnel → Dora Observatory & Dorasan Station
REMARK	• Please come to the designated meeting point (1F) on time. • On-site conference tour reservation needs to be made one day prior to the scheduled tour. • Please note that the participants MUST BRING ID to enter the DMZ area.

Sponsored by KOREA TOURISM ORGANIZATION

Gala Dinner

The Gala Dinner will be a great opportunity to network with colleagues in pleasant surroundings. Enjoy the climax of MSM19 with an excellent dinner.

WHEN	18:00-20:00, August 22 (Thu)
WHERE	B1, GECE #38
PROGRAM	Congratulatory Addresses, MSM19 Report, Celebration Performance
MENU	Korean Style Set Menu

Closing Ceremony

This ceremony is a chance for you to say goodbye to your friends, look back through this year's MSM. The winners of the MSM19 Awards will be announced!

WHEN	16:30-17:30, August 23 (Fri)
WHERE	Rm 520, GECE #38
PROGRAM	Summaries of Two Topics in MSM19, MSM19 Awards, Closing Address

PRESENTATION GUIDELINES

Oral Presentation

Presentation Time

- Invited Presentation: 25 min. presentation + 5 min. Q&A
- Oral Presentation: 12 min. presentation + 3 min. Q&A

Presentation File

- If you use fonts other than standard Windows Office 2016, please bring the font files along with the presentation file.
- Please bring your PowerPoint presentation file on USB memory stick and submit it to the staff of each presentation room at least 15 minutes before each session starts. The operator will load the presentation files to the laptop PC.
- Please check your presentation file at least 3 hours before your session starts to ensure your presentation file appears properly.
- If your presentation file contains animations or movies, you are advised to check over the technical matters 6 hours prior to your session.

No Camera & No Record

Please note that photo taking and video recording are strictly prohibited in the presentation room.

Poster Presentation

Presentation Day	Set-up Time	Presentation Time	Tear-down Time	Place
August 19 (Mon)	08:00-12:00	16:30-18:00	~ 21:00	Lobby (5F), GECE #38
August 22 (Thu)	08:00-12:00	16:30-18:00	~ 21:00	

- Each poster will be assigned a panel, which has its own paper's number at the conference.
- We do not specify the poster format, but each poster should include the paper title, authors, and affiliation and must fit within a 0.9m x 1.2m space.
- Stationeries such as scissor and tape are provided in poster session place.

MSM19 AWARDS

"MSM19 Awards" will be given to outstanding contributors in the field of Magnetic and Superconducting Materials among the abstracts presented at the conference. The Awardees will be announced at the closing ceremony.
You may be one of the winners of the MSM19 Best Young Scientist Awards & Best Poster Awards!

MSM19 Best Young Scientist Award	MSM19 Best Poster Award
Prize KRW 200,000	Prize KRW 100,000

MSM 19

PROGRAM SCHEDULE

Oral Session

Poster Session

MONDAY, August 19 Room 513

SUPERCONDUCTIVITY

08:30-09:50 Opening Ceremony & Plenary Session

Chair	Tuson Park (Sungkyunkwan University, Korea)

10:00-10:30 Heavy Fermions and the Chemistry of Superconducting Materials
S-0188 Zachary Fisk
INVITED *University of California, Irvine, USA*

10:30-10:50 Coffee Break

Chairs	Alexander Balatsky (Nordita/University of Connecticut, Sweden) Maw-Kuen Wu (Institute of Physics, Academia Sinica, Taiwan)

10:50-11:20 Unconventional Superconductivity and Electronic Correlations in Pr-based "Cage" Compounds
S-0184 M. Brian Maple
INVITED *University California San Diego, USA*

11:20-11:50 Hidden Quantum Critical Point and Unconventional Superconductivity in the Heavy Fermion Compound CeRhIn5
S-0781 Tuson Park
INVITED *Sungkyunkwan University, Korea*

11:50-12:20 Correlated Electrons: The Dark Energy of Quantum Materials
S-0169 Laura Greene
INVITED *Florida State University, USA*

12:20-14:00 Lunch

Chairs	Herve Aubin (University Paris-Saclay, France) Young-Woo Son (Korea Institute for Advanced Study, Korea)

14:00-14:30 Exciton Superfluid and Ferromagnetic Superconductivity in Graphene
S-0324 Philip Kim
INVITED *Harvard University, USA*

14:30-15:00 Electronic Structure and Electron-phonon Coupling in Twisted Graphene Layers
S-0942 Hyoung Joon Choi
INVITED *Yonsei University, Korea*

15:00-15:15 Study of Carbon-Nanotube-Tempelated, Flexible Superconducting NbN Nanowire Yarns
S-0310 Haeyong Kang[1], Jeong-Gyun Kim[2], Dongseok Suh[2]
[1]Pusan National University, Korea, [2]Sungkyunkwan University, Korea

15:15-15:30 Superconductivity of Hard Hexagonal ε-NbN Epitaxial Films
S-0487 Ming-Jye Wang[1], Hsiao-Wen Chang[1], Vankayala Krishna Ranganayakulu[2,3], Syu-You Guan[2], Min-Nan Ou[2], Yang-Yuan Chen[2], Tien-Ming Chuang[2], Chia-Seng Chang[2], Maw-Kuen Wu[2]
[1]Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan, [2]Institute of Physics, Academia Sinica, Taiwan, [3]National Tsing-Hua University, Taiwan

15:30-15:45 **Resolving Remaining Issues of Fractional Quantum Hall Effect via Non-equilibrium Many-body Dynamics**
S-1001
Jongbae Hong
Incheon National University, Korea

15:45-16:00 **Intrinsic Topological Superconductivity Induced by Textured Magnetic Order**
S-0877
Daniel Steffensen[1], Morten (Holm) Christensen[2], Brian (Møller) Andersen[1], Panagiotis Kotetes[3]
[1]Niels Bohr Institute, University of Copenhagen, Denmark, [2]University of Minnesota, USA, [3]Institute of Theoretical Physics, Chinese Academy of Sciences, China

16:00-16:15 **Edge Currents as a Probe of the Strongly Spin-polarized Topological Noncentrosymmetric Superconductors**
S-0378
Mehdi Biderang, Alireza Akbari
Asia Pacific Center for Theoretical Physics, Korea

16:15-16:30 **Topological Phase Transitions in Topological Insulators**
S-1023
Jae Hoon Kim, Kyung Ik Sim, Kwang Sik Jeong, Mann-Ho Cho
Yonsei University, Korea

16:30-18:00 **Poster Session**

MONDAY, August 19 — Room 517

MAGNETISM

08:30-09:50 **Opening Ceremony & Plenary Session**

Chair	Yunkyu Bang (APCTP/POSTECH, Korea)

10:00-10:30 **Majorana Quantization and Half-integer Thermal Quantum Hall Effect in a Quantum Spin Liquid**
M-0262
INVITED
Yuji Matsuda
Kyoto University, Japan

10:30-10:50 **Coffee Break**

Chairs	Xingjiang Zhou (Institute of Physics, Chinese Academy of Sciences, China) Changyoung Kim (Seoul National University, Korea)

10:50-11:20 **Topological Matters in Oxide Heterostructure**
M-0141
INVITED
Tae Won Noh[1, 2]
[1]Institute for Basic Science, Korea, [2]Seoul National University, Korea

11:20-11:50 **Magnetic Skyrmion in IMA System**
M-0933
INVITED
Chanyong Hwang
Korea Research Institute of Standards and Science, Korea

11:50-12:05 **In situ Electric Field Skyrmion Creation in Magnetoelectric Cu_2OSeO_3**
M-0259
Ping Huang[1], Marco Cantoni[2], Alex Kruchkov[3], Jayaraman Rajeswari[2], Arnaud Magrez[2], Fabrizio Carbone[2], Henrik Ronnow[2]
[1]Xi'an Jiaotong University, China, [2]École Polytechnique Fédérale de Lausanne, Switzerland, [3]Harvard University, USA

12:05-12:20 Observation of Skyrmion Liquid in a Chiral Magnet
M-0333 Yisheng Chai
Chongqing University, China

12:20-14:00 Lunch

Chairs	Shun-Qing Shen (The University of Hong Kong, Hong Kong) Dohun Kim (Seoul National University, Korea)

14:00-14:30 Fractionalized Spin Excitations in Kitaev Quantum Magnet α-$RuCl_3$
M-0912 Jae-Hoon Park
INVITED *Pohang University of Science and Technology, Korea*

14:30-15:00 Higgs Modes in Quantum Critical Magnets
M-0945 Bumjoon Kim
INVITED *Pohang University of Science and Technology, Korea*

15:00-15:30 Stiefel Whitney Class and Topological Phases in Condensed Matters
M-0201 Junyeong Ahn, Sung Joon Park, Bohm Jung Yang
INVITED *Seoul National University, Korea*

15:30-16:00 Gate-tunable Room-temperature Ferromagnetism in Two-dimensional Fe_3GeTe_2
M-0166 Yuanbo Zhang
INVITED *Fudan University, China*

16:00-16:30 Topological and Ferromagnetic Properties of Iron-based van der Waals Metals
M-0219 Jun Sung Kim
INVITED *Pohang University of Science and Technology, Korea*

16:30-16:45 Two-Dimensional Ferromagnetism in Oxide Heterostructures
M-0932 Changhee Sohn
Ulsan National Institute of Science and Technology, Korea

16:30-18:00 Poster Session

SUPERCONDUCTIVITY

Chairs	M. Brian Maple (University of California, Davis, USA) Ji Hoon Shim (Pohang University of Science and Technology, Korea)

09:00-09:30 **Enhanced Superconductivity and Electronics in Network of One-dimensional Metal**
S-0160 Gil Young Cho
INVITED *Pohang University of Science and Technology, Korea*

09:30-10:00 **Enhanced Superconductivity in the Vicinity of a Pressure-tuned CDW Lifshitz Transition in Multiband Superconductors 2H-PdxTaSe_2**
S-0987
INVITED Kee Hoon Kim
Seoul National University, Korea

10:00-10:15 **Pressure Induced Unconventional Superconductivity in Topological Insulator $Bi_2Te_{2.7}Se_{0.3}$**
S-1058 Hao Yu, Xiao-Jia Chen
Center for High Pressure Science and Technology Advanced Research, China

10:15-10:30 **Cexistence of Charge Order and 2D Superconductivity in $IrTe_2$ Nanosheets**
S-0895 Sungyu Park[1], So Young Kim[1, 2], Hyung Kug Kim[1, 2], Eun-Su An[1, 2], Choongjae Won[3], J.J. Yang[3, 4], Sang-Wook Cheong[4, 5], Jae-Hoon Park[2, 3], Tae-Hwan Kim[1, 2], Jung Sung Kim[1, 2]
[1]Institute for Basic Science, Korea, [2]Pohang University of Science and Technology, Korea, [3]Max Plank POSTECH Center for Complex Phase Materials, Korea, [4]Laboratory for Pohang Emergent Materials, Korea, [5]Rutgers Center for Emergent Materials, USA

10:30-10:50 Coffee Break

Chairs	Katsuya Shimizu (Osaka University, Japan) Jaeyong Kim (Hanyang University, Korea)

10:50-11:20 **Crystal and Electronic Structure of Lithium Metal**
S-0228 Shanti Deemyad
INVITED *University of Utah, USA*

11:20-11:50 **Superconductivity in Sodium Doped Triphenylene**
S-1038 Ji Hoon Shim
INVITED *Pohang University of Science and Technology, Korea*

11:50-12:20 **Discovery of Superconductivity in Phenyl Molecules**
S-0765 Xiao-Jia Chen
INVITED *Center for High Pressure Science and Technology Advanced Research, China*

12:20-14:00 Lunch

Chairs	Ching-Wu Chu (University of Houston, Lawrence Berkeley National Laboratory, USA) Kwon Park (Korea Institute for Advanced Study, Korea)

14:00-14:30 **To Unravel the Gap Sign in Unconventional Superconductors by Phase-Referenced Quasiparticle Interference**
S-0278
INVITED Haihu Wen
Nanjing University, China

14:30-15:00 **Role of Fe-vacancy in FeSe-based Superconductors**
S-0213
INVITED

Chih-Han Wang[1], Gwo-Tzong Huang[1], Ming-Jye Wang[2], Maw-Kuen Wu[1]
[1]Institute of Physics, Academia Sinica, Taiwan, [2]Institute of Astrophysics and Astronomy, Taiwan

15:00-15:15 **High-Field Specific Heat Investigation of High-Tc Superconductors**
S-0454

Camilla Moir[1], Scott C. Riggs[2], Jose Augusto Galvis[3], Xiujun Lian[4], Paula Giraldo-Gallo[5], Jiun-Haw Chu[6], Phil Walmsley[7], Ian R. Fisher[7], Arkady Shekhter[2], Gregory S. Boebinger[2]
[1]Central Research Institute of Energy Power Industry, Japan, [2]National High Magnetic Field Laboratory, USA, [3]Universidad Central, Colombia, [4]Florida State University, USA, [5]Universidad de Los Andes, Colombia, [6]University of Washington, USA, [7]Stanford University, USA

15:15-15:30 **Zero-energy Modes in Topological Materials Evidenced in Point Contact Spectroscopy**
S-0897

Grzegorz P. Mazur[1], Krzysztof Dybko[1, 2], Andrzej Szczerbakow[2], Jaroslaw Z. Domagala[2], Aleksandr Kazakov[1], Maciej Zgirski[2], Elzbieta Lusakowska[2], Slawomir Kret[2], Jedrzej Korczak[1], Tomasz Story[2], Maciej Sawicki[2], Tomasz Dietl[1, 3]
[1]International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, Poland, [2]Institute of Physics, Polish Academy of Sciences, Poland, [3]Tohoku University, Japan

15:30-15:50 Coffee Break

Chairs	Chan-Ho Yang (Korea Advanced Institute of Science and Technology, Korea) Bohm-Jung Yang (Seoul National University, Korea)

15:50-16:20 **Topological d+s Wave Superconductors in a Multi-orbital Quadratic Band Touching System**
S-0192
INVITED

GiBaik Sim[1], Archana Mishra[1], Moon Jip Park[1], Yong Baek Kim[2], Gil Young Cho[3], SungBin Lee[1]
[1]Korea Advanced Institute of Science and Technology, Korea, [2]University of Toronto, Canada, [3]Pohang University of Science and Technology, Korea

16:20-16:35 **Topological Superconductivity in the 5d Mott Insulator Sr_2IrO_4**
S-0467

Alireza Akbari[1], Mehdi Biderang[2]
[1]Pohang University of Science and Technology, Korea, [2]Asia Pacific Center for Theoretical Physics, Korea

16:35-16:50 **Field-induced Gap-like Structure in the Heavy-fermion Superconductor $CeCoIn_5$**
S-1037

K. Shrestha[1], S. Zhang[1], Laura Greene[1], J.D. Thompson[2], Y. Lai[1], R.E. Baumbach[1], K. Sasmal[3], M. B. Maple[3], W.K. Park[1]
[1]Florida State University, USA, [2]Los Alamos, USA, [3]University of California, San Diego, USA

16:50-17:05 **Probing the Driving Mechanism for Superconductivity in FeSe**
S-1004

Seung-Ho Baek[1], J.M. Ok[2], J.S. Kim[2], S. Aswartham[3], I. Morozov[4], D. Chareev[5], D.V. Efremov[3], Bernd Buechner[3]
[1]Changwon National University, Korea, [2]Pohang University of Science and Technology, Korea, [3]IFW Dresden, Germany, [4]Moscow State University, Russia, [5]Russian Academy of Sciences, Russia

17:05-17:20 **Enhanced Superconductivity in the Vicinity of a Lifshitz Transition Induced by Pressure in a 112-type Iron Based Superconductor**
S-0468

Dilip Bhoi[1, 2], Yeahan Sur[1], Byeong Hun Min[1], Dong Hyun Jang[1], Chanhee Kim[1], Seungil Hyun[3], Inho Lee[3], Ji Hoon Shim[3], Duck Young Kim[4], Keizo Murata[1], Kee Hoon Kim[1]
[1]Seoul National University, Korea, [2]The University of Tokyo, Japan, [3]Pohang University of Science and Technology, Korea, [4]Center for High Pressure Science and Technology Advanced Research, China

17:20-17:35 **Emergence of Superconductivity by Lattice Melting in a Group IV-VI Compound**
S-1040

Liu-Cheng Chen[1], Pei-Qi Chen[2], Viktor Struzhkin[3], Alexander Goncharov[4], Qian Zhang[5], Zhifeng Ren[6], Xiao-Jia Chen[3]
[1]Center for High Pressure Science & Technology Advanced Research, China, [2]Poolesville High School, USA, [3]Center for High Pressure Science and Technology Advanced Research, USA, [4]Carnegie Institution of Washington, USA, [5]Harbin Institute of Technology, China, [6]University of Houston, USA

17:35-17:50 S-0610 **Study of Second Magnetization Peak Effect and Vortex Pinning Mechanism in NbSe2 Superconductor in Presence of Cr Atoms**
Rukshana Pervin[1], Manikandan Krishnan[2], Arumugam Sonachalam[2], Parasharam M. Shirage[1]
[1]Indian Institute of Technology Indore, India, [2]Bharathidasan University, India

TUESDAY, August 20 — Room 517

MAGNETISM

Chairs	Philip Kim (Harvard University, USA) Keun Su Kim (Yonsei University, Korea)

09:00-09:30 M-0176 **INVITED**
Chiral Domain Topology, Moire Patterns, and Magnetism in Intercalated Transition Metal Dichalcogenides
Sang-Wook Cheong
Rutgers University, USA

09:30-10:00 M-0153 **INVITED**
Antiferromagnetic Ordering in 2-Dimensional van der Waals Materials Studied by Raman Spectroscopy
Hyeonsik Cheong
Sogang University, Korea

10:00-10:30 M-0542 **INVITED**
Novel States in Stacked Two-dimension Crystals
Young-Woo Son
Korea Institute for Advanced Study, Korea

10:30-10:50 Coffee Break

Chairs	Sang-Wook Cheong (Rutgers University, USA) Jeehoon Kim (Pohang University of Science and Technology, Korea)

10:50-11:20 M-0835 **INVITED**
Exploring Novel Quasiparticles in Two-dimensional Crystals
Keun Su Kim
Yonsei University, Korea

11:20-11:50 M-0785 **INVITED**
"Molecules" in Solids against Magnetism
Daniel Khomskii
Cologne University, Germany

11:50-12:20 M-0322 **INVITED**
Magnetism of Interstitial Anionic Electrons in Two-dimensional Electrides
Sung Wng Kim
Sungkyunkwan University, Korea

12:20-14:00 Lunch

Chairs	Yuanbo Zhang (Fudan University, China) Jun Sung Kim (Pohang University of Science and Technology, Korea)

14:00-14:30 M-0985 **INVITED**
Large Time-Reversal-Odd Responses in the Weyl Antiferromagnet Mn_3Sn for Antiferromagnetic Spintronics
Tomoya Higo[1,2], Huiyuan Man[1], Muhammad Ikhlas[1], Danru Qu[1], Satoru Nakatsuji[1,2]
[1]University of Tokyo, Japan, [2]Japan Science and Technology Agency, Japan

14:30-15:00 Correlated Topological Phases in Kitaev Materials
M-0827
INVITED
Yong-Baek Kim[1,2]
[1]University of Toronto, Canada, [2]Korea Institute for Advanced Study, Korea

15:00-15:30 Quantum Spin Hall Phases in (atom)Thin-layers
M-0947
INVITED
Junji Haruyama
Aoyama Gakuin University, Japan

15:30-15:50 Coffee Break

Chairs	Junji Haruyama (Aoyama Gakuin University, Japan) Gil-Young Cho (Pohang University of Science and Technology, Korea)

15:50-16:20 Magnetotransport Properties in Three-Dimensional Dirac Materials
M-0862
INVITED
Shun-Qing Shen
The University of Hong Kong, Hong Kong

16:20-16:50 'Blackswan' Metal: Viiolation of Ohm's Law in a Weyl Metal
M-0148
INVITED
Jeehoon Kim
Pohang University of Science and Technology, Korea

16:50-17:05 Pressure Induced Giant Magnetoresistance in 2H-WS_2
M-1054
Yakang Peng[1,2], Ziyu Cao[1], Ning Dai[2], Yan Sun[2], Xiaojia Chen[1]
[1]Center for High Pressure Science and Technology Advanced Research, China, [2]Shanghai Institute of Technical Physics, Chinese Academy of Sciences, China

17:05-17:35 Magnetic Skyrmions at Topological Insulator Surfaces and in Proximity to a Superconductor
M-0120
INVITED
Ilya Eremin
Ruhr-University Bochum, Germany

17:35-17:50 Underlayer Effect of Interfacial Dzyaloshinskii-Moriya Interaction: A Route toward Skyrmion State Formation on a Trilayer System
M-0443
June Seo Kim, Jinyong Jung, Chun-Yeol You
Daegu Gyeongbuk Institute of Science and Technology, Korea

SUPERCONDUCTIVITY

Chairs	Xiao-Jia Chen (Center for High Pressure Science and Technology Advanced Research, China) Shanti Deemyad (University of Utah, USA)

09:00-09:30 **Near Room Temperature Superconductivity in Superhydrides at Megabar Pressures**
S-0559 Russell J. Hemley
INVITED *George Washington University, USA*

09:30-10:00 **How Compressed Hydrides Produce Room Temperature Superconductivity**
S-0271 Warren Pickett, Yundi Quan, Soham Ghosh
INVITED *University of California Davis, USA*

10:00-10:30 **Superconductivity of H_3S Synthesized from Elemental Sulfur and Hydrogen**
S-0241 Katsuya Shimizu[1], Harushige Nakao[1], Mari Einaga[1], Masafumi Sakata[1], Naohisa Hirao[2], Saori Kawaguchi[2],
INVITED Yasuo Ohishi[2]
[1]Osaka University, Japan, [2]SPring-8, Japan

10:30-10:50 Coffee Break

Chairs	Mohammad Akhavan (Sharif University of Technology, Iran) Kyungwan Kim (Chungbuk National University, Korea)

10:50-11:20 **High Rate e-beam R2R Deposition of Complex HTS Oxide ReBCO($ReBa_2Cu_3O_{7-y}$) Coated Conductor, and Its Applications**
S-0612 Seung Hyun Moon
INVITED *SuNAM Co. Ltd., Korea*

11:20-11:50 **Magnetic-field-induced Superconductor-to-insulator Transition in Epitaxial Cuprate Thin Films at the Thickness-driven Quantum Phase Transition Regime**
S-0956 Han-Byul Jang, Chan-Ho Yang
INVITED *Korea Advanced Institute of Science and Technology, Korea*

11:50-12:05 **Spin and Charge Excitations along the Direction Perpendicular to Charge Stripes in Cuprates**
S-0564 Takami Tohyama
Tokyo University of Science, Japan

12:05-12:20 **Processing and Properties of Nitride Hetero-structures**
S-0839 Bowen Qiang, Shumpei Nakamura, Sunao Ishino, Tetsuya Hajiri, Hidefumi Asano
Nagoya University, Japan

12:20-14:00 Lunch

MAGNETISM

Chairs	Chanyong Hwang (Korea Research Institute of Standards and Science, Korea) Sanghoon Kim (University of Ulsan, Korea)

09:00-09:30 Biomedical Molecular Imaging Using Magnetic Nanoparticles as Contrast Agents
M-1010 Matthew O'Donnell
INVITED *University of Washington, USA*

09:30-09:45 Novel Scanning Magnetic Imaging Based on Diamond NV Centers
M-0569 Donghun Lee
Korea University, Korea

09:45-10:15 Ultrafast and Very Small: Discover Nanoscale Magnetism with Picosecond Time Resolution Using X-Rays
M-0254 Hendrik Ohldag
INVITED *Lawrence Berkeley National Laboratory, USA*

10:15-10:30 Magnetization Dynamics over Wide Timescales
M-1019 Dong-Hyun Kim
Chungbuk National University, Korea

10:30-10:50 Coffee Break

Chairs	Jacek Furdyna (University of Notre Dame, USA) Sungkyun Park (Pusan National University, Korea)

10:50-11:20 Switching Time Distribution and Damping Constant in Ferromagnetic Nano-structure
M-0550 Chun-Yeol You
INVITED *Daegu Gyeongbuk Institute of Science and Technology, Korea*

11:20-11:35 Switching Current for Low Error Rate and Back-Hopping Probability of Perpendicular Spin-Torque Devices
M-0875 Eunchong Baek, Indra Purnama, Chun-Yeol You
Daegu Gyeongbuk Institute of Science and Technology, Korea

11:35-12:05 Ultrafast Confined Magnons in Layered Ferromagnets
M-0224 Khalil Zakeri
INVITED *Karlsruhe Institute of Technology, Germany*

12:05-12:20 Probing Magnetic Parameters of Individual Nanoelements by Spin-wave Spectroscopy
M-0238 Oleksandr Dobrovolskiy[1], Sergey Bunyaev[2], Nikolay Vovk[3], David Navas[2], Paweł Gruszecki[4], Maciej Krawczyk[4], Roland Sachser[1], Michael Huth[1], Konstantin Guslienko[5,6], Gleb Kakazei[2]
[1]Goethe University Frankfurt am Main, Germany, [2]University of Porto, Portugal, [3]V. N. Karazin Kharkiv National University, Ukraine, [4]Adam Mickiewicz University in Poznan, Poland, [5]Universidad del País Vasco, UPV/EHU, Spain, [6]IKERBASQUE, The Basque Foundation for Science, Spain

12:20-14:00 Lunch

SUPERCONDUCTIVITY

Chairs	Laura Greene (Florida State University, USA) Heesang Kim (Soongsil University, Korea)

09:00-09:30 S-0162 **INVITED**
Spin-Orbit Induced Phase-shift in Bi_2Se_3 Josephson Junctions
Herve Aubin
University Paris-Saclay, France

09:30-09:45 S-0808
Nucleation of Vortices and Magnetization of a p-wave Mesoscopic Superconductor
Daehan Park, Heesang Kim
Soongsil University, Korea

09:45-10:15 S-0215 **INVITED**
Fractional Josephson Effect in Topological Insulator Nanoribbon
Yong-Joo Doh
Gwangju Institute of Science and Technology, Korea

10:15-10:30 S-0234
Microwave Generation by Moving Flux Quanta in Nanoscale Superconducting Hybrid Devices
Volodymyr Bevz[1], Mikhail Mikhailov[2], Olga Yuzephovich[2], Roland Sachser[3], Ruslan Vovk[1], Valerij Shklovskij[1], Menachem Tsindlekht[4], Michael Huth[3], Oleksandr Dobrovolskiy[3]
[1]V. N. Karazin Kharkiv National University, Ukraine, [2]National Academy of Sciences of Ukraine, Ukraine, [3]Goethe University Frankfurt am Main, Germany, [4]The Hebrew University of Jerusalem, Israel

10:30-10:50 Coffee Break

Chairs	Warren Pickett (University of California, Davis, USA) Hyoung Joon Choi (Yonsei University, Korea)

10:50-11:20 S-0548 **INVITED**
Shaping the Fourth Paradigm of Materials Science
Claudia Draxl[1, 2]
[1]Humboldt University Berlin, Germany, [2]Fritz Haber Institute of the Max Planck Society, Germany

11:20-11:35 S-0384
Predicting Electron-Phonon Coupling Constants of U & Lu Elements by DFT & Machine Learning
Zahra Alizadeh[1], Mohammad Reza Mohammadizadeh[1], Mohaddeseh Abbasnejad[2]
[1]University of Tehran, Iran, [2]Shahid Bahonar University of Kerman, Iran

11:35-11:50 S-0996
Computational Study on Pressure-induced Spin Transition in FeO_2
Bo Gyu Jang[1], Ji Hoon Shim[1], Duck Young Kim[2]
[1]Pohang University of Science and Technology, Korea, [2]Center for High Pressure Science and Technology Advanced Research, China

11:50-12:05 S-0777
A First Principles Study on Half-metallicity of Alkali-metal-based Half-Heusler XCrZ (X = Li, Na, K; Z = As, Sb)
Thu Thuy Hoang, S. H. Rhim, S. C. Hong
University of Ulsan, Korea

12:05-12:20 S-0576
Electronic Structure and Magnetic Properties of Gadolinium-based Ternary Intermetallic Compounds
Alexey Lukoyanov[1, 2]
[1]M.N. Miheev Institute of Metal Physics of Ural Branch of Russian Academy of Sciences, Russia, [2]Ural Federal University, Russia

12:20-14:00 Lunch

Chairs	Claudia Draxl (Humboldt University Berlin, Germany) Mohammad Reza Mohammadizadeh (University of Tehran, Iran)

14:00-14:30 **Superconductivity and Magnetism at Ferroelectric Critical Point**
S-1012 Alexander Balatsky[1, 2]
INVITED *[1]Nordita, Sweden, [2]University of Connecticut, USA*

14:30-14:45 **Static and Dynamic Properties of Polymorphic $KNbO_3$ Nanowires under High Pressure**
S-0567 Kyoung Hun Oh, Young-Ho Ko, Kwang-Joo Kim
Agency for Defense Development, Korea

14:45-15:15 **Emergent Many-Body Localization: Disorder Free Mechanisms**
S-0216 Abdollah Langari
INVITED *Sharif University of Technology, Iran*

15:15-15:30 **Two-dimensional Materials in Curved Geometry**
S-0793 Minkyu Park, Sung Hyon Rhim
University of Ulsan, Korea

15:30-15:45 **Magnetic Effect on Second Harmonic Generation in Hyperbolic Magneto-plasmonic Metasurfaces**
S-0740 Dmitry Kuzmin[1], Igor Bychkov[1], Vladimir Shavrov[2]
[1]Chelyabinsk State University, Russia, [2]Kotelnikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences, Russia

15:45-16:15 **Bose-Einstein Condensation of Triplons in an Antiferromagnet Close to the Quantum Critical Point**
S-0735 Koteswara Rao Bommisetti
INVITED *Indian Institute of Technology Tirupati, India*

16:15-16:30 **Magnetic Two-sublattice Molecular-field Model for Frustrated Pyrochlore Gd_2FeSbO_7**
S-0248 Yatramohan Jana, Saikat Nandi
University of Kalyani, India

16:30-16:45 **Thermodynamic Properties of a 2D Ising Spin-Pseudospin System**
S-0860 Yury Panov, Vasiliy Ulitko, Alexander Moskvin
Ural Federal University, Russia

16:30-18:00 **Poster Session**

THURSDAY, August 22 — Room 517

MAGNETISM

Chairs	Oleksandr Dobrovolskiy (Goethe University Frankfurt am Main, Germany) Joonho Jang (Seoul National University, Korea)

09:00-09:30 **Spin Current Detection via an Interface Molecular Paramagnet**
M-0127 Michael Farle[1], Ralf Meckenstock[1], Sabrina Masur[2]
INVITED *[1]University Duisburg-Essen, Germany, [2]University of Cambridge, UK*

09:30-10:00 **Intrinsic Spin and Orbital Hall Effects from Orbital Texture**
M-0197 Dongwook Go[1], Daegeun Jo[1], Changyoung Kim[2,3], Hyun-Woo Lee[1]
INVITED *[1]Pohang University of Science and Technology, Korea, [2]Seoul National University, Korea, [3]Institute for Basic Sciences, Korea*

10:00-10:30 **Antisymmetric Interlayer Exchange Coupling in Magnetic Multilayers**
M-0750 Myung-Hwa Jung
INVITED *Sogang University, Korea*

10:30-10:50 Coffee Break

Chairs	Khalil Zakeri (Karlsruhe Institute of Technology, Germany) Seo Hyoung Chang (Chung-Ang University, Korea)

10:50-11:20 **Giant Spin-orbit torque Generated by BiSb Topological Insulator for MRAM Applications**
M-1018 Pham Nam Hai[1,2], Nguyen Huynh Duy Khang[1], Takanori Shirokura[1], Kenichiro Yao[1]
INVITED *[1]Tokyo Institute of Technology, Japan, [2]Japan Science and Technology Agency, Japan*

11:20-11:35 **Magnetic Structures on Locally Inverted Interlayer Coupling Region of Ferromagnetic Bilayer System**
M-0357 Chanki Lee, Hee Young Kwon, Nam Jun Kim, Han Gyu Yoon, Chiho Song, Changyeon Won
Kyung Hee University, Korea

11:35-11:50 **Influence of Interface Quality of Pt/Fe_3O_4 Hybrids on Spin Hall Magnetoresistance**
M-0703 Thi Kim Hang Pham[1,2], Thi Nga Do[1,2], Jiwoong Kim[3], Quang Van Nguyen[4], Sungkyun Park[3], Tae Hee Kim[1,2]
[1]Institute for Basic Science, Korea, [2]Ewha Womans University, Korea, [3]Pusan National University, Korea, [4]University of Ulsan, Korea

11:50-12:20 **Novel Probes for Studying Correlated Electron Systems**
M-0991 Joonho Jang
INVITED *Seoul National University, Korea*

12:20-14:00 Lunch

Chairs	Alexander Kurbakov (Petersburg Nuclear Physics Institute named by B.P. Konstantinov of National Research Centre «Kurchatov Institute», Russia) Je-Geun Park (Seoul National University, Korea)

14:00-14:30 **Observation of a 4-spin Plaquette Singlet State in the Shastry-Sutherland Compound $SrCu_2(BO_3)_2$**
M-0124 Henrik Ronnow[1], Mohamed Zayed[2], Christian Ruegg[3,4], Julio Larrea[5], Andreas Laeuchli[6], Ekaterina Pomjakushina[3]
INVITED *[1]École Polytechnique Fédérale de Lausanne, Switzerland, [2]Carnegie Mellon University Qatar, Qatar, [3]Paul Scherrer Institut, Switzerland, [4]University of Geneva, Switzerland, [5]University of São Paulo, Brazil, [6]Universität Innsbruck, Austria*

14:30-14:45 **Low Temperature Structural Effects in the Frustrated Quantum Magnet $SrCu_2(BO_3)_2$**
M-0714 Mohamed (Ezzat) Zayed[1], Christian Rueegg[2], Ekaterina Pomjakushina[2], Kazimierz Conder[2], Henrik Ronnow[3]
[1]Carnegie Mellon University, Qatar, [2]Paul Scherrer Institute, Switzerland, [3]École Polytechnique Fédérale de Lausanne, Switzerland

14:45-15:00 **Magnetization Density Distribution of Sr_2IrO_4: Deviation from a Local J_{eff}=1/2 Picture**
M-0922 Jaehong Jeong[1,2], Benjamin Lenz[3], Arsen Gukasov[2], Xavier Fabrèges[2], Andrew Sazonov[4], Vladimir Hutanu[4], Alex Rouat[5], Cyril Martins[6], Silke Biermann[3], Véronique Brouet[5], Yvan Sidis[2], Philippe Bourges[2]
[1]Seoul National University, Korea, [2]The French Alternative Energies and Atomic Energy Commission, France, [3]Ecole Polytechnique, France, [4]Heinz Maier-Leibnitz Zentrum, Germany, [5]Laboratoire de Physique des Solides, France, [6]Laboratoire de Chimie et Physique Quantiques, France

15:00-15:15 The Magnetic Depth Dependence of YIG Thin Films by Polarized Neutron Reflectometry
M-0649 Tao Zhu
Institue of Physics, Chinese Academy of Sciences, China

15:15-15:30 Exploring Quantum Emergent Properties Using Resonant Inelastic X-ray Scattering and X-ray Imaging
M-0476 Seo Hyoung Chang
Chung-Ang University, Korea

15:30-16:00 Synthesis, Structural and Magnetic Properties of (NdY)–FeNb–B Nano Crystalline Permanent Magnets Produced by Rapid Solidification and Annealing
M-0533
INVITED Zubair Ahmad, Saleem Akhtar, Amer Nusair
Ibn-e-Sina Institute of Technology, Pakistan

16:00-16:15 Composite Magnetic Microactuator Based on Ferromagnetic Shape Memory Ni-Mn-Ga Heusler Alloy
M-0290 Vladimir Shavrov[1], Elvina Dilmieva[1], Victor Koledov[1], Alexander Kamantsev[1], Alexey Mashirov[1], Artemij Irzhak[2, 3]
[1]Kotelnikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences, Russia, [2]National University of Science and Technology MISiS, Russia, [3]Institute of Microelectronics Technology and High Purity Materials of Russian Academy of Science, Russia

16:15-16:30 Effect of Liquid Aid Sintering to Improve the Coercivity of Sm-Co (1:5) Intermetallic Compound
M-0755 Saleem Akhtar[1], Aamir Nusair Khan[2], Mushtaq Khan[1], Syed Husain Imran Jaffery[1]
[1]National University of Science and Technology, Pakistan, [2]Ibn-e-Sina Institute of Technology, Pakistan

16:30-16:45 Maintaining the Sensitivity by Compensative Thickness Variation in the Capping Layer for PHE Sensors
M-0773 Amir Elzwawy, SungJoon Kim, Artem Talantsev, CheolGi Kim
Daegu Gyeongbuk Institute of Science and Technology, Korea

16:30-18:00 Poster Session

SUPERCONDUCTIVITY

Chairs	Haihu Wen (Nanjing University, China) Seung-Ho Baek (Changwon National University, Korea)

09:00-09:30 On the Pairing Mechanism of High Temperature Superconductivity
S-0246 Qi-Kun Xue
INVITED *Tsinghua University, China*

09:30-10:00 Projected BCS Theory for the Unification of Antiferromagnetism and Strongly Correlated Superconductivity
S-0202 Kwon Park
INVITED *Korea Institute for Advanced Study, Korea*

10:00-10:30 A New Paradigm to Higher Tcs of the Stable Cuprates: To Break Away from the Constraints Imposed by the Universal Quadratic Tc-Dopant Relation
S-0233
INVITED Ching-Wu Chu[1, 2], Liangzi Deng[1], Yongping Zheng[3], Zheng Wu[1]
[1]University of Houston, USA, [2]Lawrence Berkeley National Laboratory, USA, [3]University of Texas at Dallas, USA

10:30-10:50 Coffee Break

Chairs	Sonny Rhim (University of Ulsan, Korea) Changhee Son (Ulsan National Institute of Science and Technology, Korea)

10:50-11:20 Development of the RCE-DR Process for Higher Performance GdBCO Coated Conductors
S-0743 Sang-Im Yoo[1], Insung Park[1], Won-Jae Oh[1], Jae-Hun Lee[2], Seung-Hyun Moon[2]
INVITED *[1]Seoul National University, Korea, [2]Nano & Advanced Materials Corporation, Korea*

11:20-11:35 Selected Elements Substituted on Tl-site of the $TlSr_2CaCu_2O_7$ System: A Short Review
S-0401 J. Nur-Akasyah, Ilhamsyah Putra Abu Bakar, Abd-Shukor R
Universiti Kebangsaan Malaysia, Malaysia

11:35-11:50 Properties of $Sm_{3-x-y}Pr_xCayBa_5Cu_8O_{19}$ Compound
S-0367 Mohammad Sandoghchi, Mohammad Akhavan
Sharif University of Technology, Iran

11:50-12:20 Topologically Protected Bogoliubov Fermi Surfaces
S-0204 Daniel Agterberg
INVITED *University of Wisonsin-Milwaukee, USA*

12:20-14:00 Lunch

Chairs	Abdelwaheb Cheikhrouhou (University of Sfax, Tunisia) Hanyong Choi (Sungkyunkwan University, Korea)

14:00-14:30 Laser ARPES on Non-Fermi-Liquid Behaviors and Superconducting Gap Symmetry of Iron-Based Superconductors
S-0607
INVITED Xingjiang Zhou
Institute of Physics, Chinese Academy of Sciences, China

14:30-14:45 S-0855

Long-range Focused Quasiparticle Scattering through the Fermi Surface on a Quasi-2D Superconductor

Howon Kim, Dominik Schreyer, Levente Rózsa, Roland Wiesendanger
University of Hamburg, Germany

14:45-15:00 S-0998

Studies of Physical Properties of SrRu1-xTixO3 (x ≤ 0.7) Series

Renu Gupta
Jawaharlal Nehru University, India

15:00-15:30 S-0482 **INVITED**

Microscopic Observation of Entangled Multi-Magnetoelectric Coupling Phenomenon

Sae Hwan Chun[1, 2], Heung-Sik Kim[3], Kwang Woo Shin[4], Kee Hoon Kim[4], John F. Mitchell[1], Philip J. Ryan[5, 6], Jong-Woo Kim[5]
[1]Argonne National Laboratory, USA, [2]Pohang Accelerator Laboratory, Korea, [3]Kangwon National University, Korea, [4]Seoul National University, Korea, [5]Advanced Photon Source, USA, [6]Dublin City University, Ireland

15:30-15:45 S-0460

Zn^{2+} Doping Tunable Multiferroicity in S = 1/2 Kagome Staircase $PbCu_3TeO_7$

Aga Shahee[1], Chang Bae Park[1], Nikita Ter-Oganessian[2], Kee Hoon Kim[1]
[1]Seoul National University, Korea, [2]Southern Federal University, Russia

15:45-16:00 S-0481

Study of Electromagnon on Terahertz Absorption for Aluminum Doped Zn_2Y Hexaferrite

Kee Hoon Kim, Kwangwoo Shin
Seoul National University, Korea

16:00-16:15 S-0432

Optimized Magnetoelectric Coupling by Stabilization of the Transverse Conical State in Chemically Tuned Co_2Y-Type Hexaferrites

Kee Hoon Kim, Chang Bae Park
Seoul National University, Korea

16:15-16:30 S-0286

Interfacial Magnetoelectric Effect in FePt/$BaTiO_3$ Multilayers

Qurat ul Ain[1], D. Odkhuu[2], S. H. Sonny Rhim[1], S. C. Hong[1]
[1]University of Ulsan, Korea, [2]Incheon National University, Korea

16:30-17:30 Closing Ceremony

FRIDAY, August 23 Room 517

MAGNETISM

Chairs	Henrik Ronnow (École Polytechnique Fédérale de Lausanne, Switzerland) Soonchil Lee (Korea Advanced Institute of Science and Technology, Korea)

09:00-09:30 M-0151 **INVITED**

Neutron Diffraction Study of the Low-dimensional Frustrated A_2MnTeO_6 (A = Li, Na, Ag, Tl) Magnetics

Alexander Kurbakov[1], Mariya Kuchugura[1], Elena Zvereva[2], Vladimir Pomjakushin[3]
[1]Petersburg Nuclear Physics Institute named by B.P. Konstantinov of National Research Centre «Kurchatov Institute», Russia, [2]Moscow State University, Russia, [3]Paul Scherrer Institute, Switzerland

09:30-09:45 M-0737

Competition between Magnetic Sub-lattices in NiCoFe-Layered Ternary Hydroxides Depending on Their Molar Ratio

Marlene González M.[1, 2], Juvencio Vazquez Samperio[1], Miguel Angel Oliver Tolentino[3], Edilso Reguera Ruiz[1], Ariel Guzman Vargas[4]
[1]Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada - Instituto Politécnico Nacional, Mexico, [2]Consejo Nacional de Ciencia y Tecnología, Mexico, [3]Universidad Autónoma Metropolitana - Unidad Iztapalapa, Mexico, [4]Catálisis Ambiental y Química Fina- Instituto Politécnico Nacional, Mexico

09:45-10:00 M-0275

Magnetostructural Phase Transition in Ni-Mn-Z (Z-Ga, In, Sn) Heusler Alloys under the Influence of High Magnetic Fields in the Isothermal and Adiabatic Conditions

Elvina Dilmieva[1], Yurii Koshkid'ko[2], Victor Koledov[1], Alexander Kamantsev[1], Alexey Mashirov[1], Jacek Cwik[2], Vladimir Shavrov[1]

[1]Kotelnikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences, Russia, [2]Trzebiatowski Institute of Low Temperature and Structure Research of Polish Academy of Science, Poland

10:00-10:15 M-1045

Giant Magnetic Anisotropy Induced by Ligand LS Coupling in Layered Cr Compounds

Donghwan Kim[1], Kyoo Kim[2], Kyung-Tae Ko[2], JunHo Seo[1, 3], Jun Sung Kim[1, 3], Tae-Hwan Jang[2], Younghak Kim[1], Jae-Young Kim[3], Sang-Wook Cheong[1, 4, 5], JaeHoon Park[1, 2]

[1]Pohang University of Science and Technology, Korea, [2]Max Planck POSTECH/Korea Research Initiative, Korea, [3]Institute for Basic Science, Korea, [4]Rutgers University, USA, [5]Max Planck POSTECH Center for Complex Phase Materials, Korea

10:15-10:30 M-0804

Interactions in the Bond-frustrated Helimagnet $ZnCr_2Se_4$ Investigated by NMR

Sejun Park[1], Sangil Kwon[2], Soonchil Lee[1], Seunghyun Khim[3], Dilipkumar Bhoi[3], Chang Bae Park[3], Kee Hoon Kim[3]

[1]Korea Advanced Institute of Science and Technology, Korea, [2]University of Waterloo, Canada, [3]Seoul National University, Korea

10:30-10:50 **Coffee Break**

Chairs	Koteswara Rao Bommisetti (Indian Institute of Technology Tirupati, India) Zubair Ahmad (Ibn-e-Sina Institute of Technology, Pakistan)

10:50-11:20 M-0265 **INVITED**

$La_{0.7}Sr_{0.3}Mn_{1-x}B_xO_3$ (B=Mo, Ti) Nanoparticles for Self-controlled Hyperthermia

Jihed Makni[1], Kalthoum Riahi[1], Firas Ayadi[2], Virginie Nachbaur[2], Wissem Cheikhrouhou-Koubaa[1], Mohamed Koubaa[1], Sadia Manzoor[3], Muhammad Asif Hamayun[3], El-Kbir Hlil[4], Abdelwaheb Cheikhrouhou[1]

[1]Sfax Technopark, Tunisia, [2]CNRS UFR Sciences et Techniques Avenue de l'Université, France, [3]COMSATS Institute of Information Technology, Pakistan, [4]Institut Néel & Université Grenoble Alpes, France

11:20-11:35 M-0577

Magnetocaloric Effect in Manganites in Alternating Magnetic Fields

A Aliev[1], Adler Gamzatov[1, 2], S.-C. Yu[2]

[1]Dagestan Scientific Center of Russian Academy of Sciences, Russia, [2]Chungbuk National University, Korea

11:35-12:05 M-0729 **INVITED**

A New Quasi-one-dimensional Spin Chain Compound $NiTe_2O_5$ and Its Critical Behavior

Yoon Seok Oh[1], Jun Han Le[1], Marie Kratochvílová[2, 3], Huibo Cao[4], Zahra Yamani[5], J. S. Kim[6], Je-Geun Park[3], Greg Stewart[6]

[1]Ulsan National Institute of Science and Technology, Korea, [2]Institute for Basic Science, Korea, [3]Seoul National University, Korea, [4]Oak Ridge National Laboratory, USA, [5]Canadian Neutron Beam Centre, Canada, [6]University of Florida, USA

12:05-12:20 M-0557

Super-paramagnetism in Nano-sized Ni2+ Substituted R-type Hexagonal Ferrites

Imran Sadiq

University of the Punjab, Pakistan

12:20-14:00 **Lunch**

Chairs	Michael Farle (University Duisburg-Essen, Germany) Chun-Yeol You (Daegu Gyeongbuk Institute of Science and Technology, Korea)

14:00-14:30 M-0627 **INVITED**

Ferrimagnetic Spin-orbitronics

Teruo Ono

Kyoto University, Japan

14:30-15:00 **Drastic Emergence of Huge Negative Spin-Transfer Torque in Atomically Thin Co Layers**
M-0326
INVITED
Soong-Geun Je[1], Dae-Yun Kim[1], Yong-Keun Park[1], Joo-Sung Kim[1], Yune-Seok Nam[1], Byoung-Chul Min[2], Sug-Bong Choe[1]
[1]Seoul National University, Korea, [2]Korea Institute of Science and Technology, Korea

15:00-15:15 **Surface Morphology and Magnetic Properties of GdCo Films with Perpendicular Magnetic Anisotropy on Anodic Alumina Template**
M-0514
Nikita Kulesh[1, 2], Anton Bolyachkin[1], Zlata Grinina[3], Vladimir Lepalovskij[1], Vladimir Vas'kovskiy[1, 3], Manuel Vázquez[2]
[1]Ural Federal University, Russia, [2]Institute of Materials Science of Madrid, Spain, [3]M.N. Miheev Institute of Metal Physics, Russia

15:15-15:45 **Programmable Magnetic Anisotropy in Ferromagnetic Semiconductor Films with Graded Composition**
M-0180
INVITED
Jacek Furdyna
University of Notre Dame, USA

15:45-16:00 **Experimental Evidences for Cubic Anisotropy Rotations in (Ga,Mn)As**
M-0905
Maciej Sawicki[1], Oleg Proselkov[1], Cezary Sliwa[1], Pavlo Aleshkevych[1], Jaroslaw Z. Domagala[1], Janusz Sadowski[1, 2], Tomasz Dietl[3, 4]
[1]Institute of Physics, Polish Academy of Sciences, Poland, [2]Linnaeus University, Sweden, [3]International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, Poland, [4]Tohoku University, Japan

16:00-16:15 **Common Exchange-Bias Effect Associated with Magnetization Reversal in $RFeO_3$ (R = Nd, Sm, Er) Orthoferrites and in $LuFe_{0.5}Cr_{0.5}O_3$**
M-0560
Roman Puzniak[1], Ivan Fita[1], Andrzej Wisniewski[1], Vladimir Markovich[2]
[1]Institute of Physics of the Polish Academy of Sciences, Poland, [2]Ben-Gurion University of the Negev, Israel

16:15-16:30 **Abnormal Anti-crossing in Photon-magnon Coupling**
M-0500
Biswanath Bhoi, Bosung Kim, Sang-Koog Kim
Seoul National University, Korea

16:30-17:30 **Closing Ceremony**

Chairs Duck Young Kim (Center for High Pressure Science and Technology Advanced Research, China)
Yuanbo Zhang (Fudan University, China)
Tomoya Higo (University of Tokyo, Japan)
Alexander Balatsky (Nordita/University of Connecticut, Sweden)
Joonho Jang (Seoul National University, Korea)
Younjung Jo (Kyungpook National University, Korea)

P-0210 The Study of Microwave Power Effect and Anisotropic Effect in Ba0.34K0.64Fe2As2 (BaK122) Superconducting Single Crystal Using Non-Resonant Microwave Absorption Technique
Tshiwela Caroline Ramashitja, Srinivasu Vijaya Vallabhapurapu
University of South Africa, South Africa

P-0295 Fractional Quantum Anomalous Hall Effect in the Wannier Stark Ladders Emerging from a Nontrivial Chern Band
Sutirtha MukherJee, Kwon Park
Korea Institute for Advanced Study, Korea

P-0338 4π-periodic Supercurrent through Surface States in $(Bi_{0.81}Sb_{0.19})_2Se_3$ Nanowire-based Josephson Junctions
Hong-Seok Kim[1], Nam-Hee Kim[1], Yeongmin Jang[1], Yasen Hou[2], Dong Yu[2], Yong-Joo Doh[1]
[1]Gwangju Institute of Science and Technology, Korea, [2]University of California, Davis, USA

P-0343 Numerical Simulation of Shapiro Steps in Topological Josephson Junction
Yeongmin Jang, Yong-Joo Doh
Gwangju Institute of Science and Technology, Korea

P-0345 Electrical Detection of Spin-Polarized Local and Non-Local Current in Topological Insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$
Taeha Hwang[1], Hong-Seok Kim[1], Holl Kim[2], Jun Sung Kim[2], Yong-Joo Doh[1]
[1]Gwangju Institute of Science and Technology, Korea, [2]Pohang University of Science and Technology, Korea

P-0349 Superconducting Quantum Interference Device of $(Bi_{0.82}Sb_{0.18})_2Se_3$ Topological Insulator Nanoribbons
Nam-Hee Kim[1], Hong-Seok Kim[1], Yiming Yang[2], Xingyue Peng[2], Dong Yu[2], Yong-Joo Doh[1]
[1]Gwangju Institute of Science and Technology, Korea, [2]University of California, USA

P-0373 Emergent Localization in Twisted Dodecagonal Bilayer Quasicrystals
Moon Jip Park, Hee Seung Kim, SungBin Lee
Korea Advanced Institute of Science and Technology, Korea

P-0379 Drumhead Surface States and Their Signatures in Quasiparticle Scattering Interference
Mehdi Biderang, Alireza Akbari
Asia Pacific Center for Theoretical Physics, Korea

P-0402 Effect of Isoelectronic Substitution of Ba with Sr or Ca Atoms on Electron Charge Distribution and Bonding Properties of $BaFe_2As_2$
Mahdieh Aghajani[1], Hanif Hadipour[2], Mohammad Akhavan[1]
[1]Sharif University of Technology, Iran, [2]University of Guilan, Iran

P-0407 Spectroscopic-Imaging Scanning Tunneling Microscope Studies on Rh-doped Iridates
Seokhwan Choi[1], Douglas Bonn[1, 2]
[1]Stewart Blusson Quantum Matter Institute, Canada, [2]University of British Columbia, Canada

P-0408 Topological Phases with Emergent Chiral Spin States on the Kagome Lattice at 1/3 Filling

Hee Seung Kim, Archana Mishra, SungBin Lee
Korea Institute of Science and Technology, Korea

P-0416 Topological Superconductors in the Interacting Luttinger Model

GiBaik Sim[1], Archana Mishra[1], Moon Jip Park[1], Yong Baek Kim[2], Gil Young Cho[3], SungBin Lee[1]
[1]Korea Advanced Institute of Science and Technology, Korea, [2]University of Toronto, Canada, [3]Pohang University of Science and Technology, Korea

P-0441 Pressure Induced Lifshitz Transition and Disappearance of Commensurate Charge Density Wave in the 2H-Pd_xTaSe_2 Superconductor

Yeahan Sur, Kee Hoon Kim
Seoul National University, Korea

P-0515 Pressure-enhanced Anomalous Hall Effect in van der Waals Ferromagnet $CrSiTe_3$

Yoonhan Lee, Chang Bae Park, Kee Hoon Kim
Seoul National University, Korea

P-0517 Tuning the Interplay between Nematicity and Spin Fluctuations in $Na_{1-x}Li_xFeAs$ Superconductors

Kee Hoon Kim[1], Dilip Bhoi[1], Kwang-Tak Kim[1], Woohyun Nam[1], S.-H Baek[2], Bernd Buchner[2], Bumsung Lee[1], Dmitri V. Efremov[2]
[1]Seoul National University, Korea, [2]Leibniz Institute of Solid State and Materials Research Dresden, Germany

P-0584 Magnetic Field Detwinning in FeTe

Younsik Kim, Soonsang Huh, Changyoung Kim
Seoul National University, Korea

P-0586 Lifted Electron Pocket and Reversed Orbital Occupancy Imbalance in FeSe

Soonsang Huh[1], Jongkeun Jung[1], Changil Kwon[2], Junsung Kim[2], Yeongkwan Kim[3], Changyoung Kim[1]
[1]Seoul National University, Korea, [2]Pohang University of Science and Technology, Korea, [3]Korea Advanced Institute of Science and Technology, Korea

P-0615 Bulk Properties of van-der-Waals Hard Ferromagnet VI_3

Suhan Son[1,2], Matthew Coak[1,3], Nahyun Lee[1], Jonghyeon Kim[4], Tae Yun Kim[2], Haryullo Hamidov[5,6], Hwanbeom Cho[1,2], Cheng Liu[5], David Jarvis[5], Philip Brown[5], Jae Hoon Kim[4], Cheol-Hwan Park[2], Daniel I. Khomskii[7], Siddharth Saxena[5,8], Je-Geun Park[1,2]
[1]Institute for Basic Science, Korea, [2]Seoul National University, Korea, [3]Warwick University, UK, [4]Yonsei University, Korea, [5]University of Cambridge, UK, [6]Navoiy Branch of the Academy of Sciences of Uzbekistan, Uzbekistan, [7]Universitat zu Koln, Germany, [8]National University of Science and Technology "MISiS", Russia

P-0620 Deviation between Magnetic Quantum- and Lifshitz- Critical Point in Electron Doped Cuprate $Pr_{1-x}LaCe_xCuO_4$

Dongjoon Song[1], Suheon Lee[2], Woobeen Jung[1], Kwang-Yong Choi[2], Changyoung Kim[1]
[1]Seoul National University, Korea, [2]Chung-Ang University, Korea

P-0623 Polarization and Orbital Angular Momentum in Rashba Spin-orbit Coupling

Jeonghun Sohn, Dongwook Go, Hyun-Woo Lee
Pohang University of Science and Technology, Korea

P-0626 K_z Dependence on the Band Structure of Electron Doped Cuprate Superconductors

Saegyeol Jung, Yunsik Kim, Dongjoon Song, Changyoung Kim
Institute for Basic Science, Korea

P-0635 **Magnetic Excitations in Non-collinear Itinerant Antiferromagnet CrB_2**

Pyeongjae Park[1, 2], Kisoo Park[1, 2], Taehun Kim[1, 2], Yusuke Kousaka[3], Jerome Jackson[4], András Deák[5, 6], Bendegúz Nyári[5, 6], László Szunyogh[5, 6], Toby Perring[7], Michel Kenzelmann[8], Je-Geun Park[1, 2]
[1]Seoul National University, Korea, [2]Institute for Basic Science, Korea, [3]Okayama University, Japan, [4]STFC Daresbury Laboratory, UK, [5]Budapest University of Technology and Economics, Hungary, [6]2MTA-BME Condensed Matter Research Group, Hungary, [7]Science & Technology Facilities Countil, UK, [8]Paul Scherrer Institute, Switzerland

