2018 APCTP
STATUS REPORT

March 22, 2019

apctp
아시아태평양이론물리센터
asia pacific center for theoretical physics

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Foreword

It has been already one year since I became the president.

In the last one year, 2018, thanks to your support and help, the center has been run smoothly and quite well. There were several usual events that I would like to report. First, two new JRG leaders had joined our center. Dr. Hiroshi Okada, a world leading researcher of Standard model phenomenology, joined in last June. And Dr. Yuji Hirono, an expert in QCD and topological properties of quark-gluon plasma, joined in the last September. Then one JRG leader, Dr. Yeom Dong Han, recently left long before his contract ends, because he had been offered a faculty position from Pusan national university. We are currently in the process of recruiting one new JRG leader. 2018 Benjamin Lee professorship was awarded to Prof. Eugene Stanley, at Boston University, who is a world renowned scholar in statistical physics and a pioneer creating several new interdisciplinary fields such as financial and econo-physics, complex social physics, etc. He visited our center and also attended the KPS fall meeting to give a plenary talk.

One good news is that our budget continues to increase and our budget in 2019 is fixed to be about KRW 4,500 million in total, which is the record high in our history. This was thanks to our Executive Director Prof. Jung and his effort.

One year ago, I promised two things as a new president.

Firstly, I will make a stronger relationship with the government and improve the stability of the center. This, I think I am doing a good job. Secondly, I will increase the benefit and activities of our member countries in order to make APCTP more visible and useful institute in the Asia-Pacific region as well as in the international community. We are pursuing this goal with several strategic directions. First, I have created an extra “cooperative external activity” and have received several proposals from our general council members to organize “pedagogical schools/workshops” with cooperation of multiple member countries. I will increase this kind of member country benefit and cooperative activities further.

Then, Kyrgyzstan is going to be a new member country of APCTP to become the 17th member countries. I am expecting that three countries, Kyrgyzstan, Uzbekistan, and Kazakhstan in central Asia region can work more efficiently with the assistance and network of the APCTP.

Finally, I would like to mention that we, APCTP, is working very well with the AAPPS to build up the active and integrated Asia-Pacific physics community. We have created three working divisions in the AAPPS, Div. of Plasma Physics, Div. of Astrophysics, Cosmology, and Gravitation, and Div. of Nuclear Physics. This number will increase. We are also completely upgrading the AAPPS bulletin to make it a representative physics journal in the Asia-Pacific physics community.

I repeat that my aim is that I want to make the APCTP as a hub-center in the AP-region which is practically useful and beneficial to all participating member countries. In this way, the APCTP will become a world leading institute not only in the AP-region but also around the world. There are still many miles to go and your strong support is essential to complete this mission.

Yunkyu Bang
President

I . Overview

1. Introduction
2. Milestones
3. Organization Chart
4. APCTP Executive Members
5. Member Countries and Membership Fees
6. Partnerships

1. Introduction

The Asia Pacific Center for Theoretical Physics (APCTP) is an international research center that pursues excellence in research, trains young scientists in all areas of theoretical physics, and promotes international cooperation among scientists from member countries/regions in the Asia-Pacific region and beyond. Under the leadership of Prof. C. N. Yang, the founding president, the Center was established in June, 1996, in Korea. As an international Non-Governmental Organization (NGO), its current member countries include Australia, Beijing, Canada, India, Japan, Kazakhstan, Korea, Lao PDR, Malaysia, Mongolia, Philippines, Singapore, Taipei, Thailand, Uzbekistan and Vietnam.

The Center aims:

- To lead research excellence in the field of theoretical physics;
- To facilitate international cooperation;
- To contribute to the advancement of physics by training young physicists;
- To improve science-based communication with the public.

To this end, the Center:

- engages in topical research in all areas of theoretical physics and beyond;
- pursues international academic collaboration and exchange of scholars;
- educates and trains young scientists;
- publishes a web journal and creates high-quality literary contents;
- offers distinguished lectures and activities accessible to the public.