P-0775 **Evidences of Superconductivity at 18 K in Nano-sized Rhombohedral Bi Enhanced by Ni-doping**

Chi-Hung Lee, Ken-Ming Lin, Yu-Hui Tang, Bo-Yong Wu, Wen-Hsien Li
National Central University, Taiwan

P-0796 **Multi-scale Quantum Criticality Driven by Kondo-lattice Coupling in Pyrochlore Systems**

Hanbit Oh[1], Sangjin Lee[1], Yong Baek Kim[2], Eun-Gook Moon[1]
[1]Korea Advanced Institute of Science and Technology, Korea, [2]University of Toronto, Canada

P-0811 **Magnetic and Electrical Anisotropy with Correlation and Orbital Effects in Dimerized Honeycomb Ruthenate Li_2RuO_3**

Seokhwan Yun[1, 2], Ki Hoon Lee[1, 2], Se Young Park[1, 2], Teck-Yee Tan[1, 2], Junghwan Park[3], Soonmin Kang[1, 2], Daniel I. Khomskii[4], Younjung Jo[5], Je-Geun Park[1, 2]
[1]Seoul National University, Korea, [2]Institute for Basic Science, Korea, [3]Samsung SDI Co. Ltd., Korea, [4]Universität zu Köln, Germany, [5]Kyungpook National University, Korea

P-0817 **Pressure Effect on the Phase Transitions of a Heterostructured Superconductor Sr_2VO_3FeAs**

ChangIl Kwon[1], Jun Sung Kim[1], Jong Mok Ok[1], Xiaojia Chen[2], D.Y. Kim[2]
[1]Pohang University of Science and Technology, Korea, [2]Center for High Pressure Science and Technology Advanced Research, China

P-0821 **Room Temperature Ferromagnetism in a Magnetic-metal-rich van der Waals Metal**

Junho Seo[1, 2], Duck Young Kim[3], Kyoo Kim[4], Gi-Yeop Kim[2], Bo Gyu Jang[2], Heejung Kim[2], Roland Stania[1], Eun Su An[1, 2], Jinwon Lee[1, 2], Youn Jung Jo[5], Byung Il Min[2], Han Woong Yeom[1, 2], Si-Young Choi[2], Ji Hoon Shim[2], Jun Sung Kim[1, 2]
[1]Institute for Basic Science, Korea, [2]Pohang University of Science and Technology, Korea, [3]Center for High Pressure Science and Technology Advanced Research, China, [4]Max Planck POSTECH/Hsinchu Center for Complex Phase Materials, Pohang University of Science and Technology, Korea, [5]Kyungpook National University, Korea

P-0822 **Passivation Dependent Surface State of Rocksalt SnSe (111) Surface**

Kunihiro Yananose, Jaejun Yu
Seoul National University, Korea

P-0832 **Observation of Toroidal Pseudo-spin Texture in a Nodal Line Semimetal $SrAs_3$**

Hoil Kim[1, 2], Bo Gyu Jang[2], Jong Mok Ok[1, 2], Chang Il Kwon[1, 2], Eun Sang Choi[3], Youn Jung Jo[4], Woun Kang[5], Yoshimitsu Kohama[6], Ji Hoon Shim[2], Jun Sung Kim[1, 2]
[1]Institute for Basic Science, Korea, [2]Pohang University of Science and Technology, Korea, [3]Florida State University, USA, [4]Kyungpook National University, Korea, [5]Ewha Womans University, Korea, [6]The University of Tokyo, Japan

P-0834 **Effects of Magnetic Frustration in the Triangular Antiferromagnet CePtAl4Ge2**

Soohyeon Shin, Tuson Park
Sungkyunkwan University, Korea

P-0837 **Magnetic Topological Insulators with Higher Chern Numbers in Electron-doped $CrSiTe_3$**

Seungjin Kang, Sungmo Kang, Jaejun Yu
Seoul National University, Korea

P-0850 Field Induced Phase Transitions between Quantum Spin Liquids with Different Fluxes
Hyeok-Jun Yang, SungBin Lee
Korea Advanced Institute of Science and Technology, Korea

P-0871 Quantun Anomalous Hall Effect with Higher Chern Numbers in Electron-Doped $CrSiTe_3$: A First-Principles Prediction
Sungmo Kang, Seungjin Kang, Jaejun Yu
Seoul National University, Korea

P-0879 Mangetic Order Phase Transition and Topological Semimetal Phase Transition in Iridium Spinel Oxide
Changhwi Park, Jaejun Yu
Seoul National University, Korea

P-0891 Linear Magnetoresistance of the Helical Antiferromagnet Al Doped CrAs
Sungmin Park, Soohyeon Shin, Tuson Park
Sungkyunkwan University, Korea

P-0898 Room Temperature Ferromagnetism in Ultrathin van der Waals Metal Fe_4GeTe_2
Eun-Su An[1], Junho Seo[1], Gyeongsik Eom[2], Geunyong Kim[1], Jieun Lee[2], Jeehoon Kim[1], Jung Sung Kim[1]
[1]Pohang University of Science and Technology, Korea, [2]Ajou University, Korea

P-0909 Nature of Magnetic Weyl Nodal Loops in 5d Cubic Double Perovskites
Young-Joon Song, Kwan-Woo Lee
Korea University, Korea

P-0919 Nature of Multi-topological Characters in Compensated Half-metallic Cr_2CoAl
Hyo Sun Jin[1], Young-Joon Song[1], Warren E. Pickett[2], Kwan-Woo Lee[1]
[1]Korea University, Korea, [2]University of California, Davis, USA

P-0929 Changes of Electronic and Crystallographic Structures at Interfaces of MBE Grown Thin Films of Bi_2Te_3 and Selected Metals
Katarzyna Balin, Mateusz Weis, Bartosz Wilk, Marcin Wojtyniak, Maciej Zubko, Jacek Szade
University of Silesia, Katowice, Poland

P-0935 Superconducting Sr_2RuO_4 Thin Film Growth with Pulsed Laser Deposition
Jinkwon Kim[1,2], Junsik Mun[2], Carla Palomares Garcia[3], Eun Kyo Ko[1,2], Bongju Kim[1,2], Miyoung Kim[2], Jason W.A. Robinson[3], Shingo Yonezawa[4], Yoshiteru Maeno[4], Tae Won Noh[1,2]
[1]Institute for Basic Science, Korea, [2]Seoul National University, Korea, [3]University of Cambridge, UK, [4]Kyoto University, Japan

P-0954 Nature of Giant Proximity Effect in MgB_2 Bilayer Fabricated by Ion Irradiations
Soon-Gil Jung[1], Jung Min Lee[1], Duong Pham[1], Tae-Ho Park[1], Han-Yong Choi[1], Tian Le[2], Xin Lu[2], Won Nam Kang[1], Tuson Park[1]
[1]Sungkyunkwan University, Korea, [2]Zhejiang University, China

P-0959 Violation of Ohm`s Law in a Weyl Metal
Dongwoo Shin, Jeehoon Kim
Pohang University of Science and Technology, Korea

P-0961 Pressure Dependent Study of Magnetism and Superconductivity in $U_2Pt_xRh_{1-x}C_2$
Sangyun Lee[1], F. Ronning[2], E. D. Bauer[2], Yongkang Luo[2], Duk Y. Kim[1], J. D. Thompson[2], Tuson Park[1]
[1]Sungkyunkwan University, Korea, [2]Los Alamos National Laboratory, USA

P-0971 **Robust Ferromagnetism in Hydrogenated Graphene Mediated by Spin-polarized Pseudospin**

Hyunyoung Kim[1], Junhyeok Bang[2], Joongoo Kang[1]
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P-0978 **Spin Valve Device on Spin-triplet Superconducting Sr_2RuO_4 for Observing Super Spincurrent**

Eun Kyo Ko[1, 2], Suk Bum Chung[3], Bongju Kim[1, 2], Jinkwon Kim[1, 2], Carla Garcia[4], Jason Robinson[4], Yoshiteru Maeno[5], Tae Won Noh[1, 2]
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P-0980 **Self-field Critical Currents of FeSe and $NbSe_2$ Nanosheets**

Yong Hyeon Kim[1, 2], Sungyu Park[1], So Young Kim[1, 2], Jun Sung Kim[1, 2]
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P-0984 **Investigation of Superconducting Vortices Using a Home-built Low Temperature Magnetic Force Microscope**

JinYoung Yun, Geunyong Kim, Jeehoon Kim
Pohang University of Science and Technology, Korea

P-1039 **Structure and Electric Transport Properties of Potassium under High Pressure of Hydrogen**

Jiafeng Yan[1], Lan Anh Thi Nguyen[1], Sanghwa Lee[1], Kwanhui Jung[1], Ziyu Cao[2], Viktor Struzhkin[2, 3], Jaeyong Kim[1]
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P-1043 **Quasiparticle Energy and Band Gap of Bulk and Few-layer $PdSe_2$**

Han-gyu Kim, Hyoung Joon Choi
Yonsei University, Korea

P-1050 **Role of Electric Fields on Electron Correlation in Surface-Doped FeSe**

Young Woo Choi, Hyoung Joon Choi
Yonsei University, Korea

P-1055 **First-principles Study of Intrinsic Anomalous Hall Conductivity in Transition Metals**

Juwon Oh, Hyoung Joon Choi
Yonsei University, Korea

P-1061 **First-principles Study of Magnetism in Doped $PdSe_2$ Monolayer**

Yosep Cho, Hyoung Joon Choi
Yonsei University, Korea

Chairs	Tao Zhu (Institue of Physics, Chinese Academy of Sciences, China) Jacek Furdyna (University of Notre Dame, USA) Seung-Ho Baek (Changwon National University, Korea) Young Jun Chang (University of Seoul, Korea) Dong-Hyun Kim (Chungbuk National University, Korea) Dong-Seok Yang (Chungbuk National University, Korea)

P-0144 Magnetic Interchain Interactions through Hydrogen Bonds and π- π Stacking in a Series of Pillared Layered Compounds
Marlene González Montiel[1, 2], Edilso Reguera[1]
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P-0273 Giant Magnetocaloric Effect and Low Temperature Properties of $NdPd_2Al_2$ Compound
Moise Tchokonte Tchoula[1], Mbulunge Hamisi Masevhe[1], Jean Jules Mboukam[2], Baidyanath Sahu[2], Andre Michael Strydom[2], Dariusz Kaczorowski[3]
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P-0281 Dy_2GaSbO_7: An Unconventional Spin-ice with Enhanced Zero-point Entropy
Saikat Nandi, Yatramohan Jana
University of Kalyani, India

P-0305 Investigation of Microstructure and Magnetic Properties of Epitaxial Permalloy on TiN Intermediate Layer
Kaifeng Dong, Qian Yu, Fang Jin, Junlei Song, Wenqin Mo, Jianqi An
China University of Geosciences, China

P-0306 Experimental Observation of the Correlation between the Interfacial Dzyaloshinskii–Moriya Interaction and Work Function in Metallic Magnetic Trilayers
Yong-Keun Park[1, 2], Dae-Yun Kim[1], Joo-Sung Kim[1], Yune-Seok Nam[1], Min-Ho Park[1], Hyeok-Cheol Choi[1], Byoung-Chul Min[2], Sug-Bong Choe[1]
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P-0311 Low Magnetic Damping of Ferrimagnetic GdFeCo Alloys
Duck-Ho Kim[1], Takaya Okuno[1], Se Kwon Kim[2], Se-Hyeok Oh[3], Tomoe Nishimura[1], Yuushou Hirata[1], Yasuhiro Futakawa[4], Hiroki Yoshikawa[4], Arata Tsukamoto[4], Yaroslav Tserkovnyak[5], Yoichi Shiota[1], Takahiro Moriyama[1], Kab-Jin Kim[6], Kyung-Jin Lee[3], Teruo Ono[1]
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P-0316 Domain-wall-motion Neuron Device
Hyun-seok Whang, Yune-seok Nam, Sug-bong Choe
Seoul National University, Korea

P-0323 Simulation of Magnetic Skyrmion Based AND Gate and NAND Gate
Fang Jin[1, 2], Hengchang Rao[1, 2], Zhi Zhao[1, 2], Kaifeng Dong[1, 2], Junlei Song[1, 2], Wenqin Mo[1, 2]
[1]China University of Geosciences, China, [2]Hubei Key Laboratory of Advanced Control and Intelligent Automation for Complex Systems, China

P-0350 Bi Dopant Role in Phase, Structure, Morphological and Photoelectrochemical Behavior of Copper Vanadate Photocatalysts
B Jansi Rani, G Ravi, R Yuvakkumar
Alagappa University, India

P-0356 Estimating Interaction Parameters of Magnetic Structures Using Machine Learning Algorithm

Han Gyu Yoon[1], Hee Young Kwon[1], Gong Chen[2], Chanki Lee[1], Chiho Song[1], Doobong Lee[1], Changyeon Won[1]
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P-0371 Comparison of Hole and Electron Doping in $Sm_3Ba_5Cu_8O_{19}$

Mohammad Sandoghchi, Mohammad Akhavan
Sharif University of Technology, Iran

P-0391 Critical Behavior of the Cooperative Jahn-Teller Distortion in Ultrathin $LaMnO_3$ Films

Yong-Jin Kim[1], Youngki Yeo[1], Byeong-Gwan Cho[2], Tae-Yeong Koo[2], Chan-Ho Yang[1]
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P-0396 Indirect Estimates of the Magnetocaloric Effect in Manganites according to the Thermophysical Measurements

Adler Gamzatov[1,2], A Aliev[1], A Batdalov[1], P.D.H. Yen[2], S.-C. Yu[2]
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P-0412 La0.7Ca0.3Mn1-xScxO3 (x= 0.0; 0.03, and 0.05) Manganites: Hybridization of Electronic State, Valence and Magnetic Properties

Alexandr Ulyanov[1], Hyun-Joon Shin[2], Ki-jeong Kim[2], Alexandr V. Vasiliev[1], Serguei V. Savilov[1], Dong-Seok Yang[3]
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P-0421 Enhanced Non-Ohmic Conduction in Exfoliated La0.7Ca0.3MnO3 Thin Films

Jungsik Park[1], Kyung Song[2], Jaehoon Shin[1], Yongjin Kim[1], Hyungwoo Lee[1], Chan-Ho Yang[1]
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P-0455 Optical Investigation of a Layered Ferromagnetic Semiconductor $CrSiTe_3$ by Spectroscopic Ellipsometry

Mangesh Diware[1], Chang Bae Park[1], Dilip Kumar Bhoi[1], Van Long Le[2], Tae Jung Kim[2], Yong Dong Kim[2], Kee Hoon Kim[1]
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P-0479 Measurement of DW Width and Exchange Stiffness with DW Motion

Yune-Seok Nam[1], Dae-Yun Kim[1], Min-Ho Park[1], Seong-Hyub Lee[1], Yong-Keun Park[1,2], Duck-Ho Kim[3], Byung-Chul Min[2], Sug-Bong Choe[1]
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P-0493 Manipulation of Charge Density Waves in Niobium Dislenide: A Hierarchy Change

Fabrizio Cossu, Igor DiMarco, Alireza Akbari
Asia Pacific Center for Theoretical Physics, Korea

P-0496 Under Pt-Layer Thickness Dependence of the Dzyaloshinskii Moriya Interaction in Pt/Co/Pt Films

Dae-Yun Kim[1], Ji-Sung Yu[1], Seong-Hyub Lee[1], Yong-Keun Park[1,2], Duck-Ho Kim[3], Byoung-Chul Min[2], Sug-bong Choe[1]
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P-0498 Excitation of Multiple Spin-wave Modes and Their Critical Angles in a Photon magnon Coupled System

Bosung Kim, Biswanath Bhoi, Sang-Koog Kim
Seoul National University, Korea

P-0501 Numerical Analysis for the Phase Diagrams of High-Tc Superconductivity Based on U(1) and SU(2) Slave-Boson Approaches to the t-J Hamiltonian

Sul-Ah Ahn[1], Hyeyoung Cho[1], Sung-Ho S. Salk[2]
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P-0503 **Artifact-free Optical Spin-orbit Torque Magnetometry**

Joo Sung Kim1, Yong Keun Park[1,2], Hyun Seok Whang[1], Jung Hyun Park[1], Byoung Chul Min[2], Sug Bong Choe[1]
[1]Seoul National University, Korea, [2]Korea Institute of Science and Technology, Korea

P-0507 **Magneto-dielectric Properties of Spinel Ferrites ($Ni_{0.5}Zn_{0.5}Fe_2O_4$) Epoxy Composites**

Ji-Eun Yoo, Young-Min Kang
Korea National University of Transportation, Korea

P-0510 **The Magneto-dielectric Properties of Z-type Hexaferrites ($Sr_3Co_{2-x}Zn_xFe_{24}O_{41}$) Epoxy Composite**

Eun-Soo Lim, Young-Min Kang
Korea National University of Transportation, Korea

P-0527 **Electrical Transport Properties of PLD Grown YBa2Cu3O7-x/Sm0.55Sr0.45MnO3 Superconductor-Ferromagnetic Thin Films**

Suman Kumari[1,2], Shital Chauhan[1,2], P. K. Siwach[1,2], K. K. Maurya[1,2], H. K. Singh[1,2]
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P-0528 **Magnetic and Magnetocaloric Properties of RM_2 Laves Phases Compounds (R = Er, Tb, Ho and M = Fe, Co, Mn)**

Abdelwaheb Cheikhrouhou
University of Sfax, Tunisia

P-0553 **Tc Variation of Niobium Thin Films with Strain and Ionic Liquid Gating**

Joonyoung Choi, Chang-Duk Kim, Sooran Kim, Younjung Jo
Kyungpook National University, Korea

P-0572 **Magneto-elastic Excitations in Multiferroic h-$YMnO_3$ Using Inelastic X-ray Scattering**

Kisoo Park[1,2], Joosung Oh[1,2], Jonathan C. Leiner[1,2], Taehun Kim[1,2], Hasung Sim[1,2], Ho-Hyun Nahm[3], Ki Hoon Lee[1,2], Jaehong Jeong[1,2], Daisuke Ishikawa[4], Alfred Q. R. Baron[4], Je-Geun Park[1,2]
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P-0575 **Investigation of Phonons in Spin-Phonon Coupling System: Pyrochlore $Cd_2Os_2O_7$**

Taehun Kim[1,2], Kisoo Park[1,2], Pyeongjae Park[1,2], Ki Hoon Lee[1,2], Choong H. Kim[1,2], Jonathan C. Leiner[1,2], Daisuke Ishikawa[3], Alfred Q. R. Baron[4], Zenji Hiroi[5], Je-Geun Park[1,2]
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P-0579 **Direct Measurements of the Magnetocaloric Effect for $La_{0.9}R_{0.1}Fe_{11.2}Co_{0.7}Si_{1.1}$ (R = Ho, Pr) in Cyclic Magnetic Fields**

A Aliev[1], Adler Gamzatov[1], N.Z. Abdulkadirova[1], P. Gębara[2]
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P-0630 **Hydrogen Ion Implantation Induced Magnetic Property Modification in FeRh Films**

Sehwan Song, Dooyong Lee, Jiwoong Kim, Sungkyun Park
Pusan National University, Korea

P-0640 **Strong Magnetoelectric Coupling in Mixed Ferrimagnetic-multiferroic Phases of a Double Perovskite**

Donggun Oh[1], Young Jai Choi[1], Nara Lee[1], Mi Kyung Kim[2,3], Jae Young Moon[1], Sang Hyup Oh[1]
[1]Yonsei University, Korea, [2]Institute for Basic Science, Korea, [3]Seoul National University, Korea

P-0644 **Thermophysical Properties of Ribbon Samples of Heusler Alloys $Ni_{50}Mn_{37-x}Al_xSn_{13}$ (x = 2,4,6 and 8)**
A.B. Batdalov[1], Adler Gamzatov[1], A. Aliev[1], Sh.K. Khizriev[1], Nguyen Hai Yen[2], Nguyen Huy Dan[2], S.-C. Yu[3]
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P-0699 **Anisotropic Magnetic Properties and Magnetocaloric Effect in Single Crystal Tb_2CoMnO_6**
Jaeyoung Moon[1], Mi Kyung Kim[2, 3], Donggun Oh[1], Jonghyuk Kim[1], Hyunjun Shin[1], Young Jai Choi[1], Nara Lee[1]
[1]Yonsei University, Korea, [2]Institute for Basic Science, Korea, [3]Seoul National University, Korea

P-0710 **Influences of Substitutional Cobalt in Magnetic Properties of Tetragonal D022 Mn3Ga**
Thi Quynh Anh Nguyen, Huynh Thi Ho, Soon Cheol Hong, Sonny H. Rhim
University of Ulsan, Korea

P-0717 **Nonmagnetic Ion Doping Effect on Spin Excitations In Hexagonal $RMn_{1-x}Ga_xO_3$ (R=Y, Ho)**
Ji-Yeon Nam[1], Seung Kim[1], Hien Nguyen Thi Minh[2], Xiang-Bai Chen[3], Hasung Sim[4, 5], Je-Geun Park[4, 5], D. Lee[4, 5], T.W. Noh[4, 5], In-Sang Yang[1]
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P-0725 **Probing the Spin System in Transition Metal Doped SnO2 and TiO2 by Using Electron Spin Resonance Measurement Techniques**
Yared Worku, Vijaya Sirnavasu
University of South Africa, South Africa

P-0758 **Spin-orbit Torques in Silicene Zigzag Nanoribbons**
Son-Hsien Chen
University of Taipei, Taiwan

P-0763 **Multi-states Anomalous Hall Resistance Changes with DW Motion in a Single Hall Bar Structure for the Neuromorphic Computing**
Yoonui Kim, Jaesuk Kwon, Hee-Kyeong Hwang, Chun-Yeol You
Daegu Gyeongbuk Institute of Science and Technology, Korea

P-0791 **Tuning Perpendicular Magnetocrystalline Anisotropy of Pt/Co/W(111) Superlattice**
Huynh Thi Ho, Sang Hoon Kim, Sonny H. Rhim, Soon Cheol Hong
University of Ulsan, Korea

P-0813 **The First Principles Study Intrinsic Spin Hall Conductivity of α-W and α-Ta**
Soon Cheol Hong, S.H. Rhim, Duc Cuong Do
University of Ulsan, Korea

P-0843 **Spin Hall Magnetoresistance in $Pt/IrMn_3/NiFe$ Structures**
Thi Nga Do[1, 2], Thi Kim Hang Pham[1, 2], Tae Hee Kim[1, 2]
[1]Institute for Basic Science, Korea, [2]Ewha Womans University, Korea

P-0846 **Dynamics Characteristics of Ferrimagnetic Gd_xFeCo_{1-x} Nanoparticles: Atomistic Simulation Study**
Jaegun Sim, Jae-Hyeok Lee, Yongsub Kim, Sang-Koog Kim
Seoul National University, Korea

P-0867 **Spin Wave Modes and Spiral Rotating Motion of Magnetic Skyrmion in Magnetic Nanotubes**
Jaehak Yang, Junhoe Kim, Bosung Kim, Young-Jun Cho, Jae-Hyeok Lee, Sang-Koog Kim
Seoul National University, Korea

P-0887 **Micromagnetic Properties of $Sn_{1-x}Mn_xTe$ Epitaxial Layers Grown on BaF_2 and GaAs Substrates**

Monika Zieba[1], Katarzyna Gas[1], Aneta Grochot[1], Grzegorz Mazur[2], Anna Kaleta[1], Anna Reszka[1], Roman Minikayev[1], Badri Taliashvili[1], Krzysztof Dybko[1, 2], Maciej Wiater[2], Tomasz Wojtowicz[2], Hanka Przybylinska[1], Maciej Sawicki[1], Tomasz Story[1, 2]
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P-0896 **Magnetic Anisotropy Engineering in the Insulating Ferromagnet (Ga,Mn)N**

Katarzyna Gas[1, 2], Rajdeep Adhikari[3], Dariusz Sztenkiel[1], Andrea Navarro-Quezada[3], Jaroslaw Domagala[1], Detlef Hommel[2, 4], Alberta Bonanni[3], Maciej Sawicki[1]
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P-0952 **Enhancement of Spin Polarization by Au Magnetoplasmonic Effect of Co Coated ZnO Nanowires**

Hua Shu Hsu, J. X. Lin, Y. T. Tseng, J. S. Lee
National Pingtung University, Taiwan

P-0968 **Synthesis and Characterization of the Magnetic Property of Cr(1-δ)Te**

InHak Lee, Byoung Ki Choi, Hyuk Jin Kim, Young Jun Chang
University of Seoul, Korea

P-0972 **Characteristics of an Mechanical Circuit Breaker with New Induction Needle and Magnets Type to Extinguish a DC Arc**

Sang-Yong Park, Hyo-Sang Choi
Chosun University, Korea

P-0974 **Stoichiometric Optimization on Strained Pyrochlore Iridate**

JeongKeun Song[1, 2], Woo Jin Kim[1, 2], Tae Won Noh[1, 2]
[1]Seoul National University, Korea, [2]Center for Correlated Electron System, Korea

P-1008 **Impact of Oxygen Adsorption on Topological Spin Structures at Ultrathin Magnetic Interfaces**

Tzu-Hung Chuang[1], Chih-Heng Huang[2], Yao-Jui Chan[2], Chii-Bin Wu[3], Chien-Cheng Kuo[2], Der-Hsin Wei[1, 2]
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P-1028 **Fabrication of Asymmetric Full Cell Supercapacitors from Binary Metal Oxides ($MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$) Nanomaterial**

Saravanakumar B[1], Shobana M[2], Ravi G[1], Ganesh V[3], Ramesh K Guduru[4], Yuvakkumar R[1]
[1]Alagappa University, India, [2]Coimbatore Institute of Technology, India, [3]CSIR–Central Electrochemical Research Institute, India, [4]Lamar University, Beaumont, USA

ABSTRACTS

Oral Session

Poster Session

S-0188 10:00-10:30, August 19 | Room 513

Heavy Fermions and the Chemistry of Superconducting Materials

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Superconductors are widely scattered but sparsely populating the space of materials. Heavy Fermions are one class of materials where we know where to look for superconductivity, namely in the vicinity of a quantum critical point.
This local/de-local boundary can be generalized to describe broadly where superconductivity is found.

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S-0184 10:50-11:20, August 19 | Room 513

Unconventional Superconductivity and Electronic Correlations in Pr-based "Cage" Compounds

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Unconventional types of superconductivity (SC) have been observed in two classes of Pr-based "cage" compounds, PrT_4X_{12} (T = Fe, Ru, Os, Pt; X = P, As, Sb, Ge) "filled skutterudites" [1] and PrT_2X_{20} (T = Ti, V, Ni, Pt, Pd; X = Zn, Cd, Al) "1-2-20" compounds [2]. The hybridization of the localized 4f-electron states of the Pr "guest" ions with the ligand states of the surrounding ions of the "atomic cages" within which the Pr ions reside leads to strong electronic correlations. The "filled skutterudite" compounds $PrOs_4Sb_{12}$ [3] and $PrPt_4Ge_{12}$ [4] exhibit unconventional SC, with SCing critical temperatures (T_c's) of 1.86 K and 7.9 K, respectively. The SC arises from multiple bands, appears to have gap nodes, and breaks time reversal symmetry; both compounds are nonmagnetic with Pr3+ singlet crystalline electric field ground states. The "1-2-20" compounds $PrTi_2Al_{20}$ and PrV_2Al_{20} have been reported to display unconventional SC with T_c's of 0.2 K and 0.05 K, respectively. The SC coexists with ferroquadrupolar (FQ) order (TFQ = 2 K) in PrTi2Al20 and antiferroquadrupolar (AFQ) order (TAFQ = 0.6 K) in PrV_2Al_{20}. We review recent experiments in which Ce and Eu substitutions for Pr have been used to probe the unconventional SC and electronic correlations in the filled skutterudite compound $PrPt_4Ge_{12}$ by means of electrical resistivity, magnetic susceptibility, and specific heat measurements as a function of Ce and Eu substituent composition x, temperature T and magnetic field H. Experiments on the $Pr_{1-x}Ce_xPt_4Ge_{12}$ system reveal a depression of T_c with x with positive curvature that is reminiscent of pair weakening interactions or the interplay between SC and the Kondo effect with a large Kondo temperature $T_K >> T_c$. Specific heat measurements indicate that SC develops in at least two bands, and the SCing order parameter has nodes on one Fermi pocket and remains fully gapped on the other. Both the nodal and nodeless gaps decrease with increasing Ce concentration with a rate of suppression that is larger for the nodal gap. Experiments on the $Pr_{1-x}Eu_xPt_4Ge_{12}$ system reveal a depression of T_c with x with negative curvature indicative of SCing electron pairbreaking by divalent Eu ions which carry localized magnetic moments of 7 μ_B. The specific heat measurements reveal the presence of short-range AFM correlations between Eu ions under the SCing dome for $x \leq 0.5$ and long-range AFM order for $x \geq 0.5$. SC and AFM most likely coexist for $0.3 \leq x \leq 0.6$. The SCing gap has line nodes for $0 \leq x \leq 0.1$ and is isotropic for $0.15 \leq x \leq 0.5$.

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S-0781 11:20-11:50, August 19 | Room 513

Hidden Quantum Critical Point and Unconventional Superconductivity in the Heavy Fermion Compound CeRhIn5

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Heavy fermion compounds belong to the family of the high-Tc superconductors in which the superconducting (SC) gap is unconventional and the ratio of Tc to Fermi energy is unusually large. The tunability of competing interactions (~ meV) of heavy fermions brings out unique opportunity to control their quantum states via non-intrusive perturbations such as pressure. In this presentation, we discuss evidences for the interplay between unconventional superconductivity and a quantum critical point (QCP) that is inherently obscured by a pressure-induced dome of superconductivity in quantum critical metals. For example, a sharp peak in the pressure dependence of the critical current density coincides with a hidden QCP in both pure and 4.4% Sn doped CeRhIn5, implying that the superconducting (SC) coupling strength is strongly enhanced where SC pair breaking is expected to be the strongest. These results underline that the ubiquitous quantum critical point (QCP) hidden inside the superconducting phase in strongly correlated materials can be exposed by the critical current density, thereby providing the direct link between a QCP and unconventional superconductivity.

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S-0169 11:50-12:20, August 19 | Room 513

Correlated Electrons: The Dark Energy of Quantum Materials

Laura Greene*

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The 80-year-old correlated electron problems remain largely unsolved; with one stunning success being BCS electron-phonon mediated “conventional” superconductivity. There are dozens of families of superconductors that are “unconventional” including the high-Tc cuprates, iron-based, and heavy fermion superconductors. Although these materials are disparate in many properties, some of their fundamental properties are strikingly similar, including their ubiquitous phase diagram; with intriguing correlated-electron (not-Fermi liquid) phases above the superconducting transition. These remain among the greatest unsolved problems in physics today; and a fun analogy stressing this will be presented. I will also present a MagLab overview and outline some of our own work on heavyfermion materials using quasiparticle scattering and planar tunneling spectroscopies, which are uniquely situated to map out non-Fermi-liquid states.

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Exciton Superfluid and Ferromagnetic Superconductivity in Graphene

Philip Kim*

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Superfluid and superconductors are two prototypical examples of quantum condensates of bosonic particles. By controlling the interaction between two fermionic particles, a composite boson can be formed by pairing fermions. A crossover behavior from weak coupling superconducting Bardeen-Cooper-Schrieffer (BCS) pairing to a superfluid Bose-Einstein condensate (BEC) of tightly bound pairs has been expected as a function of the attractive interaction in Fermi systems. In this talk, we will discuss two such examples realized in graphene heterostructures. In the first part of the presentation, we will discuss an experimental demonstration of magnetoexciton condensation. Employing two layers of graphene separated by an atomically thin insulator, we realize a superfluid condensation of magnetic-fieldinduced excitons across the double layers of graphene probed by Coulomb drag. Here, we observe dissipationless exciton motion in this system across the BEC-BCS phase boundary controlled by the magnetic field. In the second part of the presentation, we will discuss the recent development of unconventional superconductivity appeared in twisted double graphene bilayers with small twisting angles. We observed that a ferromagnetic correlated insulating state appears by controlling the flatness of the bilayer graphene band using the perpendicular electric field applied by the gate. Upon doping this ferromagnetic insulator, we obtain the superconductivity, whose transition temperature can be controlled by electric fields. Remarkably, we find that increasing in-plane magnetic field increases superconducting transition temperature, suggesting unconventional superconductivity with spin-polarized cooper pairs.

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Electronic structure and electron-phonon coupling in twisted graphene layers

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We report strong electron-phonon coupling in magic-angle twisted bilayer graphene (MA-TBG) obtained from atomistic description of the system including more than 10,000 atoms in the moiré supercell. Electronic structure, phonon spectrum, and electron-phonon coupling strength λ are obtained before and after atomic-position relaxation both in and out of plane. Obtained λ is very large for MA-TBG, with $\lambda > 1$ near the half- filling energies of the flat bands, while it is small ($\lambda \sim 0.1$) for monolayer and unrotated bilayer graphene. Significant electron-hole asymmetry occurs in the electronic structure after atomic-structure relaxation, so λ is much stronger with hole doping than electron doping. Obtained electron-phonon coupling is nearly isotropic and depends very weakly on electronic band and momentum, indicating that electron-phonon coupling prefers single-gap s-wave superconductivity. Relevant phonon energies are much larger than electron energy scale, going far beyond adiabatic limit. We also present atomistic calculations on structural and electronic properties of twisted double bilayer graphene (TDBG) consisting of two sets of rotationally misaligned Bernal-stacked bilayer graphene. Obtained equilibrium atomic structures exhibit in-plane strains and the modulation of the interlayer distances at the rotationally mismatched interface layers. We find that the electronic structure of TDBG can have an intrinsic band gap at the charge neutral point for a large range of the twist angle theta. Near $\theta = 1.25°$, the intrinsic band gap disappears and TDBG hosts flat bands at the Fermi level that are energetically well separated from higher and lower energy bands. The flat bands are easily tunable by applying vertical electric fields, and extremely narrow bandwidths less than 10 meV can be achieved for the electron-side flat bands in a wide range of the twist angle. This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (Project No. KSC-2018-CRE-0097).

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Study of Carbon-Nanotube-Tempelated, Flexible Superconducting NbN nanowire Yarns

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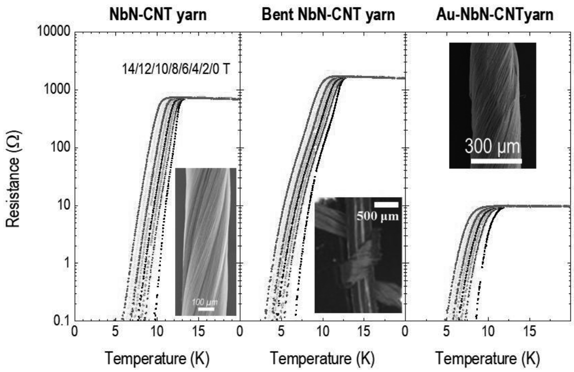
[2]*Sungkyunkwan University, Korea*

Flexible superconducting yarns were fabricated using highly aligned carbon nanotube (CNT) sheets. CNT sheets which are drawn from a dense CNT forest have high flexibility, porosity, and light weight, and can be easily transformed to yarns by twisting. In addition, because CNT sheets are easily combined with guest materials which have special functionality, they have been widely used as substrate. Superconducting nanowire arrays were obtained by sputtering deposition of an NbN layer on highly aligned CNT sheets. The superconducting properties of NbN-CNT yarns were examined, comparing a typical NbN film deposited on a SiO_2 substrate. High flexibility makes it possible for the system to maintain its superconducting state even under the harsh mechanical deformation, such as knotting or making a coil with a bending diameter of 500 µm. In addition, a twisted structure of nanoarrays results in a very interesting phenomena in electrical transport. Absolute negative resistance in a conventional four-probe method was observed near transition temperature before stable and uniform superconducting state was established throughout the whole sample. Because superconducting state in NbN film and normal metallic state in junction parts and CNT bundles are mixed near the transition temperature, the voltage difference becomes reversed, depending on the current which flows only superconducting states or passes by the normal states, which can be demonstrated by simple circuit models. In this study, we suggest that superconducting nanowire yarns based on the CNT sheets can be not only a candidate for flexible superconducting cables but a platform for exotic superconducting phenomena.



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Superconductivity of Hard Hexagonal ε-NbN Epitaxial Films

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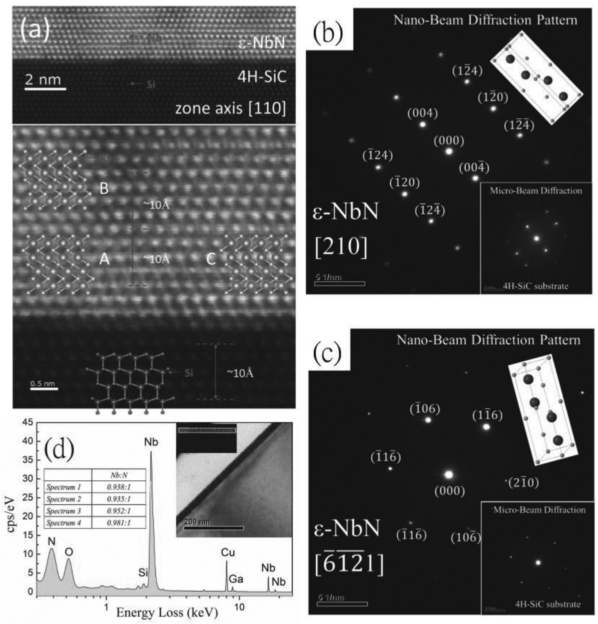
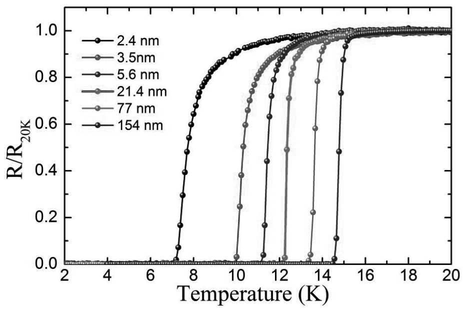
Recently, superconducting transition at 11.6 K was firstly reported in hard hexagonal ε-NbN polycrystalline sample by high pressure and high temperature synthesis, which attracts great attention on hard superconductor.
Furthermore, band structure calculation reveals that ε-NbN might have topological characteristics. In this presentation, we will report the success of growing hard hexagonal ε-NbN ultrathin film on 4H-SiC substrate by oblique-angle magnetron sputtering method for the first time. The top and cross-sectional scanning electron microscope images reveal that the films grow in columnar. The high resolution transmission electron microscope images and selected area electron diffraction patterns and X-ray diffraction confirm the hexagonal symmetry of deposited films. The cross-sectional electron dispersion spectroscopy spectrum suggest the Nb:N ratio of 1:1. The deposited films revealing a significantly shortened c-axis could be due to the enlarged a-axis by substrate effect and some Nb and N vacancies. Sharp superconducting transition was observed in both magnetic and transport measurements. The superconducting transition temperature is around 12.3 K in 21.4 nm film and reaches to 14.7 K in 154 nm film. The ε-NbN film is a strong coupling superconductor with $2\Delta/k_BT_C \sim 4.8$ from the scanning tunneling spectroscope measurement and its estimated superconducting coherent length at zero temperature in ab-plane is about 4.5 nm.





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Resolving Remaining Issues of Fractional Quantum Hall Effect via Non-equilibrium Many-body Dynamics

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Determining plateau widths and energy gaps is the remaining task to fully understand the electron dynamics in the fractional quantum Hall effect. We report that this determination is given by the degree of multi-electron correlations flowing in incompressible strips formed in a Hall bar under non-equilibrium conditions. A recent experiment shows that Hall current flows through the regions of a few micrometer width in both edge and center, as shown in the leftmost panel of Fig1. The experimental observations for Hall resistivity and energy gaps shown in Fig1 must be explained consistently along with the behavior of Hall current. The wide region of edge current can be explained by introducing multiple incompressible strips through which Hall current flows. To explain the remaining two, we propose a well type confining potential in the incompressible strip by considering speed and direction of the deformed cycloidal motion of an electron moving through the strip, and show that an electron flowing through the incompressible strip behaves as a quasiparticle comprising the electron and its image that replaces the well type confining potential. This quasiparticle is a composite boson of spin unity, and many-body interaction induces correlated quasiparticles having higher integral spins. The Zeeman effect for these integral spins of the quasiparticles yields fine splits in Landau level, which is responsible for the plateaus in Hall resistivity at fractional fillings. With such a scheme, we explicitly reproduce experimental Hall resistivity and energy gaps. Thus, we explain the three experiments shown in Fig1 consistently. In this talk, however, we consider only the lowest Landau level.

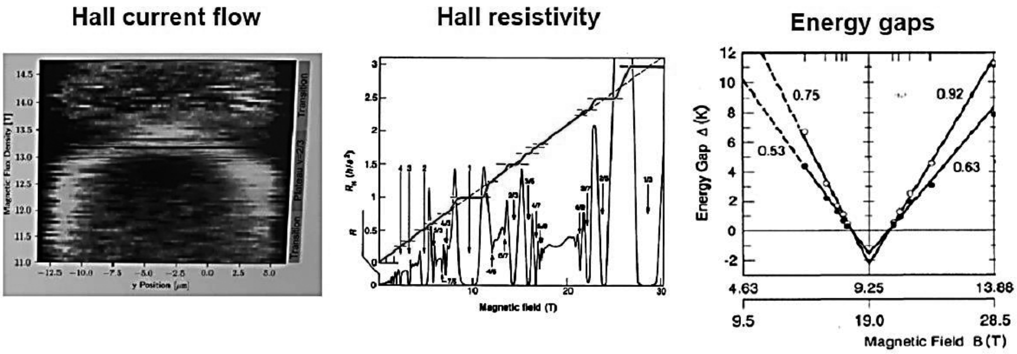

Fig1. Three experimental results for fractional quantum systems.

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Intrinsic Topological Superconductivity Induced by Textured Magnetic Order

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Systems that inherently exhibit topological superconductivity are rare in nature and the highly coveted Majorana fermions are mainly pursued in engineered hybrid devices. Here we propose to harness the possible microscopic coexistence of superconductivity and magnetism as an alternative pathway to craft intrinsic topological superconductors [1]. We focus on materials with spontaneous textured magnetic order driven by Fermi surface nesting. Our work is motivated by the iron pnictides, in which such a coexistence has been shown experimentally, e.g. see [2], and a recent theoretical analysis [3] has revealed that textured magnetism is also accessible in doped $BaFe_2As_2$ and LaFeAsO. We explore the arising topological superconducting phases in layered multiband materials with magnetic spiral, whirl or skyrmion order, coexisting with various types of spin-singlet superconductivity. The diverse magnetic phases lead to a variety of flat, unidirectional, helical and chiral Majorana edge modes. We show that this multifaceted manifestation of Majorana fermion modes stems from the interplay of topological phases with both gapped and nodal bulk energy spectra.

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Edge currents as a probe of the strongly spin-polarized topological noncentrosymmetric superconductors

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Asia Pacific Center for Theoretical Physics, Korea

Recently the influence of antisymmetric spin-orbit coupling has been studied in novel topological superconductors such as half-Heusler compounds and artificial heterostructures. We investigate the effect of Rashba and/or Dresselhaus spin-orbit couplings on the band structure and topological properties of a two-dimensional noncentrosymmetric superconductor. For this goal, the topological helical edge modes are analyzed for different spin-orbit couplings as well as for several superconducting pairing symmetries. To explore the transport properties, we examine the response of the spin-polarized edge states to an exchange field in a superconductor-ferromagnet heterostructure. The broken chiral symmetry causes the unidirectional currents at opposite edges. We propose the existence of a substantial charge current parallel to the interface between a noncentrosymmetric superconductor and a metallic ferromagnet. Our analysis focuses upon two complementary orbital-angular-momentum pairing states of the superconductor, exemplifying topologically nontrivial states which are gapped and gapless in the bulk, respectively. We derive an expression for the interface current a long with a systematic study of the current considering the qualitative differences between the gapped and gapless superconductors, which reflect the very different underlying topological properties. We argue that the interface current provides a novel test of the topology of the superconductor, and discuss prospects for the experimental verification of our predictions.

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S-1023 16:15-16:30, August 19 | Room 513

Topological phase transitions in topological insulators

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We have investigated a series of topological phase transitions in ultrathin films of Bi2Se3 by means of terahertz timedomain spectroscopy (THz-TDS). When the film thickness is reduced to below about 6 QL, there occurs hybridization of top and bottom TSSs (topological surface states) with concomitant transition to the 2D hybrid topological insulator phase. Application of an external in-plane magnetic field then drives the system to a semimetallic phase. An out-of-plane field can also modulate the existing hybridization gap. Quantization of surface conductance and its temperature dependence will also be reported.

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M-0262 10:00-10:30, August 19 | Room 517

Majorana quantization and half-integer thermal quantum Hall effect in a quantum spin liquid

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The quantum Hall effect (QHE) is one of the most remarkable phenomena in contemporary condensed matter physics, which rivals superconductivity in its fundamental significance as a manifestation of quantum mechanics on a macroscopic scale. The quantum Hall state is a topological property of quantum matter. There are two classes of the QHE, where integer and fractional electrical conductance are measured in units of e^2/h. Here we report a novel type of quantization of the Hall effect caused by charge neutral quasiparticles, i.e. Majorana fermions, in an insulating two-dimensional (2D) quantum magnet, α-$RuCl_3$ with honeycomb lattice[1][2]. This material has been suggested to be a candidate of Kitaev quantum spin liquid (QSL), where significant entanglement of quantum spins is expected. In the low-temperature regime of the QSL state, the 2D thermal Hall conductance reaches a quantum plateau as a function of applied magnetic field. Surprisingly, the plateau attains a quantization value $\kappa_{xy}/T=1/2(\pi^2 kB^2/3h)$, which is exactly half of that in the integer QHE. This half-integer thermal Hall conductance observed in a bulk material is a direct signature of topologically protected chiral edge currents of emergent Majorana fermions, whose degrees of freedom are half of those of electrons, and non-Abelian anyons in the bulk.

in collaboration with Y. Kasahara, Sixiao Ma, T. Ohnishi,(Kyoto Univ.) K. Sugii, Y. Mizukami, M. Shimozawa, M. Yamashita (ISSP, Univ. of Tokyo), N. Kurita, H. Tanaka (Tokyo Inst. of Tech.), J. Nasu (Yokohama National Univ.), Y. Motome (Dep. of Appl. Phys., Univ. of Tokyo), O. Tanaka, Y. Mizukami, and T. Shibauchi (Dep. of Adv. Mat. Sci., Univ. of Tokyo).

[1]Y. Kasahara et al. Phys. Rev. Lett. 120, 217205 (2018).
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Topological Matters in oxide heterostructure

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Recently, there have been exploding number of studies on topological matters in condensed matter physics. They have provided us new paradigms, so they opened new perspectives on our view on condensed matters. Up to this point, most studies have been made on wide band materials with large spin-orbit coupling (SOC), whose bulk physical properties could be easily understood in terms of conventional band theories.

However, there have been little experimental and theoretical efforts to search for topological matters in transition metal oxides. One of the important reasons is that they usually have strong electron correlation effects, which are difficult to describe by band theories. Our current understanding on the interplay between topology and correlation is very limited. During last seven years, in our IBS center, we have made lots of efforts to discover new emerging phenomena and novel ground states in transition metal oxides. In this talk, I will describe some of our efforts to find such correlated topological matters.We have investigated physical properties of numerous 5d pyrochlore oxides, which have intriguing magnetic ground states due to SOC. We found the unconventional spin-phonon couplings in $Cd_2Os_2O_7$ [1] and $Y_2Ir_2O_7$, magnon Raman scattering [2], and Lifshitz type metal-insulator transition [3]. We also have extended our studies to search for topological matters in oxide heterostructures. We observed direct penetration of spin-triplet superconductivity into a ferromagnet in $Au/SrRuO_3/Sr_2RuO_4$ [4]. We observed the ferroelectrically tunable magnetic skyrmions in ultrathin ferroelectric/metallic oxide bilayers [5]. Very recently, we found the strain-induced Weyl semimetallic phase in epitaxial $Y_2Ir_2O_7$ films [6]. If we would be able to discover new emergent phenomena coming from such correlated topological matters, we will have great opportunities to open new frontiers in condensed matter physics.

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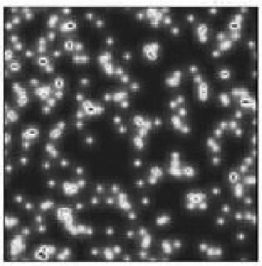

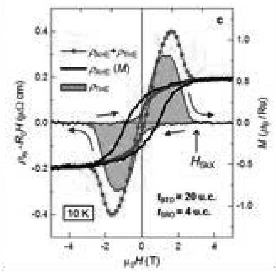

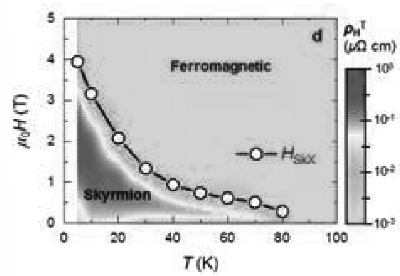

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M-0933 11:20-11:50, August 19 | Room 517

Magnetic skyrmion in IMA system

Chanyong Hwang*

Korea Research Institute of Standards and Science, Korea

Recently, understanding the topological phenomena has been an important issue even in magnetism. Finding the topologically non-trivial spin structure in magnetism becomes very important for its possible application in spintronics. Among topological spin textures, skyrmion is one of the most studied examples. However, most of these studies have been confined in perpendicularly magnetized system. We will introduce new type of skyrmions especially in the magnetic system with in-plane magnetic anisotropy. Its structure and motion under the current flow will be introduced.

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M-0259 11:50-12:05, August 19 | Room 517

In situ Electric Field Skyrmion Creation in Magnetoelectric Cu_2OSeO_3

Ping Huang[1]*, Marco Cantoni[2], Alex Kruchkov[3], Jayaraman Rajeswari[2], Arnaud Magrez[2], Fabrizio Carbone[2]*, Henrik Ronnow[2]*

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Magnetic skyrmions are localized nanometric spin textures with quantized winding numbers as the topological invariant. Rapidly increasing attention has been paid to the investigations of skyrmions due both to the fundamental properties and the promising potential in spintronics based applications. However, controlled creation of skyrmions, especially by electric means, remains a pivotal challenge towards technological applications. Due to magnetoelectric coupling effect, electric polarizations emerge in insulating Cu_2OSeO_3. The coupling between the external electric field and the emergent electric polarization thus provides a direct handle for tuning the relative energies of the competing magnetic textures. Here, we report that skyrmions can be created locally by electric field in the magnetoelectric helimagnet Cu_2OSeO_3. Using Lorentz transmission electron microscopy, we successfully write skyrmions in situ from a helical spin background. Our discovery is highly coveted since it implies that skyrmionics can be integrated into modern field effect transistor based electronic technology, where very low energy dissipation can be achieved, and hence realizes a large step forward to its practical applications.

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M-0333

12:05-12:20, August 19 | Room 517

Observation of Skyrmion liquid in a chiral magnet

Yisheng Chai*

Chongqing University, China

A wide class of condensed matter systems can be effectively described as a collection of interacting quasi-particles, like the vortices in type-II superconductors, charge density waves, Wigner crystals of electrons, and Skyrmion phase in chiral magnets, by forming a hexagonal lattice of particles. For weak disorder, the close-packed assembly generally responses to external stimulus elastically and retain their original neighbors. By contrast, for stronger disorder or longer particle-particle distance, the depinning becomes plastic with particles continuously changing neighbors over time, yielding a fluctuating liquid-like state, as confirmed experimentally in the vortices phase in Type-II superconductors. For magnetic Skyrmions, however, the liquid phase as well as a liquid to lattice phase transition have never been identified experimentally. Here, we report strong evidences for the existence of Skyrmion liquid phases in bulk MnSi by using a dynamic magnetoelectric coupling technique. This technique is able to electrically probe the ac magnetoelastic response of Skyrmion phase in MnSi via interfacial strain coupling in a composite magnetoelectric configuration. Clear out-of-phase component of the electric signal is observed only in the Skyrmion liquid phase. Moreover, by tuning the density of Skyrmion or disorder, a lattice to liquid phase transition can further be induced, in analogy to the case in vortices in type-II superconductors.

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M-0912

14:00-14:30, August 19 | Room 517

Fractionalized Spin Excitations in Kitaev Quantum Magnet α-$RuCl_3$

Jae-Hoon Park*

Pohang University of Science and Technology, Korea

Quantum spin liquids (QSLs) are long-range entangled magnetic states with a topological order without long-range magnetic ordering accompanied with symmetry breaking. This "topological" QSL state is exactly derived by fractionalizing the spin excitations into Z2 gauge fluxes and Majorana fermions in the two dimensional (2D) Kitaev honeycomb 1/2-spin network with Ising-like nearest-neighbor bond directional Kitaev exchange interactions. α-$RuCl_3$, which consists of rather ideal honeycomb lattices stacking with van der Waals bonding, has been hailed to host the 2D Kitaev model although the ground state is represented by a zigzag-type antiferromagnetic (AFM) order below the Néel temperature $T_N = 6.5$ K due to additional non-Kitaev exchange interactions. Here we present results on the spin excitations obtained from the inelastic neutron scattering. At low temperature below T_N, the spin correlation function $S(Q,\omega)$ exhibits not only a strong dispersive feature of spin wave excitations originated from the AFM order but also broad continuum excitations up to 12 meV. These continuum excitations, which maintain up to ~ 200 K, well above T_N, can be well explained in terms of thermally fractionalized Majorana fermion excitations from the Kitaev QSL state. We also discuss the dynamic spin susceptibility extracted from the spin correlation function through comparison with theoretical model analyses based on a picture of fractionalized fermions interacting with the AFM order.

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M-0945 14:30-15:00, August 19 | Room 517

Higgs Modes in Quantum Critical Magnets

Bumjoon Kim*

Pohang University of Science and Technology, Korea

Condensed-matter analogs of the Higgs boson in particle physics allow insights into its behavior in different symmetries and dimensionalities. In this talk, I will discuss on Higgs modes in two different quantum antiferromagnets in proximity to quantum critical points. First, I will discuss on the quasi-two-dimensional Ca_2RuO_4, which we study using spin-polarized inelastic neutron scattering scattering. Our spin-wave spectra of Ca_2RuO_4 directly reveal a well-defined, dispersive Higgs mode, which quickly decays into transverse Goldstone modes at the antiferromagnetic ordering wavevector. Through a complete mapping of the transverse modes in the reciprocal space, we uniquely specify the minimal model Hamiltonian and describe the decay process. Next, I will discuss on a possible Higgs mode in Raman spectra of the pyrochlore iridate $Nd_2Ir_2O_7$. An intense and broad excitation emerges as the magnetic order set in, which, however, has a significantly narrower width as compared to that of the Higgs mode in Ca_2RuO_4, reflecting its more stable nature in three dimensions.

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M-0201 15:00-15:30, August 19 | Room 517

Stiefel Whitney class and topological phases in condensed matters

Junyeong Ahn, Sung Joon Park, Bohm Jung Yang*

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In this talk, I am going to introduce the topological phases whose nontrivial band topology is endowed with the mathematical structure, dubbed the Stiefel Whitney class. The Stiefel Whitney class becomes relevant in the system with space-time inversion symmetry where the electronic wave function becomes real. Basically, the Stiefel Whitney class indicates the topological obstruction of real wave functions in the Brillouin zone. Here we propose two dimensional Stiefel Whitney insulator and three dimensional semimetal with monopole nodal lines as specific examples characterized by the Stiefel Whitney class.

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M-0166 15:30-16:00, August 19 | Room 517

Gate-tunable Room-temperature Ferromagnetism in Two-dimensional Fe_3GeTe_2

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Fudan University, China

The advent of two-dimensional van der Waals crystals creates new possibilities in developing novel spintronic devices. Recent experiments have demonstrated that it its possible to obtain two-dimensional ferromagnetic order in insulating $Cr_2Ge_2Te_6$ and CrI_3 at low temperatures. Here, we developed a new device fabrication technique, and successfully isolated monolayers from layered metallic magnet Fe_3GeTe_2. We found that the itinerant ferromagnetism persists in Fe_3GeTe_2 down to monolayer. The ferromagnetic transition temperature, T_c, is suppressed in pristine Fe_3GeTe_2 thin flakes. An ionic gate, however, dramatically raises the T_c up to room temperature. The gate-tunable room-temperature ferromagnetism in two-dimensional Fe_3GeTe_2 opens up opportunities for potential voltage-controlled magnetoelectronics.

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M-0219 16:00-16:30, August 19 | Room 517

Topological and ferromagnetic properties of iron-based van der Waals metals

Jun Sung Kim*
Pohang University of Science and Technology, Korea

Topological semimetals, new states of matters whose low energy electronic structure possesses several band contact points or lines, are generally expected to exhibit intriguing topological responses. While most of the studies on topological semimetals are limited to non-magnetic materials with time-reversal symmetry, magnetic materials can also be endowed with topological band structures in which the interplay of magnetism and band topology can generate novel correlated topological phenomena. In this talk, I will introduce iron-based van der Waals (vdW) materials, where combination of magnetism, spin-orbit interaction, and topological band structures gives rise to unusual physical properties and magnetic tunability. This demonstrates that topological and ferromagnetic vdW materials have great potential for various spin-dependent electronic functionalities.

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Two-Dimensional Ferromagnetism in Oxide Heterostructures

Changhee Sohn*

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Recent discoveries of intrinsic ferromagnetism in van der Waals materials further promote searching for new materials with Landau-broken-symmetry phases in two dimensions. Here, we propose atomically designed oxide heterostructures $[SrTiO_3]_8$/ $[Sr_2FeReO_6]_n$ (n=1, 2, 4, ∞) as a new materials system for two-dimensional ferromagnetism. In Sr_2FeReO_6, large spin-orbit coupling of 5d Re orbitals and strong electron correlations in 3d Fe orbitals stabilize anisotropic ferromagnetism with a high Curie temperature (~400 K). We found that such ferromagnetism is survived even down to the single unit cell (thickness of 8 Å) of Sr_2FeReO_6 with TC of 155 K. This magnetic transition of our superlattices has been substantially shift to higher temperature (~ 250 K) with a moderate external magnetic field (~ 1 T), implying two-dimensional nature of ferromagnetism. Simultaneously, enhancement of strong electron correlation in our superlattices induced a Mott-like metal-insulator transition, resulting in an intriguing two-dimensional ferromagnetic Mott state. The origin of the metal-insulator transition with polarized spin states will be discussed based on optical spectroscopy and the first principle calculations.

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S-0160 09:00-09:30, August 20 | Room 513

Enhanced Superconductivity and Electronics in Network of One-dimensional Metal

Gil Young Cho*

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We present a novel theory of a conducting honeycomb network of one-dimensional metals as a low-energy description of some nearly commensurate charge-density wave systems. In the model, we theoretically uncover the emergence of a huge number of flat bands and symmetry-protected quadratic/Dirac band crossings. Due to these features, the system has strong instabilities toward exotic superconducting states and topological band insulators. We explore extensively the unusual symmetry, topology, and emerging superconductivity of this new model. We compare our model with that of the twisted bilayer graphene and discuss its relevance to the experimentally available materials including transition-metal dichalcogenides.

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S-0987 09:30-10:00, August 20 | Room 513

Enhanced superconductivity in the vicinity of a pressure-tuned CDW Lifshitz transition in multiband superconductors 2H-PdxTaSe_2

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High pressure has been an important physical parameter, of which applications to solids can lead to findings of e.g., unexplored exotic phases of various quantum matters or their putative quantum mechanical ground states. With recent developments of high pressure techniques, one can now apply conventionally up to ~200 GPa in diamond anvil cells and high quality hydrostatic pressure up to ~15 GPa at high field and low temperature environment. In this talk, I'll present pressure induced optimization of superconductivity, particularly focusing on tuning of electronic states in chalcogenide superconductors PdxTaSe2. I will point out a possibility that the interplay between charge density wave (CDW) and superconductivity (SC) can exhibit unexpected change of electronic structure to strengthen superconductivity via the increase of electronic density of states and electron-phonon coupling. The enhanced superconductivity obviously seems to involve a Liftshitz transition in one of Fermi surface pockets formed within the commensurate CDW state. I'll also present experimental evidences of observing a possible quantum critical point at the Liftshitz transition.

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Pressure induced unconventional superconductivity in topological insulator $Bi_2Te_{2.7}Se_{0.3}$

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Topological superconductors are predicted to be the path leading to the long sought Majorana quasiparticle.
Inspired by this, accessing superconductivity in the topological state is the desired goal. Here, we choose a topological insulator $Bi_2Te_{2.7}Se_{0.3}$ to study its evolution path with pressure up to 44 GPa. Three phase transitions at pressures of 8, 16, and 22 GPa are observed with increasing pressure, determined by the X-ray diffraction and Raman spectroscopy. Within the first phase, we detect superconductivity in the pressure regime ranging from 4 GPa to 8 GPa. The feature of topological superconductivity is evidenced by the nonlinear Hall coefficient and the deviation of the upper critical field from the BCS theory. The intrinsic interplay between the topological order and the superconductivity in such a bulk compound is a result of an unconventional pairing state. After the first phase transition, the material enters other three superconducting phases with the boundaries at around 16 and 22 GPa.
The sign and significant changes of the carrier concentration are also observed across these transitions. The discoveries suggest the possible Majorana quasiparticle in a bulk material at high pressure.

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Cexistence of Charge Order and 2D Superconductivity in $IrTe_2$ Nanosheets

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IrTe2 holds a unique position in transition metal dichalcogenides (TMDCs) because of its intriguing correlated electronic phases including stripe charge/orbital order [1] and metastable superconductivity [2,3]. In bulk IrTe2 crystals with chemical doping or thermal quenching, the superconducting order competes with the stripe order, leading to macroscopic phase separation. In this work, we report that mechanically-exfoliated IrTe2 crystals host both stripe order and superconductivity without macroscopic phase separation. Using transport and scanning tunnelling microscopy experiments, we found that two-dimensional (2D) superconductivity occurs at Tc ~ 2 K, together with the stripe order stabilized at higher temperatures. The 2D superconductivity is found to be robust even in the sample with its thickness much larger than the coherence length of bulk IrTe2 superconductors. These observations reveal that superconductivity in thin IrTe2 nanosheets is induced in the preformed cross-layer metallic state by stripe charge order, distinct from the bulk case, demonstrating effective thickness tuning of competing phases in correlated TMDCs.

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[2] M. Yohida et al., Nano Lett. 18, 3113 (2016).

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Crystal and electronic structure of lithium metal

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In periodic table lithium is the lightest metal and the first element with core electrons. While fascinating quantum nature of condensed helium is suppressed at high densities, because of the presence of long range interactions in metallic systems, lithium is expected to adapt more quantum solid behavior under compression. Physics of dense lithium offers a rich playground to look for new emergent quantum phenomena in condensed matter. In this talk I will discuss the physics of ultra-light materials under extreme pressures and will present some of our studies on quantum contributions to the structural phase transitions of lithium at low temperature, the evolution of the Fermi surface of lithium and the crystal structure of its low temperature structure and will present our results on the resolving the long lasting mystery of lithium ground state.

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Superconductivity in sodium doped triphenylene

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Intensive studies of polycyclic aromatic hydrocarbon (PAH) superconductors have been done in recent years due to their highly-conjugated molecular orbital and delocalized extra electrons supplied by alkali metal doping. Here, we report the new PAH superconductor, sodium-doped triphenylene (Na3triphenylene), which was discovered by searching the database of PAH molecules with the parameter Δ, the energy difference between LUMO and LUMO+1, and their structural stacking. It shows the superconducting transition at Tc ≈ 14 K at ambient pressure. The discovery of new PAH superconductor based on the database suggests promising possibility of superconductivity from more diverse molecular structures and realization of high-Tc organic superconductors.

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Discovery of superconductivity in phenyl molecules

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Organic compounds are always promising candidates of superconductors with high transition temperatures Tc's. In this talk, we will first talk about our recent discovery of superconductivity with Tc values as high as 123 K in polyparaphenylene oligomers. Then we will show the experimental realization of superconductivity in other phenyl molecules such as organometallic compounds or compounds only containing C, H, and N. The evidence of superconductivity is provided by the observations of the Meissner effect and the zero-resistivity state through the measurements of the dc and ac magnetic susceptibility and resistivity measurements together with the opening of superconducting gap detected from Raman spectroscopy. The obtained superconducting parameters classify these phenyl molecules as type-II superconductors. The benzene ring is identified to be the essential superconducting unit in such phenyl compounds. The superconducting phases and their composition are determined by the combined studies of the X-ray diffraction and theoretical calculations. The Tc difference in the studied superconductors is suggested to result from the different carrier concentration and the interaction strength. The easy processability, light weight, durability of plastics, and environmental friendliness of these new phenyl superconductors have great potential for the fine-tuning of electrical properties. This discovery opens a window for exploring superconductivity in phenyl molecules.

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To Unravel the Gap Sign in Unconventional Superconductors by Phase-Referenced Quasiparticle Interference

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Quasiparticle interference (QPI) technique has been widely used in determining the Fermi surface contour in superconductors. Actually the Fourier transformed QPI ρ(q,E) contains not only the magnitude, but also the phase at each energy and momentum-transfer-vector, namely ρ(q,E)=|ρ0(q,E)| exp(-iφ). Recently it has been realized that this referenced phase at positive and negative energies contains very important message reflecting the gap sign changing in unconventional superconductors if non-magnetic impurities are used as the phase indicator. In this talk, I will give an overview about the progress in this direction. We have conducted extensive STM/STS studies on many different iron based superconductors and cuprate Bi-2212.

Concerning the iron chalcogenide superconductors without hole Fermi pockets, for example the recently discovered (Li1-xFex)OHFeSe phase with Tc ≈40 K, we have conducted systematic STM/STS investigations. Our STS spectrum clearly indicates the presence of double superconducting gaps with maximum magnitudes of Δ1=14.3 meV and Δ2=8.6 meV, and the STS mimics that of the monolayer FeSe thin film. Further analysis based on the quasiparticle interference (QPI) allow us to rule out the d-wave gap, and assign the gaps to different Fermi surfaces[1]. Then we report the spatial mapping of the density of states and use the phase-referenced QPI technique to detect the superconducting order parameter in the system without hole Fermi surfaces. Our result reveals the sign reversal of order parameters on the Fermi surfaces without hole pocket[2,3], and thus unifies the pairing mechanism of ironbased superconductors with or without the hole Fermi pockets. Recently we extend this method to other iron based superconductor Fe(Te,Se) with well defined hole and electron pockets[4]. In Bi-2212, our results illustrate nice consistency between the expectation of a d-wave gap[5]. The phase-referenced QPI shows the power in determining the gap sign changing in unconventional superconductors.

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Role of Fe-vacancy in FeSe-based Superconductors

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The exact superconducting phase of FeSe and $K_{2-x}Fe_{4+y}Se_5$ has been controversial since its discovery due to its intrinsic multiphase in early material. In an attempt to resolve this mystery, we have carried out systematic structural studies on a set of well controlled samples with exact chemical stoichiometry $K_2Fe_4Se_5$ and $K_{2-x}Fe_{4+y}Se_5$ (x=0–0.3) that are heat-treated at different temperatures. The stoichiometric Fe_4Se_5 and $K_2Fe_4Se_5$ compounds, which are Mott insulators, exhibit well-ordered Fe-vacancy with no Fe occupancy at 4d sites. Using high resolution synchrotron radiation X-ray diffraction, our investigations have determined the superconducting transition by focusing on the detailed temperature evolution of the crystalline phases. Our results show that superconductivity appears only in those samples that have been treated at high enough temperature and then quenched to room temperature. The superconducting transition strongly depends on the annealing temperature used. The most striking result is the observation of a clear contrast in crystalline phase between the non-superconducting parent compounds Fe_4Se_5 (or $K_2Fe_4Se_5$) and the superconducting $Fe_{4+x}Se_5$ (or $K_{2-x}Fe_{4+y}Se_5$) samples. We compare the structure details at two different temperature of the parent compound. 250oC is in a state of Fe-vacancy wellordered that results in antiferromagnetic order. The anti-ferromagnetism disappears as Fe-vacancy becoming disordered at 275ºC. The characteristic of block-AFM order is known to closely relate to the Fe2 (occupied Fe-16i site)-Fe2 bond distances. Our studies show that this bond distance depends strongly on the occupancy of 4d-site. A striking finding, in addition, is that the Fe1–Se2 tetrahedral angles become the ideal value (of 109.47º) in the welldisordered 4d-site occupied superconducting phase. We shall present and discuss the implications our experimental results.

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High-Field Specific Heat Investigation of High-Tc Superconductors

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High magnetic fields have been critical to examining the behavior underlying superconductivity in high-Tc superconductors. By applying magnetic fields, up to 35 T, we are able to suppress superconductivity and reveal the normal state of the iron-based high-temperature superconductor, $BaFe_2(As_{1-x}P_x)_2$. Notably, we observe √H behavior indicating a nodal superconducting gap, saturation of the heat capacity at a magnetic field corresponding to the onset of the normal state, and enhancement of the quasiparticle mass sum as calculated from electronic specific heat coefficient as optimal doping is approached [1]. Our comparison of specific heat as a function of magnetic field to specific heat as a function of temperature, as well as other measurements, forms a consistent treatment of specific heat measurements in high-temperature superconductors. I will discuss the results of our high-magneticfield measurements, as well as zero-magnetic field measurements of the same material, and how those methods can be used to investigate other high-Tc superconductors such as the cuprates.

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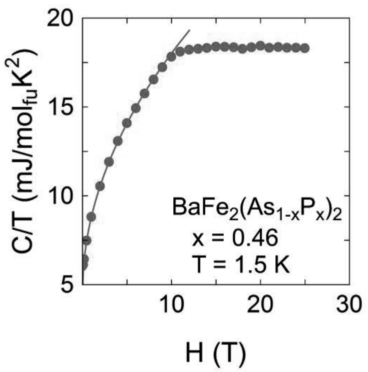

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Zero-energy modes in topological materials evidenced in point contact spectroscopy

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Point-contact spectroscopy of several topological materials reveals a phase transition to a low temperature phase that is characterized by low-energy modes superimposed on an energy gap showing a Bardeen-Cooper-Schrieffer (BCS) type of criticality. This behavior is not accompanied by a bulk superconductivity, which points to either local superconductivity or to the emergence of an unfamiliar ground state specific to topological matter. As indicated experimentally [1] and suggested theoretically [2], one of these can be a correlated many body state at surface atomic steps in topological crystalline insulators, exhibiting low-energy excitations.

Here we show [3], employing a soft point-contact method that a conductance gap with a broad zero bias conductance peak or Andreev-type characteristics develop at junctions of Ag with topological surfaces of diamagnetic, paramagnetic, and, most notably, ferromagnetic $Pb_{1-y-x}Sn_yMn_xTe$, where $y \geq 0.67$ and $0 \leq x \leq 0.10$. Our search for metal precipitates by x-ray diffraction and electron microscopy, also in the vicinity of dislocations, has not revealed presence of any nanoclustering within the state of the art resolution. Furthermore, no evidence of the Meissner effect due to superconducting Pb or Sn established by our beyond the current state of the art integral superconducting quantum interference device magnetometry precludes existence of superconducting Pb or Sn inclusion at a level exceeding 0.1 ppm. Nevertheless, the temperature dependence of the gap shows a BCS-like critical behavior with the critical temperature up to 4.5 K and the magnitudes of the critical fields independent of the orientation of the magnetic field in respect to the surface plane. This implies the emergence of a collective lowtemperature phase whose appearance is insensitive not only to the magnetic state of the metallic part of the junction, but also to the magnetic character of the topological material. The body of the accumulated evidences indicates that this new phase can be linked to carriers occupying 1D topological states adjacent to surface atomic steps, which undergo a transition to a collective state at sufficiently low temperatures and magnetic fields.

The work has been supported by the Foundation for Polish Science through the IRA Programme co-financed by EU within SG OP, the National Science Centre (Poland) through PRELUDIUM (UMO-2015/19/N/ST3/02626) and OPUS (UMO-2017/27/B/ST3/02470) projects.

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Topological d+s wave superconductors in a multi-orbital quadratic band touching system

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Realization of topological superconductors is one of the most important goals in studies of topological phases in quantum materials. In this work, we theoretically propose a novel way to attain topological superconductors with non-trivial Fermi surfaces of Bogoliubov quasiparticles. Considering the interacting Luttinger model with j = 3/2 electrons, we investigate the dominant superconducting channels for a multi-orbital quadratic band-touching system with finite chemical potential, which breaks the particle-hole symmetry in the normal state. Notably, while the system generally favors d-wave pairing, the absence of the particle-hole symmetry necessarily induces parasitic swave pairing. Based on the Landau theory with SO(3) symmetry, we demonstrate that two kinds of topological superconductors are energetically favored; uniaxial nematic phase with emergent s wave pairing ($d_{(3z^2-r^2)}$+s) and time-reversal-symmetry broken phase with emergent s wave pairing ($d_{(3z^2-r^2,xy)}$+i $d_{(x^2-y^2)}$+s). These superconductors contain either nodal lines or Fermi pockets of gapless Bogoliubov quasiparticles and moreover exhibit topological winding numbers 2, leading to non-trivial surface states such as drumhead-like surface states or Fermi arcs. We discuss applications of our theory to relevant families of materials, especially half-heusler compound YPtBi, and suggest possible future experiments.

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Topological superconductivity in the 5d Mott insulator Sr_2IrO_4

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We study superconducting pairing instabilities of the hole-doped 5d Mott insulator in the presence of antisymmetric Dzyaloshinskii-Moriya exchange, applicable to Sr2IrO4. Within the random phase approximation, we compute the spin-fluctuation-mediated pairing interactions as a function of filling and IrO6 octahedron canting angle. We find that paramagnon exchange near a spin-density-wave instability gives rise to a strong singlet d-wave pairing interaction. Besides, a Rashba type spin-orbit coupling splits the spin degeneracies of the bands and enhance the ferromagnetic contribution, which leads to mixing of even and odd parities in the superconducting order parameter. We find that mixed singlet-triplet superconductivity, d+p, is generated as a result of the antisymmetric exchange originating from a quasi-spin-orbit coupling. As a possible candidate of topological superconductivity, we study a possible trace of the nodal structure of the superconducting gap, as the edge states. These edge modes are spin polarized and emerge as zero-energy flat bands, supporting a symmetry-protected Majorana state, verified by evaluation of the winding number and Z2 topological invariant. Together with this prediction, we discuss a possible method for experimentally observing the zero- energy nontrivial edge states via the STM-based QPI approach [1].

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S-1037 16:35-16:50, August 20 | Room 513

Field-induced Gap-like Structure in the Heavy-fermion Superconductor $CeCoIn_5$

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The pairing symmetry of the heavy-fermion superconductor CeCoIn5 is known to be dx2-y2. Our planer tunneling spectroscopy data as a function of temperature down to 20 mK show sharp coherence peaks with an estimated gap of 0.65 meV on the (100) and (001) faces, and a distinct zero-bias peak on the (110) face, as expected for a superconductor with this gap symmetry. As a function of increasing magnetic field, as superconductivity is destroyed, the features evolve into an intriguing gap-like structure that increases linearly up to 18T. Possible origins of this fielddependent evolution will be discussed, including one that invokes an exotic pairing mechanism.

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S-1004 16:50-17:05, August 20 | Room 513

Probing the driving mechanism for superconductivity in FeSe

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The interplay of orbital and spin degrees of freedom is the fundamental characteristic in numerous condensed matter phenomena, including high temperature superconductivity, quantum spin liquids, and topological semimetals.
In iron-based superconductors (FeSCs), this causes superconductivity to emerge in the vicinity of two other instabilities: nematic and magnetic. Unveiling the mutual relationship among nematic order, spin fluctuations, and superconductivity has been a major challenge for research in FeSCs, but it is still controversial.
In this talk, via ^{77}Se nuclear magnetic resonance (NMR) measurements on FeSe single crystals, doped by cobalt and sulfur that serve as control parameters, we show that the superconducting transition temperature T_c increases in proportion to the strength of spin fluctuations, while it is independent of the nematic transition temperature T_{nem}.
Our observation therefore directly implies that superconductivity in FeSe is essentially driven by spin fluctuations in the intermediate coupling regime, while nematic fluctuations have a marginal impact on T_c. In addition we found that the nematic state and spin fluctuations are completely decoupled.

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Enhanced superconductivity in the vicinity of a Lifshitz transition induced by pressure in a 112-type iron based superconductor

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Most of the iron based superconductors (FeSCs) crystallize in a tetrahedral structure, where irons are tetrahedrally coordinated to pnictogens/chalcogens, with different separating layers in between. In contrast, recently discovered $Ca_{(1-x)}La_xFeAs_2$ (112-type) crystallize in a monoclinic structure and feature a unique zig-zag metallic As chain as spacer layer. Due to this lower crystal symmetry, these materials lack in-plane C_4 rotational symmetry resulting in absence of orbital polarization responsible for the nematic ordering typical in FeSCs. Here, we investigate the evolution of superconductivity under hydrostatic pressure in a La doped CaFeAs2 single crystal with $T_c \sim 46$ K. We find that with pressure, T_c reveals a dome shaped behavior with a maximum $T_c \sim 51.4$ K at 1.7 GPa, 2nd highest T_c in a bulk single crystal of FeSCs. Moreover, at this pressure, for $T \geq T_c$ resistivity shows a perfect T-linear behavior as high as 200 K possibly due to the non-Fermi liquid state in the vicinity of a quantum phase transition or multiband effect.

Combining magnetotransport measurement with theoretical calculation, we show that Fermi surface (FS) undergoes a Lifshitz transition near 1.0 GPa. Due to this transition, FS becomes more anisotropic and nesting between electron and hole pocket is maximized near the optimal pressure 1.7 GPa. Our results suggest that the low-energy spin fluctuations, which are likely tuned by the enhanced two dimensionality and nesting of the FS, dominate the normalstate scattering and thus responsible for optimal superconductivity in 112 FeSCs.

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Emergence of Superconductivity by Lattice Melting in a Group IV-VI Compound

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Inspired by the abundant physical properties of IV-VI compounds, we choose a polycrystalline Pb0.99Cr0.01Se to investigate its electronic and structural properties under pressure up to 50 GPa. The structural transitions from B1 to Pnma and then to B2 phase in this sample have been verified by the X-ray diffraction and Raman scattering measurements. The formation of the intermediate phase is suggested to be mediated by Peierls distortion, and the road hump in the temperature-dependent resistivity in the intermediate phase gives further evidence for this phenomenon. When it evolves into B2 phase, superconductivity is observed to emerge, accompanying with prodigiously melting the broad hump of resistivity. Meanwhile, Hall coefficient indicates the carrier type was switching accompanying with the structural phase transitions under pressure. These results suggest that the superconductivity in B2 phase for this sample originates from the melting Peierls lattice distortion. The present findings can also be expanded to other similar IV-VI semiconductors that superconductivity will emerge in B2 phase after melting the intermediate phase.

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Study of Second Magnetization Peak Effect and Vortex Pinning Mechanism in NbSe2 Superconductor in Presence of Cr Atoms.

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We report on the growth of quasi two-dimensional high quality CrxNbSe2 (with x=0.0005, 0.001, 0.0015) single crystal and investigate the effect of Cr impurity on the vortex dynamics of NbSe2 superconductor using magnetization hysteresis loop measurement with different relaxation rates. The field dependence nature of critical current density (Jc) is well studied using Larkin-Ovchinnikov collective pinning model and plastic creep theory. The significant improvement in the field dependence nature of Jc has been observed with increasing Cr impurities in NbSe2. In addition, this results the crossover of vortex lattice from elastic (E) to plastic (P) creep region triggering second magnetization peak (SMP) or fishtail effect at highest Cr concentration, which has not been yet reported. Also addition of Cr impurity improves the Jc up to 4 × 105 A/cm2. However, the interaction between core region of vortices and pinning centres occurs through δl pinning in Cr0.0005NbSe2 and allowing both δl and δTc mechanism in Cr0.0015NbSe2. Both, δl and δTc core pinning strongly boost the coupling between vortices in the pinning potential of Cr impurity, which makes 3D magnetic fluxes into 2D nature. Furthermore, the point pining and surface pinning mechanisms are also observed at low magnetic field region in Cr0.0005NbSe2. The presence of prominent peak in pinning force density near upper critical field (Hc2) suggests the lattice softening in Cr0.001NbSe2 and Cr0.0015NbSe2. These studies not only provide fundamental concept about different vortex phases in low Tc superconducting materials but also explore the door for further study of various pinning mechanism to improve superconducting critical parameters.

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Chiral Domain Topology, Moire Patterns, and Magnetism in Intercalated Transition Metal Dichalcogenides

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Transition metal dichalcogenides (TMDs) have been extensively investigated as 2D materials last decade. A large amount of transition metals can be intercalated into the van der Waals gaps of a wider range of TMD materials, but a limited studies have been recently reported in intercalated TMDs. The limited examples include FexTaS2 crystals with x=1/4 and 1/3, which exhibit intriguing configurations of antiphase and/or chiral domains related to ordering of intercalated M ions with 2a×2a and √3a×√3a superstructures, respectively. In addition, Cr1/3NbS2 undergoes helical spin order below 133 K, and shows an interesting solitonic behavior when in-plane magnetic fields are applied in the helical spin state. We have explored a series of chiral M1/3Ta(Nb)S(Se)2 (M=transition metals) to investigate the correlation among crystallographic and magnetic domain topologies and their physical properties. These results as well as Moire patterns with self-twisted TMDs induced by intercalation will be discussed.

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Antiferromagnetic Ordering in 2-Dimensional van der Waals Materials Studied by Raman Spectroscopy

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Magnetism in low dimensional systems is attracting much interest for the fundamental scientific interest as well as a promising candidate for numerous applications. Intense interest in 2 dimensional magentism has been stimulated by the discovery of ferromagnetism in atomically thin materials [1,2], but antiferromagnetic ordering is much more difficult to study because the lack of net magnetization hinders easy detection of such phenomena. Neutron scattering, which is a powerful tool to detect antiferromagnetic order in bulk materials, cannot be used for atomically thin samples due to the small sample volume. Raman spectroscopy has proven to be a powerful tool to detect antiferromagnetic ordering by monitoring the zone-folding due to the antiferromagnetic order [3,4] or other magnetically-induced changes in the Raman spectrum. In this talk, I will review recent achievements in the study of antiferromagnetism in 2 dimensions using Raman spectroscopy. $FePS_3$ exhibits an Ising-type antiferromagnetic ordering down to the monolayer limit, in good agreement with the Onsager solution for 2-dimensional orderdisorder transition. The transition temperature remains almost independent of the thickness from bulk to the monolayer limit, indicating that the weak interlayer interaction has little effect on the antiferromagnetic ordering. [4] On the other hand, $NiPS_3$, which shows an XXZ-type antiferromagnetic ordering in bulk, exhibits antiferromagnetic ordering down to 2 layers with a slight decrease in the transition temperature, but the magnetic ordering is suppressed in the monolayer limit. [5]

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Novel states in stacked two-dimension crystals

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Recent advances in fabricating stacked two-dimensional crystals realize interesting electronic structure in low dimensions. I will first introduce a recent success in uniting the dodecagonal quasicrystalline order and relativistic Dirac fermions in bilayer graphene system with a twist angle of 30 degrees [1]. For this system, we have developed a new theory that can describe spatially localized 12 folded resonant states and their intriguing scaling behaviors [2]. I will also introduce a possible modification of magnetism through interlayer interactions in magnetic van der Waals crystals [3].

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Exploring novel quasiparticles in two-dimensional crystals

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Two-dimensional (2D) layered semiconductors, such as black phosphorus and 2H transition-metal dichalcogenides, have emerged as a class of materials that may impact our future electronics technologies. Carrier doping to 2D semiconductors is important not only to study a new class of Dirac and Weyl fermions, but also to explore novel composite particles. In this talk, I will introduce our recent angle-resolved photoemission spectroscopy (ARPES) studies on black phosphorus and MoS2. The widely tunable band gap of black phosphorus [1] can be exploited to artificially create a topological quantum state of matter with a pair of Dirac points protected by spacetime inversion symmetry [2]. Surface doping to MoS2 [3] could be used to resolve the spectral function of Holstein polaron, a small quasiparticle that drags a cloud of self-induced lattice deformation or phonons [4].

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“Molecules” in solids against magnetism

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Close to Mott transition several novel states can appear [1]. In particular, “molecular clusters” can be formed in the solid, such as dimers, trimers, etc. [2]. Especially important for these phenomena is the role of different d-orbitals, which leads to different orbital-selective effects. In my talk I will formulate the main ideas and will illustrate such phenomena, especially dimer formation, on many examples, especially for systems with 4d and 5d electrons. The concept of orbital-selective Peierls transitions will be proposed and justified [3, 4]. In systems containing structural metal dimers there may exist in the presence of different orbitals a special state with partial formation of singlets by electrons on one orbital, while others are effectively decoupled and may give e.g. long-range magnetic order or stay paramagnetic. Similar situation can be realized in dimers spontaneously formed at structural phase transitions, which can be called orbital-selective Peierls transition [5]. Yet another consequence of this picture is that for odd number of electrons per dimer there exist competition between double exchange mechanism of ferromagnetism and the formation of singlet dimer by electron on one orbital. Such molecular states can strongly reduce and effectively suppress double exchange ferromagnetism [6]. I will discuss some implications of these phenomena, and consider examples of real systems, in which orbital-selective phase are realized.

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Magnetism of interstitial anionic electrons in two-dimensional electrides

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Electride, which is regarded as a new emergent material, is ionic crystal in which electrons serve as anions. The physical properties of electrides are determined by the topology of cavities or channels which confine anionic electrons. Recently, it was demonstrated that the intralayer space of 2D layered materials can be the confining sites for anionic electrons, showing a freedom in degree of localization. This new 2-dimensional electrides have provided fundamental difference in electronic structure from the 2-dimensional electron gas systems in topology and physical properties. In this talk, the layered structured 2-dimensional electrides, from the first discovered dicalcium nitride to various transition metal carbides, chalcogenides and chlorides, will be introduced and highlighted with their diverse physical properties. In particular, the ferromagnetism of 2-dimensional layer structured digadolinium carbide electride will be discussed. Furthermore, we have systematically controlled the magnetic properties of 2-dimensional rare-earth metal carbides, showing diverse magnetism such as superparamagnetism, antiferromagnetism and ferromagnetism. Finally, it will be introduced that 2D ferromagnetism based on two-dimensionally confined anionic electrons may be possible in electrides without magnetic elements.

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Large Time-Reversal-Odd Responses In The Weyl Antiferromagnet Mn_3Sn For Antiferromagnetic Spintronics

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In the last few years, there has been a surge of interest in antiferromagnetic (AF) materials due to their favorable properties including vanishingly small stray field and faster spin dynamics compared to their ferromagnetic counterparts [1]. In fact, motivated by these intriguing properties, several breakthroughs have been made; for example, the anisotropic magnetoresistance (AMR), even-function response under time-reversal (TR), has been found useful for detecting the collinear AF ordering [2]. Another breakthrough is the discovery of odd-function response under TR in Mn3Sn such as anomalous Hall [3] and Nernst [4] effects, magneto-optical Kerr effect (MOKE) [5], and novel type of (magnetic) spin Hall effect [6] at zero magnetic field. Moreover, both theoretical and experimental studies have revealed that Mn3Sn is the first version of a Weyl magnet possessing a large and controllable Berry curvature (fictitious field) in the momentum space because of its unique magnetic and electronic structure, and then give rise to sizable TR-odd responses [7].

In this talk, we will propose the Weyl antiferromagnet Mn3Sn as a promising material for AF spintronics. This is because Mn3Sn exhibits large TR-odd responses such as the anomalous Hall effect at zero magnetic field [3], and these spontaneous responses can be controlled by the AF domain with ferroic ordering of the cluster magnetic octupole which has been observed by the MOKE [5]. We will also show that not only Mn3Sn bulk crystals but also the thin films exhibit large TR-odd responses [8], which provides an important step for the further development of spintronics devices using AF materials.

This work is based on the collaboration with D. B. Gopman, Y. P. Kabanov, R. D. Shull (NIST), O. M. J. van 't Erve (U.S. NRL), Liang Wu (UPenn), D. Rees, S. Patankar, J. Orenstein (UCB), T. Koretsune, M.-T. Suzuki (Tohoku Univ.), R. Arita (RIKEN), Y. Li, C. L. Chen (JHU), and Y. Otani (ISSP).

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Correlated Topological Phases in Kitaev Materials

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Emergence of topological phases in quantum materials with strong spin-orbit coupling has been a recent topic of intensive study. In particular, possible presence of quantum spin liquid in Kitaev materials with strongly-bond-dependent spin exchange interactions, has received great attention. Here we consider a number of other correlated topological phases that may also arise in Kitaev materials. More specifically, we discuss topological magnons in three dimensions and topological superconductivity in two dimensional Kitaev systems. We make connections to the experimental efforts that motivated these theoretical studies.

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M-0947 15:00-15:30, August 20 | Room 517

Quantum Spin Hall Phases in (atom)thin-layers

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Topological insulating (TI) states are attracting significant attention, while the two-dimensional (2D) TI states with quantum spin Hall (QSH) phases have been researched mainly in semiconductor double quantum wells. Identifying the QSH phase in new materials and its control are crucial aspects towards the development of voltage-controlled spintronic devices with low power dissipation. The QSH phases were predicted in graphene by Kane at 2005 first and have been recently predicted in the 2D transition metal dichalcogenides (TMDCs). Here, I demonstrate realization of the QSH phases in graphene by decorating with Bi2Te3 nanoparticles only in 3% coverage by using a nanoneedle method and in thin MoS2 by on-demand laser beam patterning up to 30K. These results must open a door to innovative researches for QSH phase physics and its application to topological quantum devices.

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M-0862 15:50-16:20, August 20 | Room 517

Magnetotransport Properties in Three-Dimensional Dirac Materials

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Recently, negative longitudinal and positive in-plane transverse magnetoresistance have been observed in most topological Dirac/Weyl semimetals, and some other topological materials. We shall present the magneto-transport theory for topological Dirac materials. In a semi-classical regime, it is shown that the longitudinal magnetoresistance is negative and quadratic of a weak field B while the in-plane transverse magnetoresistance is positive and quadratic of B. The relative magnetoresistance is inversely quartic of the Fermi wave vector and only determined by the density of charge carriers, irrelevant to the external scatterings in the weak scattering limit. This intrinsic anisotropic magnetoresistance is measurable in systems with lower carrier density and high mobility. In the quantum interference regime, a formula of magnetoconductivity is presented for massless and massive Dirac fermions in Dirac materials due to quantum interference of Dirac fermions in scalar impurity scattering potentials. It reveals a striking crossover from positive to negative magnetoresistivity, uncovering strong competition between weak localization and weak antilocalization in multiple Cooperon modes at different chemical potentials, effective masses and finite temperatures. The work sheds light on the important role of strong coupling of the conduction and valence bands in the quantum interference transport in topological nontrivial and trivial Dirac materials.

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M-0148 16:20-16:50, August 20 | Room 517

'Blackswan' metal: Viiolation of Ohm's law in a Weyl metal

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In 1827, German scientist Georg Ohm published Ohm's law of constant electrical resistance in metals. Ohm's Law is one of the unbreakable rules of experience after its discovery. It was recently discovered that Ohm's law, which never seemed to be broken, was violated in BiSb alloys. The BiSb alloy shows the twisting energy band of the electron and becomes a Weyl metal in the absence of time reversal symmetry. When an electric field is applied in a certain direction, some of the electrons move in the direction of the electric field without resistance. The density of electrons flowing without resistance changes with the applied electric field. As a result, no current flows in proportion to the applied voltage. Therefore, the resistance changes according to the voltage, that is, the metal does not satisfy Ohm's law. In this talk, we will look closely at the meaning of Ohm's law and share information on the principles and applications of Ohm's law that breaks the law.

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Pressure induced giant magnetoresistance in 2H-WS_2

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Recent experiments focus on the spectacular transport properties in semimetals, such as extremely large magnetoresistance in 2H-WTe2. The realization of giant magnetoresistance in 2D system opens up various opportunities for the next generation flexible magnetic sensors and spin electronics. Motivated by the unlimited promising applications of giant magnetoresistance effect, here we report a pressure induced giant magnetoresistance in transition metal dichalcogenides 2H-WS2. The measurements of Raman scattering, electrical conductivity and Hall effects are performed at pressures up to 50 GPa in diamond anvil cells. No structure transition is observed estimating from Raman spectra. The results of electrical transport reveal an electronic phase transition from semi-conductor to semi-metallic state under pressure, simultaneously characterizing with a dramatic magnetoresistance increasing. Maximum magnetoresistance of 180 % appears at 38 GPa 2 K in a magnetic field of up to 3 T, without any signs of saturation. Upon further compression, magnetoresistance is suppressed, accompanying with the metallic state emergence. This non-saturating giant magnetoresistance can be attributed to the electronhole compensation tuned by pressure and temperature.

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Magnetic skyrmions at topological insulator surfaces and in proximity to a superconductor

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Ferromagnets in contact with a topological insulator have become appealing candidates for spintronics due to the Dirac surface states, which exhibit spin-momentum locking. Bilayer Bi2Se3-EuS structures, for instance, show a finite magnetization at the interface at temperatures well exceeding the Curie temperature of bulk EuS. Here we determine theoretically the effective magnetic interactions at a topological insulator-ferromagnet interface {it above} the magnetic ordering temperature. We show that by integrating out the Dirac fermion fluctuations an effective Dzyaloshinskii-Moriya interaction and magnetic charging interaction emerge. As a result individual magnetic skyrmions and extended skyrmion lattices can form at interfaces of ferromagnets and topological insulators, the first indications of which have been very recently observed experimentally.

In the second part of my talk I will analyze a hybrid heterostructure with magnetic skyrmions (Sk) inside a chiral ferromagnet interfaced by a thin superconducting film via an insulating barrier. The barrier prevents the electronic transport between the superconductor and the chiral magnet, such that the coupling can only occur through the magnetic fields generated by these materials. We find that Pearl vortices (PV) are generated spontaneously in the superconductor within the skyrmion radius, while anti-Pearl vortices (PV) compensating the magnetic moment of the Pearl vortices are generated outside of the Sk radius, forming an energetically stable topological hybrid structure. Finally, we analyze the interplay of skyrmion and vortex lattices and their mutual feedback on each other. In particular, we argue that the size of the skyrmions will be greatly affected by the presence of the vortices offering another prospect of manipulating the skyrmionic size by the proximity to a superconductor

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Underlayer effect of interfacial Dzyaloshinskii-Moriya interaction: A route toward skyrmion state formation on a trilayer system

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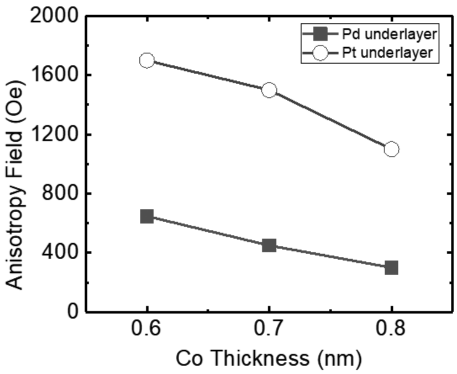
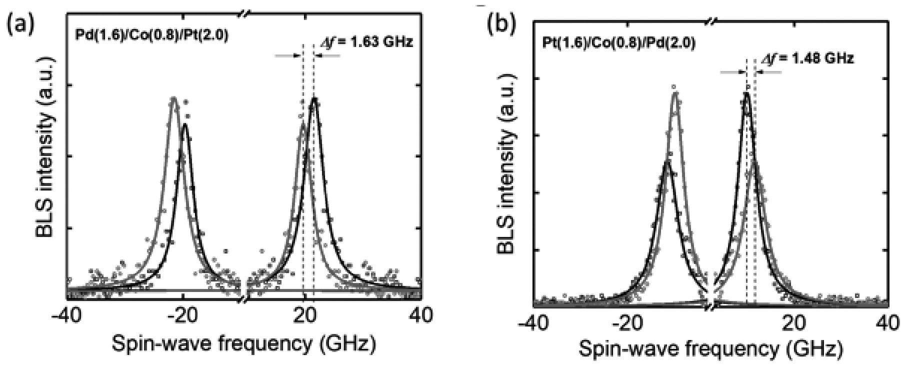
The interfacial Dzyaloshinskii-Moriya interaction (iDMI) at the interface between ferromagnet and heavy metal is an essential ingredient to create a topologically stable skyrmion state for future non-volatile memory and logic devices including neuromorphic applications. Various attempts to increase the iDM energy density have been demonstrated recently. However, the skyrmion state via interfacial spin-orbit coupling at room temperature has been challenging to achieve and has not been reported yet for ultrathin magnetic trilayer systems. Here, we demonstrate a magnetic trilayer system, which has an extremely low surface anisotropy energy density and a sustainable iDM energy density. Brillouin light scattering spectroscopy (BLS) and vibrating sample magnetometer (VSM) have been performed to measure various magnetic properties. We choose Palladium (Pd) underlayer and Platinum (Pt) top layer to suppress the perpendicular magnetic anisotropy (PMA) and retain the iDMI at the same time. As shown in Fig. 1, the saturation magnetic field with Pd underlayer, which is directly proportional to PMA, is suppressed approximately 80% (compare with Pd underlayer systems). However, the frequency differences, which is also directly proportional to the iDM energy density is slightly enhanced due to Pd underlayer (See Fig. 2). We strongly anticipate through our experimental observations that a topologically stable skyrmion state at room temperature on a trilayer system via Pd underlayer is possible and it can open a new path to fabricate new type non-volatile spintronic devices.





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Near Room Temperature Superconductivity in Superhydrides at Megabar Pressures

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Recent predictions and experimental observations of high T_c superconductivity in hydrogen-rich materials at very high pressures are driving the search for superconductivity in the vicinity of room temperature. We confirmed the existence of a new class of such materials – superhydrides (MH_x, with $x > 6$) – and developed preparation techniques for their syntheses and characterization, including measurements of structural and transport properties, at megabar pressures. Four-probe electrical transport measurements of lanthanum superhydride samples display signatures of superconductivity at temperatures ranging from 150 K to above 260 K near 200 GPa. The experiments are supported by pseudo-four probe conductivity measurements, critical current determinations, low-temperature x-ray diffraction, and magnetic susceptibility measurements. These measurements of near-room temperature superconductivity are in good agreement with density functional and BCS theory-based calculations.

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How Compressed Hydrides Produce Room Temperature Superconductivity

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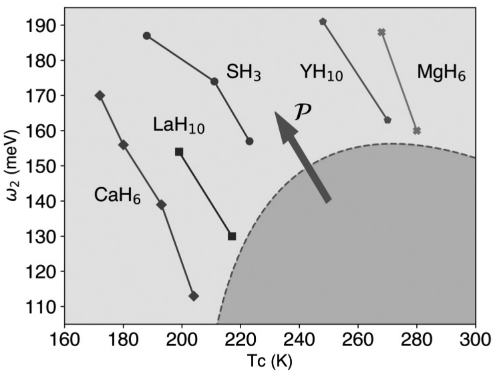
The 2014-2015 prediction, discovery, and confirmation of superconductivity above 200K in SH3, followed by the 2018 extension to record high temperature superconductivity (HTS) in the 250-280K range in lanthanum hydride -- room temperature of cold laboratories -- marks a new era in the longstanding quest for room temperature superconductivity: quest achieved. Predictions of HTS in numerous other metal hydrides at high pressure have appeared. Though the mechanism of pairing is convincingly electron-phonon coupling (EPC), nothing has been decided about the relative importance of the few underlying characteristics that determine Tc. A novel atomic decomposition of metal and H atom contributions to T_c will be described and applied to five metal (X) hydrides XHn, n=3,6,10, that have very high predicted Tc, to separate and pinpoint the role of H. Among other results, we establish that (1) while the metal X atom contributes significantly (~15-20%) to the EPC strength λ, it is practically useless in increasing Tc and (contrary to accepted wisdom) can be detrimental. Based on these results, we construct a phase diagram illustrating the position of the various classes with respect to each other and to a common lattice instability region.
The electron self-energy of H_3S will be presented and discussed, emphasizing the surprising effect it has on the spectral density in the region of the van Hove singularities at the Fermi level and the renormalization of the band structure. The vHs results in strong particle-hole symmetry breaking in H3S in both the normal and superconducting states will be presented and discussed.



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S-0241 10:00-10:30, August 21 | Room 513

Superconductivity of H_3S synthesized from elemental sulfur and hydrogen

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200-K superconducting H3S was synthesized from elemental sulfur (S) and hydrogen (H) by high-temperature treatment at high pressure using LH-DAC (Laser Heating-Diamond Anvil Cell). The sample of sulfur was compressed with pure hydrogen in LH-DAC up to 150 GPa and heated by an infrared laser. The electrical resistance was monitored by 4 probes contacted to the sample during the compression and heating process. The powder X-ray diffraction (XRD) was also monitored using synchrotron X-ray and revealed the successful synthesis of H3S sample with very sharp peaks in the diffraction pattern. The resistance drop at 200 K was observed and indicate the transformation to superconducting phase with very narrow transition-temperature width. This "direct" synthesis method can be applied to the further synthesis of hydrogen-rich systems expected to be high-temperature superconductors.

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S-0612 10:50-11:20, August 21 | Room 513

High rate e-beam R2R deposition of complex HTS oxide ReBCO($ReBa_2Cu_3O_{7-y}$) coated conductor, and its applications

Seung Hyun Moon*
SuNAM Co. Ltd., Korea

SuNAM's RCE-DR (Reactive Co-Evaporation by Deposition and Reaction) process has been proved to be a highthroughput, cost-effective production method for the deposition of superconducting layer for coated conductor(CC). We showed that higher than 1 kA/cm-width critical current tape can be produced routinely, though our standard product comes with 700~800 A/12 mm-width only because we care for overall process optimization.

The route for the high-quality superconducting layer with the high growth rate will be discussed based on the phase diagram. And various kinds of industrial applications such as SFCL(superconducting fault current limiter), high capacity electric cable(> 1GVA), ultra-high field magnet(>25 T) will be introduced based on this thin film wire technology.

In addition to our catalog of high-field magnets of 26.4 T(highest field achieved with HTS at that time) and 18 T(the first commercial high-field HTS magnet to our knowledge), we succeeded in developing highly homogeneous 9.4-T mange for 400 MHz NMR.

SuNAM's recent activities, in addition to the above mentioned ones, will be presented.

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S-0956 11:20-11:50, August 21 | Room 513

Magnetic-field-induced superconductor-to-insulator transition in epitaxial cuprate thin films at the thickness-driven quantum phase transition regime

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The magnetic-field-induced superconductor-to-insulator transition was investigated in epitaxial La1.85Sr0.15CuO4 thin films. The disorder effect became severe with decreasing film thickness, leading to the suppression of superconductivity. Our electronic transport measurements revealed bosonic insulator behavior with the emergence of a resistance peak preceding the onset of the transition at Tc = 6.9 K, which is consistent with the Bose-glass model. Finite-size scaling was performed by tuning the magnetic field near the quantum phase transition regime. The critical resistance was measured to be Rc = 5.72 kΩ which is close to the universal quantum resistance of the Cooper pair, Rq = h/4e2. Moreover, we experimentally determined the product of the spatial and temporal critical exponents, zv = 1.36, indicating the percolative transport.

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S-0564 11:50-12:05, August 21 | Room 513

Spin and charge excitations along the direction perpendicular to charge stripes in cuprates

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The ground state of the t-t'-J ladder with four legs favors a striped charge distribution for the parameters corresponding to hole-doped cuprate superconductors. We investigate the dynamical spin and charge structure factors of a 24x4 t-t'-J ladder by using dynamical density-matrix renormalization group (DMRG) and clarify the influence of stripes on the structure factors [1]. The dynamical charge structure factor along the momentum direction from q=(0,0) to (π,0) perpendicular to the stripes clearly shows low-energy excitations corresponding to the stripe order in hole doping. On the other hand, the stripe order weakens in electron doping, resulting in less lowenergy excitations in the charge channel. In spin channel, spin excitations are strongly influenced by the stripes in hole doping, resulting in two branches that form a discontinuous behaviour in the dispersion. In contrast, the electron-doped systems show a downward shift in energy toward (π,0). These behaviours along the (0,0)-(π,0) direction are qualitatively similar to momentum-dependent spin excitations recently observed by resonant inelastic x-ray scattering experiments (RIXS) in hole-doped [2] and electron-doped [3] cuprate superconductors.

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Processing and Properties of Nitride Hetero-structures

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Back ground: Anti-perovskite Nitride A3BN has been studied for recent years, because it shows variable physical properties by A-B combination. By the rapid developing of quantum computation and information technology, the combination of magnetic or topological material with superconductor is expected to play a vital role in new scientific field, like π- Josephson junctions in superconductor-magnet-superconductor structures, and Majorana zero energy mode at interface of topological materials and superconductors. Towards them, we focused on anti-perovskite nitride because it shows not only ferromagnet, but also antiferromagnet and topological properties. Mn_3GaN is reported to exhibit some specific magnetic properties,[1] which are valuable for study about magnetization switching by spin transfer torque (STT) in an antiferromagnet-ferromagnet system.[2] Cu_3PdN was predicted to be a dirac semimetal or Dirac nodal line semimetal by carefully structure control.[3] Epitaxial growth of Cu_3PdN has been reported, but nitrogen vacancy due to the hardness of Cupper-nitridation is still being the problem.[4] In this study, NbN was selected as superconductor layer for its easy growth and small lattice mismatch with antiperovskite nitride. NbN/ Mn_3GaN and NbN/ Cu3PdN epitaxial hetero-structures were prepared.

Experiments and results: All thin films were epitaxially grown by DC reactive magnetron sputtering in N_2 and Ar mixture gas. NbN bottom layer were grown on MgO(100) substrates using Nb target. Cu3PdN and Mn_3GaN top layer were grown on NbN bottom layers. A combination target was used for Cu_3PdN composed of Cu target and Pd chips on it. Mn_3GaN were grown using $Mn_{2.7}Ga$ target. Lattice structures were characterized by X-ray diffraction, electronic and magnetic properties were measured by SQUID. Figure 1 shows out of plane X-ray diffraction patterns of NbN/ Mn_3GaN and NbN/ Cu3PdN hetero-structures. Both films show (00l) peak series with low nitrogen vacancy as clattice constants show similar value with those of bulk, 0.384 nm of Cu3PdN (bulk : 0.385 nm) and 0.388 nm of Mn_3GaN (bulk : 0.389 nm). From in-plane φ scan patterns, epitaxial growth of all layers is confirmed. The temperature dependence of resistivity of NbN/ Cu3PdN and NbN/ Mn_3GaN hetero-structures is shown in Figure 2. Both films have Tc at about 13 K, as same as NbN thin films without top layers. Detailed film growth and their physical properties will be presented at the meeting.

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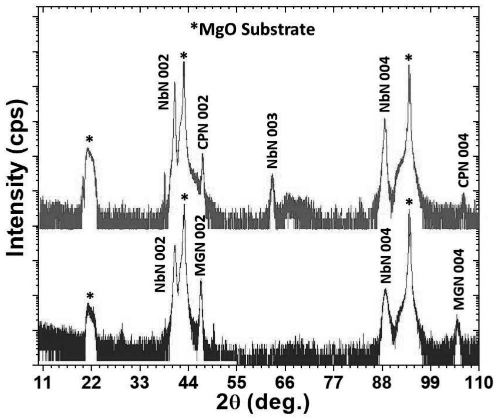

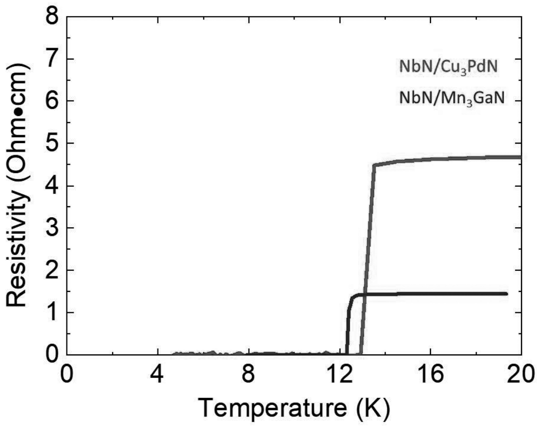

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M-1010 09:00-09:30, August 21 | Room 517

Biomedical Molecular Imaging Using Magnetic Nanoparticles as Contrast Agents

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Superparamagnetic nanoparticles have been used in a number of biomedical applications over the last twenty years, ranging from magnetic drug targeting, bioseparations, imaging, and hyperthermia. They can be functionalized for in vivo biological targeting, potentially enabling nanoagents for molecular imaging and site-localized drug delivery. In this talk, we will review several imaging technologies using functionalized superparamagnetic iron oxide nanoparticles (SPIONs) enabling robust in vivo molecular imaging.

In SPION-enhanced MRI, magnetic moments induced in nanoparticles create local magnetic fields that interact with neighboring water molecules, greatly altering both T1 and T2 relaxation times compared to native tissue. Specific MRI pulse sequences are then used to identify regions within the body where these particles are concentrated through biological targeting. Similarly, SPIONs have been used in magnetic particle imaging (MPI) to rapidly map 3D dynamics. Finally, several imaging modalities have leveraged SPION's large induced magnetic moment to induce local mechanical force. Magnetic force microscopy, for example, can map nanoparticle uptake in single cells. For in vivo applications, magnetomotive modulation of primary images in ultrasound (US), photoacoustics (PA), and optical coherence tomography (OCT) can suppress intrinsic background signals from tissue while simultaneously helping identify very small concentrations of targeted nanoagents. These techniques make sensitive and specific molecular imaging possible for a wide range of biomedical applications.

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M-0569 09:30-09:45, August 21 | Room 517

Novel scanning magnetic imaging based on diamond NV centers

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Probing and imaging magnetism at nanometer scale with high field sensitivity is of great interest in a wide range of fields, including solid-state physics, materials science and biomedical applications. In this talk, I will introduce a novel magnetic sensing and imaing method based on nitrogen-vacancy (NV) defect center in diamond. The diamond NV center has promising potential for nanometer and nanotesla magnetometry due to its atomic-scale size, long spin coherence times and high magnetic field sensitivity (e.g. $<$ nT/Hz1/2). Since these properties are robust against a wide range of operating temperature, it is also suitable for studying novel magnetic materials exhibiting temperature-dependent magnetic orders. I will present basic working principle of magnetic field sensing and introduce scanning magnetometer combined with diamond NV center. I will also show some examples of sensing and imaging magnetic samples including permalloy and room temperature skyrmions.

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Ultrafast and Very Small: Discover Nanoscale Magnetism With Picosecond Time Resolution Using X-Rays

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Today's magnetic device technology is based on complex magnetic alloys or multilayers that are patterned at the nanoscale and operate at gigahertz frequencies. To better understand the behavior of such devices one needs an experimental approach that is capable of detecting magnetization with nanometer and picosecond sensitivity. In addition, since devices contain different magnetic elements, a technique is needed that provides element-specific information about not only ferromagnetic but antiferromagnetic materials as well. Synchrotron based X-ray microscopy provides exactly these capabilities because a synchrotron produces tunable and fully polarized X-rays with energies between several tens of electron volts up to tens of kiloelectron volts. The interaction of tunable Xrays with matter is element-specific, allowing us to separately address different elements in a device. The polarization dependence or dichroism of the X-ray interaction provides a path to measure a ferromagnetic moment and its orientation or determine the orientation of the spin axis in an antiferromagnet. The wavelength of X-rays is on the order of nanometers, which enables microscopy with nanometer spatial resolution. And finally, a synchrotron is a pulsed X-ray source, with a pulse length of tens of picoseconds, which enables us to study magnetization dynamics with a time resolution given by the X-ray pulse length in a pump-probe fashion.

The goal of this talk is to present an introduction to the field and explain the capabilities of synchrotron based X-ray microscopy, which is becoming a tool available at every synchrotron, to a diverse audience. A general introduction will be followed by a set of examples, including properties of magnetic oxides, interfacial magnetism in magnetic multilayers, and dynamics of nanostructured devices due to field and current pulses and microwave excitations.

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Magnetization dynamics over wide timescales

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We report our recent investigation on magnetization dynamics observed over wide timescales : on a slow (~ sec), a faster (~ ns), and an ultrafast (~fs) timescale. The dynamics of ferromagnetic multilayer films such as Co/Pt and CoFeB/Pd as well as simple Co, Ni, Fe films was explored mainly by means of magneto-optical Kerr effect. On a slower timescale, we have found a new class of minor hysteresis behavior having rounded response at the field reversal [1], where corresponding microscopic magnetic domain patterns and domain dynamics are discussed together. On the other hand, photoinduced demagnetization and remagnetization behavior were examined on a faster and an ultrafast timescale [2,3,4], where a phonon excitation as well as spin dynamics is observed. Ultrafast signal of Kerr effect and reflectivity are fitted based on a 3-temperature model to analyze the temperatures of spin-, electron-, and lattice-subsystems. Fluence- and field-dependent ultrafast magnetization dynamics is experimentally investigated, where a separation of spin sub-system on a sub-ps time scale is found to lead to a giant magnetic cooling effect [3]. In addition to the magnetization dynamics of ferromagnetic films, several other interesting topics such as a Brownian motion of magnetic particles [5] will be discussed as well.

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Switching time distribution and damping constant in ferromagnetic nano-structure

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We solved the Fokker-Planck Equation (FPE) for STT-MRAM (Spin transfer torque Magnetic Random Access Memory) switching processes. For a given current and external magnetic field, the switching probability (Ps) or non-switching probability (Pns) are numerically obtained for the given material parameters. In addition, we also derived an analytic expression for Pn with proper assumptions. Based on the analytic solutions, we revealed that the FWHM (Full width of half maximum) of switching time distribution is inversely proportional to the damping constant. Since the determination of the damping constant and effective anisotropy field of ferromagnetic nano-structure are highly demanded but technically not easy, the proposed technique can be useful to determine the damping constant and effective anisotropy field of the ferromagnetic nano-structure.

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Switching Current for Low Error Rate and Back-Hopping Probability of Perpendicular Spin-Torque Devices

Eunchong Baek, Indra Purnama, Chun-Yeol You*

Daegu Gyeongbuk Institute of Science and Technology, Korea

With the speed and stability of reading and writing, we can determine the quality of spin transfer torque (STT) magnetic random-access memory (MRAM). We could know these factors by critical switching current, switching time, thermal stability with micromagnetic simulations and experiments. However, the micromagnetic simulation is not adequate to handle one of the important issues in commercialization of STT-MRAM, so called non-switching probability (Pns), or write soft error rate (WSER). This is the probability of non-switching event when STT-MRAM is given current over critical switching current and this shows reliability and stability of device. Therefore, the Fokker Planck Equation (FPE) combined with STT included Landau-Lifshitz-Gilbert (LLG) equations has been studied [1]. Since the FPE can solve the time dependent probability of magnetization direction for given conditions, it is useful and adequate to treat the WSER problem.

In this work, we studied the critical current and pulse length considering error rate and energy efficiency by solving the Fokker-Planck eqaution(FPE) for perpendicular spin-torque device. By solving FPE, we got non-switching probability for a given current and pulse length with numerical solution and compared it with analytic description.

Furthermore, we observed and calculated back-hopping probability for a given working condition. Back-hopping is an event in which, after turning off the current, the switched magnetization becomes non switching. In this work, we only consider effects of stochastic thermal motion. Since calculating the probability of back-hopping in the LLG equation also requires huge number of simulations, we used the FPE which is convenient way for statistical description. Furthermore, it cannot be calculated with continuous current. So, we have to use pulse shape of applied current. It gives more realistic interpretation for switching dynamics of spin torque device.

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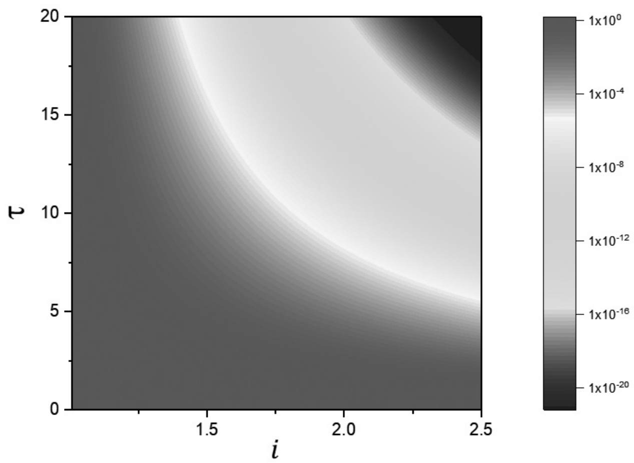

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Ultrafast Confined Magnons in Layered Ferromagnets

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In single-element bulk ferromagnets, one expects to observe a single exchange-dominated magnon band within the terahertz frequency regime. However, in atomically engineered ultrathin ferromagnetic films and multilayers the quantum confinement permits the existence of multiple magnon modes. We present our recent experimental results regarding observation of terahertz confined magnon modes in various ferromagnetic layered structures. The experiments are performed by means of spin-polarized high-resolution electron energy-loss spectroscopy. We discuss how one may tune the properties of these confined magnon modes and achieve entirely different in-plane magnon dispersions, characterized by positive and negative group velocities. Comparing the results to the ones of first-principles calculations we comment on the spin-dependent many-body correlation effects in ferromagnetic films and their role in the determination of the magnon energies. Moreover, we will discuss the possibilities to design multi-magnon band systems exhibiting magnonics band gaps.

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Probing magnetic parameters of individual nanoelements by spin-wave spectroscopy

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While micro- and nanosized magnetic elements are widely used in various microwave applications, the analytical description of spin waves that govern their magnetodynamic response is a complicated problem. This is because of the inhomogeneity of the internal demagnetizing field limiting finding exact eigenfrequencies to only few cases of simplest symmetry – circular disks and infinite stripes. Here, we employ a dipole-exchange spin-wave dispersion equation from Ref. [1] to deduce magnetization and exchange constant for individual Co-Fe nanodisks. The disks were directly written by focused electron beam-induced deposition [2] and studied by broadband ferromagnetic resonance spectroscopy with external magnetic field applied along the normal to sample plane. The finite disk radius leads to the quantization of the in-plane spin-wave vector and gives rise to resonance drum modes with circular Bessel-function profiles (left panel in the figure). We were able to record spin-wave spectra with high signal/noise ratio (shapes of at least 8 peaks can be analyzed) from the individual Co-Fe disk with thickness L = 40 nm and radius R = 200 nm, but even for the disk with R = 100 nm the positions of 3 peaks were detected (right panel in the figure).

The analytical theory has been generalized for large aspect ratios L/R ≤ 0.5 and found to agree well with numerical simulations. The proposed approach is especially valuable for the characterization of magnetic materials that are unavailable in large arrays or in bulk form.

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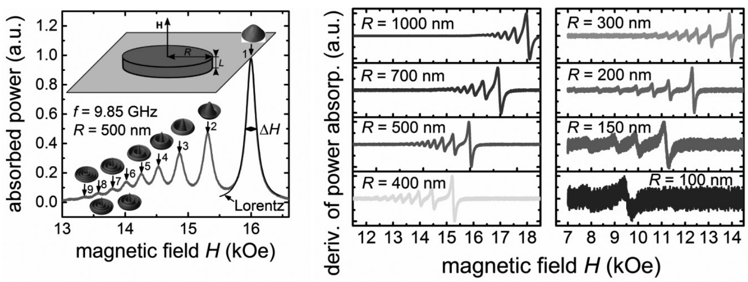
The left panel in the figure depicts the experimental spectrum of an individual Co-Fe disk with a radius of 500 nm at 9.85 GHz. The arrows indicate resonance drum modes with the shown profiles of zero-order Bessel functions. The experimental geometry is shown in the inset. Right panel: Derivatives of the experimentally measured spin-wave resonance spectra at 9.85 GHz for a series of disk radii, as indicated.



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Spin-Orbit induced phase-shift in Bi_2Se_3 Josephson junctions

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The transmission of Cooper pairs between two weakly coupled superconductors produces a superfluid current and a phase difference; the celebrated Josephson effect.

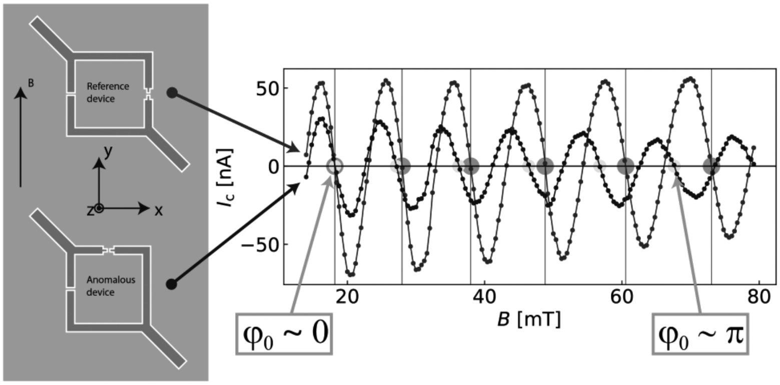
Because of time-reversal and parity symmetries, there is no Josephson current without a phase difference between the two superconductors. Reciprocally, when those two symmetries are broken, an anomalous supercurrent can exist in the absence of phase bias or, equivalently, an anomalous phase shift φ0 can exist in the absence of a superfluid current.

We report on the observation of an anomalous phase shift φ0 in hybrid Josephson junctions fabricated with the topological insulator Bi2Se3 submitted to an in-plane magnetic field. This anomalous phase shift φ0 is observed directly through measurements of the current-phase relationship in a Josephson interferometer.

This result provides a direct measurement of the spin-orbit coupling strength and open new possibilities for phasecontrolled Josephson devices made from materials with strong spin-orbit coupling.

Reference :

Assouline, A. et al. Spin-Orbit induced phase-shift in Bi2Se3 Josephson junctions. Nat. Commun. 10, 126 (2019).



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 09:30-09:45, August 22 | Room 513

Nucleation of vortices and magnetization of a p-wave mesoscopic superconductor

Daehan Park, Heesang Kim*

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In a p-wave superconductor, it is possible to have different types of a vortex, such as a skyrmion vortex and an ordinary conventional vortex. We show how these vortices are generated and how they have effects on the magnetization in the presence of the AC magnetic field in a mesoscopic system. We solve the Time-Dependent Ginzburg-Landau equations numerically to study the problem.

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S-0215 09:45-10:15, August 22 | Room 513

Fractional Josephson Effect in Topological Insulator Nanoribbon

Yong-Joo Doh*

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Topological insulators (TIs) are bulk insulators including metallic surface states, which are topologically protected by time-reversal symmetry. The topological surface states are also known to be spin-helical, meaning that the electron spin is aligned parallel to the surface and normal to the momentum. When the topological surface states are combined with superconducting proximity effect, Majorana bound state is expected to occur in TIs. We have fabricated and studied topological Josephson junctions made of $(Bi_{1-x}Sb_x)_2Se_3$ TI nanoribbon in contact with superconducting PbIn contacts. When those devices were irradiated with microwaves, we have observed anomalous Shapiro step as a signature of the 4π-periodic fractional Josephson effect. Our observations indicate that TI nanoribbons would provide a useful platform to realize Majorana quantum information devices.

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Microwave generation by moving flux quanta in nanoscale superconducting hybrid devices

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A lattice of Abrikosov vortices in type II superconductors is characterized by a periodic modulation of the magnetic induction perpendicular to the applied magnetic field. For coherent vortex motion under the action of a transport current, the magnetic induction at a given point of the sample varies in time with a washboard frequency f = v/d, where v is the vortex velocity and d is the distance between the vortices in the direction of motion [1].
In our studies, we compare the radiofrequency generation by vortices in two experimental systems, namely a Nb film and a Mo/Si multilayer.
In the Nb film, the vortex motion produces a radiofrequency voltage in the adjacent nano-wire antenna by Faraday's law of induction [2]. The voltage is peaked at the washboard frequency, f, and its subharmonics, f/5, related to the antenna width. The in-phase coupling of the magnetic flux emanating from the vortices with the circular field component around the nanowire is achieved when the vortex lattice period geometrically matches the period of the meander antenna. By sweeping the dc current value, we reveal that f can be tuned between 100 MHz and 1 GHz. In the Mo/Si multilayer [3], we have experimentally examined the idea [4] that a moving vortex lattice, as it comes to a sample surface, radiates into free space the harmonics of the washboard frequency f. The emission spectra consist of narrow harmonically related peaks which can be inely tuned in the GHz range by the dc bias current and, coarsely, by the in-plane magnetic ieeld value. Our findings show that superconductor/insulator superlattices can act as dctunable microwave generators bridging the frequency gap between conventional radiofrequency oscillators and (sub-)terahertz generators relying upon the Josephson effect.
Research leading to these results received funding from the DFG project DO1511/3-1, COST Action CA16218 (NanoCoHybri) of the European Cooperation in Science and Technology and the MSCA-RISE program of the European Commission under Grant Agreements No. 644348 (MagIC) and No. 645660 (TUMOCS).

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Shaping the Fourth Paradigm of Materials Science

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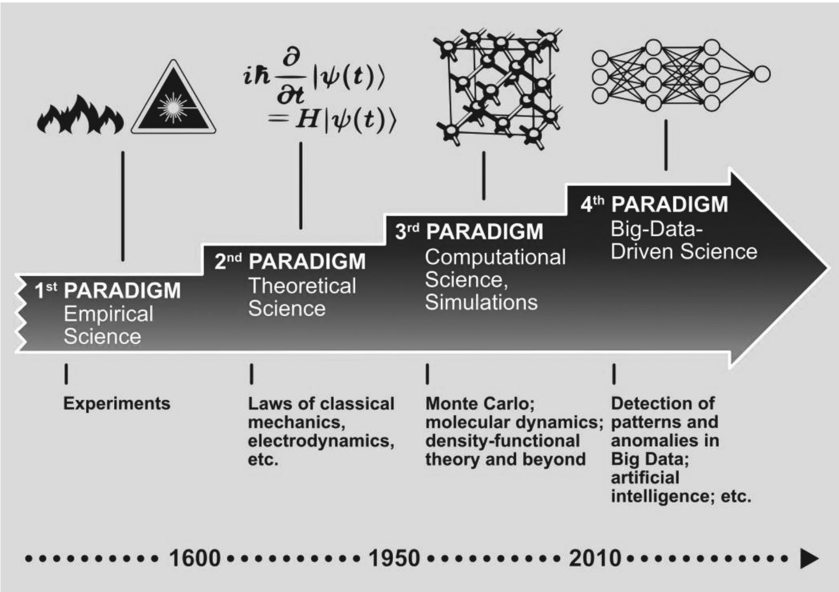
[2]Fritz Haber Institute of the Max Planck Society, Germany

The growth of data from simulations and experiments is expanding beyond a level that is addressable by established scientific methods. The so-called "4 V challenge" of Big Data –Volume (the amount of data), Variety (the heterogeneity of form and meaning of data), Velocity (the rate at which data may change or new data arrive), and Veracity (uncertainty of quality) – is clearly becoming eminent also in the sciences. Controlling our data, however, sets the stage for explorations and discoveries. Novel data-analytics tools can find patterns and correlations in data that cannot be obtained from individual calculations / experiments and not even from high-throughput studies. In the field of materials science, data-driven research is adding a new research paradigm to the scientific landscape. I will address the concepts and recent progress of data-driven materials science, issues of error estimates, the FAIR guiding principles, and the importance of Open Data.



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Predicting Electron-Phonon Coupling Constants of U & Lu Elements by DFT & Machine Learning

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In this work, by means of density functional theory calculations the electronic band structure, electronic density of states and phonon dispersion curves of uranium and lutetium elements were calculated. The amount of electronphonon interaction coefficient has been calculated, which is 0.44 for uranium and 0.37 for lutetium elements. To investigate the answer of this question 'why some materials begin to show new properties by lowering the temperature like superconductivity" [1], 13 features of the normal state property of the elements were selected to determine the effect of each feature in superconductivity. To study these properties on superconductivity, we chose 44 elements of the periodic table that their properties are available. We prioritize effective factors in superconductivity using the best attribute in WEKA [2] code. Our dataset contains the Hirsch [3] samples and attributes. He studied the effect of different attributes on superconductivity of elements by a statistical method. Our results are the same as Hirsch's, and the results show that the Hall coefficient and work function, respectively, are the most important features among the thirteen attributes to specified superconductor elements. As regarded in the BCS theory, value of the electron-phonon coupling constant is very important in transition to superconducting phase. So, this theory encouraged us to add electron-phonon coupling constant to the previous attributes to examine its impact. The result has shown this parameter is in the second ranking after the Hall coefficient. We want to predict this value by ML [4] models. In this manner we just used the superconductivity critical temperature and Debye temperature to predict the electron-phonon coupling constant. The predicted values are consistent with the available values of λ_{e-ph} with accuracy of 88%. For two elements, uranium and lutetium among the 28 superconducting elements, the electron-phonon coupling constants have not been reported yet. The estimated value of λ_{e-ph} for the lutetium element is 0.41, with an error value of 12% and for the uranium element the predicted value is 0.44 in complete agreement with respect to our DFT results.

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Computational study on pressure-induced spin transition in FeO_2

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Recent discovery of iron peroxide (FeO_2) containing more oxygen than hematite (Fe_2O_3) under high-pressure conditions can lead a paradigm change in our understanding of deep Earth's compositions [1]. However, there is no clear understanding of the electronic structure and corresponding physical/chemical properties. In this talk, I will present a theoretical study on the phase transition of FeO_2 induced by pressure. I will show computational results for an insulator-to-metal transition [2] and high-spin-to-low-spin transition using a DFT+DMFT approach, which are also confirmed by x-ray emission and Mossbauer spectra experiments [3].

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A first principles study on half-metallicity of alkali-metal-based half-Heusler XCrZ (X = Li, Na, K; Z = As, Sb)

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Even though metastable zinc-blende(zb) CrZ (Z = As and Sb) are possible candidates for spintronic applications thanks to their half-metallicity(HM), thermal instability has limited real applications to devices [1]. To improve their physical properties such as thermal stability and magnetic moment without destroying HM, alkali-metal-based half-Heusler XCrZ have been suggested [2]. In addition, their lattice constants can be engineered by controlling the concentration of the alkali-metals.
We investigate magnetism and electronic structure of alkai-metal-based half-Heusler XCrZ system (X = Li, Na, and K; Z=As and Sb) using first principles calculational method of VASP to search for applicable new HM materials. Equilibrium lattice constants are calculated to be a0= 6.00 Å, 6.42 Å, 6.37 Å, 6.94 Å, 6.74 Å, and 7.29 Å for LiCrAs, LiCrSb, NaCrAs, NaCrSb, KCrAs, and KCrSb, respectively. Wide band gaps of 2.16 eV, 2.27 eV, 1.67 eV and 1.86 eV in the minority spin states for NaCrAs, NaCrSb, KCrAs, and KCrSb exhibit HM at the equilibrium lattice constants except the Li-based ones. One more electron donation from the alkali-metals to Cr enhances magnetic moment of Cr to 4 μ_B from 3 μ_B of CrZ, compatible with the modified Slater-Pauling rule.
We also reveal strain effects on the electronic structures to consider lattice mismatch with III-V semiconductors for epitaxial growth. The half-metallicity of NaCrZ and KCrZ is quite robust under the severe strain of -10% to +10%. However, KCrZ, from formation energy calculations, turns out thermally unstable. In conclusion, we suggest that NaCrZ are most proper half-metals for spintronic applications with robust half-metallicity as well as low lattice mismatches of +1.71% and +4.03% for NaCrAs and NaCrSb, respectively, with a popular semiconductor substrate InSb.

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Electronic structure and magnetic properties of gadolinium-based ternary intermetallic compounds

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Many gadolinium-based intermetallic compounds are prominent for structural transitions and magnetic properties, including magnetocaloric effect (MCE). At room and close temperatures, MCE in some Gd-based compounds was found to be large or giant. In this work we report our recent theoretical investigations of ternary Gd(TM)Si compounds and Gd5Sb3 [J. Phys.: Condens. Matter 30, 295802 (2018)], $GdNi_2Mn_x$ [Low Temp. Phys. 44, 157 (2018)].

To describe the electronic structure, spectral and magnetic properties, including different regions of magnetic diagram from ab initio calculations, the electronic correlations were taken into account. The calculated electronic structure, exchange interactions, magnetic and optical properties are found in a very good agreement with experimental magnetic and optical data.

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Superconductivity and magnetism at ferroelectric critical point

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It is well established that multiple entangled orders emerge in quantum materials at criticality: eg superconducting states develop in the vicinity of magnetic phases. I will make the case that similar phenomena occur in quantum paraelectrics. Recent observations of strain effects and O18 isotope substitution in doped STO support the view of the key role critical ferroelectric fluctuations play in producing superconductivity [1,2,3,4]. Looking beyond superconductivity, I will illustrate how quantum ferroelectric fluctuations can induce magnetic fluctuations due to recently proposed phenomenon of dynamic multiferroicity[5,6].

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Static and Dynamic Properties of Polymorphic $KNbO_3$ Nanowires Under High Pressure.

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Ferroelectric materials with a perovskite-type structure such as KNbO3 are attracting much attention due to their novel properties. We have investigated pressure-induced structural phase transitions of orthorhombic and monoclinic KNbO3 nanowires by using x-ray diffraction and Raman spectroscopy. Monoclinic KNbO3 nanowires underwent phase transitions three times, monoclinic to tetragonal, tetragonal to cubic, and cubic to orthrhombic-2 phase near 2.2 GPa, 8.2 GPa, and 40.0 GPa respectively. On the other hand, orthorhombic KNbO3 nanowires underwent a phase transition once, orthorhombic to cubic phase near 8.5 GPa. Their exact crystal structures were determined by the Rietveld refinement and confirmed by high-pressure Raman spectroscopy. P-V equations of state for two kinds of KNbO3 nanowires were also derived from the data. Moreover, bulk moduli of the two nanowires in cubic phase were calculated. We observed that the two polymorphic nanowires transformed from distinct phases have different isothermal bulk modulus even in the same crystal phase which is possibly originated from dissimilar synthesis conditions.

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Emergent Many-Body Localization: Disorder Free Mechanisms

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Most of recent investigations evince the existence of many-body localization (MBL) in a closed quantum system through the presence of two key ingredients:
quenched disorder in the Hamiltonian and localization of all single-particle states. Here, I will discuss the emergence of MBL within two new mechanisms, which do not need the basic requirements of the conventional MBL. In the first approach [1], we consider the Kitaev toric code on the ladder geometry, where different types of anyonic defects carry different masses. Our study verifies that the presence of anyons generates a complex energy landscape solely through braiding statistics, which suffices to suppress the diffusion of defects in such clean, multicomponent anyonic liquid. This nonergodic dynamics suggests a promising scenario for investigation of quasi MBL, which shows a glassy dynamics with an exponentially diverging time scale of the full relaxation.
In the second mechanism [2], we introduce a clean cluster spin chain coupled to fully interacting spinless fermions, forming an unconstrained Z2 lattice gauge theory (LGT), which possesses dynamical proximity effect controlled by the entanglement structure of the initial state. We expand the machinery of interaction-driven localization to the realm of LGTs such that for any starting product state, the matter field exhibits emergent statistical bubble localization, which is driven solely by the cluster interaction, having no topologically trivial noninteracting counterpart, and thus is of a pure dynamical many-body effect. Our proposed setting provides possibly the minimal model dropping all the conventional assumptions regarding the existence of MBL.

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Two-dimensional materials in curved geometry

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In this work, we consider curved two-dimensional materials and study how electronic band structures are altered by curvature. A single-particle Green function which contains the information of single-particle density of states is a relatively accessible object that is affected by the curvature. Based on the previous work of Bunch and Parker, we calculate the Green function in momentum space where first-order perturbation correction is proportional to the curvature. A tunneling spectroscopy experiment can be employed to verify the change in the density of states since the differential conductance dI/dV is proportional to the density of states at low temperatures.

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Magnetic effect on second harmonic generation in hyperbolic magneto-plasmonic metasurfaces

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Nowadays, hyperbolic plasmonics attracts researchers' attention by its exciting optical properties [1-6]. Hyperbolic metasurfaces (HMSs) support highly localized low-loss surface plasmon-polaritons (SPPs), providing drastic increase of the light-matter interactions near the surface. Moreover, HMSs allow the very effective manipulation by SPPs varying from routing them towards specific directions within the sheet, dispersion-free propagation (canalization), and to the negative refraction.

Usually HMSs are realized by deeply subwavelength grating of plasmonic (metallic) surface [1-6]. For non-linear magneto-plasmonics, metal-ferromagnet multilayer structures have a great potential [7]. Hyperbolic magnetoplasmonic metasurface may be constructed by combination of these two ideas, i.e. by subwavelength grating of magneto-plasmonic multilayers. Here, depending on the position of ferromagnet and grating depth three variants are possible: noble metal covered by ferromagnetic metasurface (similar structure has been investigated recently [8], but for non-hyperbolic regime), hybrid metal-ferromagnet structure covered by noble metal based metasurface, and noble metal covered by hybrid metal-ferromagnet metasurface (similar structures have been investigated in [9], but not for hyperbolic regime as well).

In order to investigate SHG in hyperbolic magneto-plasmonic MSs, theoretical model based on effective medium approximation has been performed. In contrast to hybrid metal-ferromagnet plasmonic structure, hyperbolic magneto-plasmonic MSs will have a highly anisotropic dielectric permittivity tensor. This leads to significantly anisotropic SHG signal (with respect to SPPs propagation direction).

In directions where SPPs cannot propagate, SHG signal will have the similar behavior as for the system without the metasurface, while in directions where canalization of SPPs observed SHG signal significantly increase. In contrast to usual hybrid metal-ferromagnet multilayers, proposed structure will have an additional surfaces for SHG signal caused by grating. For hybrid metal-ferromagnet multilayers non-magnetic SHG is caused by z-component of non-linear polarization Pz at all the interfaces (z-axis is perpendicular to the interfaces, x- and y- axis lies in-plane), while magnetic SHG is caused by Px. For noble metal covered by ferromagnetic metasurface and for noble metal covered by hybrid metal-ferromagnet metasurface an additional z-component of non-linear polarization will be induced by interfaces between magnetic metal and air in grating. In turn, for hybrid metal-ferromagnet structure covered by noble metal based metasurface, and for noble metal covered by hybrid metal-ferromagnet metasurface an additional x-component of non-linear polarization will be induced by interfaces between non-magnetic metal and air in grating.

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Bose-Einstein condensation of triplons in an antiferromagnet close to the quantum critical point

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The Bose–Einstein condensate (BEC) of triplons, a fascinating state of matter, has been observed in many quantum spin-gap insulators when the critical magnetic field is applied to close the magnitude of spin gap. The empirical realizations include TlCuCl3, BaCuSi2O6, Ba3Cr2O8, Sr3Cr2O8, Ba3Mn2O8, etc [1]. Many of these systems have large critical magnetic fields. Herein, we introduce a new kind of antiferromagnetic material which exhibits magnetic longrange order (LRO) and the field induced BEC of triplons at very low critical magnetic fields.

The structure of K2Ni2(MoO4)3 consists of S=1 tetramers formed by Ni2+ ions [2]. The magnetic susceptibility and specific heat data on a single crystal show a broad maximum due to the low-dimensional nature of the system with short-range correlations. A sharp peak is seen in magnetic susceptibility and heat capacity at about 1.1 K, well below the broad maximum. This is an indication of magnetic LRO i.e., the absence of spin-gap in the ground state.

Interestingly, the application of a small magnetic field (H > 0.1 T) induces magnetic behavior akin to BEC of triplon excitations observed in some spin-gap materials mentioned above. Our results demonstrate that the temperaturefield phase boundary follows a power-law with an exponent close to 3/2 as predicted for BEC scenario. The observation of BEC of triplon excitations under the application of small magnetic fields in a non-spin gap system infers that K2Ni2(MoO4)3 is located in the proximity of a quantum critical point, which separates the magnetically ordered antiferromagnetic state and quantum spin gap state of the phase diagram. We anticipate that the ground state K2Ni2(MoO4)3 might have a mixture of singlets and triplets. Due to this reason, a small magnetic field could induces the BEC state of triplons.

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Magnetic two-sublattice molecular-field model for frustrated pyrochlore Gd_2FeSbO_7

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In this work, we have extensively studied magnetic and heat capacity properties of a frustrated pyrochlore Gd_2FeSbO_7 in the light of cooperative two-sublattice model taking account of nearest-neighbor (n.n.) intra-sublattice (Gd-Gd and Fe-Fe) and inter-sublattice (Gd-Fe) magnetic interactions. We have chosen this compound because it contains magnetic Fe^{3+} moments at half of the four B-sites of pyrochlore $A_2B_2O_7$ structure. The Fe^{3+} moments, whose 3d orbitals ($3d_5$: $3t_{2g}^3e_g^2$) are half-filled and hence carry a large magnetic moment, play a significant role in fascinating magnetic and thermal properties of A_2FeSbO_7 pyrochlores [1]. Gd_2FeSbO_7 remains paramagnetic down to 12 K with effective antiferromagnetic n.n. interactions determined by Curie-Weiss temperature, $\theta_{CW} = -12.62$ K. Fe sublattice exhibits a weak ferromagnetic transition at TC ≈ 5 K, as evidenced from first order derivatives of magnetization, dM/dT and dM/dH curves, versus temperature and magnetic field, respectively. The frustration index $f = |\theta_{CW}|/T_C$ becomes 2.5 indicative of moderate frustration, and hence Palmer-Chalker ground state configuration of Gd sublattice [2] at lower temperature could not be expected in the system. Heat capacity C_p exhibits a broad anomaly at 3.1 K and calculated magnetic heat capacity C_m/T attains a peak at ~1 K, but is much weaker than for other pyrochlores Gd2B2O7 (B = Sn, Ti, Ge, Pt) which are all found to order at 1 K or lower. Arrott plots, M2 versus Heff/M isotherms, were plotted and consideration of Banerjee criterion [3] indicates that the above transition is of second-order nature. Magnetocaloric effect for Gd_2FeSbO_7 was evaluated from the field-dependence of isothermal magnetization. Magnetocaloric entropy attains maximum at TC and follows a power law with applied field, $\Delta S_M^{max} \propto H^{1.6}$. Finally the magneto-thermodynamic properties were analyzed involving crystal-field easy-planer anisotropy at Gd-site and three exchange coupling constants, e.g., $J_{Gd\text{-}Gd} = -0.16$ K, $J_{Fe\text{-}Fe} = 0.29$ K, and $J_{Gd\text{-}Fe} = -0.137$ K. The halffilled Fe^{3+} orbitals create additional Gd-O-Fe-O-Gd pathways (Fig. 1), involving 2p6 orbitals of intermediate O^{2}- ions, which result in antiferromagnetic superexchange interactions among the Gd-Gd spins as well as for the Gd-Fe bonds.

We noticed that in absence of Gd-Fe interaction, two independent interpenetrating Gd^{3+} and $Fe^{3+}Sb^{5+}$ sublattices can not precisely demonstrate the measured thermo-magnetic properties of Gd_2FeSbO_7. The 3d-4f magnetic interactions offer Gd_2FeSbO_7 a unique place in the series of gadolinium pyrochlores and hence the present study opens up a new window to further study the geometric magnetic frustration

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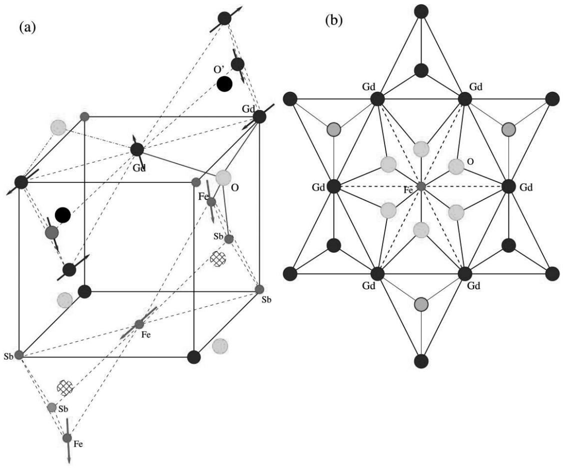

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Thermodynamic Properties of a 2D Ising Spin-Pseudospin System

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One of the topical problems of the cuprate physics is the coexistence and competition of the antiferromagnetic, superconducting, and charge orders. In the framework of a pseudospin formalism for strongly correlated 3d compounds [1,2] we elaborate a simplified static 2D spin-pseudospin model to consider the competition of magnetic and charge orderings in cuprates. The spin-pseudospin model takes into account both the usual spin exchange interaction and on-site and inter-site charge correlations. The model is equivalent to the 2D dilute antiferromagnetic (AFM) Ising model with two types of charged impurities. In a mean-field approximation (MFA), the five phases are realized in the ground state, depending on the concentration of charged impurities and the relation between the spin exchange and the on-site and inter-site correlation parameters [3]. The Monte Carlo simulations show that the cases of strong spin exchange and strong charge correlation differ qualitatively [4]. For a strong spin exchange, the spin AFM phase is unstable with respect to the phase separation (PS) into the charge and spin subsystems. The temperature dependence of the specific heat in this case exhibits two successive phase transitions: first, the AFM ordering in the spin subsystem diluted by randomly distributed charged impurities, and second, the condensation of impurities in the charge droplets. The critical temperature of PS was found analytically in a framework of the Maxwell's construction [5]. In case of the strong inter-site charge correlation, the singularity of the magnetic susceptibility and the charge ordering appear in the AFM phase in the framework of the MFA, that is inconsistent with the Monte Carlo results at low densities of charged impurities. We consider this contradiction to be related with the percolation limit of charged impurities on a single sublattice and a specific temperature dependence of the nearest-neighbor charge-charge correlator.

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Spin Current Detection via an Interface Molecular Paramagnet

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Pure spin currents are considered as key processes for future low-dissipation electronics. Current detection schemes use the inverse spin Hall effect for converting the spin current into an electrical voltage. Here, we present an alternate, contact-free detection scheme based on a paramagnetic molecular probe layer which in principle allows the integration of spin currents into molecular electronics. In a measurement without the requirement of lithographically tailored samples and electrical contacts we detect changes of the electron spin resonance (ESR) in the probe layer when a spin current is injected from a microwave (mw) driven ferromagnetic layer. Tuning the microwave resonance conditions of the ferromagnetic and molecular layer to the same resonance condition we observe the flow of spin momentum at the interface through the change of the microwave power dependent absorption of the adsorbed molecular layer [1]. We use oleic acid (OA) as the molecular probe layer on iron films.

These results are compared to classical results of conduction spin electron resonance where diffusive spin currents have been discussed [2, 3] as a "transport of magnetization" across a ferromagnetic / paramagnetic metal interface of Cu and permalloy. This earlier model was based on a phenomenological exchange coupling constant of d electrons to the s electrons travelling across the interface in both directions.

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Intrinsic Spin And Orbital Hall Effects From Orbital Texture

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We show theoretically that both the intrinsic spin Hall effect (SHE) and orbital Hall effect (OHE) can arise in centrosymmetric systems through momentum-space orbital texture, which is ubiquitous even in centrosymmetric systems unlike spin texture. The OHE occurs even without spin-orbit coupling (SOC) and is converted into the SHE through SOC. The resulting spin Hall conductivity is large (comparable to that of Pt) but depends on the SOC strength in a nonmonotonic way. This mechanism is stable against orbital quenching. This work suggests a path for an ongoing search for materials with stronger SHE. It also calls for experimental efforts to probe orbital degrees of freedom in the OHE and SHE. Possible ways for experimental detection are briefly discussed.

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Antisymmetric interlayer exchange coupling in magnetic multilayers

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The exchange interaction governs static and dynamic magnetism. This fundamental interaction comes in two flavors - symmetric and antisymmetric. While the symmetric interaction leads to ferro- and antiferromagnetism, the antisymmetric interaction has attracted significant interest owing to its major role in promoting topologically nontrivial spin textures that promise fast, energy-efficient devices. So far, the antisymmetric exchange interaction has been found to be rather short–ranged and limited to a single magnetic layer. Here, we report a long-range antisymmetric interlayer exchange interaction in perpendicularly magnetized synthetic antiferromagnets with parallel and antiparallel magnetization alignments. Asymmetric hysteresis loops under an in-plane field reveal a unidirectional and chiral nature of this interaction, resulting in canted magnetic structures. We explain our results by considering spin-orbit coupling combined with reduced symmetry in multilayers. Our discovery of a long-range chiral interaction provides an additional handle for engineering magnetic structures and could enable three-dimensional topological structures.

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Giant spin-orbit torque generated by BiSb topological insulator for MRAM applications

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Topological insulators (TIs) are exotic materials with insulating (semiconducting) bulk states and metallic surface (edge) states. The electron spin on the surface of TIs is locked to its momentum, resulting in many novel physics.

These include the quantum spin Hall effect in two-dimensional TIs, the quantum anomalous Hall effect in magnetic TIs, and Majorana Fermions at TI/superconductor interfaces. So far, those novel physics have been observed in TIbased heterostructures at extremely low temperatures, making them less attractive for device applications at room temperature. Here, we present our recent results on the giant spin Hall effect at room temperature in a conductive topological insulator, BiSb. We show that BiSb have both high electrical conductivity and giant spin Hall angle at room temperature, which are very promising for applications to ultralow power spin-orbit torque magnetoresistive random access memory (SOT-MRAM). Evaluation of spin-orbit torque in BiSb/MnGa bi-layers reveals a colossal spin Hall angle of 52 and a spin Hall conductivity of 1.3 107 ħ/2e Ω-1m-1 at room temperature. We demonstrate that BiSb thin films can generate a colossal spin-orbit field of 2.3 kOeMA-1cm2 and a critical switching current density as low as 1.5 MAcm-2 in BiSb/MnGa bi-layers. Furthermore, we identify the origin of the giant SHE in BiSb thin films by measuring the spin Hall angle under controllable contribution of surface and bulk conduction. Our quantitative analysis shows that the giant SHE in BiSb is almost governed by contribution from the topological surface states.

Thus, BiSb is the best candidate for the first industrial application of topological insulators.

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Magnetic structures on locally inverted interlayer coupling region of ferromagnetic bilayer system

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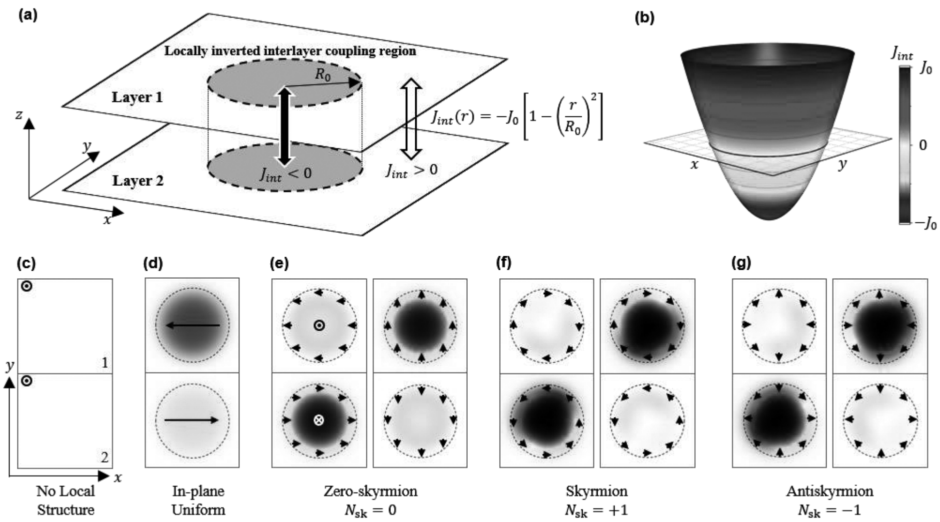
Kyung Hee University, Korea

Recently, researches on two-dimensional magnetic structures are actively conducted due to their interesting properties and possibilities in future applications. Especially, the magnetic structures possessing a definite skyrmion number, such as magnetic skyrmions and magnetic vortices, have been extensively explored since they are known to be stable due to topological protection and controllable by spin torques or external fields. We studied the magnetic structures under locally inverted interlayer interaction in a ferromagnetic bilayer system with micro-magnetic simulation. Multiple magnetic structures including magnetic skyrmion, antiskyrmion, in-plane uniform state, and non-skyrmion state are stabilized on a locally inverted interlayer coupling region. The size of stabilized structures depends on various factors such as the area of the region, the anisotropy, the interlayer coupling strength and the exchange interaction strength. We investigated their stabilization conditions and found critical conditions of structural transition among those structures. The dipole interaction and Dzyaloshinskii-Moriya interaction affect the spin configuration and the stability of the magnetic structures. We also found that an effective asymmetric interaction can arise from spontaneously broken inversion symmetry which occurs when a magnetic skyrmion is generated in one layer and coupled with uniform magnetization in the other layer. Although the system contains no explicit Dzyaloshinskii-Moriya interaction, the direction of magnetization on the rim of the skyrmion shows a definite chirality with the effective asymmetric interaction.



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Influence of Interface Quality of Pt/Fe_3O_4 hybrids on Spin Hall Magnetoresistance

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The effective generation and detection of the spin currents at Heavy metal (HM)/ferromagnet (FM) interfaces, based on the spin Hall effect (SHE) or the Inverse the spin Hall effect (ISHE), have been explored intensively for future spintronic device applications [1]. The efficiency of spin current transport at the interface is determined by spin mixing conductance, the key factor governing spin Hall magnetoresistance (SMR). It has been reported that the spin mixing conductance sensitively depends on the quality of the HM/FMI interface.

In this work, we systematically investigate how different interface structures of Fe_3O_4 prior to the Pt deposition impact the SMR in Pt/Fe_3O_4 hybrid structures. The different levels of surface/interface roughness ranging from 0.4 to 1.2 nm were provided by using different film growth techniques and changing the growth conditions. Moreover, the chemical variation was introduced between Fe_3O_4 and Pt layers by inserting a 2-nm-thick Al_2O_3 or MgO thin film. The films were prepared by oxide-MBE and RF-magnetron sputtering technique under different deposition parameters on substrate and substrate temperature, and then followed by vacuum annealing. The careful analysis of the surface properties of Fe_3O_4 was performed using AFM and XPS for structural and chemical characterization, respectively. As the interface roughness increases, we observed significant enhancement of spin-mixing conductance that is extracted from the SMR effect measured at low temperature (77 K lower than the Verway transition temperature of magnetite), and the SMR effect persists even in the hybrid structure with a MgO interlayer. Our results provide further insights into this phenomenon to develop highly effective SHE devices.

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Novel Probes For Studying Correlated Electron Systems

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The multitude of emergent topology and order in strongly correlated phases, such as fractional quantum Hall phases and unconventional superconductivity, that develop from the dominant electron-electron interactions have fascinated researchers for decades. While traditional transport measurements have played monumental roles in initially discovering many of the quantum phases, more conclusive identification of the theoretically proposed models requires the development of new experimental methods because the signatures of certain wave functions are often very subtle to distinguish in transport experiments.

In this talk, I will discuss novel experimental techniques that can extract proper spectroscopic information from quantum correlated low-dimensional electron systems, employing ultra-sensitive electric and magnetic field sensing [1,2,3]. I will also argue that further improvement of these tools, combined with conventional transport devices, can help unravel definitive "clues" and advance our understanding of strongly interacting phenomena and various topological quantum phases.

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Observation of a 4-spin Plaquette Singlet State in the Shastry-Sutherland compound $SrCu_2(BO_3)_2$

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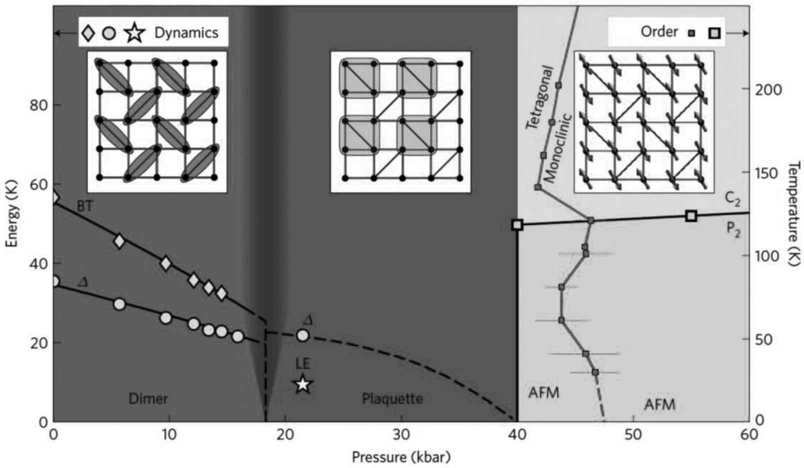
The study of interacting spin systems is of fundamental importance for modern condensed matter physics. On frustrated lattices, magnetic exchange interactions cannot be simultaneously satisfied, and often give rise to competing exotic ground state. The frustrated 2D Shastry-Sutherland lattice realized by SrCu2(BO3)2 is an important test to our understanding of quantum magnetism. It was constructed to have an exactly solvable 2-spin dimer singlet ground state within a certain range of exchange parameters and frustration. While the exact dimer state and the antiferromagnetic order at both ends of the phase diagram are well-known, the ground state and spin correlations in the intermediate frustration range have been widely debated. We report here the first experimental identification of the conjectured 4-spin plaquette singlet intermediate phase in SrCu2(BO3)2. It is observed by inelastic neutron scattering after pressure tuning at 21.5 kbar. This gapped singlet state leads to a transition to an ordered Neel state above 40 kbar, which may represent a deconfined quantum critical point.



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Low temperature structural effects in the frustrated quantum magnet $SrCu_2(BO_3)_2$

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The frustrated quantum magnet $SrCu_2(BO_3)_2$ has attracted considerable interest as a realization of the exactly solvable Shastry-Sutherland model. Recently various new phases including a novel four-spin plaquette singlet, an antiferromagnetic ordered state (AFM) and a monoclinic structurally distorted AFM have been observed under pressure. Furthermore, several subtitle interplays between the magnetic and the structural properties have been detected at low temperatures.
We present here a neutron diffraction study of the low temperature crystal structure of $SrCu_2(BO_3)_2$ and our results on the temperature dependence of the lattice parameters down to 1.6 K. While the tetragonal space group I-42m survives to base temperature, structural effects related to the spin-lattice coupling occur upon entering the spin gap regime (T ~35 K). The a-axis undergoes an unusual negative thermal expansion while the Cu–Cu dimer length and the magnetic coupling angle Cu–O–Cu increase as temperature is reduced. The relations between the magnetic properties and the low temperature structure and are discussed.

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Magnetization density distribution of Sr_2IrO_4: Deviation from a local j_{eff}=1/2 picture

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5d iridium oxides are of huge interest due to the potential for new quantum states driven by strong spin-orbit coupling. The strontium iridate Sr_2IrO_4 is particularly in the spotlight because of the novel jeff=1/2 state consisting of a quantum superposition of the three t_{2g} orbitals with nearly equal population, which stabilizes an unconventional Mott insulating state [1-3]. Here, we report an anisotropic and aspherical magnetization density distribution measured by polarized neutron diffraction in a magnetic field up to 5 T at 4 K, which strongly deviates from a local j_{eff}=1/2 picture. Once reconstructed by the maximum entropy method and multipole expansion model refinement, the magnetization density shows cross-shaped positive four lobes along the crystallographic tetragonal axes with a large spatial extent, showing that the xy orbital contribution is dominant. Theoretical considerations based on a momentum-dependent composition of the j_{eff}=1/2 orbital and an estimation of the different contributions to the magnetization density casts the applicability of an effective one-orbital j_{eff}=1/2 Hubbard model into doubt. The analogy to the superconducting copper oxide systems might thus be weaker than commonly thought.

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The magnetic depth dependence of YIG thin films by Polarized neutron reflectometry

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Yttrium iron garnet (YIG) is a well-known ferrimagnetic insulator. The YIG/Pt multilayer has become the model system for investigating spin Seebeck effect or spin Hall magnetoresistance effect [1]. Here, I report a polarized neutron reflectometry (PNR) study on the depth dependence of both the structure and magnetism for YIG and YIG/Pt thin films deposited on gadolinium gallium garnet (GGG) substrates. The PNR measurement was carried out at the multi-purpose reflectometer (MR) at China spallation neutron source (CSNS), which is an instrument optimized for examining thin films with nanometer scale structure, especially in regard to their magnetic properties. The PNR results show the interfacial nonmagnetic "dead" layer near the GGG is limited in these sputtered YIG film.

The magnetization of YIG is near the nominal value (135 emu/cm3). However, it finds the existence of an interfacial layer at the YIG/Pt interface. The suppressing of this interfacial layer maybe important for investigating the physics of spin Hall magnetoresistance.

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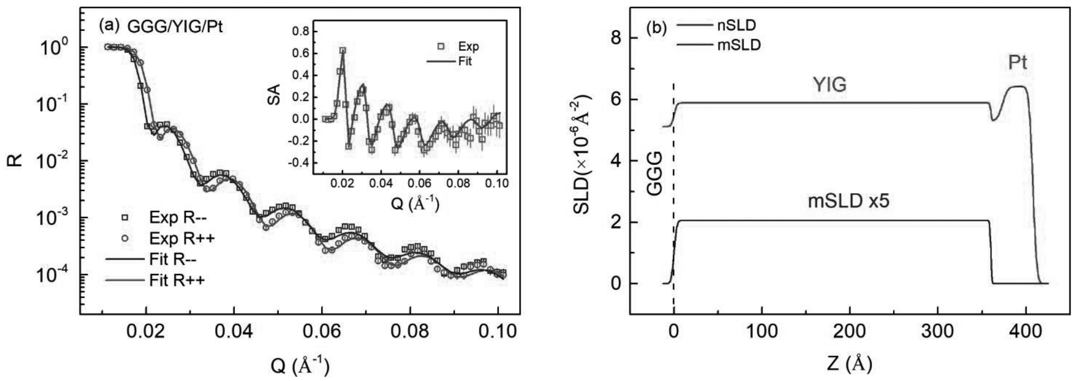

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Exploring Quantum Emergent Properties using Resonant Inelastic X-ray Scattering and X-ray Imaging

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Quantum emergent properties of correlated systems have been intensively investigated using various experimental techniques. Moreover, some researchers have searched for new ground states via revisiting the concept of 'spinorbit coupling' and using advanced X-ray techniques. However, understanding of the new physical properties in a model system is yet incomplete due to experimental limitations.

Here, we propose a new experimental approach combined with resonant inelastic x-ray scattering (RIXS), Coherent Bragg Rod Analysis (COBRA), and X-ray Reflection Interface Microscopy (XRIM). Using the advanced X-ray techniques, we will systematically investigate quantum properties (j_{eff} system) of lacunar spinel (GaTa4Se8) and iridates. Our studies offer a comprehensive approach based on the realization of theoretically-proposed model systems combined with an advanced hard x-ray RIXS, COBRA, and XRIM. These are powerful and dedicate tools to unveil the detailed mechanisms and to detect elementary excitations related to spin-orbit coupling. Furthermore, we will present in situ techniques combined with high pressure and electric field, which can generate new phases and quantum emergent physical properties.

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Synthesis, Structural and Magnetic Properties of (NdY)–FeNb–B Nano Crystalline Permanent Magnets produced by Rapid Solidification and Annealing

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Rare earth nanocrystalline permanent magnets have attracted scientific and technological interest for the development of advanced permanent magnets. These magnets are used as a thin magnet application such as microgear for micro-motors, vibrator for cellular phone, relays for electromechanical devices, etc. Present work describes the synthesis, structural and magnetic properties of NdY-FeNb-B based permanent magnets. Magnet in rod, sheet and cone were produced by rapid solidification and subsequent annealing. Magnetic and microstructural properties were enhanced by optimizing the alloy composition and processing. X-ray diffraction analysis showed formation of Nd2Fe14B, Y2Fe14B, α-Fe and Fe3B phases. Electron microscopy revealed 40-50nm (Nd,Y)2Fe14B, 20-25nm α-Fe and 10nm Fe3B nanograins. Three-dimensional atom probe microanalysis indicated the segregation of Nd, Y and Nb atoms into hard phase while Fe at the grain boundaries. Henkel plots provoked strong magnetic exchange interactions between magnetically hard Nd2Fe14B and soft α-Fe, Fe3B phases. Magnetometer measurements elucidated that magnetic properties in these magnets stem from the homogenous microstructure consisting of exchange coupled, soft magnetic (α-Fe, Fe3B) and hard magnetic (NdY)2Fe14B phases. The Fe70B19Nd7Nb4 magnet demonstrates magnetic properties such as Br of 0.61T, iHc of 76kA/m and (BH)max of 50.2 kJ/m3. Micro-addition of Zr, Cu and Ti to quaternary Fe70B19Nd7Nb4 alloy led to increase the mass fraction of hard magnetic phase, strengthen the ferromagnetic exchange interactions and enhance the magnetic properties by refinement of magnetic phases. A coercivity up to1115kA/m is obtained in these magnets. Enhancement of coercivity is mainly resulting by the hard phase increment, domain wall pinning, while strengthening of exchange coupling is caused by grain size refinement as well as increase in the Curie temperature of the magnetic phases. The Fe67B19Nd7Gd2Nb4Si1 magnetic alloy exhibits sound magnetic properties such as intrinsic coercivity, iHc of 1115kA/m, remanence, Br of 0.57T and maximum energy product (BH)max of 65.7kJ/m3. The synthesis of NdYFeNb-B based nanocrystalline permanent magnets as well as their characterization in the current research work would be helpful for tailoring the microstructural and magnetic properties of nanocrystalline permanent magnets.

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Composite magnetic microactuator based on ferromagnetic shape memory Ni-Mn-Ga Heusler Alloy

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Heusler alloys attract great interest due to the combination of ferromagnetism and thermoelastic martensitic transition, which is accompanied by shape memory effect (SME) [1]. Recently, application of the technology of selective ion etching (FIB) allowed creating two-layer composite actuators and tools based on rapidly quenched nonmagnetic alloys with SME, such as Ti2NiCu [2]. These composite actuators can change their shape reversely and produce mechanical work using only "one-way" SME of the alloy [3]. This opens possibility of creating technology for production of micro-sized magnetic-field-controlled tools and devices on the base of Heusler alloys. The aim of this work is double. These are the development of a technique for the production of composite microtools based on rapidly quenched Heusler alloy Ni-Mn-Ga showing SME and the control of microactuator's giant reversible strain by a magnetic field (magnetic-field-induced martensitic transformation). The samples of microactuators were prepared starting form rapidly quenched alloy ribbons of composition Ni53Mn24Ga23 showing the martensitic transition temperature at about 336 K. The properties of these ribbons were described elsewhere [4,5]. The method of preparation of microactuators by FIB is illustrated in Fig. 1. A layer of Pt was deposited on the surface of preliminary pseudo-plastically stretched NiMnGa ribbon at room temperature.

Then the two-layer composite was cut by FIB milling.The next stage was the realization of composite microactuator attached to a silicon wafer (Fig.1). The typical dimensions of the obtained microactuators were 27x2x1.5 μm3.

The sample of microactuator was placed in Bitter magnet with field up to 8 T [6]. The experimental setup included optical microscope and thermostat, which allowed getting video-record of sample's shape depending on temperature and magnetic field (Fig.2). The reversible bending deformation of the microactuators about 1% (the stroke more than 1 μm) in a magnetic field up to 8 T was demonstrated at constant temperature. The blocking force of microactuator was measured by AFM.

Figure 1. NiMnGa/Pt composite microactuator on silicon wafer.

Figure 2. Deformation of microactuator at constant temperature due to magnetic-field-induced martensitic transition: a) austenite, b) martensite.

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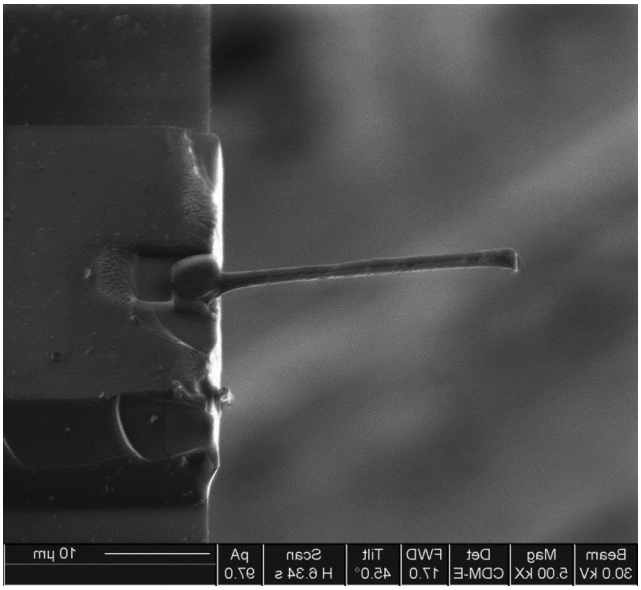

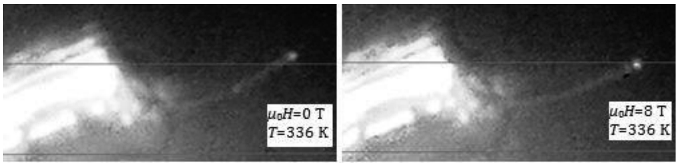

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Effect of Liquid Aid Sintering to Improve the Coercivity of Sm-Co (1:5) Intermetallic Compound

Saleem Akhtar[1], Aamir Nusair Khan[2]*, Mushtaq Khan[1], Syed Husain Imran Jaffery[1]

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$SmCo_5$ intermetallic compounds are well known for its high coercive properties. The coercivity of the material largely depends upon the particle size. A critical particle size corresponds to the size of the domain of the subject compound. However, during the bulk magnetic production, the sintering temperature is high enough for the growth of the grain size. This clearly deteriorates the required magnetic properties. Hence, the reduction in sintering temperature may help in retaining the size of the carefully tailored particles. This can be achieved by adding an appropriate amount of samarium rich SmCo alloy. In this study, systematic experimentation has been made firstly to obtain a very close particle size distribution and then optimizing the amount of samarium rich SmCo alloy in the parent chemical composition. The decrease in the sintering temperature and the presence of samarium rich phase at the grain boundaries demonstrate comparatively high values of intrinsic coercivity. In this regard, a correlation between the microstructure, metallurgical phases and the magnetic properties are also made.

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Maintaining The Sensitivity By Compensative Thickness Variation In The Capping Layer For PHE Sensors

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The planar Hall effect (PHE) based sensors emerged as a unique type of sensors in the area of low magnetic moment and biosensing applications. The low offset, high signal to noise ratio, linearity at small magnetic field magnitudes nominates PHE sensors as another solution which outcomes giant magnetoresistance (GMR) and tunnel magnetoresistance (TMR) sensors. The insertion of the nonmagnetic spacer layer in the ferromagnetic/antiferromagnetic interface alters the operating field range and exchange bias, while, the addition of an additional capping layer has a major effect on the output voltage due to shunt current contribution. In the present study, a new technique to simultaneously modify the variation in the output voltage and exchange bias based on planar Hall effect sensors has been introduced. The spacer and capping layer thicknesses are varied interdependently in a way that the variation of the operating magnetic field range is performed without a significant change of sensitivity. The mathematical relation ruling this equi-sensitive approach is derived and matched well with the experimental results. The effects of ferromagnetic material change in terms of sensitivity, operating field range, magnetic anisotropy, interface coupling energies, and shunt current were calculated for NiFe/IrMn and NiFeMo/IrMn bilayers. Structural effects on the interface and planes were analyzed by high-resolution transmission electron microscopy (HRTEM). This approach provides a valued perception into the industrial processes for lowering power consumption into an end product.

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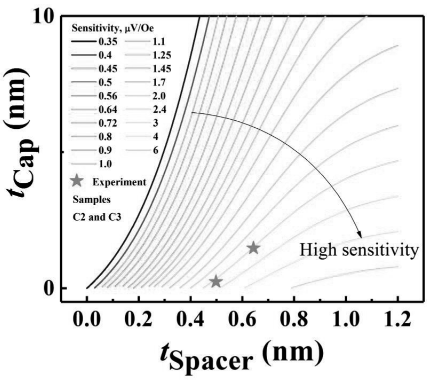

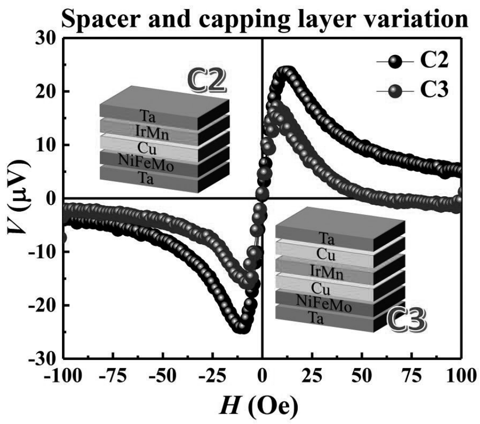

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S-0246 09:00-09:30, August 23 | Room 513

On the pairing mechanism of high temperature superconductivity

Qi-Kun Xue*

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We investigate the pairing mechanism of high Tc superconductivity in cuprates and iron-pnictides by using state-ofthe-art molecular beam epitaxy (MBE)-scanning tunneling microscopy (STM). By two approaches in sample preparation, namely Ar+ ion bombardment and ozone-assisted MBE growth, we are able to study the gap structures of superconducting copper oxides and FeSe planes directly by STM. We show that the pairing symmetry in both systems is isotropic. We propose a model for understanding the complicated phase diagram and particularly the mechanism of unconventional high temperature superconductivity.

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S-0202 09:30-10:00, August 23 | Room 513

Projected BCS theory for the unification of antiferromagnetism and strongly correlated superconductivity

Kwon Park*

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At the core of the high-temperature superconductivity problem lies the relationship between strong correlation and superconductivity. One of the most exciting prospects on their relationship is that strong correlation is the very source of high-temperature superconductivity. To investigate the validity of this prospect, we perform an analysis of the BCS model Hamiltonian projected onto the constrained Hilbert space with infinitely strong correlation imposing the condition of no double occupancy also known as the Gutzwiller projection. Let us call such an analysis the projected BCS theory.
Specifically, we compute the overlap between the exact ground states of the projected BCS theory and the t-J model via exact diagonalization. As a result, we show that the projected BCS theory provides excellent variational states for the exact ground states of the t-J model in a wide range of hole concentration including both half filling and finite doping. It is emphasized that the resonating valence bond (RVB) state, i.e., the projected BCS wave function is closely related to the ground state of the projected BCS theory, while quite different at low doping. What makes the difference is whether the projection is applied to the ground state of the Hamiltonian or the Hamiltonian itself.

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S-0233 10:00-10:30, August 23 | Room 513

A New Paradigm to Higher Tcs of the Stable Cuprates: To Break Away from the Constraints Imposed by the Universal Quadratic Tc-Dopant Relation

Ching-Wu Chu[1,2]*, Liangzi Deng[1], Yongping Zheng[3], Zheng Wu[1]

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To achieve a higher transition temperature (T_c) of superconductors has been the primary driving force for the sustained research efforts for decades in the superconductivity field. The T_c and doping have been found to have a dome-like general relation and the peak position is the maximum T_c, which is consistent with previous experimental results at lower pressure range. In this talk, by using our newly developed ultra-sensitive magnetization measurement technique under high pressure, we discovered a universal resurgence of T_c in BSCCO passing the peak predicted by the universal quadratic T_c-p (doping) or -P (pressure) relation for cuprate high temperature superconductors. We have attributed this resurgence of T_c to a pressure-induced electronic transition in the stable high T_c cuprates, in qualitative agreement with our density functional theory calculations. This offers a new way to raise the T_c of the layered cuprate high temperature superconductors to a new height. In the present talk, if time permits, I shall discuss briefly what we have in store for a crucial role of HTS in their present stage in the global sustainable economic development through optimization, by the development of a HTS/LH_2 energy super-highway.

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S-0743 10:50-11:20, August 23 | Room 513

Development of the RCE-DR process for higher performance GdBCO coated conductors

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Long-length high-Ic GdBa2Cu3O7-d (GdBCO) coated conductors (CCs), composed of GdBCO CCs/LaMnO3/Epi-MgO/IBAD-MgO/Y2O3/Al2O3/Hastelloy (or Stainless steel), have been routinely fabricated via the RCE-DR (Reactive Co-Evaporation Deposition & Reaction) process by SuNAM Co. in Korea. Although the RCE-DR process for GdBCO CCs is known cost-effective because of its high yield and high production rate, the Ic properties of GdBCO CCs in high fields are inferior to those of REBCO CCs produced by other processing technologies such as PLD (Pulsed Laser Deposition), MOD (Metal-Organic Deposition), and MOCVD (Metal-Organic Chemical Vapor Deposition). To improve the flux pinning properties of GdBCO CCs, without a significant degradation in Tc values, we have tried to refine the Gd2O3 particles trapped in the GdBCO matrix and also to vary the stacking fault density produced in the GdBCO matrix by controlling the processing parameters on the basis of the GdBCO stability diagram, experimentally determined for the nominal composition of Gd:Ba:Cu=1:1:2.5. In this talk, our recent results will be presented, and future plan for further development on the basis of materials science approach will be suggested.
This work (Grants No.S2660496) was supported by project for Cooperative R&D between Industry, Academy, and Research Institute funded Korea Ministry of SMEs and Startups in 2018.

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Selected elements substituted on Tl-site of the $TlSr_2CaCu_2O_7$ system: A short review

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This review is based on the selected elements substituted on Tl-site of the TlSr2CaCu2O7 system. The objective of this paper were to review the elements that helps TlSr2CaCu2O7 system becomes superconducting. The selected elements are Pb, Bi, Cr, V, Re, Ce, Zr, In, Er, Gd, La, Na, K, Rb and Se. The ionic radii, the valence state and the coordination number of the selected elements are studied. This paper also focused on the preparation method, sintering temperature, effect on critical temperature (T_c), phase and structural stability as well as optimization of hole concentration.

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Properties of $Sm_{3-x-y}Pr_xCayBa_5Cu_8O_{19}$ Compound

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Recently, the superconductivity in the $Y_3Ba_5Cu_8O_y$ compound has been reported [1]. Also, it is well established that the superconducting transition temperature of the cuprates depends on the amounts of carrier on the CuO_2 plane.

Therefore, by doping of the compound one can investigate the effects of dopant on the transition temperature. On the other hand, praseodymium doping is an interesting case. In the family of $REBa_2Cu_3O_7$ compounds (RE= rare earth elements except Ce, Tb), the $PrBa_2Cu_3O_7$ is not superconductor [2]. Moreover, the transition temperature of $RE_{1-x}Pr_xBa_2Cu_3O_7$ compound is suppressed by increasing Pr, and the compound finally becomes an insulator at some critical value of x [3,4]. On the other hand, the replacement of RE element with Ca introduces hole carrier in the compound. As a result, Ca doping can somehow counterbalance the effect of Pr doping. Understanding the relation of transition temperature to the doped hole and electron carrier can give some clue on the theory of superconductivity in the cuprates. In addition, the $RE_3Ba_5Cu_8O_{19}$ phases can decompose to the $REBa_2Cu_3O_7$ and $REBaCu_2O_5$ phases [5] by absorbing a small amount of energy (~ 45 meV) during its preparation process. Therefore, the counterbalancing effects of Pr by Ca doping may also be observed in the RE3Ba5Cu8O19 compound, which can be helpful in discriminating the $RE_3Ba_5Cu_8O_{19}$ and $REBa_2Cu_3O_7$ properties.

Here, we investigate the effects of Pr and Ca doping in the $Sm_{3-x-y}Pr_xCa_yBa_5Cu_8O_{19}$ compound. For the constant value of y, the results show the reduction of transition temperature with the increasing amounts of x. However, for a constant value of x, the transition temperature increases up to a maximum and then reduces. This maximum happens for the value of $y \cong x$. While there is a maximum transition temperature for each value of x, this maximum reduces almost linearly by increasing Pr. These results indicate that equal amount of Pr or Ca introduces almost the same electron and hole in the compound, but the hole doping by Ca cannot completely compensate the effect of the assumed electron doping by Pr to restore the transition temperature to the case of un-doped sample. As a result, in the case of $Sm_3Ba_5Cu_8O_{19}$ compound, similar to the case of $REBa_2Cu_3O_7$, the role of Pr is more than hole filler agent, consistent with the Abrikosov-Gorkov pair-braking theory. Therefore, both hole filling and pair-breaking mechanism should be considered to describe the observed results. As a result, following the Neumeier, et al., the Tc(x,y) has been modelled.

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Topologically protected Bogoliubov Fermi surfaces

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It is commonly believed that, in the absence of disorder or an external magnetic field, there are three possible types of superconducting excitation gaps: The gap is nodeless, it has point nodes, or it has line nodes. Here, we show that, for an even-parity nodal superconducting state which spontaneously breaks time-reversal symmetry, the low-energy excitation spectrum generally does not belong to any of these categories; instead, it has extended Bogoliubov Fermi surfaces. These Fermi surfaces are topologically protected from being gapped by a non-trivial Z2 invariant. In this talk, I will discuss the physical origin, topological protection, and energetic stability of these Bogoliubov Fermi surfaces, using superconductivity in j=3/2 fermions as a representative example.

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Laser ARPES on Non-Fermi-Liquid Behaviors and Superconducting Gap Symmetry of Iron-Based Superconductors

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We have studied electronic structure of iron-based superconductors by high resolution laser-based angle-resolved photoemission spectroscopy (ARPES) [1]. In this talk, I will introduce two of our recent work. (1). Emergence of superconductivity from fully incoherent normal state in optimally-doped (Ba0.6K0.4)Fe2As2 superconductor (Tc~38 K)[2]. We find that, while sharp superconducting coherence peaks emerge in the superconducting state on the holelike Fermi surface sheets, no quasiparticle peak is present in the normal state. Its electronic behaviors deviate strongly from a Fermi liquid system. The superconducting gap of such a system exhibits an unusual temperature dependence that it is nearly a constant in the superconducting state and abruptly closes at Tc. These observations provide a new platform to study unconventional superconductivity in a non-Fermi liquid system. (2). Orbital origin of robust nodal superconducting gap in the nematic state of bulk FeSe superconductor (Tc~9K) [3]. We reveal highly anisotropic Fermi surface and extremely anisotropic superconducting gap in the nematic state of the FeSe superconductor that are robust against twin boundaries and disorder [4]. We find that the low-energy excitations of the entire hole pocket at the Brillouin zone center are dominated by the single dxz orbital. The superconducting gap exhibits an anticorrelation relation with the dxz spectral weight near the Fermi level. These observations provide new insights in understanding the interplay between orbital, nematicity and superconductivity in the iron-based superconductors.

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Long-range focused quasiparticle scattering through the Fermi surface on a quasi-2D superconductor

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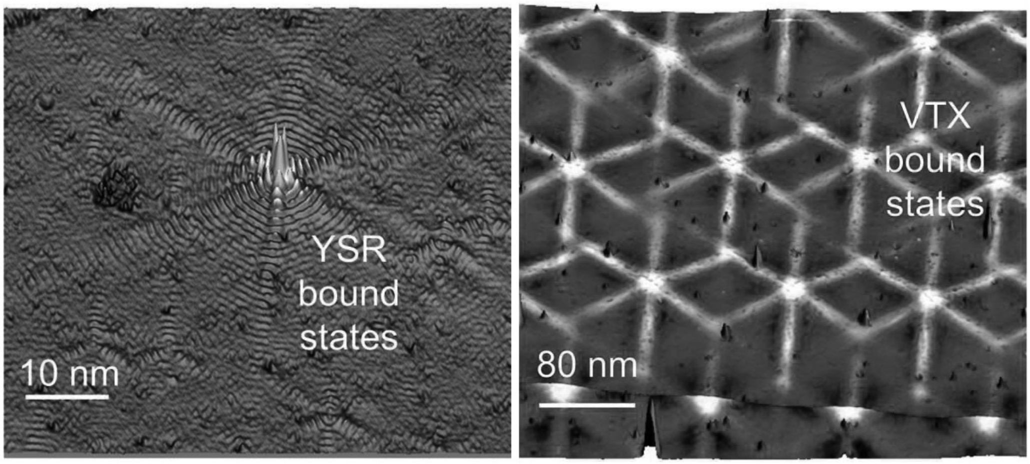
University of Hamburg, Germany

Quasiparticle excitations in superconductors have attracted much attention not only for conventional s-wave superconductors but also for the exotic unconventional superconductors which are promising platforms to host Majorana bound states. In general, quasiparticle excitations in a superconductor can be generated by creating vortices in an external magnetic field as well as by introducing magnetic impurities to the superconductor. The quasiparticles form quantum-mechanical bound states, such as vortex bound states (VBS) inside the vortex cores or so-called Yu-Shiba-Rusinov (YSR) bound states at the magnetic impurities. Recently, a long-range extension of YSR bound states on two-dimensional (2D) superconducting NbSe2 has been reported using scanning tunneling microscopy and spectroscopy (STM/S). However, the mechanism of the long-range extension of YSR states and its correlation with VBS are not clear.

Here, we report long-range extensions of both VBS and YSR states on quasi-2D superconducting La(0001) thin films grown on a Re(0001) surface using STM/S. We found that the La(0001) surface exhibits a quasi-2D electronic structure originating from localized surface states (Tamm-type) and a clean superconductor, which means the electronic mean free path is longer than the superconducting coherence length. Additionally, we observed both VBS and YSR states extending over an extremely long range with strong anisotropic nature at different length scales. We consider both the dimensionality and association with the Fermi surface topology for the observed long-range and directional extensions of the quasiparticle states. Our study provides a direct correlation of the quasiparticle bound states and their scattering nature with the dimensionality of the system and the Fermi surface. This will shed light on the fundamental understanding of quasiparticle bound states in low-dimensional superconducting systems.



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Studies of Physical Properties of SrRu1-xTixO3 (x ≤ 0.7) Series

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We have studied the effect of site dilution with nonmagnetic Ti4+(3d0) substitution in SrRu1-xTixO3 (x < 0.7). The nature of ferromagnetic state in SrRuO3 is believed to be of itinerant type with transition temperature (Tc) ~ 162 K. Crystallographically, SrRuO3 has distorted orthorhombic structure. Substitution of Ti+4 (0.605 Å) for Ru+4 (0.62 Å) does not introduce significant structural modification due to their matching ionic radii. This substitution, on the other hand, is expected to tune the electronic correlation effect (U) and the d electron density in the system. With Ti substitution, we find that magnetic moment and Curie temperature decreases but Tc remains unchanged which has been attributed to opposite tuning of U and density of states within the framework of itinerant ferromagnetism. The estimated critical exponent (β) related to magnetization implies a mean field type of magnetic nature in SrRuO3. The value of β further increases with x which is understood from the dilution effect of magnetic lattice. The system evolves to exhibit Griffiths phase like behavior above Tc which is usually realized in diluted ferromagnet following local moment model of magnetism. Our detail analysis of magnetization data indicates that magnetic state in SrRuO3 has contribution from both itinerant and local moment model of magnetism. Further, to understand magnetic state in SrRu1-xTixO3 series have studied the critical behavior using standard techniques such as modified Arrott plot, Kouvel-Fisher plot and critical isotherm analysis across the magnetic transition temperature Tc. The estimated exponents do not match with any established theoretical models for universality classes, however, the exponent obey the Widom relation and the scaling behavior and this behavior matches with isoelectronic doped Sr1-xCaxRuO3 exponents which consider as formation magnetic clusters. The transport behaviors have studied in terms of electrical resistivity (0T and 8T) and specific heat of SrRu1-xTixO3 series (x ≤ 0.7). The ρ(T) of SrRuO3 shows metallic however it shows MIT by Ti substitution. The specific heat (Cp) study also shows strong correlation effect at low temperature
and broadening of Tc around phase transition by Ti substitution.

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Microscopic Observation of Entangled Multi-Magnetoelectric Coupling Phenomenon

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Ferroelectricity emerges when the broken inversion symmetry of crystal structure leads to spontaneous alignment of electric dipoles. Bipolar electric states in conventional ferroelectrics involve the ionic displacement that is controlled by external electric field. Spin-cycloid multiferroics with ferroelectricity driven non-collinear magnetic order opens a new avenue for utilizing giant magnetoelectric (ME) coupling to control the electric states by external magnetic field.

Two theoretical frameworks of inverse Dzyaloshinskii-Moriya (IDM) interaction and spin-current model that are accompanied with and without ionic displacement, respectively, have provided the phenomenological understanding. However, the microscopic origin for this "improper" ferroelectricity remains elusive due to the difficulty in unambiguous probing the femtometer-scale phenomenon. In this work, we present evidence for the IDM interaction that leads to the ionic displacement in a room-temperature spin-cycloid multiferroic $Ba_{0.5}Sr_{2.5}Co_2Fe_{24}O_{41}$.

Entanglement of multiple ME effect mechanisms of the IDM interaction and p-d hybridization is identified in-situ xray diffraction, allowing for detection of such subtle lattice distortion. The capability of cooperative tuning between two ME effect mechanisms may offer a novel functional control for ME devices.

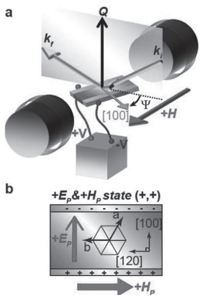

Fig. 1 (a) The x-ray diffraction geometry using vertical scattering plane defined by the incident (k_i) and out-going (k_f) wave vectors. *H* is applied normal to the scattering plane. Ψ is the angle between [100] and the scattering plane. (b) Preparation of a single (+,+) ME state by applying the poling *E* and *H* at Ψ = 0˚.

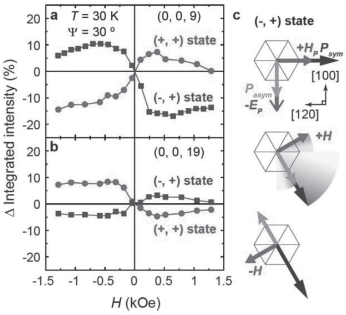

Fig. 2 (a,b) The (0, 0, 9) and (0, 0, 19) intensities at Ψ = 30˚ and their antisymmetric behaviors between (+,+) and (+,-) ME states. (c) The initial configuration of P_{sym} (electric polarization related symmetric change of the intensity) and P_{asym} (electric polarization related antisymmetric change of the intensity) for the (-,+) state prepared at Ψ = 0˚ (top). The parallel and antiparallel rearrangements of the polarizations realized at Ψ = 30˚ for +*H* (middle) and -*H* (bottom). These arrangements are opposite to the (+,+) state as depicted in Fig. 2(i).

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Zn^{2+} doping tunable multiferroicity in S = 1/2 kagome staircase $PbCu_3TeO_7$

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$PbCu_3TeO_7$ with Cu^{2+} in a spin half state is an insulating anisotropic frustrated magnet system. The Cu^{2+} (quantum spin, S = ½) ions are arranged in a buckled kagome-staircase geometry like that of $Ni_3V_2O_8$ with significant intra and inter-kagome plane couplings [1]. The Cu^{2+} with quantum spin state of S= ½ spins occupies two inequivalent crystallographic sites so called cross-tie with tetrahedra and spine with octahedra environment. It exhibits two magnetically orders states with antiferromagnetic transitions at TN1 = 35 K and TN2 = 24 K. Below TN2, it displays magnetic field induced an inversion symmetry-breaking spin-flop transition coupled with ferroelectricity (multiferroicity) above field (Hs) ~ 8.3 T [2]. Thus $PbCu_3TeO_7$ provides a good platform for tuning multiferroic and magnetic phases by chemical substitution or pressure. In order to tune competing magnetic phases and stabilize the multiferroic phase at zero fields, we have doped non-magnetic Zn^{2+} ion at Cu^{2+} site in $Pb(Cu_{1-x}Zn_x)_3TeO_7$ ($0.0 \le x \le 0.2$) polycrystals. T_{N1} and T_{N2} suppressed rapidly with increase in Zn doping [3]. Simultaneously, the spin-flop transition field Hs also reduces from ~ 8.3 T for x = 0 to ~ 1 T for x = 0.2, and multiferroicity is induced at zero magnetic fields with a significant reduction in 9T electric polarization [3]. Monte Carlo simulation indicates that the substantial reduction in magnetic transtion temperatures with the increase of substitution is due to the non-magnetic nature of Zn^{2+} and its cross-tie site preferences [3]. Based on magnetization, dielectric, electric polarization and MC simulations results we have developed a magneto-electric phase diagram of $Pb(Cu_{1-x}Zn_x)_3TeO_7$ as a function of Zn substitution and temperature. The possible origin of tuning of multiferroicity in PbCu3TeO7 viz nonmagnetic Zn^{2+} doping will be discussed.

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[2] K. Yoo, et al., npj Quantum Materials 3, 45 (2018).
[3] Aga Shahee et al., to be submitted.

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S-0481 15:45-16:00, August 23 | Room 513

Study of electromagnon on terahertz absorption for aluminum doped Zn_2Y hexaferrite

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We have investigated the electromagnon which elementary excitation of magnon activated by electric dipole using the terahertz time domain spectroscopy (THz-TDS) in $Ba_{0.5}Sr_{1.5}Zn_2(Fe_{1-x}Al_x)_{12}O_{22}$ hexaferrites. When crystal axis [001] only was paralled with THz electric field, the electomagon was observed in all Zn_2Y hexaferrites which agree with selection rule on electromagnon studies in hexaferrites. The THz absorptions become broader and stronger as Al doped which correspond with conical magnetic structures and especially at x=0.08 electromagnon survived up to 200 K. These electromagnon properties can be explained by the microscopic exchange striction mechanism and also the macroscopic L, S block Hamiltonian exchange striction mechanism.

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S-0432 16:00-16:15, August 23 | Room 513

Optimized magnetoelectric coupling by stabilization of the transverse conical state in chemically tuned Co_2Y-type hexaferrites

Kee Hoon Kim*, Chang Bae Park

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We present on the magnetoelectricity in Co_2Y-type hexaferrite $Ba_{2-x}Sr_xCo_2(Fe_{1-y}Al_y)_{12}O_{22}$ ($1.0 \leq x \leq 1.9$, $0.00 \leq y \leq 0.08$) single crystal. We found that, among the grown crystals, the specimen with the nominal composition of x = 1.8 and y = 0.04 exhibits the largest magnetic field induced polarization ~ 60 $\mu C/m^2$ at room temperature. As cooled down to 10K, the polarization of this compound reaches ~ 430 $\mu C/m^2$. Furthermore, we present comprehensive study of the ferroelectric phase boundary in these compounds with various x and y values. In addition, we have investigated the metastable properties of each ground state in the Co_2Y hexaferrites. Not only transverse conical (TC) spin structure but also alternating longitudinal conical (ALC) spin structure has appeared and competed in the all specimens, of which volume fraction are sensitive to the field and temperature histories. Maximum ME coupling in the sample with x = 1.8 and y = 0.04 can be thus explained by an optimized volume ratio of ALC to TC. We also discuss the outcome and sensitivity of such interplay of complex metastable spin phases.

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Interfacial magnetoelectric effect in FePt/$BaTiO_3$ multilayers

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Recently multiferroics have attracted great attention, where interplay between ferromagnetic (FM) and ferroelectric (FE) degree of freedom, the magnetoelectric (ME) coupling is essential. Heterostructure comprised of FM as well as FE is an archetype, which paves path for highly scalable, ultra-low power, and non-volatile memories. Here, we investigate the interfacial ME coupling coefficient (αI) at the FM/FE FePt/BaTiO3 interface in the framework of density functional theory. Magnetic moment of Fe at the interface changes upon reversal of polarization (P) of BaTiO3. We predict huge value of αI = 4.37x10-9 ⟦G·cm⟧^2/V. We also demonstrate spin reorientation, out-ofplane to in-plane transition upon polarization switching under tensile strain (η). The underlying mechanism is the appreciable reduction in major positive contribution of magnetocrystalline anisotropy in Fe, more specifically

<xy, ↓|L_z| x^2-y^2, ↓ > and <xz, ↓ | L_z| yz, ↓ > matrix at X point for P>0 at η=1.75%. The calculated huge ME response provides a viable route towards low-power spintronic devices.

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Neutron Diffraction Study of the Low-dimensional Frustrated A_2MnTeO_6 (A = Li, Na, Ag, Tl) Magnetics

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[3]*Paul Scherrer Institute, Switzerland*

A new A_2MnTeO_6 family was investigated. These compounds are analogues of the well-known A_xMTeO_6 (M = Sn, Ge) [1], but differ from them by the presence of a magnetic ion. More generally, AxMnTeO6 are compounds with layered structures based on various stacking arrangements of MTeO2/6 layers and can crystallize in with fairly close, but different crystallographic symmetries, namely P-31c, P6322, P-31m, P31c, P312, R-3 et al. [1]. Experiments carried out at room temperature on the HRPT neutron powder diffractometer at the SINQ spallation source, in the PSI Switzerland, revealed that all manganese-based A_2MnTeO_6 (A =Li, Na, Ag, Tl) samples crystallize in the P-31c sp.gr. with triangular arrangement of magnetic ions within the layer. The interlayer spacing (c/2) changes significantly from 4.77 to 7.33 Å for Li and Tl compounds, whereas the period in the layer, that is, the Mn-Mn distance varies by less than 2%. The large difference in the unit cell parameter perpendicular to the magnetic layers naturally affects the magnitude of the interlayer exchange interactions. Moreover, triangular arrangement within a layer must inevitably leads to the frustration of magnetic interactions, their complicated character and, all together determines complex magnetic structure. Everything stated above was confirmed by further neutron diffraction measurements at helium temperature. In weak magnetic field ~ 0.1 T, the temperature dependence of the magnetic susceptibility shows no signs of ordering in the temperature range from 2 K to 300 K, and with an increase in the magnetic field, maximum appears, which can be interpreted as a sign of antiferromagnetic ordering. Data on specific heat confirm antiferromagnetic type of the ordering. The temperature dependences of the magnetic susceptibility in the paramagnetic phase are satisfactorily described within the framework of the modified Curie-Weiss law. The parameters of the magnetic subsystem indicate the dominance of antiferromagnetic interactions ($\Theta < 0$) and significant frustration on the triangular lattice. The effective magnetic moment is in satisfactory agreement with theoretical estimates. In addition, at temperatures below ~ 100 K, a noticeable deviation of the $\chi(T)$ dependences from the Curie-Weiss law is observed for all samples, which is indicative of the scale of short-range exchange interactions and the nontrivial ground state of the investigated objects.
Neutron diffraction measurements on HRPT at a low temperature T = 1.5 K unambiguously indicated antiferromagnetic ordered states various types. Fig.1 graphically demonstrates a significant difference in the magnetic ordering of two studied compositions. If the compounds with the minimum sizes of the ionic radii of the Acation (Li and Na) exhibit the normal long-range ordering of the antiferromagnetic nature, then in the Ag sample we observe a mixture of long-range and short range order simultaneously. For the Tl_2MnTeO_6 composition with the largest ionic radius, only the short-range order is formed at temperatures up to 1.5 K. A model the spiral magnetic ordering of Li_2MnTeO_6 at 1.5 K with the propagation vector k=(1/3;1/3;0) was constructed. Since only two compositions with the smallest ion-radius sizes, Li_2MnTeO_6 and NA_2MnTeO_6 according to the experiments carried out on the high resolution HRPT diffractometer at T = 1.5 K showed long-range magnetic ordering only these compositions were investigated at high intensity DMC diffractometer (λ = 2.47 Å) at several temperatures below and slightly above TN ~ 6 K for both compositions. The appearance of additional magnetic peaks at small diffraction angles unambiguously indicated the AFM long-range nature of the magnetic ordering. It was not obvious from the data of measurements of the temperature dependences of the magnetic susceptibility at all. The main result of the work can be considered that nontrivial effect is discovered: a covert magnetic order in the A_2MnTeO_6 family.

The reported study was funded by Russian Science Foundation according to the research project № 18-12-00375.

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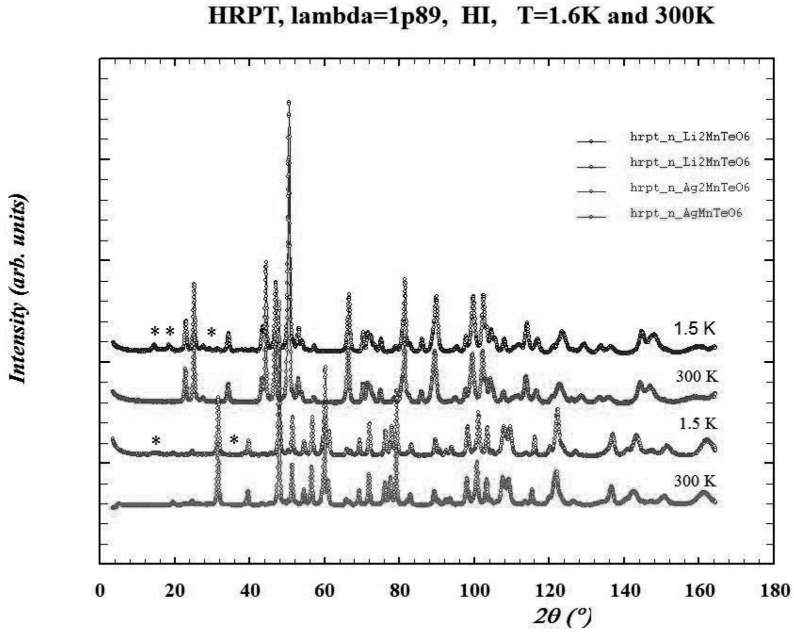

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Competition between magnetic sub-lattices in NiCoFe-Layered Ternary Hydroxides depending on their molar ratio

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In this work, three NiCoFe Layered Ternary Hydroxides materials with different Co:Ni ratios, maintaining the same divalent and trivalent ratio were synthesized. As the system shows a mixture of a ternary Ni-Co-Fe ions randomly coordinated by six hydroxyl groups, a change in the magnetic and catalytic behaviors at different temperatures intervals is observed, depending of the formers ratio. The interlayer distance is very similar for all samples, then, the magnetic contribution by dipolar interactions is considered small. Hence, the differences in the magnetic behavior can be correlated with the chemical compositions and with the cation arrangement on the layer.

Using X-Ray Magnetic Circular Dichroism (XMCD) at three different temperatures, we obtained the valence states of the divalent and trivalent metal ions, their spins alignment, orbital and spin contributions at room and lower temperatures; because a Low (LS) to High spin (HS) transition is suggested by the ZFC FC measurements, with a thermal hysteresis from 6-76K and 10-350K. The spin cross over from low to high spin process can be attributed to divalent Co^{+2} ion and Fe^{+3} ion since both can present this transitions separately or simultaneously.

The $Ni_{0.33}Co_{0.32}Fe_{0.34}$ sample displayed a single magnetic sub-lattice, whereas the $Ni_{0.47}Co_{0.20}Fe_{0.32}$ and $Ni_{0.27}Co_{0.39}Fe_{0.33}$ samples shown one and two compensation temperatures, suggesting the presence of two and three different magnetic sub-lattices respectively (see figure 1a); this behavior may be caused to the random cations distribution and to spin frustration exhibited in $FenM_{7-n}$ (n≤ 2) site, this competing magnetic interactions on the brucite layers give rise to spin-glass behavior. The random distribution of spins in the network cause magnetic disorder and promotes competing disorder. The divergence of the non-linear susceptibility in the out of phase component can confirm a glassy phase transition for $Ni_{0.47}Co_{0.20}Fe_{0.32}$ sample (see figure 1b).

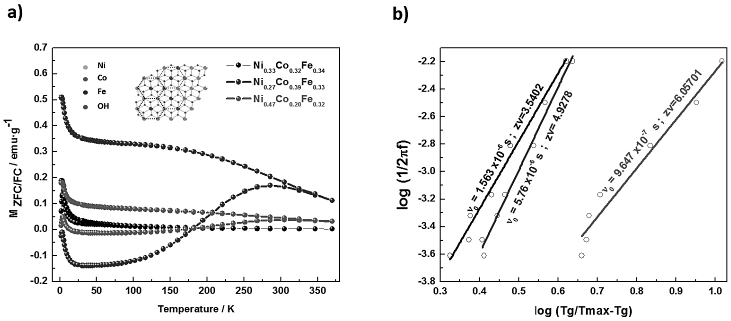

Figure 1. a) ZFC/FC magnetization curves for the three samples, the inset shows how random the coordination can be. b) The fitting of the frequency dependence of the out of phase susceptibility (X''_M) using the 3D critical scaling law for spin dynamic. The values obtained for sample $Ni_{0.47}Co_{0.20}Fe_{0.32}$ falls in the range for canonical spin glasses (from 10^{-7} to 10^{-12} and 4 to 12 for υ_0 and *zv*, respectively).

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Magnetostructural phase transition in Ni-Mn-Z (Z-Ga, In, Sn) Heusler alloys under the influence of high magnetic fields in the isothermal and adiabatic conditions

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At present there is interest to materials with strong interaction between the crystal lattice and magnetic degrees of freedom [1], which leads to a thermodynamic magnetic phase transition of the first order (PT). Such phase transitions which have strong bond between the atoms of the crystal lattice and the magnetic spin system, lead to a simultaneous change in the magnetic and structural properties, and are called magnetostructural PT (MPT) [1]. MPT can be induiced by temperature, magnetic fields or pressure. In MPT, the coupling of magnetic and structural transitions leads to the appearance of various effects, such as giant magnetocaloric effect (MCE), magnetoresistance and other.

MCE is an adiabatic temperature change or isothermal heat emission/sorbtion in a magnetic materials when exposed to an external magnetic field [2,3]. MCE in magnetic compounds opens up the possibility of creating magnetic refrigerators [4]. MCE is maximum near magnetic and magnetostructural PTs. There are a number of problems in the MCE study. 1) The prevailing most of authors at studying MCE use the indirect method for determining the MCE (error reaches 30%) or direct method in small magnetic fields, which are not enough to complete the first-order PT [3]. 2) The parameter relative cooling power RCP is used mainly. However, this parameter does not reflect the real efficiency of the material in the process of magnetic cooling. 3) In alloys with MPT, the contributions from the structural and magnetic subsystems to the MCE are decisive [5]. However, a detailed study of the structure directly in the process of a magnetoinduced MPT remains a challenge. Solving of this problem will allow us to understand the nature of the interaction of the subsystems of a solid body and their contributions to the MCE.

The authors created unique devices to solve the presented problems in the study of MPT and MCE. There are extraction magnetic calorimeter for direct measurement of MCE in Bitter coil magnet at adiabatic and quasiisotremal conditions [6,7]; optical microscope for in-situ observation of manetoinduced structure change at adiabatic, isotremal conditions in wide temperature range in magnetic materials [8].

As suggested, the best candidates as the working body of magnetic refrigerators will be materials with MPT at room temperature. Such materials include the Ni-Mn-Z (Z = Ga, In, Sn) Heusler alloys [6]. Therefore, unique techniques and studies MPT and MCE in Heusler alloys in high magnetic fields [6,7,8]. will be presented in work

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Giant Magnetic Anisotropy Induced by Ligand LS Coupling in Layered Cr Compounds

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We propose a novel origin of magnetic anisotropy to explain the unusual magnetic behaviors of layered ferromagnetic Cr compounds ($3d^3$) wherein the anisotropy field varies from ~ 0.01 to 3 T on changing the ligand atom in a common hexagonal structure. The effect of the ligand p orbital spin-orbit (LS) coupling on the magnetic anisotropy is explored by using four site full multiplet cluster model calculations for energies involving the superexchange interaction at different spin axes. Our calculation shows that the anisotropy energy, which is the energy difference for different spin axes, is strongly affected not only by the LS coupling strength but also by the degree of p - d covalency in the layered geometry. This anisotropy energy involving the superexchange appears to dominate the magnetic anisotropy and even explains the giant magnetic anisotropy as large as 3 T observed in CrI_3.

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Interactions in the Bond-frustrated Helimagnet $ZnCr_2Se_4$ Investigated by NMR

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Incommensurate helical spin order observed in ZnCr2Se4 due to bond frustration has attracted attention in the past decades. Magnetostriction, negative thermal expansion, and simultaneous magnetic and structural phase transitions occurring at 21 K [1-3] indicate the strong spin-lattice coupling. A noble feature of this material is that the half-filled spherical t_{2g} orbital of Cr^{3+} ions at octahedral centers is Jahn-Teller inactive from the pure ionic point of view. The orbital angular momentum is quenched and therefore magnetostricition is not originated from the spin-orbit interaction. Instead of these conventional mechanisms, the spin driven Jahn-Teller effect during which magnetic frustration is released through distortion has been considered as the origin of the spin-lattice coupling. Information on the spin and orbital states is crucial to understanding the bond frustration and the spin-lattice coupling in this material. In this work, we report estimation of the coupling constants between Cr ion spins and the spin spreading from a Cr ion to neighboring Se ions observed by NMR. We estimated the coupling constants by comparing temperature dependence of the resonance frequency with theoretical prediction of sublattice magnetization, $M(T) \sim T^2$, calculated by the linear spin wave theory for incommensurate spiral spin order. The comparison shows that ferromagnetic J_1 coupling competes with antiferromagnetic J_3 coupling resulting in the bond frustration. The isotropic and anisotropic hyperfine fields of a Cr ion provide the evidences that the electronic configuration is different from d^3 and the magnetic moment is reduced below 3 μ_B. The hyperfine field of a Se ion strongly implies that the spin polarization of a Cr ion is significantly transferred to a Se ion due to the strong covalent bond between them. These observations indicate that the Jahn-Teller effect is not completely missing in $ZnCr_2Se_4$.

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$La_{0.7}Sr_{0.3}Mn_{1-x}B_xO_3$ (B=Mo, Ti) nanoparticles for self-controlled hyperthermia

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In this work, we report the study of the magnetic and biomedical characterization of magnetic $La_{0.7}Sr_{0.3}Mn_{1-x}B_xO_3$ (B=Mo, Ti) nanoparticles for hyperthermia applications. Our nanoparticules were prepared through an aqueous combustion process (Glycine Nitrate Process, GNP), and are characterized with a mean crystallite size about 18 nm.

The incorporation of Ti^{4+} and Mo^{6+} in Mn-site induced a structural transition from rhombohedral structure with R-3 C space group for $La_{0.7}Sr_{0.3}MnO_3$ compound to orthorhombic one with Pnma space group for $_{0.7}Sr_{0.3}Mn_{0.95}Mo_{0.05}O_3$ and $La_{0.7}Sr_{0.3}Mn_{0.95}Ti_{0.05}O_3$ compounds. The mean grain size is distributed in the range of 82–90 nm. All samples exhibit a classical behavior from ferromagnetic (FM) to paramagnetic (PM) transition as the temperature increases. A decrease in Curie temperature (TC) has been observed from 84 °C to 54°C and 82°C for $La_{0.7}Sr_{0.3}MnO_3$, $La_{0.7}Sr_{0.3}Mn_{0.95}Ti_{0.05}O_3$ and $La_{0.7}Sr_{0.3}Mn_{0.95}Mo_{0.05}O_3$ respectively. According to the Arrott plots, the slopes of the curves of all the samples are positive, signature of second order transition.

The magnetic heating characteristics in AC field were measured in alternating magnetic fields of 23.89 mT at a fixed frequency of 518.7 kHz. The intrinsic loss power (ILP) has been calculated from SAR values. The different nanoparticles present enough high ILP values and may be useful for hyperthermia treatment of cancer cells.

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Magnetocaloric effect in manganites in alternating magnetic fields

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Magnetic refrigeration machines have a number of significant advantages over conventional cooling systems. But here are many problems with creation of such. Materials with giant values of the magnetocaloric effect (MCE) are needed for the production of magnetic refrigerators and recent studies were focused on the search for new promising materials. The most of currently existing prototypes of refrigerators operate at cycle frequencies up to 4 Hz. One of the ways to improve the efficiency of cooling machines is increasing their working cycles' frequencies. But the materials for magnetic cooling technology cannot be considered as suitable, until they are tested for their magnetocaloric properties in alternating (cyclic) magnetic fields. It is due to the fact that magnetocaloric properties of materials can significantly differ at single or continues cyclic magnetic field application. There are several reasons for this.

Due to the various relaxation processes, the increase of the frequency of AC field can lead to a decrease of the MCE value. Effect on the MCE value in this case depends on the frequency of the field change. Measuring value of the MCE will also depend on the field frequency due to the reduction of the ability of the working material to exchange energy with heat exchanger when the frequency of cycle increases. There are also mechanisms that can affect on the MCE value, even at low frequencies the field changes. Hysteresis effects, the accumulation of structural defects, incompletion of phase transitions at field application are some of them. These mechanisms cannot be manifested at single cycle of the field application, but can significantly affect on the MCE value at continues cycles. These mechanisms can also depend on the field frequency and the rate of the field change. So we see a growing interest in the MCE study in cyclic magnetic fields in recent years, but current studies are limited by a few cycles of field application and the frequencies of the used magnetic fields - by several hertz.

In this papre direct measurements of the magnetocaloric effect in La0.7Ca0.3MnO3, La1-xAgyMnO3, and Sm1-xSrxMnO3 manganites in alternating magnetic fields at frequencies up to 20 Hz and an amplitude of 6.2 kOe are carried out. In all studied manganites a decrease of the MCE with the field frequency reaching 20%, 55% and 70% in La0.7Ca0.3MnO3, Sm1-xSrxMnO3 and La1-xAgyMnO3 are discovered. The value of cooling power increases for all compounds and the highest value reached in La0.7Ca0.3MnO3 manganite – that is the most promising for use in the magnetic refrigeration technology among the studied materials. The data are compared with those for Gd in the same conditions.

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A new quasi-one-dimensional spin chain compound $NiTe_2O_5$ and its critical behavior

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The critical exponent, power of critical behavior near phase transition and critical point, depends on global properties such as the space dimensionality, the symmetry of the order parameter, and the range of interaction, rather than microscopic details. For example, there have been plenty of investigation about the critical phenomena associated with space and spin dimensions of the quantum magnet. Here we introduce a new quasi-one-dimensional spin chain compound $NiTe_2O_5$. Performing a comprehensive study of the structure and magnetic properties, we found that $NiTe_2O_5$ undergoes intriguing long-range antiferromagnetic order at T_N = 30.5 K. Below the Neel temperature, longitudinal component of Ni^{2+} spin-1 along the chain are ferromagnetically ordered but transverse component has alternating ferromagnetic-antiferromagnetic coupling. In addition, temperature evolution of the antiferromagnetic order parameter accompanies an unconventional critical behavior. In this talk, we present and discuss the physical properties and the nature of the phase transition of $NiTe_2O_5$.

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Super-paramagnetism in nano-sized Ni2+ substituted R-type hexagonal ferrites

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In order to understand the effect of divalent Ni2+ structural and magnetic properties of hexagonal ferrites, a series of Sr1-xNixMn2Fe4O11 (x = 0, 0.1, 0.2, 0.3) of R-type hexagonal ferrites were synthesized by Sol-gel auto combustion method. The structural, particle size, absorption band and magnetic properties were calculated through XRD, TEM, FTIR and VSM. X-ray diffraction assured that all the synthesized materials depicted a single phase characteristics. The lattice parameter varied as concentrations increased. The ranges of crystalline size, measured by Scherer formula, was in the range of 11-15nm. The particle size from TEM and HR-TEM was found to vary in the range of 10-15 nm.

These nanoparticles are spherical in shape and exhibit single domain. The particle size is an excellent agreement with the crystalline size. FTIR spectrum also confirms its single phase character. VSM results reveal its superparamagnetic nature. It does not have appreciable magnetic hysteresis loop due to zero Coercivity and negligible values of Mr indicates that it is superparamagnetic. The reason behind the reduction in magnetic saturation is due to spin canting effect and magnetic dilution.

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Ferrimagnetic spin-orbitronics

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Antiferromagnetic spintronics is an emerging research field which aims to utilize antiferromagnets as core elements in spintronic devices. Antiferromagnets are expected to show much faster spin dynamics than ferromagnets because they have higher resonance frequencies than ferromagnets. However, experimental investigations of antiferromagnetic spin dynamics have remained unexplored mainly because of the immunity of antiferromagnets to magnetic fields.

We show that fast field-driven antiferromagnetic spin dynamics is realized in ferrimagnets at the angular momentum compensation temperature TA. Using rare-earth–3d-transition metal ferrimagnetic compounds where net angular moment is nonzero at TA, the field-driven DW mobility remarkably enhances up to 20 km s−1T−1. The collective coordinate approach generalized for ferrimagnets and atomistic spin model simulations show that this remarkable enhancement is a consequence of antiferromagnetic spin dynamics at TA. Correlation between TA, the magnetization compensation temperature, and the Curie temperature has been investigated [2]. Vanishing the skyrmion Hall effect at TA has been also demonstrated [3]. Our finding allows us to investigate the physics of antiferromagnetic spin dynamics and highlights the importance of tuning of the angular momentum compensation point of ferrimagnets.

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Drastic Emergence of Huge Negative Spin-Transfer Torque in Atomically Thin Co Layers

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Current-induced domain wall motion has drawn great attention in the last decades as the key operational principle of emerging magnetic memory devices. As the major driving force of the motion, the spin-orbit torque on chiral domain walls has been proposed and extensively studied nowadays. However, we demonstrate here that there exists another driving force, which is larger than the spin-orbit torque in atomically thin Co films. Moreover, the direction of the present force is found to be opposite to the prediction of the standard spin-transfer torque, resulting in the domain wall motion along the current direction. The symmetry of the force and its peculiar dependence on the domain wall structure suggest that the present force is, most likely, attributed to considerable enhancement of a negative nonadiabatic spin-transfer torque in ultra-narrow domain walls. Careful measurements on the giant magnetoresistance manifest a negative spin polarization in the atomically thin Co films, which might be responsible for the negative spin-transfer torque.

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Surface morphology and magnetic properties of GdCo films with perpendicular magnetic anisotropy on anodic alumina template

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Magnetic films and multilayers with strong perpendicular anisotropy (PMA) are promising candidates for applications in magnetic recording and spin logic systems [1,2]. Recording media based on PMA films should often have strong separation between bits or ordered pinning sites, which prevent the domain wall propagation and increase coercivity. Patterning of magnetic films can be done at nanoscale by several ways including ultraviolet lithography, electron beam lithography, and self-assembly methods, such as using polystyrene spheres and anodic alumina templates. Although the last method attracted significant attention due to simplicity, reproducibility, and low cost, there are few reports directly addressing the problem of local geometry and its role in the formation of micromagnetic structure, macroscopic hysteresis properties, and the resulting magnetic anisotropy. In this work we investigated antidot lattices obtained by depositing a PMA film on top of mechanically polished anodic alumina membrane synthesized by standard two-step anodization process [3]. As a host material we chose amorphous GdCo films due to the strong PMA and the absent of complications introduced by the technology, such as multilayer deposition and annealing of Co/Pt and Co/Pd multilayers, or by a large single-ion anisotropy of rare earth elements (e.g. Tb or Dy).

Antidot patterned and referent Ta(5nm)/Gd20Co80(t)/Ta(5nm) films (t = 10, 20, and 30 nm) were synthesized by magnetron co-sputtering of Co and Gd targets on anodic alumina or glass substrates. The distance between centers of the pores was fixed at 105, the diameters were set at 35 nm and 75 nm. Hysteresis properties were studied at room temperature using magnetooptical Kerr effect (MOKE) microscopy and vibrating sample magnetometery (VSM). The distribution of magnetic material over the surface and inside the pores was analyzed by scanning electron microscopy (SEM).

Typical out-of-plane hysteresis loops measured on the continuous and the antidot films are shown in Fig. 1 (a).

MOKE and VSM loops measured for the continuous film have almost identical rectangular shape, whereas loops measured for antidot film differ significantly. The low-field slope and the reduced remanence of the VSM loop can be explained by the significant magnetization rotation, which takes place along with a relatively steep magnetization reversal by magnetic wall movement (observed directly using MOKE microscopy). Considering SEM images and almost rectangular shape of the MOKE loop of the antidot samples, we used a model presented in Fig. 1 (b), which includes the magnetic material inside the pores with tilted anisotropy (local anisotropy axes shown by arrows).

Magnetization reversal was simulated using micromagnetic modelling and allowed us to reproduce qualitatively the features of experimental hysteresis loop. To better understand the mechanisms effecting the magnetization reversal in antidot films, in our simulation we also considered the influence of antidot parameters, near-pore geometrical features, and magnetic anisotropy configurations.

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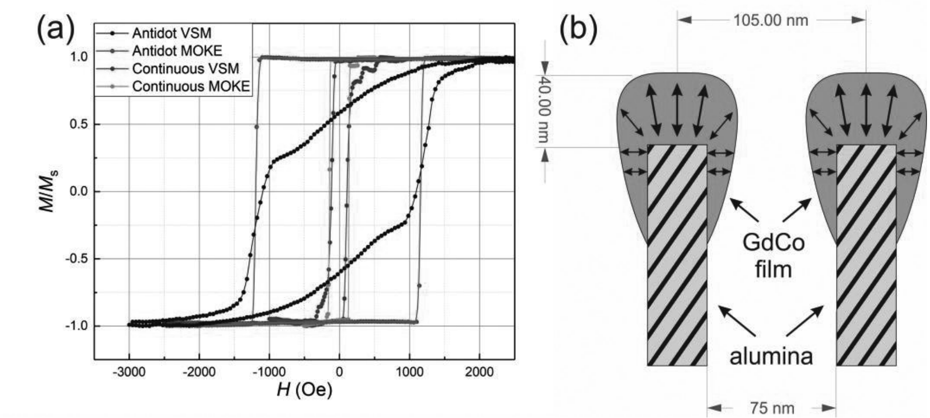

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Programmable Magnetic Anisotropy in Ferromagnetic Semiconductor Films with Graded Composition

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Developing strategies for manipulating magnetic properties of ferromagnetic semiconductors such as Ga1-xMnxAs is of interest both because of the basic science involved and of its potential for spintronic applications. In this presentation we explore the effects of compositional grading of such alloys on their ferromagnetic properties. For this purpose we chose the quaternary alloy Ga1-xMnxAs1-yPy grown by molecular beam epitaxy on a GaAs substrate, with Mn concentration kept constant at $y \approx 0.06$, while the concentration of P is graded along the growth direction. This is achieved by growing a Ga1-xMnxAs1-yPy multilayer with the P-concentration is increased stepwise from $y \approx 0.0$ to $y \approx 0.28$.

Note that in a uniform Ga1-xMnxAs1-yPy film the presence of P leads to three important consequences. First, it affects the exchange interaction between Mn ions, and thus the Curie temperature of the material. Second, the presence of P automatically affects the strain in the film due to lattice mismatch with the substrate, which in turn affects its magnetic anisotropy. And, finally, in a graded Ga1-xMnxAs1-yPy film, grading the P concentration will result in a gradient of the concentration of holes that mediate the Mn-Mn exchange. Importantly, the existence of interfaces between layers in the graded sample will also lead to removal of inversion symmetry between successive layers along the gradient. One thus expects that the properties arising from graded strain and composition will result in an entirely new magnetic system, with novel ferromagnetic behavior. In fact, in an earlier study of magnetic domains in this system, it has already been found that domain walls in such a graded structure display an entirely new behavior [1], giving rise to speculation that Dzyaloshinskii-Moriya interactions may play a key and novel role in such systems.

Our magneto-transport studies of this graded structure revealed a series of entirely new effects, the most conspicuous being the following: (1) Despite the fact that the specimen consists of distinct layers with different magnetic properties due to differences in the P content, the sample behaves as a single magnetic domain; and (2) applying a strong magnetic field changes the magnetic anisotropy of this system by "imprinting" an internal field onto the system that persists after the initial field is removed, thus permanently changing the magnetic anisotropy of the graded specimen. While the mechanism causing such internal field to form is not presently understood, we speculate that its formation may be related to the removal of inversion asymmetry due to grading, which (along with spin-orbit coupling) leads to pronounced Dzyaloshinskii-Moriya interactions. On a practical end, such ability to permanently manipulate magnetic anisotropy of a ferromagnetic semiconductor holds out the possibility of novel magnetic memory applications.

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Experimental evidences for cubic anisotropy rotations in (Ga,Mn)As

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Historically, comprehensive studies of dilute ferromagnetic semiconductors, e.g., p-type (Cd,Mn)Te and (Ga,Mn)As, paved the way for a quantitative theoretical description of effects associated with spin-orbit interactions in solids, such as crystalline magnetic anisotropy. In particular, the theory was successful in explaining uniaxial magnetic anisotropies associated with biaxial strain and non-random formation of magnetic dimers in epitaxial (Ga,Mn)As layers. However, the situation appears much less settled in the case of the cubic term: the theory [1] predicts switchings of the easy axis between in-plane <100> and <110> directions as a function of the hole concentration, whereas only the <100> orientation has been found experimentally. Here, we report on the experimental observation of such switchings by magnetization and ferromagnetic resonance studies on a series of high-crystalline quality (Ga,Mn)As films [2]. Our findings are described by the mean-field p-d Zener model [1] augmented with three new ingredients [2]. The first one is a scattering broadening of the hole density of states, which reduces significantly the amplitude of the alternating carrier-induced contribution. This opens the way for the two other ingredients, namely the so-far disregarded single-ion magnetic anisotropy and disorder-driven non-uniformities of the carrier density, both favouring the <100> direction of the apparent easy axis. Accordingly, when the disorder gets reduced a switching to the <110> orientation is possible in a certain temperature (as presented in Fig. 1) and hole concentration range.
Fig.1. Temperature dependence of cubic anisotropy constants, KC. Solid points are obtained from analysis of uniaxial hard axis magnetization curves M(H), open ones are obtained from analysis of in-plane angular dependence of FRM resonance positions (their cubic component is shown in the inset). Dashed lines are guides for the eye only. In the notion adopted here the positive/negative sign of KC indicates that the cubic easy axes are aligned along <100> / <110> directions, respectively.
The work has been supported by the National Science Centre (Poland) through MAESTRO UMO -2011/02/A/ST3/00125 grant.

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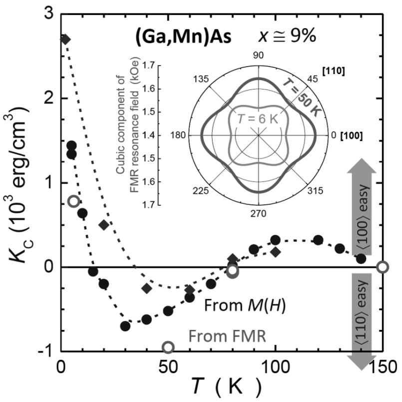

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Common Exchange-Bias Effect Associated with Magnetization Reversal in $RFeO_3$ (R = Nd, Sm, Er) Orthoferrites and in $LuFe_{0.5}Cr_{0.5}O_3$

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The ordinary exchange-bias (EB) effect represents a shift in magnetization hysteresis loop from the origin, emerging due to the exchange interaction at the interface between strongly anisotropic antiferromagnetic (AFM) and soft ferromagnetic (FM) phases. [1] However, the exchange coupled ferrimagnetic-antiferromagnetic (fM-AFM) systems may have essentially the same properties, as it was pointed by Meiklejohn (Ref. [2]) already in 1962. Recently, the Dzyaloshinskii-Moriya (DM) interactions, which play a crucial role in the magnetism of orthoferrites, were found to be essential for the possible mechanisms of EB in fMs. [3]

We showed that the field-induced ferromagnetic moment reversal in known compensated ferrimagnets $RFeO_3$ (R = Nd, Sm, Er) is analogously exchange biased around their compensation temperatures T_{comp}. [4] It appears that, in spite of very different R-Fe interactions, T_{comp} values, and spin-reorientation temperatures, the EB field similarly emerges and diverges upon approaching T_{comp} and changes sign with crossing T_{comp}. In addition, $SmFeO_3$, with a complicated AFM order caused by the nonequivalent spin configuration, shows EB also at temperatures far above T_{comp}, and its sign alters from negative to positive with increasing cooling field.

The exchange-bias effect was also found and investigated in $LuFe_{0.5}Cr_{0.5}O_3$ ferrite-chromite, which is a weak ferrimagnet exhibiting two canted Fe and Cr AFM sublattices with oppositely directed weak FM moments, signified at low temperatures by the magnetic moment reversal and negative magnetization. [5] It was found that the fieldcooled magnetization hysteresis loops show the EB effect, namely both vertical and horizontal shifts from the origin.

The EB is positive below T_{comp} and negative above T_{comp} due to weak ferrimagnetic behavior of $LuFe_{0.5}Cr_{0.5}O_3$ permitting the magnetic moment reversal governed by a specific competition of the DM interactions between Fe^{3+} and Cr^{3+} ions. Specific symmetric shift of the FC loops with respect to the polarity of applied field together with peculiar behavior of the magnetization near 50 kOe demonstrate that actually the maximal FM overturning fields are not reached and magnetization curves most likely reflect a contribution of the field-induced spin-reorientation near $T_s \approx 50$ K.

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Abnormal anti-crossing in photon-magnon coupling

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Understanding and exploiting the interactions of excited modes in hybrid quantum systems are the keys to achieve the ambitious goal of quantum information processing [1-2]. Therefore, collectively excited modes (i.e., magnons) in ferromagnets, being coupled to elementary excitations of electromagnetic waves (photons), have increasingly been studied in a variety of hybrid structures of two or more different systems [3-5]. The interaction (coupling) between the magnon and photon modes usually demonstrated by showing the modes' splitting near their common resonant frequency within the so-called anti-crossing region or the level repulsion, as described well by a classical model for coupled oscillators [4] and also by a two-level quantum model [5].

Here, we report the experimental demonstration of an abnormal, opposite anti-crossing dispersion (or level attraction) in a photon-magnon-coupled system that consists of an Yttrium Iron Garnet film and an inverted pattern of split-ring resonator structure (noted as ISRR) in a planar geometry. It is found that the normal shape of anticrossing dispersion typically observed in photon-magnon coupling is changed to its opposite anti-crossing shape just by changing the position/orientation of the ISRR's split gap with respect to the microstrip line axis along which ac microwave currents are applied. Characteristic features of the opposite anti-crossing dispersion and its linewidth evolution are analyzed with the help of analytical derivations based on electromagnetic interactions. The observed opposite anti-crossing dispersion is ascribed to the compensation of both intrinsic damping and coupling-induced damping in the magnon modes. This compensation is achievable by controlling the relative strength and phase of oscillating magnetic fields generated from the ISRR's split gap and the microstrip feeding line. We provided a phase diagram of the dispersion type in the photon-magnon coupling region according to the strength and phase of microwave magnetic fields acting on the hybrid system. The position/orientation of an ISRR's split gap provides a robust means of controlling the dispersion shape of anti-crossing and its damping in a photon-magnon coupling, thereby offering more opportunity for advanced designs of microwave devices.

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The Study of Microwave Power Effect and Anisotropic Effect in Ba0.34K0.64Fe2As2 (BaK122) Superconducting Single Crystal Using Non-Resonant Microwave Absorption Technique.

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Non resonant microwave absorption technique at liquid helium temperature has been used to study the microwave power effect and anisotropic effect on the hysteresis loops of superconducting BaK122 single crystals measured at 9.4GHz below Tc (32 K). We have found a striking microwave power effect on the hysteresis loops that were measured and a strong anisotropy was found for the two distinct cases where magnetic field applied parallel and perpendicular to the Iron Arsenide plane. We interpret the wide and narrow hysteresis loops as due to the microwave power induced phase locking of several numbers of junctions into coherent groups and then the destruction of the phase locking by the applied DC field leading to the fluxon motion, which gives the loss in individual junctions belonging to these otherwise coherent groups.

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P-0295 16:30-18:00, August 19 | Lobby (5F)

Fractional Quantum Anomalous Hall effect in the Wannier stark Ladders emerging from a nontrivial Chern band

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Since the topology of any two-dimensional band is directly manifested in the winding numbers of the Wannier-Stark ladder (WSL) emerging under an electric field, WSL basis can be extremely useful to construct and properly understand the fractional quantum anomalous Hall effect, well known as the fractional Chern insulator (FCI), states in nontrivial Chern bands. The electric field basically introduces a natural length scale in the system, due to the broken translational symmetry along its direction, which was missing in the previous understanding of FCI states in terms of the Bloch or Wannier basis. The WSL basis, being localized in one direction along with the winding property and extended in the other, can be considered as a perfect substitution of the Landau level basis for the fractional quantum Hall effect in Chern bands. Constructing a many-body basis using the WSL states, we diagonalize the interacting Hamiltonian in a lattice with electrons projected onto a nontrivial Chern band at 1/3 filling. Our results strongly indicate the occurrence of FCI states and their one to one correspondence with the usual fractional quantum Hall states in a torus with different possible aspect ratio.

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4π-periodic supercurrent through surface states in $(Bi_{0.81}Sb_{0.19})_2Se_3$ nanowire-based Josephson junctions

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Topological insulator (TI) nanowire combined with conventional s-wave superconductor is expected to provide the topological superconducting state for hosting the Majorana fermion, which is essential for the topological quantum computation. Here, we report the experimental evidences of the topological supercurrent through surface states in (Bi0.81Sb0.19)2Se3 TI nanowire-PbIn superconductor Josephson junctions. When an axial magnetic filed is applied, the Josephson supercurrent oscillates, and their period is consistent with the Aharonov-Bohm (AB) oscillations of normal conductance, indicate that the supercurrent is caused by the topological surface states. Furthermore, when we applied microwaves to the junctions, anomalous Shapiro steps with the first step missing are observed at around 300 mK. In the topological superconducting state, the supercurrent has a 4π-period and is expected to show doubled Shapiro steps, so called the fractional Josephson effect. Therefore, our anomalous Shapiro steps can be caused from the topological supercurrent, and it is also verified by numerical calculations. To the best of our knowledge, our experimental results are for the first time in the world to simultaneously demonstrate the surface supercurrent AB oscillations and fractional Josephson effect in a topological nanowire.

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P-0343 16:30-18:00, August 19 | Lobby (5F)

Numerical Simulation of Shapiro Steps in Topological Josephson Junction

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Topological Josephson junctions are expected to exhibit 4π-periodic current-phase relation due to the existence of Majorana zero mode. The 4π-periodic current-phase relation, which is the so-called fractional Josephson effect, would result in anomalous Shapiro steps under the irradiation of microwave. We performed numerical simulations of microwave response of topological Josephson junction, based on the resistively and capacitively shunted junction (RCSJ) model. We modified the RCSJ model with 4π-periodic supercurrent term in addition to a conventional 2π-periodic one. In this simulation, we investigated progressive evolution of Shapiro steps with varying 4π-periodic supercurrent ratio, microwave frequency, microwave power and hysteresis parameter of the junction. Our simulation study can be used to quantify the ratio between topological supercurrent and conventional supercurrent, in comparison with the experimental results obtained from the Josephson junctions made of topological insulator nanoribbons.

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P-0345 16:30-18:00, August 19 | Lobby (5F)

Electrical Detection of Spin-Polarized Local and Non-Local Current in Topological Insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$

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Spin-momentum locked (SML) topological surface state (TSS) provides an exotic property for spintronics applications of topological insulators (TIs). The spin-polarized current due to SML can be directly detected using spin potentiometric measurement. In this report, we electrically measure spin polarization ratio of Bi1.5Sb0.5Te1.7Se1.3 which is a low-doped topological insulator. Ferromagnetic Co contact was chosen intentionally to minimize interfacial band bending at the interface, at which the spin-dependent potentiometric measurement takes place.

The spin voltage was measured as a function of the current bias, temperature, and gate voltage. We also report, for the first time in our best knowledge, a spin-potentiometric measurement using non-local spin-polarized current, which is unique property of TI. The polarization ratio is obtained to be p=0.036 (0.183) for local (non-local) measurement, respectively. The higher spin polarization ratio obtained from the non-local current is attributed to reduction of bulk carrier contribution. Our observations provide highly enhanced way to determine spin-polarization ratio, which is inherent in the TSS in TI.

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P-0349 16:30-18:00, August 19 | Lobby (5F)

Superconducting quantum interference device of $(Bi_{0.82}Sb_{0.18})_2Se_3$ topological insulator nanoribbons

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Topological insulators(TIs) with topologically protected surface states are fascinating materials for detecting the Majorana fermion when coupled with a superconductor. Since the Majorana fermion has charge neutrality and zero energy, the superconducting quantum interference devices(SQUIDs) are received attention. The SQUID is very sensitive to a magnetic flux, so it plays a crucial role for a superconducting flux qubit. Here, we report the fabrication and measurement of SQUIDs, made of $(Bi_{0.82}Sb_{0.18})_2Se_3$ TI nanoribbons(NRs) connected with Pb0.5In0.5 superconducting electrodes. A TI NR is transferred onto a SiO_2/Si while the $Pb_{0.5}In_{0.5}$ electrodes are deposited using electron-beam lithography and electron-beam deposition techniques. Below the transition temperature of the superconducting $Pb_{0.5}In_{0.5}$ electrodes, periodic oscillations of the critical current are observed in the TI NR SQUID with a magnetic field applied perpendicular to the plane due to the flux quantization. Moreover, the envelope of the voltage modulation of the SQUID shows Fraunhofer-like patterns of each single junction. We also measure the Aharonov-Bohm oscillations under a magnetic field along the topological surface state of the NR.

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Emergent Localization in Twisted Dodecagonal Bilayer Quasicrystals

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A new type of long-range ordering in the absence of translational symmetry gives rise to drastic revolution of our common knowledge in condensed matter physics. Quasicrystal, as such unconventional system, became a plethora to test our insights and to find exotic states of matter. In particular, electronic properties in quasicrystal have gotten lots of attention along with their experimental realization and controllability in twisted bilayer systems. In this talk, we present how quasicrystalline order in bilayer systems can induce unique localization of electrons without any extrinsic disorders. We focus on dodecagonal quasicrystal that has been demonstrated in twisted bilayer graphene system in recent experiments. In the presence of small gap, we show the localization generically occurs due to nonperiodic nature of quasicrystal, which is evidenced by the inverse participation ratio and the energy level statistics.
We understand the origin of such localization by approximating the dodecagonal quasicrystals as an impurity scattering problem.

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Drumhead surface states and their signatures in quasiparticle scattering interference

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We consider a two-orbital tight-binding model defined on a layered three-dimensional hexagonal lattice to investigate the properties of topological nodal lines and their associated drumhead surface states. We examine these surface states in centrosymmetric systems, where the bulk nodal lines are of Dirac type (i.e., fourfold degenerate), as well as in noncentrosymmetric systems with strong Rashba and/or Dresselhaus spin-orbit coupling, where the bulk nodal lines are of Weyl type (i.e., twofold degenerate). We find that in noncentrosymmetric systems the nodal lines and their corresponding drumhead surface states are fully spin polarized due to spin-orbit coupling.
We show that unique signatures of the topologically nontrivial drumhead surface states can be measured by means of quasiparticle scattering interference, which we compute for both Dirac and Weyl nodal line semimetals.

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Effect of Isoelectronic Substitution of Ba with Sr or Ca atoms on Electron Charge Distribution and Bonding Properties of $BaFe_2As_2$

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$BaFe_2As_2$ is an antiferromagnetic metal at low temperature and ambient pressure. It undergoes structural, magnetic and superconducting phase transitions under pressure. Isoelectronic substitution of Ba with Sr and Ca atoms (which have smaller atomic radii) reduces critical pressure for these transitions [1]. For example, the structural transitions from orthorhombic to tetragonal phase in $BaFe_2As_2$, $SrFe_2As_2$ and $CaFe_2As_2$ compounds occur at pressures about 29, 4.5 and 0.3 GPa, respectively [2,3]. In our previous work [4], we have investigated the effects of chemical and mechanical pressure effects on some physical properties in these compounds. However, there is a need to describe the ambient-pressure phase of the three compounds in detail, and we have focused on bonding properties and electron charge density in present work. The electron charge density plays an important role in the characterization of the many-body systems and reflects faithfully the chemical composition, geometry of the system and strength of bonds. The scalar-relativistic calculations are done in the framework of density functional theory with PBE parameterization. The ultrasoft pseudopotentials with the semi-core electrons are used to better describe the electron charge densities. Considered supercell for the antiferromagnetic phase is obtained more stable (95±5 eV) than the nonmagnetic phase. The magnetic moments of the Fe atoms decrease from 2.38 to 2.21 μ_B by isoelectronic substitution of Ba with Ca atom and thus the As-mediated superexchange interaction reduces. It can be due to that the d_z^2 and d_{xy} orbitals have larger magnetic moments than three other Fe-3d orbitals. Also, the differences of charge densities between the antiferromagnetic and nonmagnetic phases confirm that these two orbitals have more charge densities in the antiferromagnetic phase and they are magnetically more active. The isoelectronic substitution with smaller atoms results in the increase of Fe-As layer thickness in unit of the c lattice parameter, and thus the strength of intera-(inter-)layer interactions decreases (increases). Also, charge distribution decreases around the Fe and the A (A=Ba, Sr, Ca) atoms, and it increases around the As atoms. These effects are the same as the hole doping effects in the iron arsenides.

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Spectroscopic-Imaging Scanning Tunneling Microscope studies on Rh-doped Iridates

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It has been known that high-temperature superconductivity emerges from a doped Mott insulating state in the cuprates. When extra carriers are doped into the parent state, the electrons become mobile but the strong electron correlations from the Mott state are believed to survive [1]. However, we still lack an understanding of how dopants drive the evolution. A spin-orbit coupled Mott insulator Sr2IrO4 is thought to be a prime candidate to host this evolution due to its similarities with the cuprates, so it is worthwhile to study the influence of dopant atoms using a local probe. Using spectroscopic-imaging scanning tunneling microscope (SI-STM), we report the electronic structure and its evolution on Rh-doped Sr2IrO4, which has weak spin-orbit coupling compared to the parent compound, and will discuss how the Rh dopants play a role in the material.

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Topological Phases with Emergent Chiral Spin States on the Kagome Lattice at 1/3 filling

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The study of kagome lattice and materials with kagome lattice structure like herbertsmithites and jarosites have been an active area of research. The credit of the discovery of some exotic phases of matter like quantum spin liquid goes to the materials with kagome lattice structure. Recently, kagome lattice has also gained attention in the study of system with non-trivial topology. Motivated by the richness of the model and the possible realization in real materials, we study the interacting kagome lattice at 1/3 filling in the presence of the spin-orbit coupling. Using mean-field approximation, we present the phase diagram and report new types of topologically trivial and non-trivial phases accompanied with unique charge and spin orderings on the kagome lattice: spin-charge density wave, Chern ferromagnet insulator, time reversal broken quantum spin Hall insulator, Chern umberlla insulator, etc. In particular, the presence of spin-orbit coupling and electron interaction generically open a new type of Chern insulating phase stabilized by umbrella like spin ordering with finite spin chirality. We discuss these new phases on symmetry grounds and Hartree-Fock mean-field perspective.

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Topological superconductors in the interacting Luttinger model

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We consider the interacting Luttinger model, where j=3/2 multi-orbital electrons form a quadratic band touching at the Brillouin zone center. [1-3] We consider a realistic situation of finite chemical potential, which induces breaking of the particle-hole symmetry. Performing exact decoupling of electron interactions into pairing channels, we adopt the Landau theory of complex tensor order parameters including both s-wave and d-wave pairings, and study the Landau free energy functionals in terms of invariants under SO(3) symmetry. [1] Remarkably, in the absence of particle-hole symmetry, the system energetically favors particular d-wave superconducting states where subdominant s-wave pairing is always accompanied. Both of these superconductors have gapless Bogoliubov quasiparticles and furthermore have topological invariants for each nodal line or Bogoliubov Fermi pocket and related surface states.[4,5] We also perform a self-consistent calculation of the Bogoliubov-de Gennes equations to obtain a pairing symmetry of the system with lower symmetry.

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P-0441 16:30-18:00, August 19 | Lobby (5F)

Pressure induced Lifshitz transition and disappearance of commensurate charge density wave in the 2H-Pd_xTaSe_2 superconductor

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At ambient pressure 2H-Pd_xTaSe_2 exhibits an incommensurate charge density wave (ICDW) phase near 110 K, a commensurate charge density wave (CCDW) phase near 70 K and a superconducting transition below 2.6 K. In this work, we have investigated the pressure dependent phase diagram of 2H-Pd_xTaSe_2 single crystal by resistivity, Hall effect and Raman spectroscopy up to 35.8 GPa. With application of pressure, both ICDW and CCDW phases are suppressed, while the superconducting transition temperature exhibits a domelike shape with an optimal Tc = 7.35 K. The ICDW phase traced from resistivity becomes untracable at 22.1 GPa, in consistent with the optimal T_c.

Temperature dependent Hall coefficient, which shows a decreasing behavior near the CDW onset temperature, also becomes saturated near 22.1 GPa. Moreover, the A_{1g} ^{CDW} peak in the Raman spectra associated with the CCDW shows a gradual decreasing trend heading to the critical pressure, suggesting the possibility of a Lifshitz transition related to the disappearance of the commensurate charge density wave phase. The interplay between superconductivity and the charge density waves in 2H-Pd_xTaSe_2 will be discussed carefully.

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P-0515 16:30-18:00, August 19 | Lobby (5F)

Pressure-enhanced Anomalous Hall Effect in Van der Waals Ferromagnet $CrSiTe_3$

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Recently, a layered van der Waals material, $CrXTe_3$ (X=Ge, Si) attracts a lot of attention as a candidates of 2D ferromagnetic material. This tri-chalcogenide material is predicted to have topologically non-trivial bands in its conduction band so that a 2D Chern insulator could be realized in a single-layer $CrXTe_3$ with tuning of the Fermi level. Moreover, a 3D Chern insulator or ferromagnetic Weyl semimetal phase can appear in a bulk $CrXTe_3$ if we stack such 2D layers of the Chern insulating $CrXTe_3$ to form a 3D system. In this study, we have investigated pressuredependent transport properties of a $CrSiTe_3$ bulk single crystal using a diamond anvil cell up to ~40 GPa. We have observed a metal-insulator transition and emergent large anomalous Hall effect with increasing pressure. At ambient pressure, resistivity at 300 K ρ300 of $CrSiTe_3$ is larger than 1000 Ω·cm, and its temperature-dependence exhibits quite insulting behavior. As pressure increases, the resistivity of $CrSiTe_3$ reduced systematically, and around 10 GPa, it reaches ρ_{300}~10^{-3} Ω·cm and exhibits metallic behavior down to low temperatures. Furthermore, anomalous Hall effect starts to be observed at pressure between 6.0 GPa and 13.5 GPa; the term of σ_{xy} ^{AHE} at 2 K starts at 0.4 $\Omega^{-1}\cdot cm^{-1}$ at 6.0 GPa and increases up to 61 $\Omega^{-1}\cdot cm^{-1}$ at 10.4 GPa, forming an enhancement of more than 100 times enhancement. Furthermore, the temperature dependence of σ_{xy} ^{AHE} exhibits a rapid increase with decreasing temperature and does not saturate until 2 K. This is in contrast with the behavior of saturating magnetization of $CrSiTe_3$ below ~20 K at ambient pressure, which obviously rules out a classical skew scattering as an origin of the anomalous Hall effect. We discuss the possible origin of the anomalous Hall effect in this compound based on the band structure evolution.

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Tuning the interplay between nematicity and spin fluctuations in $Na_{1-x}Li_xFeAs$ superconductors

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Strong interplay of spin and charge/orbital degrees of freedom is the fundamental characteristic of the iron-based superconductors (FeSCs), which leads to the emergence of a nematic state as a rule in the vicinity of the antiferromagnetic state. Despite intense debate for many years, however, the origin of the nematic state/whether it is driven by spin or charge/orbital degree of freedom remains unsettled. To elucidate this issue, we investigate the doping-temperature phase diagram of $Na_{1-x}Li_xFeAs$ up to x = 0.1, which were successfully synthesized for the first time by overcoming intriguing difficulties in forming single phase materials. By use of transports, magnetization, and 75As nuclear magnetic resonance (NMR) measurements, we observe a striking transformation of the relation between nematicity and spin fluctuations (SFs) with doping; For x ≤ 0.02, the nematic transition promotes SFs which diverges towards a static spin density wave (SDW) order. In contrast, for x ≥ 0.03, the SDW transition vanishes, and the system undergoes a phase transition at a temperature T0 into a new nematic state, which suppresses SFs. This implies that as x exceeds a critical doping x ≤ 0.03 nematic fluctuations becomes strongly entangled with SFs, resulting in a distinct nematic state associated with a charge density wave (CDW) like order. Our work demonstrates that the very nature of a nematic state is determined by a delicate balance between spin and orbital degrees of freedom, rather than by one of them. Most importantly, by tuning the interplay of nematicity and SFs in one FeSC system, we have shown that a CDW like charge/orbital order can develop above the bulk SC state, providing a new insight into the role of nematicity and charge/orbital degree of freedom in high temperature superconductivity in FeSCs.

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Magnetic field detwinning in FeTe

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Iron-based superconductors (IBS) has a nematic phase where rotational symmetry is spontaneously broken. The nematic phase has attracted much attention as it is believed to be closely linked to the superconductivity as in the cases of other unconventional superconductors. However, since IBS has twin domain in the nematic phase, it is hard to observe pure symmetry broken phase by using macroscopic experimental tool. Here, we report a novel method to detwin FeTe single crystal by magnetic field. Detwinning effect was measured by resistivity anisotropy using Montgomery method and FeTe was almost fully detwinned at 2T. Furthermore, detwinning effect is retained when the field is turned off after field cooling.

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Lifted electron pocket and reversed orbital occupancy imbalance in FeSe

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The FeSe nematic phase has been the focus of recent research on iron based superconductors (IBSs) due to its unique properties. A number of electronic structure studies were performed to find the origin of the phase. However, such attempts came out with conflicting results and caused additional controversies. Here, we report results from angle resolved photoemission and X-ray absorption spectroscopy studies on FeSe with detwinning by a piezo stack.

We have fully resolved band dispersions with orbital characters near the Brillouin zone corner which reveals absence of a Fermi pocket at the Y point in the 1Fe Brillouin zone. In addition, the occupation imbalance between dxz and dyz orbitals is found to be opposite to that of iron pnictides, which is consistent with the identified band characters. These results settle down controversial issues in the FeSe nematic phase and shed light on the origin of nematic
phases in IBSs.

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Bulk properties of van-der-Waals hard ferromagnet VI_3

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We comprehensively measured the structural, magnetic, and electronic properties of the interlayer van der Waals ferroelectric VI3 to low temperatures. Despite belonging to a well-studied family of transition metal trihalides such as CrI_3, a-$RuCl_3$ and $TiCl_3$, VI_3 has received little attention. High-resolution powder X-ray diffraction measurements reveal the structural transition at 79 K supported by the peak of heat capacity. Furthermore, we suggest the modified room-temperature crystal structure Magnetization measurements confirm that VI3 is a hard ferromagnet with high magnetic anisotropy (9.1 kOe coercive field at 2 K), and the pressure dependence of magnetic properties provide evidence for the two-dimensional nature of the magnetic order. Optical and electrical transmission measurements show that this material is an insulator with an optical bandgap of 0.67 eV. Previous theoretical predictions of d-band metallicity have led VI_3 to believe VI_3 is a correlated Mott insulator. Our latest band structure calculations support this picture and are in good agreement with the experimental data. We expect VI_3 with great potential in the thriving field of low dimensional magnetism.

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Deviation between magnetic quantum- and Lifshitz- critical point in electron doped cuprate $Pr_{1-x}LaCe_xCuO_4$

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Since the high-T superconductivity in copper oxide (cuprate) and Fe-based material arises near the antiferromagnetic (AF) order phase boundary, relation between the magnetic quantum criticality and superconductivity has attracted extensive interest. On the other hand, there is an argument in many novel superconductors that the key role in inducing superconductivity is played by Lifshitz transition (LT) which leads to Fermi surface transformation without symmetry breaking.

We performed systematic doping and temperature dependent muon spin rotation (mSR) measurement and angle resolved photoemission spectroscopy (ARPES) on the electron-doped cuprate $Pr_{1-x}LaCe_xCuO_4$ in order to resolve the interplay among the magnetic quantum criticality, Lifshitz transition, and superconductivity. While the long-range AF order phase boundary is located around heavily under doped regime, the Lifshitz transition associated with nodal hole pocket takes place in the vicinity of optimal doping concentration. In this talk, we will present the magnetic and electronic phase diagram of electron doped cuprate $Pr_{1-x}LaCe_xCuO_4$, and discuss the implication of our results on the generic phase diagram of high-T_c cuprate superconductors.

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Polarization and orbital angular momentum in Rashba spin-orbit coupling

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The Rashba spin-orbit coupling is a crystal momentum(k)-dependent spin splitting in non-centrosymmetric systems. This coupling is an essential ingredient for various interfacial spin phenomena [1-2] and modern spintronics applications [3-5]. The coupling is commonly interpreted as the relativistic effect by which makes an electric field is felt as an momentum-dependent effective magnetic field. But this common interpretation is hard to explain various properties of the Rashba coupling. Recent studies reported that the coupling may be large even in situations with very small electric field [6-8]. It is also reported [9] that the Rashba coupling may be order of magnitude enhanced by an in-plane potential gradient instead of out-of-plane direction gradient. Although all these properties can be explained within first-principles calculations, the conceptual understanding is rather limited. There are suggestions that wavefunction distortion near nucleus core is important [10], but there are strong criticisms against such suggestions [11]. There are suggestions that orbital angular momentum near nuclues cores is important [6,7,12].

Our theoretical analysis starts from the three essential ingredients of the Rashba coupling; atomic spin-orbit coupling, inversion symmetry breaking, and deviations of k from time-reversal invariant points. We demonstrate that these ingredients naturally lead to orbital angular momentum, spin-dependent wavefunction polarization, and spindependent kinetic energy. Furthermore, we find that our analysis quantitatively agrees with Rashba constants and Rashba splitting gaps reported in experiments [6-9]. Our investigation is expected to give new insight to the Rashba coupling. Some guidelines are proposed for giant Rashba materials.

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P-0626 16:30-18:00, August 19 | Lobby (5F)

K_z dependence on the band structure of electron doped cuprate superconductors

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Most minimal models describing cuprate superconductors starts with an approximately half-filled single d_{x-y}^2 band on a two dimensional square lattice. This single-band models were widely used because there exists no strong experimental evidence supporting multi-band structure. However recently, angle resolved photoelectron spectroscopy (ARPES) data of significant k_z dispersion along the antinodal direction was reported on hole-doped cuprate superconductors (LSCO). This results propose possibility that kz dependent d_z^2 band might be important element for superconductivity. To clarify this suggestion, electron doped cuprate superconductors which have no apical oxygen could be good control group. Therefore we did photon energy dependent ARPES experiment for $Pr_{0.85}LaCe_{0.15}CuO_4$ (PLCCO) and observe no kz dispersion along both nodal and antinodal direction.

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P-0635 16:30-18:00, August 19 | Lobby (5F)

Magnetic Excitations in Non-collinear Itinerant Antiferromagnet CrB_2

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Frustration and non-collinear magnetic ordering can introduce a wide variety of interesting physics; like a quantum spin liquid phase in insulators or topological band structures in metals, to name a few. Many studies have been made on the nature of magnetic excitations in non-collinear insulating magnets, while few experimental data exist for non-collinear metallic magnets. Using an inelastic neutron scattering technique, we report the magnetic excitation spectra of single crystal CrB_2; a metallic magnet in which magnetic moments of Cr on triangular lattice form incommensurate spin spiral ordering (k =(0.285,0.285,0)). Severely damped magnons are observed along with clear phonon modes sharp as a limit of instrumental resolution, yet most of them can be explained by Heisenberg Hamiltonian and a linear spin wave theory. Also, we mapped the inverse magnon lifetime Γ(q, E) using the data and the behavior of Γ(q, E) seems different from those seen in collinear cases. Based on the DFT calculations, we compare these experimental results with the theoretical point of view.

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Evidences of Superconductivity at 18 K in Nano-sized Rhombohedral Bi Enhanced by Ni-doping

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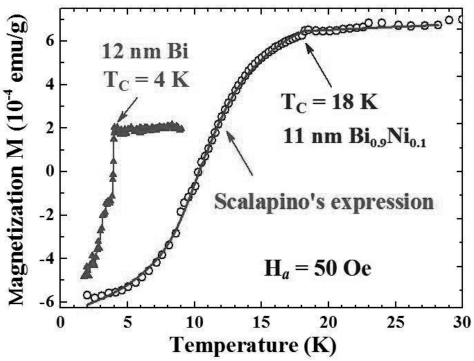
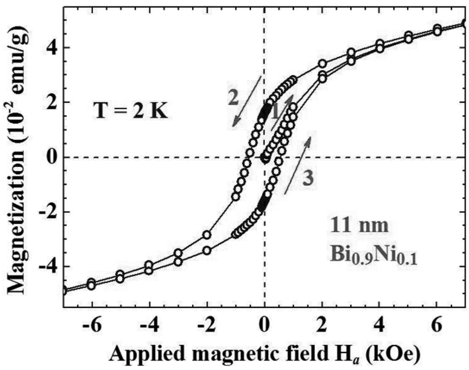
Superconductivity has not been found in the ambient pressure of the bulk bismuth. However, the superconducting properties was found under the high pressure or in the amorphous film and nanowire with the transition temperatures of 8.3 K [1], 6 K [2], and 0.64 K [3], respectively. The superconducting transition temperature estimated in the BCS formalism gives an upper limit of 1.3 mK for the crystalline bismuth [4]. In this presentation, we report on the observations of largely enhanced superconductivity in rhombohedral Bi nanoparticle (NP) by Ni-doping, and superconductivity coexists with ferromagnetism. The Ni-doped Bi NPs were fabricated employing the gascondensation method, using a chamber equipped with two decoupled evaporation sources for separate evaporation of Bi or Ni. X-ray diffraction reveals a rhombohedral Bi crystalline structure for the resultant NPs, but with a much shorter lattice constant for the Ni-doped NPs. No diffraction peaks from crystalline Ni can be identified from the Xray diffraction pattern. C of 4.2 nm Bi NPs reaches 4 K at ambient pressure. Surprisingly, a nearly three-fold increase of T_C to reach 12 K was found when 5% of Ni was incorporated into the 4.3 nm Bi NPs, and $_C$ reaches 18 K in the Bi NPs with 10% Ni (Figure 1). Isothermal M(Ha) reveals a Langevin profile and magnetic hysteresis is clearly revealed in the superconducting phase (Figure 2), showing the coexistence of superconductivity and ferromagnetism. Interestingly, the electronic charge distribution of $Bi_{0.9}Ni_{0.1}$ NPs is considerably different from that of Bi NP. The DFT calculations also show that Ni-doping gives rise to a large increase of the density of states (DOS) near the Fermi energy EF. Surprisingly, the DOS near E_F for the $Bi_{0.875}Ni_{0.125}$ reaches as high as 14 times that of Bi.





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Multi-scale Quantum Criticality driven by Kondo-lattice Coupling in Pyrochlore Systems

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Pyrochlore systems ($A_2 B_2 O_7$) with A-site rare-earth local moments and B-site 5d conduction electrons offer excellent material platforms for the discovery of exotic quantum many-body ground states. Notable examples include U(1) quantum spin liquid (QSL) of the local moments and semi-metallic non-Fermi liquid of the conduction electrons.

Here we investigate emergent quantum phases and their transitions driven by the Kondo-lattice coupling between such highly-entangled quantum ground states.

Using the renormalization group method, it is shown that weak Kondo-lattice coupling is irrelevant, leading to a fractionalized semimetal phase with decoupled local moments and conduction electrons.

Upon increasing the Kondo-lattice coupling, this phase is unstable to the formation of broken symmetry states.

Particularly important is the opposing influence of the Kondo-lattice coupling and long-range Coulomb interaction.

The former prefers to break the particle-hole symmetry while the latter tends to restore it. The characteristic competition leads to possibly multiple phase transitions, first from a fractionalized semimetal phase to a fractionalized Fermi surface state with particle-hole pockets, followed by the second transition to a fractionalized ferromagnetic state. Multi-scale quantum critical behaviors appear at non-zero temperatures and with the external magnetic field near such quantum phase transitions. We discuss the implication of these results to the experiments on $Pr_2Ir_2O_7$.

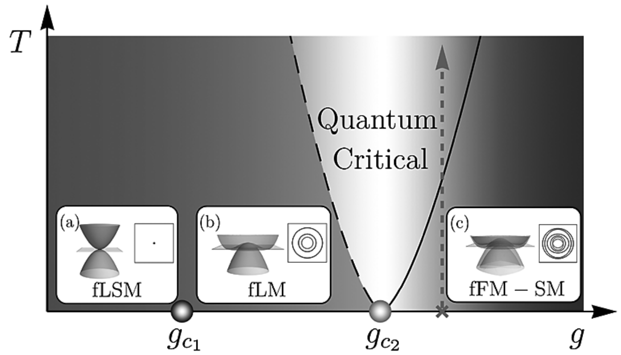

FIG. 1. Schematic phase diagram. The coupling constant g characterizes strength of the Kondo-lattice coupling.

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Magnetic and electrical anisotropy with correlation and orbital effects in dimerized honeycomb ruthenate Li_2RuO_3

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Li_2RuO_3 has a layered honeycomb structure like α-Li2IrO3, but it has the unique lattice symmetry (P21/m). It is also known to be non-magnetic down to very low temperatures. Instead, it has a transition to a valence bond solid (VBS) phase at a fairly high temperature of ~540 K [1]. At the transition, the otherwise uniform honeycomb lattice of Ru gets distorted and forms a herring-bone structure with a largest ever reported value of the bond shrinkage of about ~ 0.5 Å. This transition was interpreted to arise from dimerized Ru 4d band through strong lattice effects, involving off-centering of Li atoms at the center of the Ru honeycomb lattice [2].

Despite several studies on the origin of the VBS transition [1-5], both theoretical and experimental, however its origin and its effect on physical properties still remain to be understood. In this work, using high quality single crystals we investigated the anisotropy of resistivity (ρ) and magnetic susceptibility (χ) to find a very clear anisotropy: $\rho_{c^*} > \rho_b > \rho_a$ and $\chi_b > \chi_a > \chi_{c^*}$. For possible theoretical interpretations, we carried out density functional calculations to conclude that these anisotropic behavior is due to the correlation effects combined with the unique orbital structure and the dimerization of Ru 4d bands.

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Pressure effect on the phase transitions of a heterostructured superconductor Sr_2VO_3FeAs

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A naturally-grown heterostructured superconductor Sr_2VO_3FeAs has an unusual phase transition at T0 ~ 155 K, in addition to the superconducting one, which was recently identified as the C4 symmetric ordering due to competing interactions between the superconducting $[SrFeAs]^{+1}$ layers and the Mott-insulating $[SrVO3]^{-1}$ layers. In this work, we report the pressure effect on the superconducting and the C4 symmetric ordering temperatures and additional phase transition T'. We found that T_0 and T_c transitions have similar positive pressure dependence at relatively lower pressures (P < 2 Gpa). At higher pressure up to 13 GPa, additional T' anomaly is observed and systematically shifts to lower temperatures with pressure. Possible origins for such complex pressure effects will be discussed.

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Room temperature ferromagnetism in a magnetic-metal-rich van der Waals metal

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In spintronics, two dimensional (2D) van der Waals (vdW) crystals constitute a most promising material class for long-distance spin transport or effective spin manipulation at room temperature. To realize all-vdW-material-based spintronic devices, however, new vdW materials with itinerant ferromagnetism at room temperature are needed for spin current generation and thereby serve as an effective spin-source. We report theoretical design and experimental realization of a new iron-based vdW ferromagnet Fe_4GeTe_2 showing the highest c of 280 K among vdW ferromagnets, together with a large magnetization and a high conductivity. Our findings highlight Fe_4GeTe_2 as a promising candidate for spin source operation at room temperature and hold a promise to further increase T_c in vdW ferromagnets by theory-guided material discovery.

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Passivation Dependent Surface State of Rocksalt SnSe (111) Surface

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The rocksalt SnSe compound is known as a topological crystalline insulator in which the gapless surface state is protected by the non-trivial mirror Chern number of (110) mirror plane[1]. In the absence of the spin-orbit coupling, however, it becomes a topological nodal line semimetal. The nodal line is a line of degenerate points in the k-space between the conduction and the valence bands. In the system having an inversion and time-reversal symmetry the Zak phase (Berry phase) is quantized and jumps by π at the nodal line. It was suggested that the drum-head like flat surface band appears in the π-Zak phase region of surface Brillouin zone of nodal line semimetal. But some exceptions are also reported, and related arguments are ongoing.[2,3] In our first principle study, we show that the surface state of rocksalt SnSe (111) surface exist in π-Zak phase region out of the projection of the nodal line when the surface is not passivated. However, with the passivation Dirac cone or drumhead surface state arises inside the projection of nodal-ring, where is the 0-Zak phase region, according to the existence of SOC. In the context of the topological crystalline insulator, these surface states are protected by mirror symmetry whether it is passivated or not.

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Observation of Toroidal pseudo-spin texture in a Nodal line semimetal $SrAs_3$

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Dirac electronic state have gathered interests by their unconventional electronic states characterized by intrinsic chirality of (pseudo) spins. Recently, we found that SrAs3 is a strong candidate of nodal-line semimetal confirmed by band structure calculations. We observed angular-dependent Shubnikov-de Haas (SdH) oscillations of a high-quality SrAs3 single crystal. The berry phase factor extract from landau fan diagram shows strong angle dependence. We discuss how these observations related to unique toroidal pseudo-spin texture in a nodal-line semimetal SrAs3 .

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P-0834 16:30-18:00, August 19 | Lobby (5F)

Effects of Magnetic Frustration in the Triangular Antiferromagnet CePtAl4Ge2

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CePtAl4Ge2 crystallizes with the trigonal structure (R-3m, 166) and exhibits a Kondo metallic behavior. An antiferromagnetic (AFM) ordered state appears below 2.3 K and anisotropic spin interactions exist due to geometrical frustration in the Ce-triangular lattice [1]. In this presentation, we discuss neutron scattering study on this triangular system that reveals the incommensurate structure with ordering wave vector (k) of (1.39, 0, 0.09) in the AFM state, which persists down to the lowest measuring temperature of 70 mK. When the magnetic field is applied along the crystallographic [100] direction, the neutron scattering intensity shows a sharp peak around 1 tesla with the same k. On the other hand, a sudden change of k is induced near 1.2 tesla for the field applied along the [001] direction. This anisotropic field dependence of magnetic ordering wave vector is consistent with that of electrical resistivity and magnetization. The origin and mechanism of the unusual magnetic structure and field dependence in CePtAl4Ge2 will be discussed in connection with the crystal field analysis.

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P-0837 16:30-18:00, August 19 | Lobby (5F)

Magnetic Topological Insulators With Higher Chern Numbers In Electrondoped $CrSiTe_3$

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We investigate one of the two-dimensional materials consisting of transition-metal chalcogenides, e.g., $CrSiTe_3$ transition-metal trichalcogenides (TMTC) as a candidate material of magnetic topological insulators. From firstprinciples calculations, we found that $CrSiTe_3$ exhibits intriguing topological features and novel magnetic interactions in their electronic band structure. Further, we demonstrate that the topological characteristics like Chern insulators can be achieved by electron-doping. While transition metal atoms are responsible for the ferromagnetic ground state, the band topology depends on the hopping matrix elements through chalcogen atoms. The nontrivial band topology is confirmed to have a nonzero Chern number, quantized Hall conductivity, and chiral edge states by using the Wannier function analysis. The specific role of each hopping was analyzed in the multiorbital tight binding scheme. We also find that the structural distortion can induce various topological phase transition. Considering that there is a bunch of order parameters for the oxide layers to choose from, one can expect that the two-dimensional can serve as a building block for spintronics, valleytronics, and topological electronics as well.

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Field induced phase transitions between quantum spin liquids with different fluxes

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The antiferromagnetic pseudospin-1/2 system on the pyrochlore lattice has been focused to be a candidate for U(1) quansum spin liquid (QSL). Integrating out the quantum fluctuations, the low-energy physics is described by the gapped spinon, magnetic monopole and gapless photon. The spinon experiences the gauge flux through the minimal plaquette, which minimizes the magnetic field energy. We study the possible phase transitions between QSLs with different fluxes in the presence of a external magnetic field along [111]-direction. It is demonstrated that the phase transtions out of different QSLs via the spinon condensation give rise to different magnetic orderings.

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Quantun Anomalous Hall Effect with Higher Chern Numbers in Electron-Doped $CrSiTe_3$: A First-Principles Prediction

Sungmo Kang, Seungjin Kang, Jaejun Yu*

Seoul National University, Korea

In past decades, transition metal tri-chalgonides (TMTC) materials has been well known as one of candidates of ferromagnetic insulator. In recent, there has been a number of researches which report nontrivial topology of TMTC materials theoretically such as $PdPS_3$ or La(Lu)-doped $CrSiTe_3$($CrGeTe_3$) thin film. Nontrivial topology with broken time reversal symmetry under loss of external magnetic field can give rise to quantum anomalous Hall effect (QAHE) and this kind of materials are so called Chern insulators. Here, we reported single layer structure of $CrSiTe_3$ become Chern insulators with higher Chern numbers under electron doping. We also found that the choice of Hubbard U value plays crucial role for determining magnetic ground state and ferromagnetism become stable with physical U value. We performed first-principles density-functional-theory (DFT) calculations to analyze its electronic structure and found the minimum energy configuration for both atomic and magnetic structure. We used Wannier function to calculate Berry curvatures and found nontrivial conduction bands consisting of Cr eg orbitals hybridized with neighboring Te p orbitals in the honeycomb-lattice network of CrTe6 octahedrons. Further, we demonstrated that the electron-doping can raise the Fermi level to the middle of the Cr eg band manifold together with about 20 meV band gap due to spin orbit coupling. Finally, we construct tight binding model to compare and analyze DFT calculation results and found a varitey of different nontrivial Chern insulator phases by controlling tight binding parameters which may suggest that there is a new family of Chern insulators in the form of MAX_{2}- or MX_{3}-type two dimensional materials.

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Mangetic order phase transition and topological semimetal phase transition in iridium spinel oxide

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Motivated by recent study of magnetic multipole moment (MMM) and their topological semimetal phase transitions in pyrochlore Ir system, we studied spin phases and topologcial semimetal phases in iridium spinel oxide without cations in the tetrahedral site. The nearest neighbor (NN) and next nearest neighbor (NNN) with Hubbard interaction model effectively described as a NN plus NNN spin interaction model in iridium spinel J_{eff} half doublets. As a result, there are 3 different types of spin phases so-called all-in-all-out phase (m_A), local-xy phase (m_E) and Palmer-Chalker phase (m_{T2}) with the ordering vector Q = 0, also there are 5 different Q non-zero phases including the newly discovered octagonal-prism phase. In this study, we found the ground state of iridium spinel oxide is local-xy phase by calculating density-functional-theory (DFT). We also found this spin phase can be controlled by pressure. The ground state in controlled region is splayed-ferro phase (mT1). This spin phase transition is an extended form of J_{eff} half NNN interaction model with Q = 0. Also, topological semimetal transitions can be described in this scheme.

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Linear Magnetoresistance of The helical Antiferromagnet Al doped CrAs

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CrAs, with MnP orthorhombic structure, orders in a non-collinear helimagnetic structure below T_N=260K, which is accompanied by a discontinuous lattice expansion along the crystalline b-axis and contraction along a- and c-axes. Under physical pressure, T_N is suppressed, while superconductivity is induced, showing a superconducting(SC) dome centered around the projected T_N=0K critical pressure of 8 kbar, implying interplay between AFM fluctuation and superconducting order. When doped with Al, the projected critical pressure in CrAs is successfully shifted to 4.5 kbar and is detached from the pressure-induced SC state, suggesting that superconductivity is independent of the AFM QCP [1].

Linear magnetoresistance (LMR) in Al-CrAs is observed below 40 K at ambient pressure. In the non-doped CrAs, LMR was also reported at 9 kbar and ascribed to the interplay between nontrivial band crossing protected by nonsymmorphic crystal symmetry and strong magnetic fluctuations near the projected QCP [2]. Temperature dependences of the magnetic susceptibility χ(T), and electrical resistivity ρ(T) of Al-CrAs, however, show a Fermiliquid behavior, implying that critical spin fluctuations may be not critical in LMR of Al-CrAs. We argue that LMR for Al-CrAs rather comes from a change in electronic structure, which is observed in Hall measurements below 70 K.

Taken together, these results indicate that LMR for Al-CrAs is pertinent to a band structure with a linear dispersion relationship.

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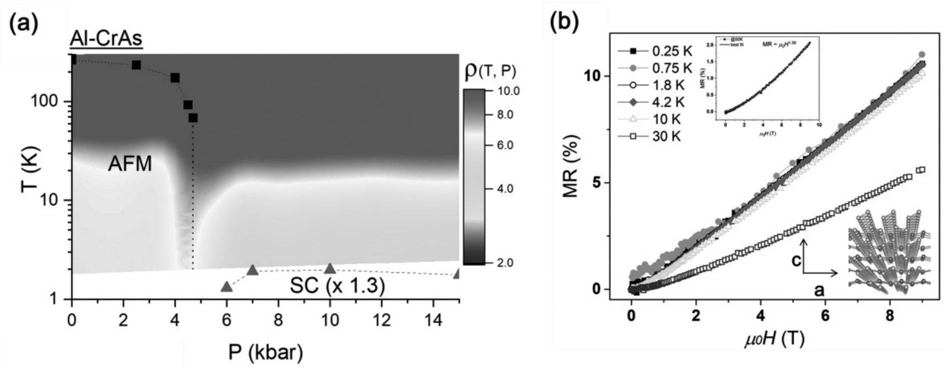

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Room Temperature Ferromagnetism in Ultrathin van der Waals Metal Fe_4GeTe_2

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Two-dimensional (2D) van der Waal (vdW) crystals, hosting exceptional transport, optical and spin-related properties, have strong potential for spintronic applications. While graphene, the first 2D vdW crystal, turns out to be the bestperforming spin-channel material due to its ultralong spin diffusion length, establishing the ultrathin ferromagnetic (FM) and metallic vdW crystals, as a possible 2D spin-source, has remained challenging so far. Here we report that nanometer-thick vdW crystals of Fe_4GeTe_2 showing the highest Curie temperature (Tc) of 280 K among vdW ferromagnets with magneto-transport, magnetic force microscope and magnetic circular dichroism measurement.

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Nature of Magnetic Weyl Nodal Loops in 5d Cubic Double Perovskites

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In topological physics, the effects of spin-orbit coupling(SOC) play a crucial role to emerge topologically nontrivial phases. These effects can lead to being gapped and inverted in linearly crossing bands, resulting in the gapless surface state. This state is a main origin of the quantum spin Hall effect.[1] Moreover, crystalline symmetries, such as the mirror, rotation, and non-symmorphic symmetries, are also vital to protect the topological states. For example, nodal lines(NLs) are protected by the mirror and non-symmorphic symmetry. Dirac and Weyl points(WPs) can be appeared on the axis of the rotation symmetry.[2,3] Recently, extensive researches for topological semimetals have been performed theoretically and experimentally.

In this presentation, we will address the nature of topological characters in the fcc-like cubic double perovskites with 5d orbitals, using first-principles calculations and the tight-binding(TB) model Hamiltonian representing the partially filled t2g manifold. With the time-reversal symmetry(TRS), Dirac nodal lines(DNLs) occur on the mirror planes in the momentum space. Then, inclusion of SOC splits all node points, leading to a topologically nontrivial insulating phase.

However, breaking TRS generates magnetic Weyl nodal lines(WNLs) that are robust even for considering SOC. For material realizations, we adopted cubic double perovskite(DP) materials with 5d1 (5d2) states, which show a strong SOC and moderate correlation strength. In magnetic states with SOC(001), because of the strong magnetic anisotropy, magnetic WNLs are robust on the mirror plane of kz=0 or π, which is perpendicular to the direction of SOC(001). Our calculated anomalous Hall conductivity shows a single sharp peak at the energy of WNLs, suggesting these WNLs to be readily measurable. Furthermore, we will discuss detailed analyses about our TB model and firstprinciples results.

Acknowledgements: This research was supported by NRF-2019R1A2C1009588.

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Nature of multi-topological characters in compensated half-metallic Cr_2CoAl

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In recent years, finding and understanding of three-dimensional(3D) topological materials are one of the hot topics in condensed matter physics due to their exotic features and possible applications to various fields. These systems, commonly with linearly crossing bands, can be classified by the dimension of the band touching points in momentum space; the Dirac, Weyl, and triple nodal points(TNPs) are zero dimensional(0D), whereas the nodal line is onedimensional(1D). More recently, another novel state, so called the nexus fermion, has been proposed without any material realization. In the nexus fermion, 0D TNPs are interconnected with 1D nodal lines (or 3D nodal loops).

In this presentation, based on first-principles calculations, the nature of topological characters has been investigated in the non-centrosymmetric compensated half-metallic inverse-Heusler Cr_2CoAl. In the absence of spin-orbit coupling(SOC), this system has 12 pairs of magnetic Weyl points and three pairs of TNPs, which are connected to nodal lines near the Fermi level EF. This connection provides the nexus fermion, which is protected by the six mirror and three C_2 rotational symmetries. Considering the tiny SOC strength of ~10meV, the observed high Curie temperature of T_c ~750 K, and no macroscopic magnetic moment in the compensated half-metals, this nexus fermion right above EF should be experimentally feasible. Therefore, our findings provide a promising platform to search for novel topological phases with potential applications.

Acknowledgements: This research was supported by NRF-2019R1A2C1009588.

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Changes Of Electronic And Crystallographic Structures At Interfaces Of MBE Grown Thin Films Of Bi_2Te_3 And Selected Metals

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The nature of Topological Insulators class of material resulting from its unique spin nature in s gaining in importance when one realize that TIs properties may entail generation of quasiparticles and electronic states which are not accessible in classical condensed-matter systems. [1] The existence of metallic surface states on insulating bulk is the most important feature of this class of materials. It is well known that defects, strain and doping influence that important feature of the TI's. E.g. Coulomb, magnetic or disorder perturbations can modify the surface states of this class of compound. The explanation of particular effects observed in pure TI is complex and becomes even more complicated when TI's heterostructures are considered. In such case, also inevitable effects of inter-diffusion and chemical stability have to be taken into account.

In this work we examined practical challenges of the formation of well-defined Bi_2Te_3 and (3d, 4f)-metals junction region, in which injection of spin from (3d, 4f)-metal to topological insulator would be possible, and which could be applied to some transport device. Analyzed heterostructures consist of 15nm thick Bi_2Te_3 monocrystalline [2] layer were grown on mica substrate in the co-deposition mode; the layer was later covered with 0.5 or 2.0nm of Fe, Eu or Gd and finally covered with 2nm thick layer of Bi_2Te_3 . We expanded the scope of research on the analysis of Bi_2Te_3 films doped with (3d,4f)-metals, and heterostructures containing additional Bi or Te layer.

The response of a Bi_2Te_3 surface to the disorder introduced by a layer or dopant of Bi, Te, Fe and Eu was studied in terms of the electronic and crystallographic structure. The structural characterization was conducted in-situ using the RHEED and LEED diffractometers. The electronic structure studies were conducted in-situ at each step of the growth process using the X-ray photoelectron spectrometer. With the use of time of flight secondary ion mass spectrometer, we examined (ex-situ) the 2D micro- and 3D nanostructure of obtained heterostructures.

The results indicated that assumed layered structure was not preserved. Structural measurements of heterostructures formed from stack of Bi_2Te_3 /(3d, 4f)-metals/Bi_2Te_3 realized with the use of RHEED and LEED techniques indicated possibility of growth of monocrystalline 3d-metal, or textured polycrystalline 4f-matal on the surface of monocrystalline Bi_2Te_3 . By the XPS studies, we showed that the deposition of (3d, 4f)-metal films on bismuth telluride leads to its chemical instability and formation of the new phases between (3d,4f) and Te and separation of metallic Bi layer. The reaction at the TI-(3d, 4f) interfaces is taking place at room temperature, and it strongly depend on the thickness of linear layer. This should be taken into account during designing and fabrication of novel TI-based heterostructures or junctions, which presumably will have multiple applications in next generation electronic or spintronic devices.

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Superconducting Sr_2RuO_4 thin film growth with pulsed laser deposition

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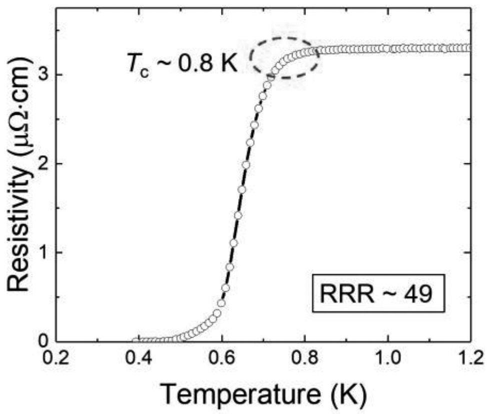
The layered perovskite superconductor Sr_2RuO_4 (bulk T_c ~ 1.5 K) has been studied extensively since it is considered as a strong candidate for p-wave superconductor with chiral gap function ($p_x \pm ip_y$) [1,2]. The possible topological superconductivity of Sr_2RuO_4 are interesting with not only the physical advances, but also providing fruitful device application such as quantum-computing circuits [3]. In this respect, Sr_2RuO_4 thin film has been highly required in order to enable Josephson junction for revealing odd-parity of Sr_2RuO_4 as well as realizing micro-fabricated devices. However, superconducting Sr_2RuO_4 film growth has been limited since the superconductivity of Sr_2RuO_4 is extremely vulnerable to structural impurity and stoichiometry. Especially, the Ru stoichiometry plays a crucial role to the superconducting transition temperature (Tc) of Sr_2RuO_4 film [4].
In this presentation, we will explain our superconducting Sr_2RuO_4 films growth by pulsed laser deposition (PLD) technique. We succeed to achieve epitaxial Sr_2RuO_4 films with high crystallinity, confirmed by synchrotron X-ray diffraction and transmission electron microcopy. Our Sr_2RuO_4 film exhibits superconductivity up to 0.8 K, which is comparable to the previously reported superconducting Sr_2RuO_4 films. Our work suggests a new method to obtain superconducting Sr_2RuO_4 film by PLD.



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P-0954 16:30-18:00, August 19 | Lobby (5F)

Nature of Giant Proximity Effect in MgB_2 Bilayer Fabricated by Ion Irradiations

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We investigate an origin of the giant proximity effect (GPE) in MgB_2 bilayers which are obtained by using low-energy ion irradiations. Ion irradiation is an effective way to create disorders in materials, therefore leading to a change in superconducting transition temperature (Tc) of superconductors. The T_c (~ 40 K) of MgB_2 thin films is significantly reduced to a few Kelvin by 140 keV Fe-ion irradiation, and superconducting volume fraction is also largely suppressed. However, interestingly, the decreased T_c is restored to the pristine T_c (~ 40 K) of MgB_2 films with an increase in the thickness of the non-irradiated MgB_2 (S) layer which is contacted with the damaged MgB_2 (S') layer by irradiations. The thickness of the S' layer is 10 times larger than the coherence length of the S layer, indicating the GPE between S layer and S' layer. The results on magnetization and resistivity of S' layer show that a small superconducting volume fraction with a high T_c ~ 39 K is still survived in the S' layer. In this presentation, we argue that the inhomogeneous local superconducting order parameter with large energy gap in the S' layer is the origin to enhance the length scale of proximity effect MgB_2 bilayers.

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P-0959 16:30-18:00, August 19 | Lobby (5F)

Violation of Ohm`s law in a Weyl metal

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Weyl metal is one of the topological non-trivial materials holding Weyl fermions which are massless and have a chirality. The Weyl metal has been described in terms of axion electromagnetism rather than in Maxwell electromagnetism, and has peculiar properties such as chiral anomaly, the presence of magnetic monopole in the reciprocal lattice space and negative longitudinal magneto resistance. In this presentation, by transportation experiment besides negative longitudinal magneto resistance, we observed ohm's law was broken in the Weyl metal and carried experimental and theoretical analysis of the violation of ohm`s law [1].

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P-0961 16:30-18:00, August 19 | Lobby (5F)

Pressure Dependent Study of Magnetism and Superconductivity in $U_2Pt_xRh_{1-x}C_2$

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[2]Los Alamos National Laboratory, USA

We report comprehensive x-pressure-temperature phase diagram of $U_2Pt_xRh_{1-x}C_2$ from electrical resistivity measurements for three kinds of doping(x = 0, 0.5, and 0.9) under pressure. x = 0 and 0.5 are antiferromagnets at 22.1 K and 9.4 K, respectively. Néel temperature of the both x = 0 and 0.5 is gradually decreasing with increasing pressure. However, only x = 0.5 shows that Néel temperature becomes zero Kelvin at 1.6 GPa (Pc), while that of x = 0 is continue to suppress up to our maximum pressure (2.6 GPa). At Pc, signature of enhanced quantum fluctuation is observed by analysis of temperature exponent n of resistivity and temperature coefficients A. Furthermore, x = 0.9 is a superconductor at 1.09 K, whose superconducting transition temperature is reduced by pressure. At ambient pressure, It still has large upper critical field (H_{c2} ~7 T). Application of pressure not only reduces superconducting transition temperature but also affects coherence temperature by localized f-electron with reduction of distance between uranium atoms.

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P-0971 16:30-18:00, August 19 | Lobby (5F)

Robust Ferromagnetism in Hydrogenated Graphene Mediated by Spinpolarized Pseudospin

Hyunyoung Kim[1], Junhyeok Bang[2], Joongoo Kang[1]*
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[2]Korea Basic Science Institute, Korea

The possibility of long-range magnetic order in graphene has been recently questioned by the experimental findings that point defects in graphene, such as fluorine adatoms and vacancies, lead to defect-induced paramagnetism but no magnetic ordering down to 2 K. It remains controversial whether collective magnetic order in graphene can emerge from point defects at finite temperatures. This work provides a new framework for understanding graphene's ferromagnetism, highlighting the key contribution of the pseudospin polarization as a "mediator" of longrange magnetic interactions in graphene. Using first-principles calculations of hydrogenated graphene, we found that the unique 'zero-energy' position of H-induced quasilocalized states enables notable spin polarization of the graphene's sublattice pseudospin. The spin-polarized pseudospin mediates long-range magnetic interactions between the H-induced magnetic moments, stabilizing the two-dimensional ferromagnetic ordering with Curie temperatures of $T_c = nH \times 34{,}000$ K for the atomic concentration nH of H adatoms. These findings show that atomicscale control of hydrogen adsorption on graphene can cause a robust magnetic order.
This work was supported by the DGIST R&D Program of the Ministry of Science and ICT of Korea (Grant No. 18-BT-02).
Keywords: graphene, ferromagnetism, Density functional theory

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Spin Valve Device on Spin-triplet Superconducting Sr_2RuO_4 for Observing Super Spincurrent

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Superconducting spintronics is a promising area because it can enhance the central effect of spintronics devices such as dissipationless spincurrent and colossal magnetoresistance. There have been many theoretical and experimental studies on superconducting and ferromagnetic junctions. We can say π-junction and superconducting spin valve. In addition, engineering spin-triplet Cooper pairs enables long-range proximity effects [1]. However, all the research is about spin-singlet superconductors. We are going to introduce a new spin valve platform on spin-triplet superconductors.
Sr_2RuO_4 is considered as the most promising spin-triplet superconductor. Half-height magnetization steps in Sr_2RuO_4 shows it has spin-triplet equal-spin pairings [2]. Equal-spin pairings can deliver a spin-polarized super-current called super spincurrent. A Spin valve device having the geometry of $SrRuO_3$/Sr_2RuO_4/$SrRuO_3$ (where $SrRuO_3$ is ferromagnetic material) was proposed to observe super spincurrent [3]. Andreev reflection at the interface between $SrRuO_3$ and Sr_2RuO_4 shows an inverse proximity effect, which will lead to spin-polarized Cooper pairs [4].
We are going to make a spin valve device on Sr_2RuO_4 single crystal. $SrRuO_3$ is deposited by pulsed laser deposition (PLD), which is characterized by X-ray diffraction and atomic force microscopy. Spin valve device is fabricated by UV or e-beam lithography, ion milling and e-beam evaporation.

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Self-field critical currents of FeSe and $NbSe_2$ nanosheets

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In this work we present the magnetic penetration depth of superconducting FeSe and $NbSe_2$ nanosheets using selffield critical current measurements.[1] FeSe and $NbSe_2$ are cleaved down to thickness below the reported value of penetration depth at absolute zero λ(0) and electrical contact is patterned by the graphene technique. From their temperature dependence of critical current density JC, we observe a clear kink in λ(T) of FeSe, including the multi-gap behavior, whereas $NbSe_2$ exhibits a dominant single-gap behavior. The estimated gap and penetration depth are consistent with previous results on FeSe and $NbSe_2$.[2,3] Pressure and doping dependence of penetration depth and gap will also be discussed.

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Investigation of Superconducting vortices using a Home-built low temperature magnetic force microscope

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Magnetic force microscope (MFM) has become an essential tool to investigate unconventional magnetic domains of topological magnetic materials as well as the strong antiferromagnetic nature of superconductors on the submicron scale. We have built low-temperature MFM, which operates at temperature down to 4 K and in magnetic field up to 6 T. We adopted optical fiber interferometry for sensing cantilever motion [1] and employed an x-y-z walker for coarse approach, an x-z fiber walker, and an x-y-z scanner, all of which are home-built. We show superconducting vortices images measured from several superconducting materials together with the magnetic penetration depth using our home-built MFM.

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Structure and Electric Transport Properties of Potassium under High Pressure of Hydrogen

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Hydrogen-rich materials with high phonon frequency are considered as strong candidates for high T_c superconductors. Based on the Ab initio study, metallic potassium is expected to exhibit a superconducting transition temperature in the range of 58.6 K to 69.8 K at 166GPa with a form of KH6 [1].

To synthesize hydrogen-rich samples, metallic potassium was reacted with hydrogen in a diamond anvil cell at high temperature. The structural data were measured at HPCAT of Argonne National Laboratory and PO.02 beamline of PETRAIII up to 80 GPa equipped with a laser-heating system. Ruby and gold were used for a pressure marker.

The results of X-ray diffraction data revealed that metallic potassium forms monohydride of an fcc structure with a lattice constant a =5.7 Å at relatively low pressure, and the structure transformed to bcc (a= 4.6 Å) near 4 GPa. After the pulse-laser heating above 60 GPa, the samples showed multiple structures of potassium polyhydrides as increasing pressure and temperature.

Our structural results are expected to provide a pathway to discover the hydrogen-rich superconductors and a large capacity of energy storage materials.

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P-1043 16:30-18:00, August 19 | Lobby (5F)

Quasiparticle energy and band gap of bulk and few-layer $PdSe_2$

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We studied the electronic band structure of $PdSe_2$ using the density functional theory (DFT) and the GW method. It is known that $PdSe_2$, a material with stacks of pentagonal layer structure, has a semiconducting band structure experimentally. However, DFT calculations show that bulk $PdSe_2$ has a semi-metallic band structure because of DFT underestimation of the band gap of the material. To obtain the band gap of $PdSe_2$ correctly, we calculated the quasiparticle band structure of bulk $PdSe_2$ using the one-shot GW method and obtained a band gap which is consistent with experimental results. Then we calculated the electronic structure of two-dimensional $PdSe_2$ to investigate the layer-number dependence on the energy gap. We discuss band-to-band transition energies and other physical properties obtained from band structures of $PdSe_2$.
This work is supported by the NRF of Korea (Grant No.2011-0018306). Computational resources have been provided by KISTI Supercomputing Center (Project No. KSC-2018-CRE-0097).

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P-1050 16:30-18:00, August 19 | Lobby (5F)

Role of Electric Fields on Electron Correlation in Surface-Doped FeSe

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Electron-doped high-T_c FeSe reportedly has a strong electron correlation that is enhanced with doping. It has been noticed that significant electric fields exist inevitably between FeSe and external donors along with electron transfer. However, the effects of such fields on the electron correlation are yet to be explored. Here we study potassium- (K-) dosed FeSe layers using density-functional theory combined with dynamical mean-field theory to investigate the roles of such electric fields on the strength of the electron correlation. We find, very interestingly, that the electronic potential-energy difference between the topmost Se and Fe atomic layers, generated by local electric fields of ionized K atoms, weakens the Se-mediated hopping between Fe d orbitals. Since it is the dominant hopping channel in FeSe, its reduction narrows the Fe d bands near the Fermi level, enhancing the electron correlation. This effect is orbital dependent and occurs in the topmost FeSe layer only. We also find the K dosing may increase the Se height, enhancing the electron correlation further. These results shed new light on the comprehensive study of high-T_c FeSe and other low-dimensional systems.
This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (Project No. KSC-2017-C3-0079). Y. W. C. acknowledges support from NRF of Korea (Global Ph.D. Fellowship Program NRF-2017H1A2A1042152).

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First-principles study of intrinsic anomalous Hall conductivity in transition metals

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We study intrinsic anomalous Hall conductivity (AHC) of 3d ferromagnetic materials such as Fe, Co and Ni, based on the noncollinear-spin density function theory (DFT) calculation including spin-orbit coupling. We implement the AHC calculation to the SIESTA code which uses localized pseudoatomic orbitals to expand electronic wavefunctions, and test the convergence of AHC with respect to various parameters of the DFT calculation including real-space grids and k-point grids. We also test the dependence of AHC on different types of pseudopotentials, exchange-correlation functionals, and pseudoatomic orbital basis sets. Since the electrostatic repulsion among 3d electrons is underestimated in the local density approximation or the generalized gradient approximation, we also consider the Coulomb interaction parameters, U and J, for 3d electrons and examine their influence on AHC values. We analyze the energy and momentum dependences of the Berry curvature, and compare our AHC values and their temperature dependence with previous theoretical results as well as experimentally measured results. This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (Project No. KSC-2018-CRE-0097).

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First-principles study of magnetism in doped $PdSe_2$ monolayer

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Doping induced magnetism in two-dimensional materials has drawn great interest. Previous density functional theory (DFT) calculations showed that decrease of the total number of electrons can induce Stoner-type ferromagnetism in $PdSe_2$ monolayer (ML) due to very high density of states near the valence band maximum. In our present work, we perform DFT calculations using virtual crystal approximations and supercell calculations to study dependence of magnetism in $PdSe_2$ ML on doping methods. We consider different atomic species of dopants and different spatial distributions of dopant atoms and analyze their effects on induced magnetic properties in $PdSe_2$ ML.
We discuss Stoner-type ferromagnetism and localized magnetic moments to understand magnetic properties in hole-doped $PdSe_2$ ML. This work was supported by NRF of Korea (Grant No. 2011-0018306) and KISTI supercomputing center (KSC-2018-CRE-0097).

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Magnetic interchain interactions through hydrogen bonds and π- π stacking in a series of pillared layered compounds

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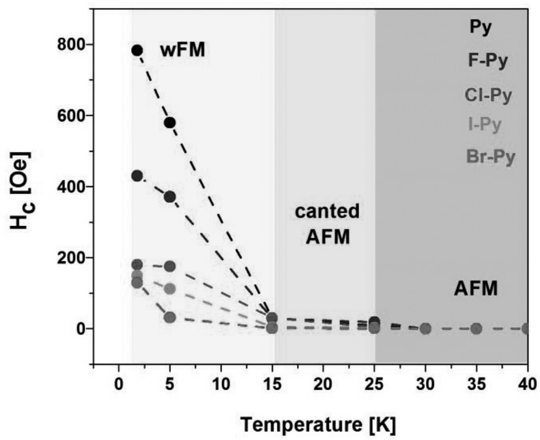
The intercalation of pyridine and its 3-substituted halogen derivatives (X-pyr) between layers of nickel tetracyanonickelate provides an example of magnetic interaction through π-π stacking. The intercalation process results in the formation of 3D solids with formula unit $Ni(X\text{-}pyr)_2[Ni(CN)_4]$. In the interlayer region, the intercalated molecules are coordinated to the axial positions for the external Ni. Neighboring molecules remain interacting through their dipole and quadrupole moments. For a coplanar configuration of their aromatic rings, the corresponding π-π clouds appear overlapped, which makes possible the appearance of a weak ferromagnetic interaction between Ni metal centers, to form an ordered system of magnetic chains separated about 10 Å. The halogen substituent in the pyridine molecule modulates the π-π clouds overlapping and, in consequence, the magnetic interaction through the chain. Such interaction coexists with a weak antiferromagnetic coupling between Ni atoms through the CN bridges in the 2D system, $\{Ni[Ni(CN)_4]\}$, but at low temperature, the interaction through the π-π clouds overlapping dominates. For the hybrid 3D inorganic-organic solids, $Ni(X\text{-}pyr)_2[Ni(CN)_4]$, an intrachain Isinglike canted anti ferromagnetic behavior was observed along the –Ni- $(X\text{-}pyr)_2$ – Ni- chains. Below 15K the weak ferromagnetic interaction along the chain dominates and it is confirmed by the appearance of a well-defined hysteresis loop in the magnetization curves vs magnetic applied field, and the divergence of the ZFC/FC curves, indicating the presence of an irreversibility temperature. This study reveals the role of the substituent atom in the magnetic interaction through π-π clouds overlapping.



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Giant magnetocaloric effect and low temperature properties of $NdPd_2Al_2$ compound

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The giant magnetocaloric effect (MCE) was investigated based on the magnetic entropy change (ΔSM(T)) estimated from the isothermal magnetization measurement. Maximum values of ΔS_M^{max} = 16.53 J/kg.K with the corresponding relative cooling power (RCP) / refrigeration capacity (RC) values of 160.3 / 125.7 J/kg were obtained for a field change of 7 T. The Arrott – plot indicates a first – order nature of the antiferromagnetic (AFM) transition. The low temperature properties were investigated through measurements of magnetic susceptibility, χ(T), magnetization, $M(\mu_0H)$, heat capacity, Cp(T) and electrical resistivity, ρ(T). The low temperature χ(T) and Cp(T) data indicate an anomaly associated with AFM phase transition at T_N = 3.2 and 3.1 K, respectively. χ(T) data above 100 K follows the Curie – Weiss behavior, given a Weiss temperature, θ_p = –8.5(6) K and an effective magnetic moment, μ_{eff} = 3.673(5) μ_B close to the value of 3.62 μ_B, expected for Nd^{3+}+ - ion. Above T_C, the ρ(T) variation is characteristic of electron – phonon interaction in the presence of s – d scattering and crystalline – electric field.

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Dy_2GaSbO_7: an unconventional spin-ice with enhanced zero-point entropy

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Geometrically frustrated pyrochlore with spin-ice properties has the peculiarity of Pauling zero-point 'residual' entropy, S_0 =1.67 J/K mol due to six fold '2-in, 2-out' spin-ice configuration out of sixteen possible configurations per tetrahedron unit, and therefore, the measured entropy becomes $\Delta S \approx 4.1$ J/(mol K) for a spin-1/2 frustrated system. Archetypal examples are Dy based pyrochlores, e.g., $Dy_2Ti_2O_7$, Dy_2NbScO_7, $Dy_2Sn_{2-x}Sb_xO_7$, which showed conventional spin-ice properties due to large magnetic moment of Dy^{3+} ions (hence possess large dipolar interactions) and strong crystal-field anisotropy. In this work, we showed that Dy_2GaSbO_7 has a spin-ice ground state that is similar to its titanate analogue $Dy_2Ti_2O_7$, but with enhanced zero-point entropy. We report here the measurements of dc and ac magnetization, and heat capacity of Dy_2GaSbO_7 at zero field. Curie-Weiss fit to the dc susceptibility yields positive Curie-Weiss temperature, $\theta_{CW} = 1.61$ K indicative of ferromagnetic nearest-neighbor interactions among Dy^{3+} ions and effective magnetic moment $\mu_{eff} = 10.013\ \mu_B$/Dy. The magnetization of Dy_2GaSbO_7 at 2 K saturates to the value of 5.06 μ_B/Dy, which is half of the effective moment of Dy^{3+} free ion. Isothermal magnetization data can be expressed by a local easy-axis anisotropy at Dy site along the local <111> D3d trigonal axes of the tetrahedral unit appropriate for an effective spin-1/2 system. AC magnetic susceptibility χac(T) data show distinct anomalies in its imaginary (χ") part at lower temperature, T_s ~3 K, indicating spin-ice-like freezing of Dy^{3+} ions in Dy_2GaSbO_7, as also observed in canonical spin-ice systems, e.g., $Dy_2Ti_2O_7$, Dy_2NbScO_7, $Dy_2Sn_{2-x}Sb_xO_7$ [1,2]. To further investigate the unique behavior of Dy_2GaSbO_7, the magnetic entropy has been determined after subtracting off the lattice specific heat from the zero field heat capacity data. The Schottky heat capacity is found to be negligible below 20K due to large gap (Δg ≈ 200K) between the ground and the first excited Kramers doublets of Dy^{3+} ion in Dy_2GaSbO_7. The magnetic entropy of Dy^{3+} at zero field reaches to 2.9 J/K mol around 15K, which is lower than the conventional spin-ice value. This reduction may be associated with the increase in residual entropy if we assume that any four (excluding six '2-in, 2-out' configurations) of sixteen configurations are energetically forbidden and hence only 12 configurations are available to the spins in tetrahedron. Consequently residual entropy becomes 2.88 J/(mol K) and hence the entropy recovered at zero field is $\Delta S = (5.76 - 2.88) = 2.88$ J/(mol K) which was observed above in the present case. Structural and crystal-field investigations showed that the observed deviation from the canonical spin-ice behavior for Dy_2GaSbO_7 may be attributed to its different axial distortion and chemical pressure effect at Dy site due to larger ($Ga^{3+}Sb^{5+}$) ions compared to its sister compound, $Dy_2Ti_2O_7$.

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Investigation of Microstructure and Magnetic properties of Epitaxial Permalloy on TiN Intermediate Layer

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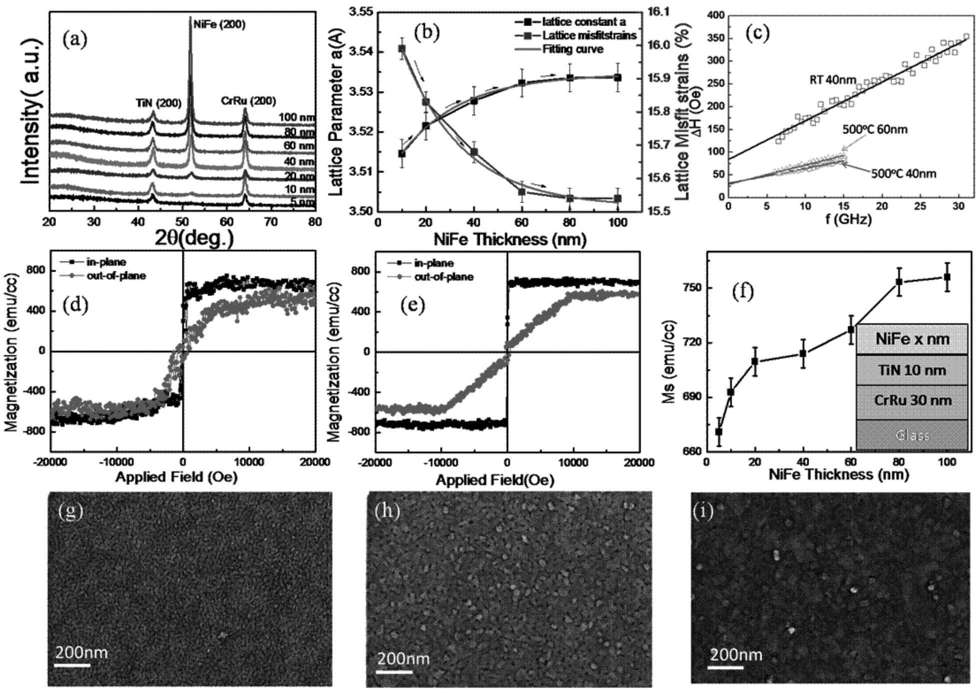
Permalloy is one of the most commonly used magnetic materials in ultra-low magnetic field sensor technologies, due to its high magnetic susceptibility, low coercive field and small magnetic anisotropy. For such applications, highquality epitaxial films are strong candidates since the film uniformity and the magnetic anisotropy are well controlled. In order to achieve this aim, great progresses have been made in the fabrication of permalloy thin films by selecting MgO(100) or $SrTiO_3$(100) single crystal, or polycrystalline underlayers such as Pd (100), Au (100), or Si(100) as the substrate to epitaxial grow permalloy. However, the results reported showed that all these underlayer/intermediate layer had some disadvantage. The objective of this work is introduced an appropriate intermediate layers for the growth of permalloy films with good (100) texture. $Ni_{80}Fe_{20}$ films with different thickness were fabricated on TiN 10 nm/CrRu 30nm/Glass by a magnetron sputtering system with a base pressure better than 2×10-8Torr, respectively, and the films structure are shown in Fig.1. It can be seen that all the $Ni_{80}Fe_{20}$ films exhibited (100) preferred orientation (Fig.1a). This is due to the epitaxial growth of the $Ni_{80}Fe_{20}$ on the (200) textured TiN intermediate layer.

The lattice constant aNiFe increased and the lattice mismatch between the$Ni_{80}Fe_{20}$ and TiN decreased, indicating the strain was relaxed with increasing $Ni_{80}Fe_{20}$ thickness. Moreover, the damping constant was measured using FMR, and the line width vs. frequency curve was shown in Fig.1c. All curves showed good linearity indicating that the method was well suited. It is well known that damping constant is proportional to the slope of the line width vs. frequency curve. After fitting, it can be seen that the (200) textured $Ni_{80}Fe_{20}$ had smaller damping constant of 0.0046 than that of disordered $Ni_{80}Fe_{20}$ (0.0127). Furthermore, all the samples exhibited in-plane magnetic anisotropy even for the 5nm $Ni_{80}Fe_{20}$ film (Fig.1d and e) and the magnetization increased with increasing the$Ni_{80}Fe_{20}$ thickness. These VSM results were consistent with the XRD results. The SEM results shows that with increase $Ni_{80}Fe_{20}$ thickness the morphologies of the$Ni_{80}Fe_{20}$ films changed from maze-like to continuous, which influenced the magnetic properties of $Ni_{80}Fe_{20}$ films. All these indicate the $Ni_{80}Fe_{20}$ films with good (200) texture and smaller damping constant could be obtained on TiN intermediate layer. This may offer a new method for fabrication of nanostructured $Ni_{80}Fe_{20}$ thin films for industry application.

Fig.1 XRD spectra (a), summaries of lattice parameter a and lattice mismatch (b), the line width vs. frequency curve in FMR (c), M-H loops (d, e) and summaries of magnetization (f), SEM images (g, h, i) of NiFe (x nm)/TiN/CrRu/glass films with different NiFe thickness, as well as the insert is the films structure, (d) for NiFe 5 nm, (e) for NiFe 60 nm, and (g) for NiFe 10 nm, (h) for NiFe 20 nm, and (i) for NiFe 60 nm.



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Experimental observation of the correlation between the interfacial Dzyaloshinskii–Moriya interaction and work function in metallic magnetic trilayers

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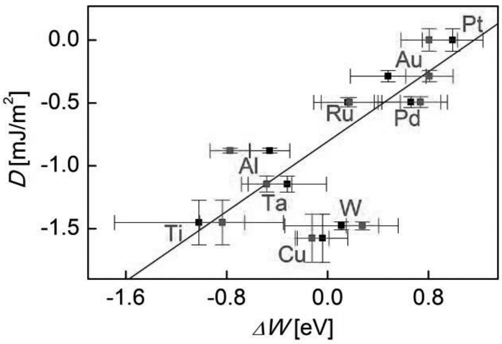
The Dzyaloshinskii-Moriya interaction (DMI) has been extensively studied due to academic interests and technological opportunity. It is found in multilayered structure that the DMI appears at interfaces with inversion asymmetry system, but detailed relation between the D, the strength of the DMI, and the nature of the interface remains elusive. Here, we show an experimental relation between the D and the work function difference ΔW of the materials at interfaces.

We fabricate a series of Pt/Co/X (X=Pt, Pd, Au, Ru, Al, Ta, W, Ti, and Cu) films. The films have the same structure except the upper layer material X, to compare the relative contribution of the upper Co/X interfaces. We obtain the D from spin torque efficiency measurement, and work function W from ultraviolet photoelectron spectroscopy.

The figure plots D with respect to ΔW(=WX-WCo), where WX, WCo are the work functions of material X and Co. The figure shows a noticeable correlation between D and ΔW. The present observation provides a guideline to design the film structure for optimal DMI.



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Low magnetic damping of ferrimagnetic GdFeCo alloys

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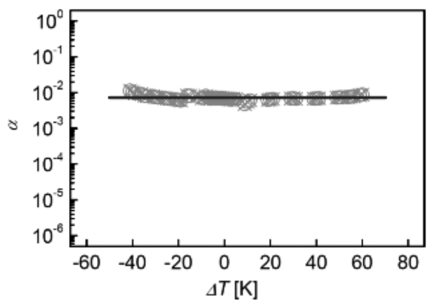
Magnetic damping, commonly described by the Gilbert damping parameter, represents the magnetization relaxation phenomenon, describing how quickly magnetization spins reach equilibrium. Understanding the fundamental origin of the damping as well as searching for low damping materials has been a central theme of magnetism research.

Several theoretical models for magnetic damping have been proposed and compared with experiments. However, the majority of these studies have focused only on ferromagnetic systems. We investigate the Gilbert damping parameter α for rare earth (RE)–transition metal (TM) ferrimagnets over a wide temperature range. Extracted from the field-driven magnetic domain-wall mobility, α was as low as 7.2×10^{-3} and was almost constant across the angular momentum compensation temperature T_A, starkly contrasting previous predictions that α should diverge at T_A due to vanishing total angular momentum (see Fig. 1). Thus, magnetic damping of RE-TM ferrimagnets is not related to the total angular momentum but is dominated by electron scattering at the Fermi level where the TM has a dominant damping role.



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Domain-wall-motion neuron device

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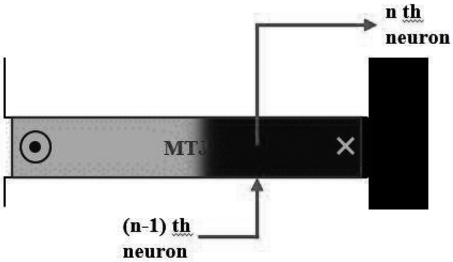
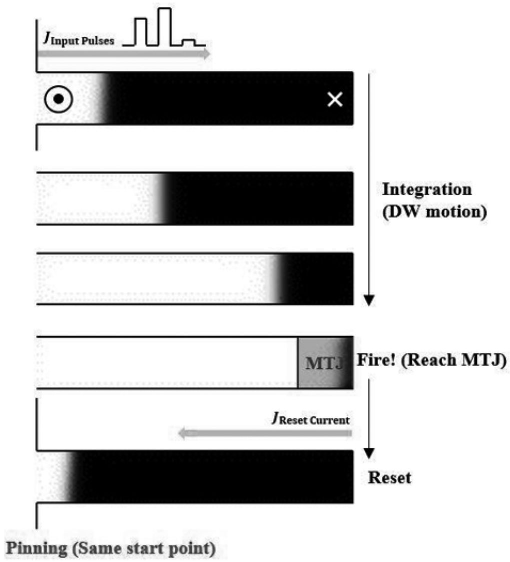
As artificial neural network (ANN) gains significant amount of attention with its promising applications in artificialintelligence fields, the necessity to decrease machine complexity rises. Since Von-Neumann architecture encounter size and complexity limitations due to its separated memory and processing units, a new architecture that imitates the biological neural network has been suggested – namely, neuromorphic architecture. The neuromorphic architecture consists of synapse and neuron units which independently can have memory and processing functions inside the units. To accomplish this, the weight-plasticity and the integrate-and-fire features for synapse and neuron units should be realized without additional memory units. The non-volatile memory feature and electric controllability of spintronic devices can fulfil this. The spintronic synapse unit utilizing domain-wall (DW) motion and magnetic tunnel junction (MTJ) has already been suggested [1]. Figure 1 shows the schematics of a domain-wallmotion synapse unit where the weight plasticity is realized by electrically controlled DW position which is detected via MTJ. Here, we introduce a new concept of a neuron unit also utilizing DW motion and MTJ. As in figure 2, the input pulses drive the domain wall through the wire. If the integrated input pulses are enough to reach the MTJ site, the neuron fires and the reset current drives the DW to the original pinning site to wait for the next cycle. Simple enough, this neuron unit can accomplish the integrate-and-fire function with DW position as non-volatile memory of integrated input pulses. Conclusively, we can configure all DW-motion synapse and neuron units which are possible candidates for future neuromorphic devices.





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Simulation of Magnetic Skyrmion Based AND Gate and NAND Gate

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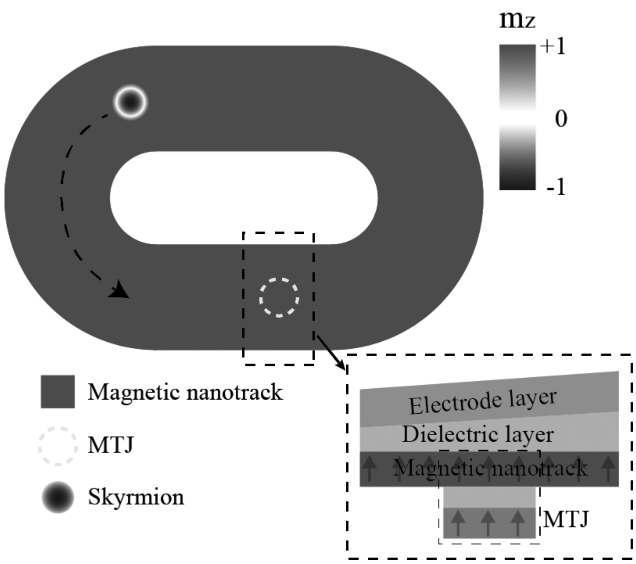
Magnetic skyrmion can be used as the basic unit of information coding for binary data, because of its nanosize and topological protection characteristics. Therefore, magnetic skyrmion can be used in next-generation memory and logic devices. At present, straight track structure is applied to skyrmion based logic device design. However, straight track structure may cause the skyrmion to stay in the nanotrack after the logic gate is operated, which may affect the subsequent use. In this work, a circular nanotrack structure is proposed. The periodic motion of magnetic skyrmion is driven by the gradient of voltage-controlled magnetic anisotropy gradient. (The structure is shown in Figure 1. The circular track is divided into three layers: the electrode layer, the dielectric layer and the ferromagnetic layer. The single skyrmion is generated in the ferromagnetic layer of the circular track. The skyrmion is periodically driven by the voltage in the nanotrack. The MTJ (Magnetic tunnel junction) is placed below the ferromagnetic layer for reading the skyrmion's status). In this way, AND and NAND logic are implemented based on this circular nanotrack structure and the implementation of logic functions are verified by micromagnetic simulation. The simulation results show that the logic gates with circular nanotrack structure have excellent repeatability, which provides theoretical guidance for the design of a new generation of skyrmion based logic devices.



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Bi dopant role in phase, structure, morphological and photoelectrochemical behavior of copper vanadate photocatalysts

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An ultimate aim of clean energy production by using low cost and efficient photoelectrodes via hydrothermal method was achieved. Synthesis of bare CuV_2O_6 monoclinic phase nanostructures and the phase changing mechanism of Bi dopant in CuV_2O_6 monoclinic phase and the conversion mechanism of $Cu_3(VO_4)_2$ anorthic phase from CuV_2O_6 monoclinic phase was revealed by XRD spectra. Other standard characterization techniques such as Raman, PL and FTIR studies were supported the result of XRD pattern. The band gap variations of two different phases and also the dopant and morphological effect on band structure of the synthesized copper vanadate nanostructures were examined in detail via UV spectra and Tauc plot results. The bare and Bi doped copper vanadate nanostructures were also confirmed by EDS spectra. Interestingly, three different diverse morphology of bare CuV_2O_6, 10% Bi doped $Cu_3(VO_4)_2$ and 20% Bi doped $Cu_3(VO_4)_2$ nanostructure as nanospheres, nano-net and nano flowers were investigated in detail with SEM and TEM results. The photoelectrochemical performance of the fabricated electrodes was analyzed by LSV, EIS, Mott-Schottky plot and CA studies under illumination and dark condition. The synergistic effect of nanoflower morphology, Bi dopant effect on $Cu_3(VO_4)_2$ phase showed the higher current density of 1.76 mA/cm2 in LSV with higher electronic conductivity. The lowest flat band potential achieved from Mott-Schottky plot also supported the PEC result of LSV for the 20% Bi doped $Cu_3(VO_4)_2$ nanoflowers. Long time stability of the same photoeelctrode for 5 h of illumination was reported. From these results, the phase and morphological changing mechanism of Bi dopant in copper vanadate nanostructures were proposed and the proficient electrode has been suggested for efficient photoelectrochemical water splitting applications.

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Estimating Interaction Parameters of Magnetic Structures Using Machine Learning Algorithm

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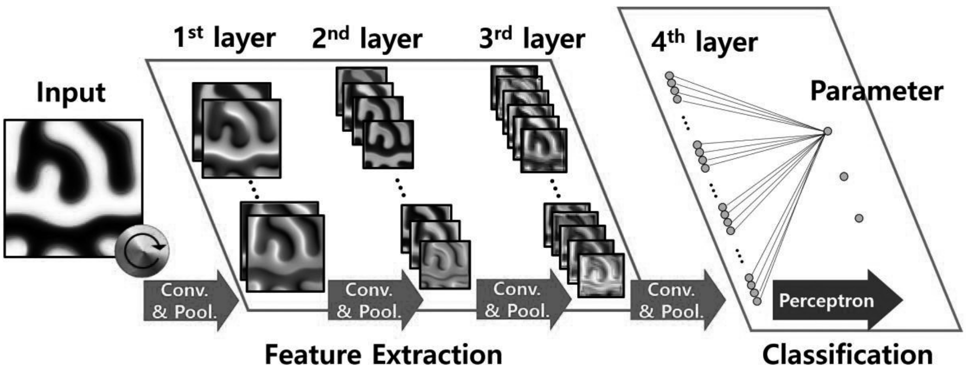
Computational simulation methods are widely used to study complicated magnetic structures generated under various interactions such as dipole interaction and DM interaction. The interaction parameters of the computational simulation should be searched in order to explain experimental results. We used machine learning algorithms to obtain interaction parameters. First, training data sets of simulated spin configurations were generated through Monte-Carlo method, and they were used to train Fully Connected Neural Network (FCNN) and Convolutional Neural Network (CNN). We obtained magnetic parameters of magnetic structures which had been experimentally observed from SPLEEM. FCNN, the simplest network model, shows good estimation for the true magnetic parameters, and the results from CNN become more accurate. The figure shows that the features of magnetic structures were successfully extracted by CNN.



<Figure> The structure of Convolutional Neural Network

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Comparison of hole and electron doping in $Sm_3Ba_5Cu_8O_{19}$

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The path to increase the superconducting transition temperature is one of the interesting subjects in the field of superconductivity. For this purpose, manipulating the structure of a known compound such as YBCO is one possible scenario, which suggests a possible increment of 10 K in the transition temperature of this family of Cuprates ($R_3Ba_5Cu_8O_y$) [1]. However, it seems that the preparation of pure $R_3Ba_5Cu_8O_y$ is somehow a challenging task. There are some reports that argue that the transition temperature of $YBa_2Cu_3O_7$ and $Y_3Ba_5Cu_8O_y$ compounds and the corresponding X-ray spectrums are almost the same. On the other hand, a density functional calculation has been shown that $Y_3Ba_5Cu_8O_{19}$ is a stable compound [2]. But this compound can easily decompose to the $YBa_2Cu_3O_7$ and $YBaCu_2O_5$ phases by absorbing a small amount of energy (~ 45 meV) under the standard preparation conditions, such as the solid-state reaction or sol-gel method. In addition, the $YBaCu_2O_5$ itself may decompose to the $YBa_2Cu_3O_7$ phase. As a result, formation of the dominant $YBa_2Cu_3O_7$ phase and therefore reduction of the transition temperature is unavoidable during the synthesis process of $Y_3Ba_5Cu_8O_{19}$. Therefore, investigation of the corresponding doped samples may be helpful to discriminate the $R_3Ba_5Cu_8O_y$ and RBa2Cu3Oy phases.

Here, we have tried to synthesise the $Sm_3Ba_5Cu_8O_{19}$ and $SmBa_2Cu_3O_7$ compounds by the same preparing conditions.

The transition temperature of the prepared compounds seems to be identical. Then, the authors tried to compare the effects of the same percentage of Pr doping on the properties of these compounds. The results suggest that superconductivity is destroyed in the range of (30%, 40%) doping in both compounds. Similar to the case of $SmBa_2Cu_3O_7$, the transition temperature of $Sm_{3-x}Pr_xBa_5Cu_8O_{19}$ compound reduces with the increasing amounts of praseodymium almost linearly. This linear behaviour is similar to the reduction of transition temperature due to the presence of paramagnetic impurities [3]. Therefore, the Abrikosov-Gorkov pair-breaking theory has been used to estimate the exchange interaction constant for this compound. This result is similar to the case of the $SmBa_2Cu_3O_7$ compound [4]. On the other hand, the hole doping of $Sm_{3-y}Ca_yBa_5Cu_8O_{19}$ only shows a reduction in the transition temperature in the range of $0< y \leq 0.3$ and then transition temperature saturates to 80 K. Also, to compare the effects of the hole or electron doping on the structure of $Sm_3Ba_5Cu_8O_{19}$, the X-ray spectra of some of the $Sm_{3-x}Pr_xBa_5Cu_8O_{19}$ and $Sm_{3-y}Ca_yBa_5Cu_8O_{19}$ compounds has been presented. The results suggest that the electron-doping is more destructive for the superconducting properties of the $Sm_3Ba_5Cu_8O_{19}$ compound.

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Critical behavior of the cooperative Jahn-Teller distortion in ultrathin $LaMnO_3$ films

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The orbital degree of freedom has played a significant role in determining the electronic and magnetic properties by means of double or super-exchange interactions in manganites [1-3]. In particular, $LaMnO_3$ (LMO) has attracted attention as the parent compound of colossal magnetoresistance materials [3] as well as a canonical system of orbital ordering accompanying the cooperative Jahn-Teller distortion (CJTD) below ~750 K [4,5]. The CJTD of a MnO_6 octahedron lifts up the degeneracy of eg orbitals in Mn^{3+} ($t_{2g}^3e_g^1$), and $3x^2$-r^2 /3_y^2-r^2 orbitals are alternatingly occupied within the orthorhombic ab-plane harmonizing with the CJTD leading to the ($\pi\pi$0) order [4-6]. At low temperatures below T_N ~ 140 K, an A-type antiferromagnetic spin alignment is stabilized in which ferromagnetic planes are stacked antiferromagnetically via the super-exchange interaction [7, 8]. For hole-doped LMO thin films, many researchers have studied physical properties by controlling thickness, and they have found critical thickness below which ferromagnetic and metallic phase becomes suppressed [9]. In this study, we have investigated on the film thickness dependence of the CJTD in ultrathin LMO films. The high quality LMO thin films are grown by using pulsed laser deposition and orbital orderings accompanied by the CJTD are identified by resonant x-ray scattering. We present the minimum film thickness for having the orbital ordering. Our finding provides useful insight into the CJTD at reduced dimension and the relation between orbital ordering and CJTD.

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Indirect estimates of the magnetocaloric effect in manganites according to the thermophysical measurements

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As it is known, manganites are bright representatives of strongly correlated electronic systems in which there is a close connection between the electronic, magnetic and lattice subsystems [1-4]. This means that the parameters characterizing the state of one of the subsystems will correlate with the parameters of the other two. Any external influence (magnetic field, pressure, etc.), leading to a change in the magnetic state of the system near the temperature of the magnetic phase transition leads to a change in the parameters describing these subsystems (electrical resistance, magnetization, heat capacity, magnetostriction, etc.). Striking examples of changes in these parameters in manganites in a magnetic field are the effect of colossal magnetoresistance, a giant magnetocaloric effect, a giant magnetostriction, etc. The idea of this work is that in manganites, a change in the spin state in a magnetic field near the TC leads not only to the appearance of the CMR effect, MCE, and giant magnetostriction, but also to a change in electro- and heat transfer mechanisms due to a change in scattering mechanisms [1-4]. This is due to the change in the spin-phonon interaction in the magnetic field near the transition temperature FM-PM. Therefore, according to changes in resistivity, thermal conductivity, thermal diffusivity in a magnetic field, it is possible to qualitatively establish a connection between the parameters describing the magnetic subsystem and kinetic coefficients.

This paper presents the results of an analysis of the relationship of the magnetocaloric effect with the thermophysical parameters of the Pr0.7Sr0.2Ca0.1MnO3 manganite.

To estimate ΔS in PSCMO manganite, were used both classical methods (according to the magnetization data M(T, H), specific capacity C_P(T, H) and ΔT(H, T)) and the results of the study of magnetostriction Δε(H, T), resistivity ρ(H, T), thermal diffusivity η(H, T) and thermal conductivity κ(H, T). The results of our studies show (Fig. 1) that, whatever the real mechanisms leading to the anomalies of the parameters studied near TC, changes in these parameters in a magnetic field allow us to estimate the magnetocaloric effect.

Acknowledgement

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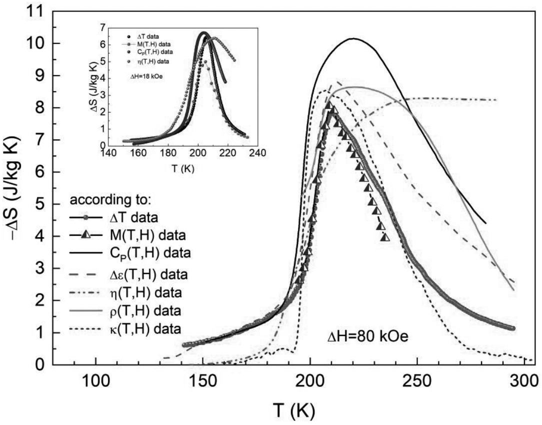

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$La_{0.7}Ca_{0.3}Mn_{1-x}Sc_xO_3$ (x= 0.0; 0.03, and 0.05) manganites: hybridization of electronic state, valence and magnetic properties

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Electron structure and magnetic properties of $La_{0.7}Ca_{0.3}Mn_{1-x}Sc_xO_3$ (x= 0.0; 0.03, and 0.05) perovskites were studied by x-ray absorption spectroscopy at Mn K- and L-edges, and at O K-edge, and with the x-ray diffraction and magnetization measurements. With x increase the Curie temperature (Tc) decreases and lattice parameters increase because of the different electron configuration and radii of trivalent manganese and scandium ions. Fourier transform of the EXAFS spectra shows a change of local crystal structure caused by the larger Sc^{3+} than the Mn^{3+} ions. The Tc decrease is attributed to the change of level of hybridization of O 2p and Mn 3d states. This is manifested by the parallel shift of O K-edge, change of intensity of Mn L3(2p3/2) and L2(2p1/2) spectrum lines and TC with x increase. No change of the Mn K-edge was observed indicating no change in average manganese valence even the substitution of Sc^{3+} ions for the Mn^{3+} ions leads for decrease of the formal manganese valence from 3.3 (at x=0.0) to 3.15 (at x=0.05) causing the essential decrease of the TC. The similar result was observed at studying the vacancy-doped $La_{1-x}MnO_{3+\delta}$ oxides where the formal manganese oxidation state and TC changed with x increase but Mn K-edge position showed the tiny change only [1,2]. Notable, in $La_{1-z}Ca_zMnO_3$ oxides the Mn K-edge position shifts for about 4.0 eV and TC increases for a few ten degrees at changing of Mn valence state from Mn^{3+} to Mn^{4+} with increase of z-value from zero to unit [3,4]. The results show a difference in manifestation of the change of formal/observed manganese valence and TC at hole doping, and of the vacancy-doping and B-site substituting in perovskite-like manganites. Note, a change of Mn K – pre-edge spectra in $La_{1-z}Ca_zMnO_3$ [4] and $Pr_{0.67}Sr_{0.33}MnO_3$ [5] oxides were observed with increase of z and temperature, respectively. This was attributed to the change of hybridization between Mn 3d and 4p orbitals. At the same time, no change at the Mn K-pre-edge spectra was revealed at present research.
The reported study was funded by Russian Foundation for Basic Research (RFBR) according to the project No. 18-08-01071 A. The authors are also indebted to N.Yu. Starostyuk for the help at preparing the samples.

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Enhanced non-Ohmic conduction in exfoliated La0.7Ca0.3MnO3 thin films

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We present a significantly different transport characteristic of the exfoliated La0.7Ca0.3MnO3 dead layer from its strained counterpart. One can exfoliate the La0.7Ca0.3MnO3 film by growing a water-soluble sacrificial layer of Sr3Al2O6 between SrTiO3 substrate and La0.7Ca0.3MnO3 film. We discover that the exfoliated film displays a large electroresistance over a wide range of temperatures. The drastic change in resistance appears to come from direct tunneling through antiphase boundaries, the effect of which is magnified due to revived phase separation in the exfoliated film. Our results suggest a possible reduction of the dead layer in the exfoliated membrane, which indicates a hitherto unexplored avenue to overcome the serious hurdle of the dead layer in making ultrathin nano device.

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Optical investigation of a layered ferromagnetic semiconductor $CrSiTe_3$ by spectroscopic ellipsometry

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Discovery of graphene invoke a great interest in two-dimensional (2D) materials, and the members in this family have been growing since, showing a broad range of optical and electronic properties. Recently, layered CrI_3 and $CrMTe_3$ (M = Si and Ge) have attracted considerable attention because of the absence of itinerant electrons which help to stabilize the ferromagnetic (FM) order down to the extreme 2D limit.[1, 3] The $CrMTe_3$ are semiconductors and undergoes a paramagnetic (PM) to FM order change at ~ 33K and ~ 60K, respectively. In this work, we have investigated the temperature evolution of the optical properties of a CrSiTe3 single crystal using spectroscopic ellipsometry. At room temperature, CrSiTe3 has an indirect band gap, Eig ~ 0.64 eV, and direct band gap, E_{dg} ~ 1.01 eV. The E_{dg} shows the usual lattice dilation effect due to temperature variation. On the other hand, Eig shows an unusual evolution with decreasing temperature. E_{dg} increases from 300 to 200 K due to lattice dilation effect, remains almost flat from 200 to 50 K and decreases abruptly from 0.88 to 0.63 eV across the paramagnetic to ferromagnetic transition. This suggests that ferromagnetic order renormalizes the electronic structure which lowers the conduction band and reduces the indirect gap. Our results provide a clear insight into the correlation between magnetic order and electronic band structure of $CrSiTe_3$.

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Measurement of DW width and Exchange Stiffness with DW motion

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Domain wall (DW) motion of ferromagnetic wires with perpendicular magnetic anisotropy (PMA) got great attention due to its possibility for utilize for new type of memory and logic devices. Many studies have devoted to optimize the DW motion for application [1,2]. Also properties of magnetic material such as domain wall width λ and exchange stiffness A are important to improve the DW motion. In this study, we provide λ and A with thickness of magnetic layer by measuring domain wall motion. For this study, 5.0-nm Ta/3.0-nm Pt/t_{Co} Co/1.5-nm Pt films with PMA are made by dc magnetron sputtering. Here, t_{Co} is thickness of Co layer sputtered as 0.27, 0.33, 0.52, 0.65, 0.78, and 1.17 nm. Also 10 μm-wide micro strips are patterned by photo lithography. λ is obtained by domain wall demagnetizing field HD, which can be approximated as HD ≅ $(2\ln 2/\pi^2)M_s t_{Co}/\lambda$ [3,4]. Here, HD can be obtained by measuring spin orbit torque efficiency εSOT with in-plane magnetic field H_x. ε_{SOT} is measured by observing domain wall motion by injecting electric current and magnetic field [4]. The A will be achieved from DW energy density σ0 by measuring uniaxial magnetic anisotropy K_u in further research.

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Manipulation of charge density waves in Niobium dislenide: a hierarchy change

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We report on a hierarchy change of charge density waves in Niobium diselenide ($NbSe_2$) in the presence of atomic adsorbates, by means of <it>ab-initio</it> calculations. Starting from the most favoured, the triangular hollowcentred, the triangular chalcogen-centred and the hexagonal structures are found in the clean limit, in agreement with the literature, whereas with adsorption of Co and Mn, we find that two solutions related to the hexagonal structure are favoured, a symmetric one and an asymmetric one. In the asymmetric solution, we analyse how the charge distribution changes in direct and reciprocal space, proposing a connection to a recently observed stripe phase in NbSe2 [1].

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Under Pt-Layer Thickness dependence of the Dzyaloshinskii-Moriya Interaction in Pt/Co/Pt Films

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The Dzyaloshinskii-Moriya Interaction (DMI) has received a substantial attention owing to its possibility to state-ofthe-art application of magnetic memory and logic devices [1]. It has been known that the DMI attributes to the structural inversion asymmetry in ferromagnetic film [2]. Therefore, the DMI strength of ferromagnetic film with symmetric structure, such as Pt/Co/Pt film, is expected to be negligible. Interestingly, however, the strong DMI is observed in Pt/Co/Pt film, with narrow thickness of the under Pt layer t_{Pt}^{Under}. Moreover, it is also observed that the DMI changes sensitively depending on t_{Pt}^{Under}. To systematically analyse the role of t_{Pt}^{Under} on the DMI, 5.0-nm Ta/t_{Pt}^{Under}-nm Pt/0.3-nm Co/1.5-nm Pt films were fabricated on a Si/100-nm SiO2 substrate by using dc and ac magnetron sputtering, where t_{Pt}^{Under} varied from 1.8 nm to 5.0 nm. All films exhibited perpendicular magnetic anisotropy and clear domain-wall motion under the out-of-plane magnetic field. The DMI-induced effective field HDMI was then measured by using magneto-optical Kerr microscope equipped with in-plane and out-of-plane electromagnet [3]. Interestingly, HDMI decreases as t_{Pt}^{Under} increases and then, finally saturates to zero. We experimentally demonstrated that the morphology of the under Pt/Co interface becomes more similar to upper Co/Pt interface, as tPt

Under increases, which results in approach of HDMI into zero. The detailed analysis will be discussed in the presentation. We expect that our present observation may provide a deep understanding of DMI and guideline for an optimal design of film structure in the presence of DMI.

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Excitation of multiple spin-wave modes and their critical angles in a photonmagnon coupled system

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Magnons, as quanta of collective dynamic modes of individual magnetization vectors, represent the eigenstates of spin-wave (SW) modes excited in ordered magnets such as ferro-, ferri-, and anti-ferromagnets. In particular, spinwaves of wavelengths lying within the micrometer-to-millimeter range, the so-called magnetostatic spin-waves (MSWs) [1], can propagate over long distances in low-damping magnets e.g. yttrium iron garnets (YIG). Therefore, magnonics has been attracting significant interest owing both to novel underlying physics of MSWs and their potential applications to information processing technologies. When the external magnetic field is applied with a particular angle respect to the film plane and the wave vector, only the uniform mode resonance peak appears as a single resonance, referred as the critical angle effect [1,2]. Despite many theoretical and experimental studies of the critical angle for in-plane magnetized film, the critical angle effect for the external magnetic field changed from parallel to perpendicular to the film has been inconclusive. Also, the search is still ongoing for an alternative and easy method to excite and probe higher-order SW modes with arbitrary magnetic-field configurations due to the limitation in experimental arrangement and detection of low intensity of spin-waves.

In the present work, we explored multiple spin-wave modes excitation for different magnetic-field directions spanning all of the solid angles with enhanced gains due to photon-magnon interaction [3] in an YIG film coupled to inverted split-ring resonator (ISRR) at room temperature. An effective and convenient method of the simple scattering parameter measurement of a planar YIG/ISRR hybrid sample with rotatable electromagnets was used for observation of multiple spin-wave modes to be excited in the YIG film. The coherent photon-magnon coupling gives rise to a strongly modified spectrum when spin-waves are near the ISRR resonance, as indicated by the anti-crossing features in the measured transmittance spectra. Representative pure spin-wave modes and their mixture as well as a phase diagram of the multiple spin-wave mode excitations on solid angles were explored. The critical angles at which zero group velocity was obtained were analytical derived, which agreed with the experimental observations. The results provide understanding of the critical angle in the spin-wave transition with varying the external magnetic field angle and show its application to the quantum computing devices as well as spin-wave devices.

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P-0501 16:30-18:00, August 22 | Lobby (5F)

Numerical Analysis for the Phase Diagrams of High-Tc Superconductivity Based on U(1) and SU(2) Slave-Boson Approaches to the t-J Hamiltonian

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One of the major theoretical challenges in high-Tc superconductivity is to reproduce the observed phase diagrams which display the monotonously decreasing pseudogap temperature and the dome shaped superconducting transition temperature in the plane of temperature vs. hole concentration. Earlier Lee and Salk [Phys. Rev. B 64, 052501 (2001); ibid. 71, 134518 (2005)] reported a successful reproduction of the phase diagrams by introducing a realistic slave-boson approach to the Heisenberg term in the t-J Hamiltonian. More recently, Shin et.al. [J. Supercond. Nov. Magn. 23, 637 (2010)] presented both the temperature and the doping dependencies of magnetic susceptibility and spin pairing correlations involved with spin dynamics in high-Tc superconductivity in good agreement with the inelastic neutron scattering measurements. Most recently, Salk [Quantum Studies: Mathematics and Foundations 5, 149 (2018)] reported a detailed study with emphasis on the physics of high temperature superconductors. In addition, highly plausible room temperature superconductivity was proposed by demonstrating that the higher, the antiferromagnetic coupling strength J, the higher, the superconducting transition temperature Tc. Here we present a hither-to-less studied numerical analysis of the phase diagrams, specifically paying attention to the comparison of the slave-boson approach of U(1) gauge symmetry with that of SU(2) gauge symmetry for the t-J Hamiltonian.
Judicious comparison between the two approaches will be made by adding studies of both spin and charge dynamics referring spin susceptibility and optical conductivity respectively.

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P-0503 16:30-18:00, August 22 | Lobby (5F)

Artifact-free optical spin-orbit torque magnetometry

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Current control of magnetization via the spin-orbit torque (SOT) has opened a new horizon for magnetic memory devices. SOT causes magnetization switching and domain wall motion that enable read/write operations in spintronic memory devices. For more efficient operation of such spintronic devices and further investigation of underlying SOT mechanisms, a precise and artifact-free SOT quantification method is required. In this circumstance, however, planar Hall effect (PHE) and anomalous Nernst effect (ANE) signals complicate SOT analysis in the electrical harmonic measurement method. Our optical setup utilizes photoelastic modulation (PEM) and balanced detection (BD) to measure the polar magneto-optic Kerr effect (pMOKE) signal exclusively. We demonstrate an optical SOT measurement scheme that is free from artifacts such as the optic PHE and optic ANE

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Magneto-dielectric properties of spinel ferrites ($Ni_{0.5}Zn_{0.5}Fe_2O_4$) epoxy composites

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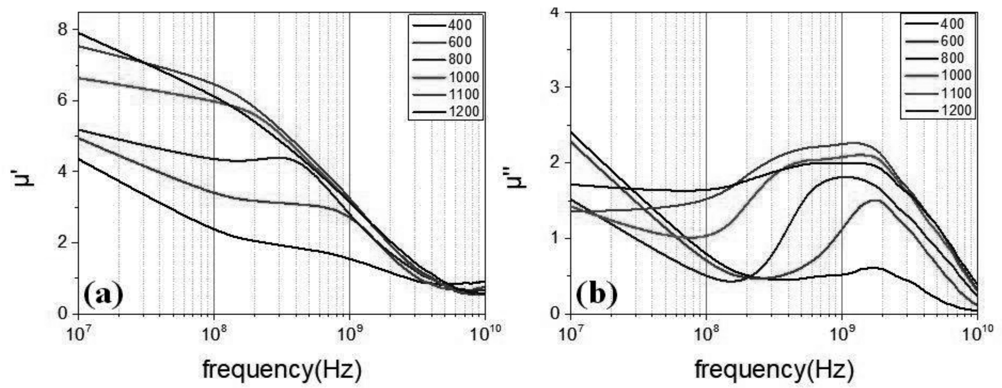
Soft magnetic Ni-Zn spinel ferrites have been widely used in electromagnetic devices, such as telecommunication, microwave devices due to their suitable magnetic and dielectric properties at high frequency. The tuning of the magnetic and dielectric properties of the spinel ferrites suitable to the high frequency applications is essential to the material research and development.

In this research, Ni0.5Zn0.5Fe2O4 spinel ferrites were prepared by sol–gel auto combustion technique using precursors of $Ni(NO_3)_2$• $6H_2O$, $Zn(NO_3)_2$• $6H_2O$, and $Fe(NO_3)_2$• $9H_2O$. The as-burned powders were fired in a furnace at the temperatures of 400 ºC, 600 ºC, 800 ºC, 1000 ºC, 1100 ºC, and 1200 ºC for 4 h in air. Then, the respective powders were mixed with epoxy binder (10 ~ 20 wt %) and pressed into toroidal shapes, which were finally cured at 180 ºC 1h in air. Single cubic spinel phase were confirmed by X-ray diffraction (XRD) analysis. Scanning electron microscope (SEM) was used for the microstructure observation. The frequency dependence of complex permeability, μ = μ' - j μ" and complex permittivity, ε = ε' - j ε" were measured by using a vector network analyzer (100MHz to 10GHz). With increasing the firing temperature, the height of μ' and μ" spectra increased and the peak of μ" spectra was broaden as shown in Fig. 1. The real and imaginary part of permittivity ε′, ε″ of the composites were almost constant in the full measured frequency range. The values of ε′= 4~7 and ε″ = 0 ~ 0.3, respectively. The effect of epoxy weight fraction and graphite addition on the permittivity and permeability properties will be also discussed.



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The magneto-dielectric properties of Z-type hexaferrites ($Sr_3Co_{2-x}Zn_xFe_{24}O_{41}$) epoxy composite

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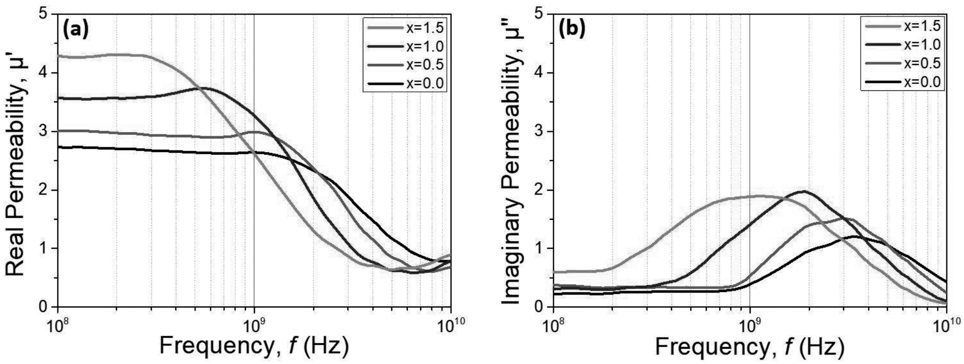
Among the six different types of hexaferrites, Z-type hexaferrites are one of the suitable materials for GHz frequency range electromagnetic wave absorber or antenna miniaturization applications owing to their suitable magnetic and dielectric properties. Thus, modulating of the permeability and permittivity properties in the frequency range of GHz is very important. In this researches, Z-type hexaferrites ($Sr_3Co_{2-x}Zn_xFe_{24}O_{41}$, x = 0, 0.5, 1.0, 1.5) were synthesized by solid-state reaction routes. Almost pure Z-type hexagonal phase could be obtained after sintering at 1210 °C for 2 h in air. The grinded powders were mixed with epoxy binder (10~20 wt%) and pressed into toroidal shapes, which were finally cured at 180 °C 30 minute in air. Phase and microstructure were analyzed by XRD and SEM, respectively. The M-H curves were measured by using vibrating sample magnetometer (VSM). The frequency dependence of complex permittivity and permeability (100 MHz to 10 GHz) of the samples were measured on the toroidal samples by using a vector network analyzer. When the Zn substitution x increased up to x =1.5, both of the real (μ') and imaginary part (μ") of permeability spectra of the composites shifted to low frequency direction with increasing the height of both μ' and μ" spectra. The real and imaginary part of permittivity ε', ε" of the composites were almost constant in the full measured frequency range. The values of ε' = 8 ~ 11 and ε" = 0 ~ 2, respectively. Besides, the effect of epoxy binder weight fraction, graphite powder addition on the permeability and permittivity spectra will be discussed.



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Electrical Transport Properties of PLD Grown YBa2Cu3O7-x/Sm0.55Sr0.45MnO3 Superconductor-Ferromagnetic Thin Films

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Interaction between superconductivity (SC) and ferromagnetism (FM) has been studied through electrical transport measurements in composite thin films of phase separated manganite Sm0.55Sr0.45MnO3 (SSMO) and superconductor YBa2Cu3O7-x (YBCO). The composite thin films having nominal composition (YBCO)0.90(SSMO)0.1 were deposited on single crystal MgO (100) substrate by pulsed laser deposition with KrF laser (=248 nm) at 4 Hz repetition frequency, with an energy density ~1.2 J/cm2. The deposition temperature was maintained at 750 ºC under the oxygen pressure of 80 mtorr. The deposited composite thin films were characterized by high resolution xray diffraction (HRXRD) and temperature dependence resistance (R-T) and IV measurements. HRXRD shows oriented growth of YBCO as the dominant phase and very weak presence of SSMO as evidenced by the presence of low intensity diffraction peak. For the reference we also prepared SSMO and YBCO thin films as well studied the electrical transport on the composite target also. The R-T data of pure SSMO film shows insulator to metal transition in cooling and warming cycle TIMC ≈ 98 K & TIMW ≈ 101 K respectively. The normal state conductivity is also lowered with a concomitant broadening of the SC transition and Tc depression. The pure YBCO film shows the typical critical temperature Tc (R=0) ~ 82 K (Fig. 1b, solid curve) whereas the composite (YBCO)0.90(SSMO)0.1 film shows a strong depression of superconductivity with much lower Tc ~ 50 K (Fig. 1b, open symbol-blue curve). The depression of superconductivity is also supported by the temperature dependent IV and hence the critical current (IC) measurements. From the strong suppression of the IC values in the composite thin film (Fig. 1c), the antagonistic effect of ferromagnetism is evident. The IV measurements also reveal that an intermediate state where both SC and FM coexist appears between the normal and the superconducting states. The observed phenomenon is explained in terms of the interplay between the FM phase that exists at T<TC~100 K with the SC phase which nucleates at ~90 K in YBCO.

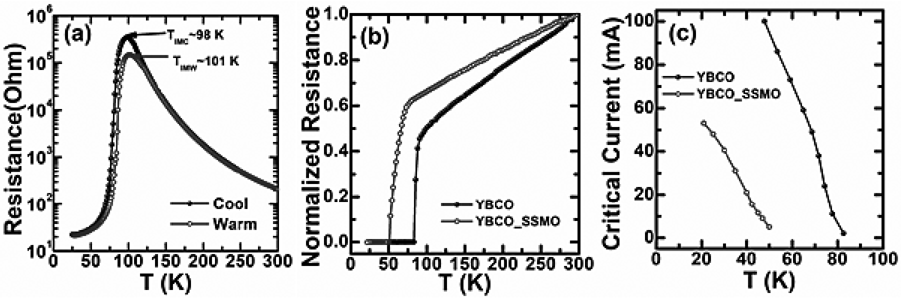

Figure 1: Temperature dependence of resistance of (a) the pure SSMO film. The R-T of the YBCO and the $(YBCO)_{0.90}(SSMO)_{0.1}$ film on MgO (b). The temperature dependent critical current data of YBCO and $(YBCO)_{0.90}(SSMO)_{0.1}$ film (c).

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Magnetic and magnetocaloric properties of RM_2 Laves phases compounds (R = Er, Tb, Ho and M = Fe, Co, Mn)

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RT2 type intermetallic compounds (where R = rare earth, T = transition metal) have been intensively studied for more than 3 decades for their distinct and complex magnetic behaviors. These materials have taken a special interest in the research of new magnetic devices for application in magnetic refrigeration based on the magnetocaloric effect. The interesting magnetic performances of such compounds are due to the combination of the complementary characteristics of 3d itinerant and 4f localized magnetism.

In this work, magnetic and magnetocaloric effect (MCE) properties of the $R(Fe_{0.125}Co_{0.875})_2$ Laves phases compounds (R=Er, Tb and Ho) have been investigated. X-ray diffraction (XRD) analysis revealed that these compounds crystallize in the C15 type Laves phase structure, with Fd-3m Space Group. The magnetization curves indicate a ferrimagneticordering induced by computational interactions between the magnetic moments of the rare-earth and those of transition element. The transition temperature (TC) was determined using the dM/dT curves and was found to be 245K for $Er(Fe_{0.125}Co_{0.875})_2$, 270K for $Ho(Fe_{0.125}Co_{0.875})_2$ and 410K for $Tb(Fe_{0.125}Co_{0.875})_2$. MCE was calculated according to the Maxwell relation based on isothermal magnetization measurements. A maximum value of magnetic entropy change (-ΔSM) under a magnetic applied field of 5T was found to be 2.7 Jkg−1K−1 for $Er(Fe_{0.125}Co_{0.875})_2$. We studied also the substitution effect of iron and manganese by cobalt on the magnetic and magnetocaloric properties of $Er(Fe_{0.8}Co_{x+y}Mn_{0.2-y})_2$ and finally we studied the effect of the substitution in the rare-earth site of the $RR'(Fe_{0.125}Co_{0.875})_2$ with R= Er, Ho and R'=Tb and Gd.

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P-0553 16:30-18:00, August 22 | Lobby (5F)

Tc variation of Niobium thin films with strain and ionic liquid gating

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Niobium (Nb) thin films were deposited on silicon (Si) substrates using a DC magnetron sputtering system and the thickness was controlled by changing deposition time. We have found that uniform strain caused by lattice mismatch between Nb and substrate lowers the critical temperature, Tc. As the film thickness decreases, the (110) peak of Nb using XRD shifts more to a lower angle than that of bulk Nb, indicating that the tensile strain occurs. To elucidate how the strain impact the Tc, we performed theoretical calculations of electron-phonon coupling modifying in-plane lattice constants. We found that the main contribution to the Tc is density of states at the fermi energy where the DOS for a strain-free Nb shows a local maximum at slightly lower than the fermi energy. Compressive and tensile strain both reduce the DOS that are consistent with lowering Tc. In addition, DOS can be increased by adding carrier density. In order to improve Tc, we used ionic liquid gating to dope 0.4 hole per atom without structural deformation.

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P-0572 16:30-18:00, August 22 | Lobby (5F)

Magneto-elastic excitations in multiferroic h-$YMnO_3$ using inelastic X-ray scattering

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We have used inelastic X-ray scattering measurements and a model calculation considering spin-lattice coupling to investigate magnon-phonon coupling in hexagonal $YMnO_3$. Such coupling is clearly evidenced by an additional magneto-elastic excitation mode locked to a magnon mode in the magnetically ordered phase, reproduced by an exchange-striction model with a first principle phonon calculation result. Along with the Einstein site-phonon model, We show such exchange-striction can induce the additional in-plane Mn trimerization below T_N, enhancing the ferroelectricity along c-axis. With this unified microscopic mechanism, we shed lights on the spin-lattice coupling of YMnO3.

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P-0575 16:30-18:00, August 22 | Lobby (5F)

Investigation of Phonons in Spin-Phonon Coupling System: Pyrochlore $Cd_2Os_2O_7$

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Pyrochlore $Cd_2Os_2O_7$ exhibits interesting phenomena such as metal-to-insulator transtion and all-in-all-out (AIAO) magnetic ordering. At Neel temperature of 227 K, paramagnetic metal phase go to antiferromagnetic insulator phase.
And the strong renormalizations of the specific phonon modes were observed at long wavelength limit due to the strong spin-phonon coupling. Here, we focus on the phonon spectra observed by inelastic X-ray scattering (IXS) to understand the nature of spin-phonon coupling in AIAO ordered state. We observed the phonon dispersion relations in large Q space and the phonon calculations was obtained by the density functional theory (DFT) with the consideration of AIAO ordered state. Our experimental and calculated results are in good agreement. We also found an evidence of momentum dependent coupling related to the main mechanism of the coupling in this system.

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Direct measurements of the magnetocaloric effect for $La_{0.9}R_{0.1}Fe_{11.2}Co_{0.7}Si_{1.1}$ (R = Ho, Pr) in cyclic magnetic fields

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It is known that magnetic materials in magnetic refrigerators are subjected to the repeated cyclic action of magnetic fields; therefore, carrying out the magnetocaloric effect (MCE) investigations in cyclic magnetic fields is an important task. Such studies are currently at the initial stages and are conducted by individual scientific research groups.

Compounds based on the La(Fe,Si)13 phase are among the most promising magnetocaloric materials.

Experimental study of the frequency dependences of the MCE, when the applied field varies according to the law $\Delta H=H_0\sin(\omega t)$ (where for our experiments the amplitude value H_0=6.2 kOe, ω=0.3-30 Hz is the cyclic frequency) have been started relatively recently and are of great interest due to the fact, that the investigation of MCE in cyclic fields is as close as possible to the actual operating conditions of the magnetic cooling device. Depending on the phase transition nature and the type of magnetic ordering, the MCE behaviour can strongly depend on the frequency of the field change. In addition, the cyclic action of the magnetic field causes irreversible effects leading to MCE decrease and degradation of the magnetocaloric material, which requires further research also. Also, the magnetocaloric effect was measured by a modulation method at a magnetic field frequency of 0.2 Hz and an amplitude of 18 kOe in the heating and cooling regimes. In this work we present the results of an investigation of the direct measurements of the MCE in $La_{0.9}R_{0.1}Fe_{11.2}Co_{0.7}Si_{1.1}$ (R = Ho, Pr) in alternating magnetic fields with frequencies f =0.5-20 Hz and an amplitude ΔH = 6.2 kOe are carried out. In the investigated system the MCE value decreases with increasing frequency of the field change. Almost complete suppression of the MCE is observed at a field change frequency of 20 Hz.

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Hydrogen ion implantation induced magnetic property modification in FeRh films

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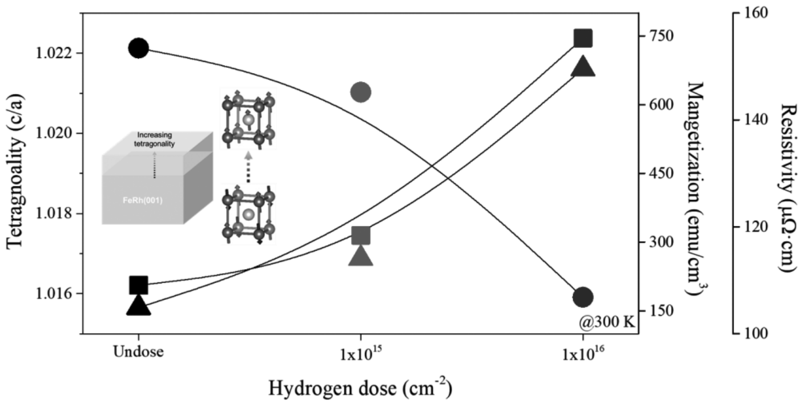
BCC-B2 phase of FexRh1-x (0.48 ≤ x ≤ 0.52) exhibits a metamagnetic phase transition from antiferromagnetic (AFM) to ferromagnetic (FM) about 370 K. During the phase transition; it is known that the 1% isotropic volume expansion and variation of magnetoresistance owing to the electronic structure modification is presented. Presently, it is believed that the magnetic properties (phase transition temperature and width, magnetization at AFM regime, etc.) are affected by Fe/Rh ratio, chemical doping, external pressure or magnetic field. Despite numerous researches, an essential interaction of transition is still unclear.

In this presentation, we showed the correlation between structural modification induced by implanted hydrogen ions and physical property variations of FeRh/MgO(100). The DC-magnetron sputtered FeRh/MgO(100) films were irradiated by various hydrogen ions (1x1015 and 1x1016 H/cm2) using the Korea Multi-Purpose Accelerator Complex (KOMAC). Temperature-dependent magnetic properties showed the phase transition temperature reduced, and magnetization at AFM region increased with hydrogen dose. Also, temperature-dependent electrical resistivity showed a similar behavior of magnetic properties. To understand the physical property variations, we measured inplane and out-of-plane x-ray diffraction of FeRh films. As a result, in-plane lattice constant did not change and outof-plane lattice constantly increased with increasing hydrogen ion dose. These observations suggest that the ferromagnetic domain may induce tetragonality of the structure.

This study is supported in part by NRF-2017K1A3A7A09016305 and NRF-2018R1D1A1B07045663 and S. Song was supported by the Global Ph.D. Fellowship Program (NRF-2018H1A2A1062253) through the NRF Korea funded by the Ministry of Education.

Figure 1. Square, triangle, and circle indicate tetragonality, magnetization, and resistivity respectively at room temperature. Inset shows that schematics of correlation between tetragonality and spin configuration of FeRh film



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Strong magnetoelectric coupling in mixed ferrimagnetic-multiferroic phases of a double perovskite

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Exploring new magnetic materials is essential for finding advantageous functional properties such as magnetoresistance, magnetocaloric effect, spintronic functionality, and multiferroicity. Versatile classes of double perovskite compounds have been recently investigated because of intriguing physical properties arising from the proper combination of several magnetic ions. In this study, it is observed that the dominant ferrimagnetic phase is coexisted with a minor multiferroic phase in single-crystalline double-perovskite Er_2CoMnO_6. The majority portion of the ferrimagnetic order is activated by the long-range order of Er^{3+} moments below T_{Er} = 10 K in addition to the ferromagnetic order of Co^{2+} and Mn^{4+} moments arising at T_C = 67 K, characterized by compensated magnetization at T_{Comp} = 3.15 K. The inverted magnetic hysteresis loop observed below T_{Comp} can be described by an extended Stoner– Wohlfarth model. The additional multiferroic phase is identified by the ferroelectric polarization of ~0.9 μC/m^2 at 2 K. The coexisting ferrimagnetic and multiferroic phases appear to be strongly correlated in that metamagnetic and ferroelectric transitions occur simultaneously. The results based on intricate magnetic correlations and phases in Er_2CoMnO_6 enrich fundamental and applied research on magnetic materials through the scope of distinct magnetic characteristics in double perovskites.

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Thermophysical properties of ribbon samples of Heusler alloys $Ni_{50}Mn_{37-x}Al_xSn_{13}$ (x = 2,4,6 and 8)

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Heusler alloys are characterized by a sequence of magnetic, structural, and modulation phase transitions, which can be controlled by external fields, and a set of functional properties, which are promising for applications related to these transitions. Moreover, Heusler alloys are excellent model objects to study the physical properties of strongly correlated electronic systems. In magnetic cooling technology, preference will be given to ribbon samples, providing the necessary rate of heat removal. Therefore, it is important to know their thermophysical properties. This report presents experimental results on the study of the thermophysical properties of rapidly quenched ribbons of Heusler alloys $Ni_{50}Mn_{37-x}Al_xSn_{13}$ (x = 2,4,6 and 8) (thermal conductivity (k), heat capacity (C_P), thermal diffusion (η)) in the interval T = 80-350K and in magnetic fields up to 1.8 T.

Thermal conductivity was determined both by the steady thermal flow method and using data on thermal diffusivity and heat capacity using the well-known ratio $\kappa=(d / M)C_P\eta$, where d is the sample density, M is its molar mass.

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Anisotropic magnetic properties and magnetocaloric effect in single crystal Tb_2CoMnO_6

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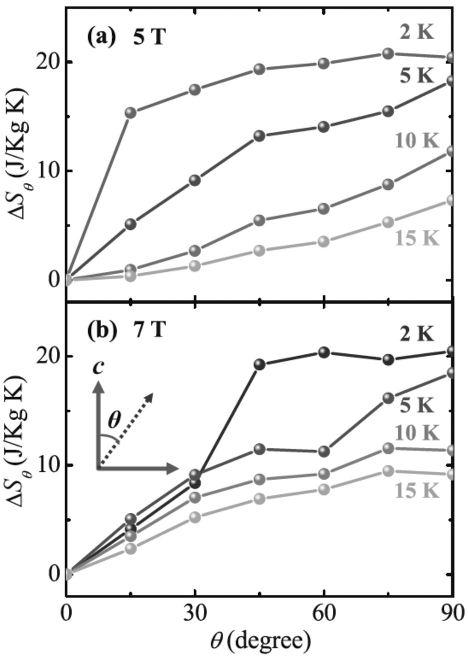
We investigated the anisotropy of the magnetic and magnetocaloric properties of single-crystalline double perovskite Tb_2CoMnO_6, which crystallizes in a monoclinic $P2_1/n$ structure. Due to dissimilar magnetic anisotropy, the ferromagnetic order of the Co^{2+} and Mn^{4+} moments emerges along the c-axis at T_C = 100 K, and the larger Tb^{3+} moments align perpendicular to the c-axis, below T_{Tb} = 15 K. The intricate temperature development of the metamagnetism along the c-axis results in a large negative change in the magnetic entropy at low temperature. On the other hand, the larger but almost reversible magnetization, perpendicular to the c-axis, results in a small and positive entropy change. This highly anisotropic magnetocaloric effect (MCE) leads to a giant rotational MCE, estimated to be 20.8 J/kg·K. Our findings, based on the magnetic anisotropy in Tb_2CoMnO_6, enrich fundamental and applied research on magnetic materials, considering the distinct magnetic characteristics of double perovskites.



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P-0710 16:30-18:00, August 22 | Lobby (5F)

Influences of Substitutional Cobalt in Magnetic Properties of Tetragonal D022 Mn3Ga

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University of Ulsan, Korea

Heusler compounds have recently attracted interests among researcher because of rich physics and broad possibility of application, where Mn3Ga is one of them. Here, magnetism of Mn3-xCoxGa (x=0~1) is studied using of density functional theory. Mn3Ga (x=0) crystallizes in tetragonal D022 structure, which exhibits ferrimagnetic ordering. Two Mn sites, octahedral and tetrahedral ones denoted as Mn-I and Mn-II, respectively, have different moments. Co substitution to different Mn sites gives quite contrast behaviors: when x=0.5, moments of Co into Mn-I have 1.33 μB, while that into Mn-II is much smaller giving 0.137 μB. Furthermore, when x>0.5 cubic phase is stable, which is unstable without Co substitution, become more energetically favored over tetragonal phase. The underlying difference is discussed in terms of low- and high spin competition and different symmetry of two Mn sites.

Keyword: Heusler compound, density functional theory, tetragonal D022 structure, low spin state, high spin state,

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P-0717 16:30-18:00, August 22 | Lobby (5F)

Nonmagnetic Ion Doping Effect On Spin Excitations In Hexagonal $RMn_{1-x}Ga_xO_3$ (R=Y, Ho)

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We present a study of the nonmagnetic ion substitution effect on the spin-excitation scattering in hexagonal $RMn_{1-x}Ga_xO_3$ (R=Y, Ho) through Raman spectroscopy. Raman peaks due to spin excitations are observed in rather high energy range of ~ 800 cm-1. In both $YMn_{1-x}Ga_xO_3$ (x=0, 0.05, 0.10, 0.15, 0.25) single crystal and $HoMn_{1-x}Ga_xO_3$ (x=0, 0.05, 0.10, 0.33) thin films, the intensity of the spin-excitation peaks decreases as Ga ion increases, with virtually no change in the wavenumber (energy) of the spin excitation. Our results suggest that the spin excitations in hexagonal $RMn_{1-x}Ga_xO_3$ could only be excited in the Mn-Mn planes, and that they are robust against non-magnetic ion doping.

The Ga-substitution dependence of the Neel temperatures of $RMn_{1-x}Ga_xO_3$ thin films could be obtained from the temperature profile of the intensity of the peak. Raman measurements of spin excitations provide an easy optical method of measuring the Neel temperatures which are difficult to obtain from magnetization measurements of $HoMnO_3$ system due to strong paramagnetic moment of 4f electrons in Ho-ions.

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Probing the spin system in transition metal doped SnO2 and TiO2 by using Electron Spin Resonance measurement techniques

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In recent diluted magnetic semiconductors (DMS) have attracted a great deal of interest due to the possibility of inducing room temperature ferromagnetism. These materials are of particular interest for Spintronics devices .In this study we investigated the magnetic properties, surface morphology and crystal structure in transition metal doped (tin oxide) Sno2 thin films,tin oxide nano fiber and titanium oxide(TiO2) fiber. A pure and (Fe,Cu,TiO2,Au,Ni) doped tin oxide thin films were formed on glass substrates by pulse laser deposition (PLD) method and electro spinning method for SnO2 nano fibers. The prepared thin films and nono fibers samples were characterized by ESR and PPMS measurements with cycling the sweeping applied field in order to understand the spin dynamics and magnetization in the produced samples. Some characterization techniques were used as X-ray diffraction (XRD), UV–vis spectroscopy and atomic force microscopy (AFM) to study the effect of method conditions and do-pants on the structural, morphological, and optical properties of thin films. According to XRD results, no phase attributed to dopants were detected, which suggests the incorporation of do-pants in SnO2 network. The electron spin resonance spectra high and low fields were measured and the temperature dependence of the g-factor in the temperature range 20-300 K was obtained. It was found that the magnetic field and the temperature dependence of magnetization have a paramagnetic character. The room temperature hysteresis loop measurements confirm ferromagnetic nature of all transition metal doped SnO2 thin films. The changes in the line width, g-factor and intensity as functions of temperature were studied to understand the nature of spin-dynamics in the system. The magnetic measurements indicate that the properties of these materials are highly dependent on the types of dopants, dopant concentration, temperature and the preparation method. We obtained room temperature ferromagnetism also in TiO2 fiber and SnO2 Nano fiber .Other supportive experimental data from UV-Vis, PL and Raman analysis give a clear picture of defect structures in the form of oxygen vacancies that facilitates the occurrence of room temperature ferromagnetism The findings of this study could be of a great interest in advancing research in spinronics, memory devices and low magnetic field sensors.

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Spin-orbit torques in silicene zigzag nanoribbons

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Silicene, a group IV nanosheet [1,2], possesses lattice buckling and exhibits a larger intrinsic spin orbit (SO) coupling [3] supporting greater spin-orbit torques (SOTs) than graphene. Here we study the SOT in silicene nanoribbons of zigzag edges. We obtain the SOT based on a Green function formalism which are separated into Fermi sea (Ts) and Fermi level (Tl) contributions. The former only contributes to the field-like torques TFL, while the later accounts for the current-induced torques giving both TFL and anti-damping TAD that is responsible for the magnetic switching (MS). The TAD and TFL are identified by the out-of-plane spin accumulations induced by the inverse spin-galvanic effects [4–5]. Due to the particle-hole symmetry of Dirac materials, the trokance induced by the applied bias is an odd function of the Fermi energy EF; contrarily, at zero bias, the torque is even in EF. Since Tl originates from the bias, this symmetry implies Tl=0 at the Dirac point. The torques are independent of the azimuthal angle of the ferromagnet magnetization and are symmetric in magnetization polar angle. When the magnetization is in-plane, only current-induced torques show up. For large enough in-plane magnetizations, the maximum (among different EF) TFL occurs at the Dirac point. Under certain small magnetizations characterized by the SO coupling, the maximum TAD is also identified at the crossing point of two Dirac linear bands (Figs. 1 and 2). We find that the buckling potential is essential to achieve MS (inset in Fig. 1). Reversing the applied electric fields yield a reversal of the antidamping torque. Accordingly, silicene provides a full electric control of the torques.

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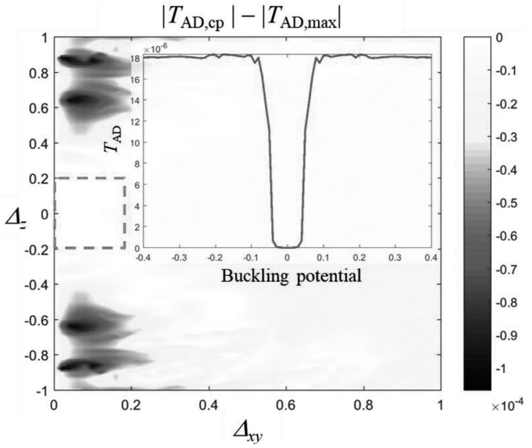

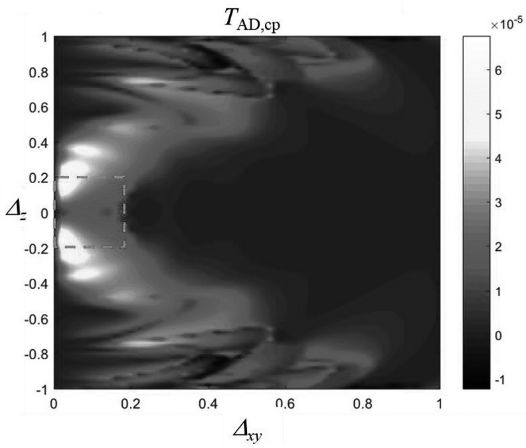

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Multi-states anomalous Hall resistance changes with DW motion in a single Hall bar structure for the neuromorphic computing

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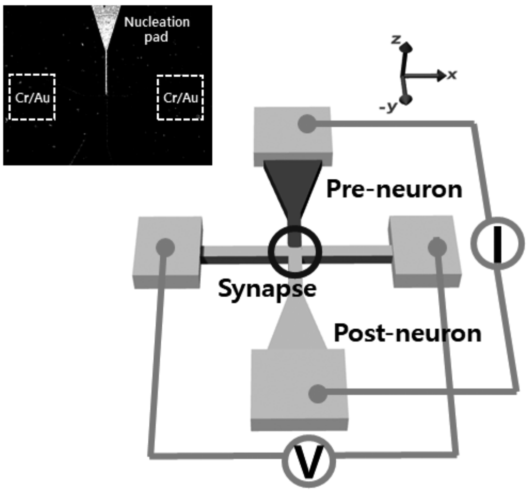
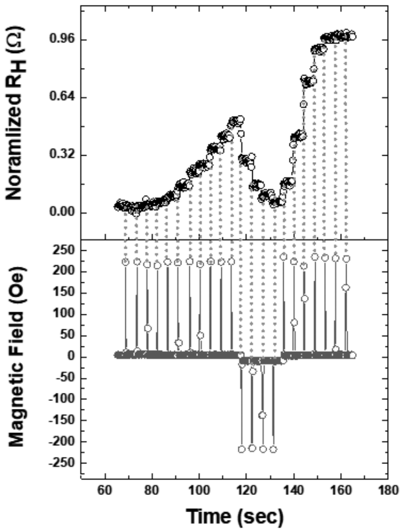
Various spintronic devices based on the magnetic domain walls (DWs) motion has been investigated for non-volatile memories such as 3D racetrack memories and logic device applications in the last several decades. Those novel devices could be alternatives to the conventional von Neumann architecture, which shows bottle-neck problem between CPU and memory. Memristor is the fourth element in the RLC circuit in addition to the resistor, capacitor, and inductor. It has recently attracted a lot of attention because of its unique functionality, the resistance value remembers the history, which is an essential ingredient for the neuromorphic devices. In agreement with a previous report, memristive behavior was found in our DW based spintronic devices. Here, we demonstrate the multi-states anomalous Hall resistance (RH) changes depending on the field-driven DW displacement at a single Hall cross. The Ta(4nm)/Pt(3)/[Co(0.6)/Pt(0.6)]4/Co(0.6)/Pt(2) multilayers with perpendicular magnetic anisotropy (PMA) were deposited on the Si/SiO2(100) substrate by dc magnetron sputter. The single Hall bar structure is fabricated by photolithography and ion-milling system and its width is 10 μm. We observed the DW motion using by anomalous Hall effect (AHE) and Kerr microscope measurement, simultaneously. For DW initialization, the device is first saturated in the ∓z direction by applying a larger field (413.7 Oe) than the coercivity [Co/Pt]4 stack (321.8 Oe). Once the DW is first generated in nucleation pad by employing field pulses, programming field pulses are applied for DW propagation toward Hall cross. The field pulses with the intensity of +231 Oe (-188 Oe) and a range of 0.4 sec to 0.9 sec duration are applied for up-down (down-up) propagation DW as depicted in Fig. 1. As the up-down DW expands gradually at the Hall cross, it should be seen that the RH values increase with a large number of states (8-12 states) as a function of time. A diverse of changing shape in RH caused by modulating DW pinning/depinning process form the edge of the single Hall cross. Advantages of a series of intermediate RH states, high endurance characteristics, and easy to adjust consider spintronics devices using DW motion as a possible candidate of artificial synapse in neuromorphic computing.





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Tuning Perpendicular Magnetocrystalline Anisotropy of Pt/Co/W(111) Superlattice

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Ab initio calculations have been performed to investigate magnetocrystalline anisotropy (MCA) of Pt/Co/W superlattice. Recently, Pt/Co and heavy-metal capped superlattices have been intensively and extensively explored in spintronics,[1] while W, in particular, is reported to enhance MCA in magnetic tunneling junction[2] and to exhibit large spin Hall conductivity[3]. Here, the role of W-capping on Pt/Co is exhaustively studied for MCA dependence and the character of interface. MCA of Pt/Co without W is first examined for different lattice constants (Pt, Co, and W). The interface of W-capping is then determined by energetics, where three possible phases, α-, β-, and fcc are taken into account. The role of W-capping for different phases is revealed and discussed in electronic structure perspective.

Keywords: magnetocrystalline anisotropy, Pt/Co/W(111) superlattices, thickness effect

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The First Principles Study Intrinsic Spin Hall Conductivity of α-W and α-Ta

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Intrinsic spin Hall conductivity (SHC) of α-W and α-Ta in bcc structure are studied using first principles calculations, whose values are -783 and -142 (Ω.cm)-1, respectively, which are in good agreement with previous studies [1,2].
From analysis of k-dependent spin Hall conductivity, it was found that the large contribution to SHC comes from the lifted degeneracies, which are inherently from non-symmorphic feature of group of k-point in Brillouin zone of bcc structure. Calculated SHC with different chemical potential revealed the possibility of the band filling control of the SHC in α-W and α-Ta

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Spin Hall magnetoresistance in Pt/$IrMn_3$/NiFe structures

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In this work, we investigated the role of the antiferromagnetic (AF) inserted layer in spin Hall magnetoresistance (SMR) for the non-magnetic (NM)/AF/FM magnetic hybrid structures. Magnetoresistance (MR) behaviors in a set of 3.0-nm-Pt/x-nm-$IrMn_3$/1.5-nm-$Ni_{0.8}Fe_{0.2}$ structures were systematically explored by varying $IrMn_3$ thickness ranging from 0 to 3.0 nm. $IrMn_3$ films were grown on unetched Si wafers buffered with a 1.5-nm-thick permalloy ($Ni_{0.8}Fe_{0.2}$) by co-evaporation of Ir and Mn in UHV-MBE system, and then followed by in situ deposition of a 3.0-nm-thick Pt through a meal shadow to fabricate laterally defined Hall bars. Based on the results of zero-field cooled (ZFC) resistivity versus temperature measurements of Pt, grown on the $IrMn_3$ films thinner than 5.0 nm, the existence of antiferromagnetic order at the interfaces was seen clearly below 200 K. This is inaccessible information of the interface magnetic properties obtained by conventional magnetometers. The field-dependent MR (FDMR) and angular-dependent MR (ADMR) results provide evidence for the SMR effect, for the trilayer structures with an $IrMn_3$ inserted layer thicker than 3.0 nm. The SMR ratio was observed to be ~ 0.036 % at 77 K (T < TNéel of $IrMn_3$ thin films) for the SMR device with a 3.0 nm-thick-$IrMn_3$ inserted layer. Additionally, the sign change of SMR was observed for applying the magnetic field over 6 kOe. Our results highlight that the correlation of the Néel vector direction and the external magnetic field directions can be the key for the further understanding of the SMR behaviors in NM/AF/FM magnetic hybrid structures.

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Dynamics characteristics of ferrimagnetic Gd_xFeCo_{1-x} nanoparticles: Atomistic simulation study

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A central motivation for antiferromagnetic spintronics is the expectation that antiferromagnetic spin dynamics are much faster than their ferromagnetic counterpart[1] and that the antiferromagnet has no magnetic stray field, which properties are beneficial for integrated circuits due to the fact that the stray field is the primary source of detrimental magnetic perturbations.[2] However, for realization of such magnetic memory devices in the future, it is necessary to understand the intrinsic mechanism of the dynamics. The fast dynamics of the antiferromagnet also are observed in the ferrimagnet, which fact is very helpful for understanding antiferromagnetism, owing to its ease of measurement.[3] Ferrimagnetic GdFeCo[4] material is one of the robust model systems for the study of the ferrimagnetic resonance (FMR) dynamic modes as a function of Gd atomic content across the magnetization and angular momentum compensation points. The experimental observations of FMR near both compensation points are not consistent with the theoretical predictions.[5]

Here, as further work, we calculated the temperature dependence of sublattice magnetizations and resonant magnetization dynamics over a given Gd-concentration range (0-48%) [6]. In this calculation, we used the VAMPIRE software package, which uses a simple text file format to define and run an atomistic simulation [7]. The magnetization directions of FeCo and Gd are opposite to each other, and therefore they exhibit antiferromagnetic coupling between the sublattices. The magnetization(TM) and angular momentum(TA) compensation points exist within a Gd-concentration range of 24-44% and increase linearly with that concentration [8]. According to the literature,[9-11] g_{FeCo}(~2.2) is slightly larger than g_{Gd}(~2), owing to the spin-orbit coupling of FeCo and the zero orbital angular momentum of the half-filled 4f shell of Gd. T_A is expected to be higher than T_M in GdFeCo. We confirmed that the correlation of the resonance frequency of magnetization dynamics is a function of the sublattice composition and thermal fluctuations. We confirmed that atomistic simulations of magnetic materials are useful for understanding the mechanism of the fast dynamics of the ferrimagnet.

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Spin wave modes and spiral rotating motion of magnetic skyrmion in magnetic nanotubes

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Magnetic skyrmions are particle-like, topologically protected magnetization entities that are promising candidates as information carriers in racetrack memory [1]. Magnetic skyrmion has features that can operate at nanoscale, topological stability and ultra-low critical current density, and thus a deep understanding of dynamic mode is essential for the application of these skyrmion motions. In the conventional two dimensional plane, several fundamental dynamic modes of skyrmion crystals have been found theoretically by M. Mochizuki [2] and also experimentally by Y. Onose et al. [3] Both revealed the existence of skyrmion-core gyration modes of either the clockwise (CW) or counter-clockwise (CCW) rotation sense, as excited by in-plane ac magnetic fields, as well as another breathing mode excited by out-of-plane ac magnetic fields. Whereas the above studies focused on the fundamental dynamic modes of skyrmions in 2D flat system, skyrmion dynamic modes in 3D curved systems have yet to receive much attention. Due to the chiral symmetry breaking of the nanotubes, unforeseen dynamic effects such as the Cherenkov-like effect of spin wave emission [4], artificial DMI [5], and asymmetric spin wave propagation [6] can be observed. Skyrmion dynamic behaviors in 3D nanotubes also have different effects from dynamics in 2D flat systems.

In the present study, we study spin wave modes of magnetic skyrmion excited by microwave magnetic fields in low aspect ratio of magnetic nanotubes wherein the crystalline anisotropy and the DMI axis perpendicular to the surface of the nanotube. Two peaks of spin wave resonances are found for in-plane ac magnetic field where CCW (CW) gyration mode occurs in low (high) frequency regime. Directions of the circulations are opposite between these two modes: distributions of the out-of-plane spin components near the core circulate CW and CCW direction, respectively. A breathing-type mode is also found for an out-of-plane ac magnetic field based on the skyrmion core.

By intensively exciting the CCW gyration mode, a spiral rotating motion of magnetic skyrmion is achieved along the circumference of the nanotube. Moreover, we found that the multiple skyrmions can also be dragged by excitation of CCW spin wave modes. This finding provides physical insight into the skyrmion dynamics in the curvature system and would be of use to potential skyrmion-based 3D racetrack memory applications.

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Micromagnetic Properties of $Sn_{1-x}Mn_xTe$ epitaxial layers grown on BaF_2 and GaAs substrates

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In our quest for high quality topological crystalline insulator nanostructures based on SnTe, which would combine both topology and ferromagnetism, we grew by molecular beam epitaxy (MBE) a series of $Sn_{1-x}Mn_xTe$ layers (Mn content x up to 0.08) on various substrates: BaF_2 (111), BaF_2 (001), and GaAs (001). In the last case a 4-micron-thick CdTe buffer layer was grown first in another dedicated MBE chamber. The layers were comprehensively characterized, both from structural and electrical point of view. The crystal structure, chemical composition and interface morphology were examined by X-ray diffraction, transmission electron microscopy (TEM) and energy dispersive spectroscopy. Magnetization measurements were carried out with superconducting quantum interference device (SQUID) techniques. Magnetic anisotropy studies were facilitated using both SQUID and the ferromagnetic resonance (FMR) techniques.

We find that in our layers, even in these having the highest Mn content and optimal hole concentration, the ferromagnetic transition temperature TC remains consistently below 10 K, and thus is about twice smaller than in corresponding bulk crystals [1]. This finding correlates with the observation of roughly twice smaller magnitudes of saturation magnetization with respect to those expected for a given technological values of x. Therefore, our results confirm previous, unexpected observations [2] that in a non-equilibrium MBE growth regime the substitution of Mn ions for cations in the rock-salt lattice of SnTe, as opposite to the case substitution of Mn in zinc-blende III-Mn-V dilute magnetic semiconductors, is substantially less efficient than in the equilibrium Bridgman growth.

The analysis of the results of magnetic anisotropy studies reveals a dominant shape anisotropy contribution for all investigated layers, with the easy magnetization axis located in the plane of the layer. However, while all (001) oriented layers were found to exhibit perfect cubic symmetry, those grown on BaF_2 (111) substrates reveal features in angular dependence of FMR resonant field, which are characteristic of material with rhombohedral distortion along the [111] direction. Such distortion is known in SnTe and GeTe based crystals. However, in contrast to closely related $Ge_{1-x}Mn_xTe$ layers, where such crystal distortion induces perpendicular magnetic anisotropy [3], in our $Sn_{1-x}Mn_xTe$ layers the easy direction of the magnetization remains in the plane of the layer. We summarize experimental results on the magnetic anisotropy by quantifying contributions due to dipolar interactions (shape anisotropy) and single-ion magnetocrystalline effects including: layer thickness, epitaxial strains, stoichiometry regime in SnTe matrix, and the Mn content.

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Magnetic anisotropy engineering in the insulating ferromagnet (Ga,Mn)N

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The dilute ferromagnetic insulator (Ga,Mn)N has reached the status of a model material system in which two fields of research developed so far independently, namely piezoelectricity of wurtzite semiconductors and electrical control of magnetization in hybrid and composite magnetic structures, are successfully combined [1]. Through the inverse piezoelectric effect, an applied electric field deforms the crystal field surrounding the magnetic ions (Mn), and modifies their ground state, for instance the magnetic anisotropy (MA). This piezoelectro-magnetic coupling paves the way towards the realization of repeatable magnetization switching in ferromagnetic (Ga,Mn)N. It however can only be realized for technologically feasible magnitudes of electric field if the alloy has a sizeable reduced MA, i.e. a marginally weak trigonal deformation. Such a reduction can be achieved in (Ga,Mn)N by a sizable Mn concentration x and/or by growing the layers on substrates or buffers which induce compressive stress, like e.g. (Al,Ga)N.

We report here on MA studies of $x \cong 3$ and 4% (Ga,Mn)N layers grown by molecular beam epitaxy [2] on $Al_{0.25}Ga_{0.75}N$ buffers deposited by metalorganic vapor phase epitaxy on Al_2O_3. Such a combination of growth methods allows to change the sign of the deformation potential with respect to the conventional case of GaN templates on Al_2O_3. High precision SQUID magnetometry performed between 2 and 300 K and up to 7 T confirms that instead of the generally observed strong in-plane magnetic anisotropy in (Ga,Mn)N grown on GaN/Al_2O_3 [2,3], in the considered layers a weak perpendicular magnetic anisotropy emerges. This advancement in material science opens the technological path for the demonstration of only-electrical magnetization switching in ferromagnetic insulators.

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Enhancement of spin polarization by Au magnetoplasmonic effect of Co coated ZnO nanowires

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The realization of a ferromagnetic semiconductor with large spin polarization is important to the development of next-generation spintronic devices. Most relevant works have focused on ferromagnetic diluted magnetic semiconductors, in which mutual interaction between "substitutional" magnetic ions and s (or p) electrons is expected to occur. However, taking into account the large specific surface area, and high density of states (DOS) from dangling bonds of semiconductor nanostructures, surface modifications by covering materials with electronic properties different from the semiconductor host has been considered as an effective way to induce spin polarization. Hence, whether coating a ferromagnetic metal on semiconductor nanostructures can make them ferromagnetic is worthy of investigation. This work proposes that a deliberately designed hybrid structure can be utilized to realize room-temperature semiconductor nanostructures with large spin polarization by engineering the DOSs at the Fermi level in oxide nanostructures. Experimentally, covering ZnO nanowires (NWs) with Co layers yields an enhancement in the ZnO interfacial spin-polarization near semiconductor band edge by additional Au coating evidenced by magnetic circular dichroism (MCD) spectroscopy. The ZnO NWs array was grown by electro-chemical deposition. Following electro-chemical deposition, the Co layers were coated on the ZnO NWs by sputtering. The Au layers were further coated on the Co/ZnO NWs by sputtering under similar conditions for 1 minutes to modify the magnetic interactions.

The high-resolution transmission electron microscopy image revealed that the ZnO NWs had a hexagonal wurtzite structure with the rods oriented along the c-axis. Most of Co coated near the top of the ZnO NWs due to the shadowing effect. Both Au and Co distributions were evident, verifying efficient Au coating on the Co/ZnO NWs. The RT MCD spectra of the Co coated ZnO NWs without and with Au coating reveal two main broad and large peaks with opposite signals. One component (feature A), is positive (400 nm~800 nm), the other component, (feature B), is negative (300 nm~400 nm) under 0.8T. The feature B near ZnO energy band gap can be associated with the spin polarization from ZnO [1]. Furthermore, an additional Au coating o Co interface resulted in a change in the shape of feature A. A hump near 540 nm which can be associated with the Au plasmonic MCD signal [2] was observed. The appearance of Au plasmonic MCD will also enhance the ZnO spin polarization significantly. These results inspire a phenomena model of the hybridization between Au magnetoplasmonic effect and Co/ZnO NWs interfaces to interpret the observed results. Our delicate design of the hybrid structure sheds new light on effective manipulation of spin polarized band near the surface on oxide nanostructures for future spintronic applications.

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Synthesis and characterization of the magnetic property of Cr(1-δ)Te

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Chromium based Telluride (Cr(1-δ)Te) has been known as P-type ferromagnetic material with various quire temperature(170K to 350K). Depending on the amount of Cr deficiency composition of Chromium and Tellurium changes, and also the magnetic character of the Cr(1-δ)Te, also changes(ex Tc, Hc). Although their magnetic property has been studied already, the origin of their magnetic property has not been studied yet. In our research, we used Xray absorption(XAS) and X-ray magnetic circular dichroism(XMCD) to find the origin of magnetic property of Chromium based Telluride (Cr(1-δ)Te) by measuring various composition of epitaxial Cr(1-δ)Te film. The composition of Chromium based Telluride (Cr(1-δ)Te) has been controlled by the growth condition. By increasing Chromium vacancies, XMCD normalized intensity has been decreased.

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Characteristics of an mechanical circuit breaker with new induction needle and magnets type to extinguish a DC arc

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Permanent magnets are drawing much attention as they are applied in hybrid types to application devices requiring high magnetic force. There are many types and characteristics of permanent magnets. They need to be tested for conformance of the equipment to which it is applied. The NdFeB permanent magnets of the sintered method have large coercive force and are applied to various devices. Nowadays, Direct current(DC) transmission and distribution systems are being actively developed. NdFeB magnets are being usefully used in circuit breakers to protect the systems.
DC always has a constant current value because it has no frequency. It is very difficult to cut-off large transient current when an accident occurs in the power system. Therefore, we combined a new type of induction needle and permanent magnets(NdFeB) near the contact terminals of mechanical circuit breaker. The induction needle was connected in series with the ground wire. This new breaking technique pushes the arc towards the induction needle to extinguish it, and the induction needle was connected to the ground. The permanent magnet applied to this circuit breaker must be resistant to arc energy and generate a high magnetic force. We verified the simulation results through finite element method (FEM) and time difference method (TDM) using Maxwell, an electromagnetic field analysis application. Also, we analyzed a characteristics of the arc. The results confirmed that the arc induction was enhanced by combination of induction needles with magnets.

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Stoichiometric optimization on strained pyrochlore iridate

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From the discovery of quantum hall effect (QHE) to the extensive investigation on graphene, the two dimensional topological materials in strong spin-orbit coupling (SOC) regime have drawn intensive attention. However, the regime that the combinational influence between electron correlation and strong orbit coupling (SOC) was not studied, but it drew intensive interest due to promising plethora of correlated topological phases. X. wan, et al, the possible candidate to exhibit correlated topological phase is the pyrochlore iridate.
The pyrochlore iridate (R2Ir2O7, R=rare earth) has been proposed to exhibit many exotic topological phases, such as Weyl semimetal and Axion insulator [1]. Despite its promising proposal, the pyrochlore iridate has not been intensively studied because of the extreme difficulties on the epitaxial growth, such as the iridium dissociation during the deposition and the structure complexity [2,3]. Nonetheless, we succeed in the in-situ epitaxial growth of Nd2Ir2O7 thin film, using the dual target method in the pulsed laser deposition system. The stoichiometry of the film was controllable by differing the ratio between the Nd2Ir2O7 and IrO2 target. The x-ray diffraction patterns and the resistivity curves reveal the transition from Nd3IrO7 to Nd2Ir2O7 phase when the ratio between two targets was varied. Our growth technique of epitaxial Nd2Ir2O7 thin film will enable the further studies on the emergent topological phenomena in the other pyrochlore iridate system.

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Impact of Oxygen Adsorption on Topological Spin Structures at Ultrathin Magnetic Interfaces

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The study of non-collinear spin structures, originated from Dzyaloshinskii-Moriya interaction (DMI), has attracted much attention. The chiral textures have been recently studied by X-ray magnetic circular dichroism (XMCD) based photoemission electron microscopy (XPEEM) in MgO/Co/Pt, demonstrating the possibilities of investigating chiral spin structures by XPEEM [1]. In addition, an imaging of magnetic stripe domains in epitaxial Fe/Ni bilayers on Cu(001) has suggested the existence of Néel-type chiral domain walls with a fixed chirality, meaning even a weak DMI can stabilize a non-collinear spin structure [2]. Recently, it has been predicted that the DMI can be manipulated by the adsorption of oxygen atoms due to the hybridization of transition metals and the oxygen [3]. However, at this moment there is still no direct experimental proof.

Here we report that by using XPEEM with XMCD contrast at BL05B2 end-station at the Taiwan Light Source, a microscopic insight on how the oxygen adsorption modulates the spin reorientation transition (SRT) of a Fe/Ni bilayer on Cu(100) is provided, and the evolution of the featured stripe-domains across SRT at different thicknesses of oxygen coverage is visualized [4]. The change of SRT thickness towards thinner Fe films due to the decrease of magnetocrystalline anisotropy by oxygen is visualized by the shifting of stripe-domain region. The change of the width of stripe domains by the oxygen adsorption is then discussed with the help of micromagnetic simulations. It is found in experiment that the averaged domain width is increased when the thickness of oxygen passivation is increased. It could be an evidence that the DMI-magnitude is decreased when the oxygen atoms are passivated on top of the Fe surface, which is supported by first-principle calculation [3] and the micromagnetic simulations. Realizing the control of the DMI in ultrathin metal films is of great importance in the surface/interface physics and it will pave the way towards the design of chiral magnetic properties through interface engineering.

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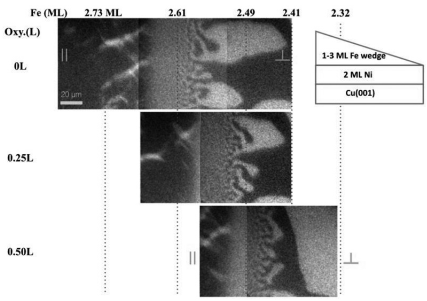

Figure 1 | XMCD-PEEM images around SRT of Fe/5 ML Ni/Cu(100) and its evolution by oxygen passivation (0 to 0.5 L). The scale bar of the images is 20 μm. The structure of the sample is shown in the inset. All images were obtained by taking the ratio of Fe L_3 and L_2 edges at 300 K [4].

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Fabrication of Asymmetric full cell supercapacitors from binary metal oxides ($MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$) Nanomaterial

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In this work, the $MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$ nanoparticles were synthesized at different optimized conditions by Solvothermal method and it's the fundamental characterization analysis like, X-Ray diffract meter, Raman spectroscopy, Fourier transforms infra-red spectra, FESEM, XPS confirms the formation corresponding binary metal oxides nanoparticles. Further to understand the morphology of obtained three different mixed metal oxides ($MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$) nanomaterial was carefully analyzed by FESEM and TEM for different experimental conditions.

An asymmetric Supercapcitor with two-electrode configuration was fabricated, In view of the fact that, the threeelectrode setup could overvalue the performance of the electrode materials. A hybrid capacitor using mixed metal oxides ($MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$) nanoparticles as a positive electrode and AC as a negative electrode was assembled [1-4]. The electrochemical properties of the asymmetric capacitors were investigated and estimate by Cyclic Voltammetry and galvanostatic charge–discharge measurements in a potential window (0–2 V). The mass ratio of ($MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$) nanoparticles as a positive electrode to AC electrode varies due to different specific capcitance value achieved in three electrode sytem. The total Area of active materials in the asymmetric SC electrodes is about 1 cm × 1 cm and immersed in 2 M KOH.

The results obtained by employing the asymmetric full cell setup which has been carried for best three different mixed metal oxides ($MnFe_2O_4$, $CuCo_2O_4$ and $MnMoO_4$) as one of the electrodes for asymmetric full cell supercapacitor devices. The synthesized MnFe2O4/AC - asymmetric full cell clearly exhibited 96 F/g of specific capacitance and 34.1 Wh/Kg energy density at 1 mA/cm^2 and retains the cyclic stability up to 72.2% after 5000 cycles and could be the suitable and best material for supercapacitors applications. Moreover, the prepared CuCo2O4nanocomposite/AC - asymmetric full cell demonstrated 178.1 F/g of specific capacitance and 35.6Wh/Kg energy density at 1 mA/cm2 and it retains the cyclic stability up to 96% after 3000 cycles and could be act as the preferred and superlative material for supercapacitors applications. Furthermore, $MnMoO_4$/AC - asymmetric full cell show evidence of 139.1 F/g of specific capacitance and 49.5 Wh/Kg energy density at 1 mA/cm2 and it retains the cyclic stability up to 98% after 3000 cycles at 8 mA/cm2 and could be considered as the suitable material for supercapacitors applications.

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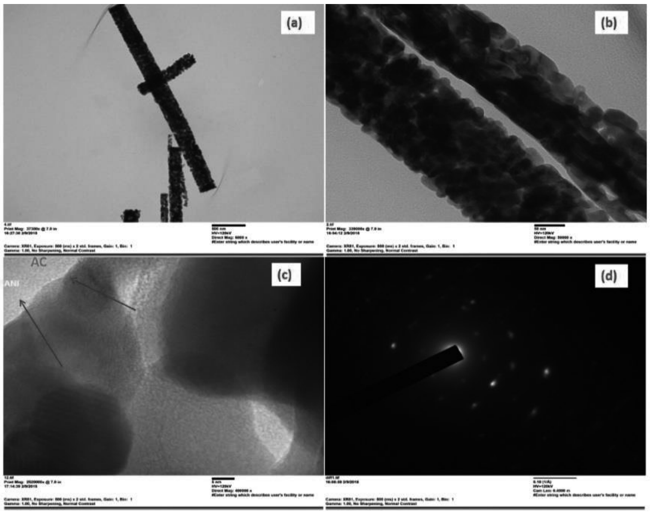

Fig .1.HRTEM image for $CuCo_2O_4$/AC/PANI nanocomposite (PM3) (a) 500, (b& c) 50nm scale, (d) SAED pattern

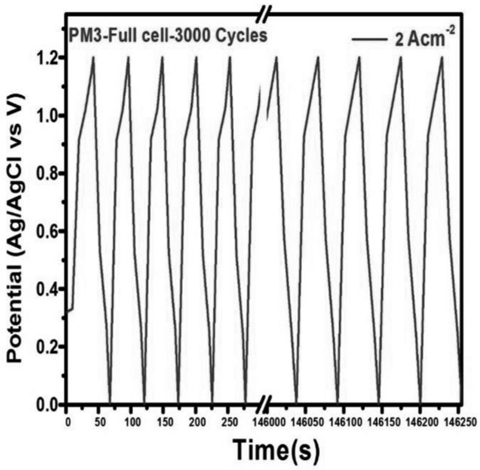

Fig .2.GCD cyclic stability test-$CuCo_2O_4$ nanocomposite (PM3) /AC Asymmetric Full cell

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KIMTECH high pressure cell (KTO3 / KTO4)
(Oil clamp type for PPMS™)

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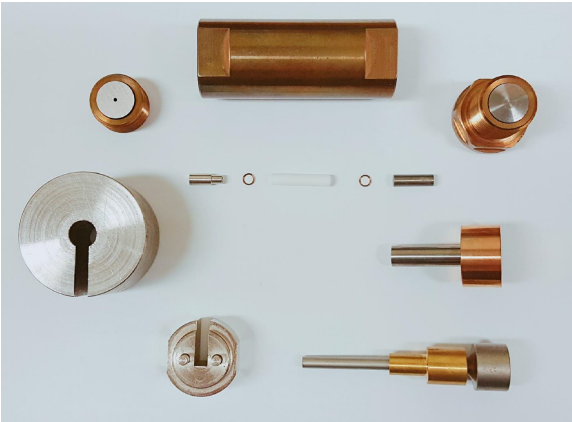
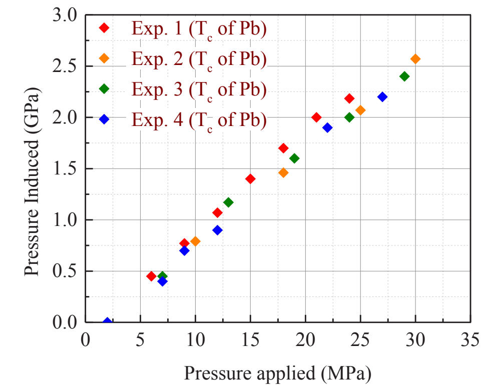
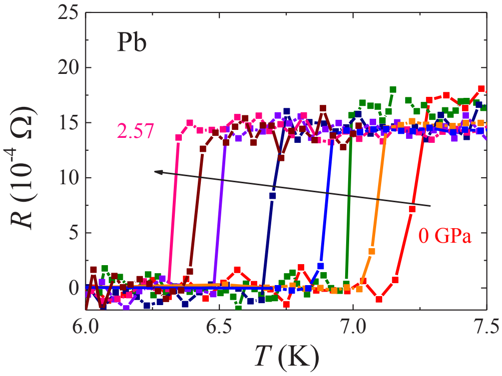
KTO3/KTO4 Cells : parts and configuration



Pressure calibration : superconducting transitions of Pb





◆ Pressure is calibrated by T_c of Pb.

$$T_c(P) = T_c(0) - (0.365 \pm 0.03)\, P$$

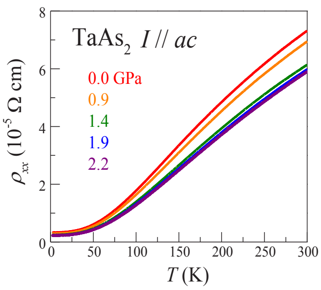
Ref. A. Eiling *et al.*, J. Phys. F : Metal Phys., **11**, 623 (1981)

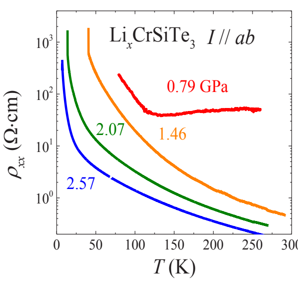
Specifications of the high pressure cell

Product name	KIMTECH high pressure cell (Oil Clamp Type for PPMS™)
Inner diameter size	4 mm
Hybrid cylinder size	OD 25 mm × height 62 mm
Hybrid cylinder material	CuBe & NiCrAl
Sample tube material	Teflon
Obturator material	CuBe (KTO3) / NiCrAl (KTO4)
Parts of high pressure oil cell	1. Lower screw 2. Hybrid cylinder 3. Upper screw 4. Pedestal 5. Obturator 6. Ring 7. Piston 8. Teflon tube 9. Push rod 10. Removal rod 11. Clamp jig 12. Bottom adaptor for a PPMS puck 13. Sn, Pb, and Mn manometers 14. Daphne 7373 Oil

- KTO3 & KTO4 targets a maximum pressure up to 3&4 GPa respectively
- Other types (DAC or different diamters) can be also fabricated per customers' orders

Experimental data taken using KTO4





◆ ρ_{xx} of 2 samples, $TaAs_2$ and $Li_xCrSiTe_3$ were measured by using a PPMS™ inside a KTO4 high pressure cell.

◆ $TaAs_2$ shows a gradual decrease in the ρ_{xx} value with applied pressure.

◆ $Li_xCrSiTe_3$ shows an enormous decrease in ρ_{xx} by more than 2 orders.

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