2. Milestones

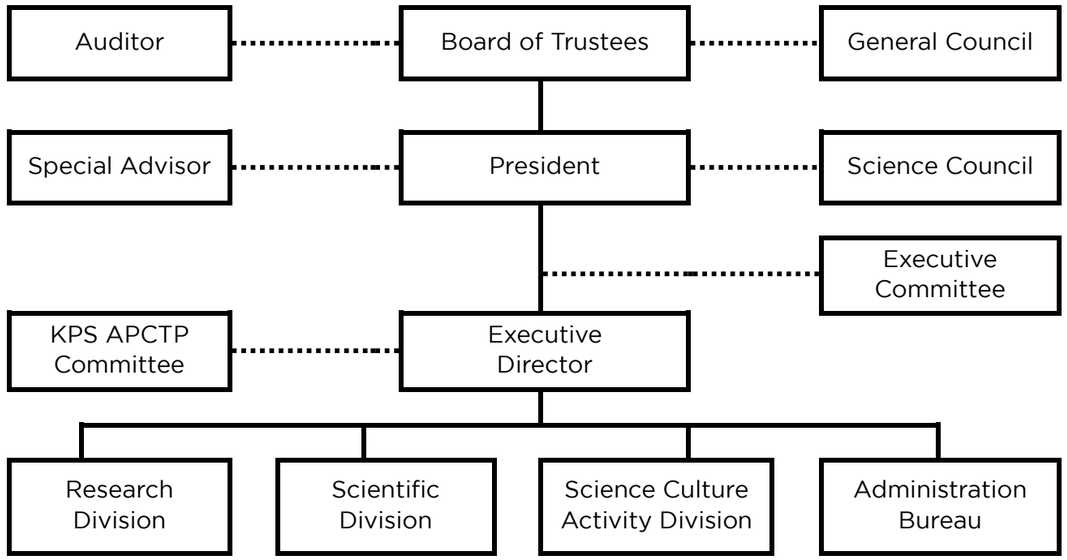
1993	Feb.	The International Planning Committee (IPC) is formed.
1994	May.	IPC recommends Korea as the host of the APCTP headquarters.
	Nov.	Association for Science Cooperation in Asia (ASCA) endorses the proposal to host the APCTP in Korea.
1995	Sep.	UNESCO PAC, IUPAP, and AAPPS endorse the proposal for APCTP.
1996	Jun.	Inauguration conference is held and APCTP is established.
		The Agreement of Collaboration is exchanged with ICTP.
	Nov.	The president of Korea announces the supports for APCTP at APEC Science Ministers Meeting in Seoul.
1997	Jan.	The Board appoints Prof. C. N. Yang (1957 Nobel Laureate for Physics) as the 1st President and Chairperson.
	Apr.	APCTP Foundation is registered at the Korean Ministry of Science & Technology.
1998	May.	Biannual APCTP Bulletin is launched.
	Oct.	The Agreement of Collaboration is exchanged with CRM.
1999	Dec.	The Agreement of Collaboration is exchanged with NCTS.
		An annex building is opened in Kangnam-gu, Seoul for KFAS.
2001	Jan.	Activity-Financing Contract is made between UNESCO and APCTP.
	Apr.	Prof. A. Arima (Former Minister of Education of Japan) is elected as the 2nd Chairperson of the Board of Trustees.
	Jul.	The Agreement of Collaboration is exchanged with PIMS.
	Aug.	APCTP Headquarters move to the campus of POSTECH.
		Seoul Branch Office opens in the annex building of the KOFST.
2003	Mar.	The Agreement of Collaboration is exchanged with ECT*.
	Jun.	The Agreement of Collaboration is exchanged with TPI.
2004	Apr.	The Board appoints Prof. R. B. Laughlin (1998 Novel Laureate for Physics) as the 2nd President.
	Nov.	Young Scientist Training Program is launched.
2005	Feb.	Science Communication program is launched.
	Mar.	The APCTP headquarters are relocated to Hogil Kim Memorial Building of POSTECH.
	Jul.	The Agreement of Collaboration is exchanged with ITP.
	Oct.	APCTP Web journal “Crossroads” is launched.
	Dec.	Prof. N. V. Hieu is elected as the 3rd Chairperson of the Board.

2006	Jul.	The Agreement of Collaboration is exchanged with JINR.
	Nov.	APCTP 10th Anniversary Celebration Ceremony is hold.
		The Agreement of Collaboration is exchanged with RIKEN.
		Lao PDR and Mongolia are admitted as new members of the APCTP.
2007	Jan.	The Agreement of Collaboration is exchanged with IPNS/KEK.
	Mar.	The Board appoints Prof. P. Fulde as the 3rd President.
		The Agreement of Collaboration is exchanged with YITP.
	Aug.	The Agreement of Collaboration is renewed with ICTP.
	Oct.	The Agreement of Collaboration is exchanged between APCTP, MPG and POSTECH.
		The Agreement of Collaboration is exchanged with IOP, ISSP.
2008	Mar.	India is admitted as a new member of APCTP.
	Jun.	Junior Research Groups (JRG) is launched.
	Oct.	The Agreement of Collaboration is renewed with TPI.
	Nov.	The Agreement of Collaboration is exchanged between ASEAN and APCTP.
2009	Jan.	The Agreement of Collaboration is exchanged with AAPPS.
		The Agreement of Collaboration is exchanged with IOP/VAST.
	Apr.	The Agreement on the Consortium of Asian Physics Institutions (KITPC/ITP, ICTS, IPNS/KEK, CQUeST, KIAS, and APCTP) is exchanged.
	Jun.	The Agreement of Collaboration is exchanged with PI.
2010	Mar.	The Agreement of Collaboration is exchanged with ITAP.
	Apr.	The Board appoints Prof. P. Fulde as the 4th President.
		Prof. Won Namkung is elected as the 4th Chairperson of the Board.
		The Agreement of Collaboration is exchanged with ThEP.
	Dec.	The Agreement of Collaboration is exchanged with NBIA/NBI.
2011	Apr.	Uzbekistan is admitted as a new member of APCTP.
2012	Mar.	The Agreement of Collaboration is exchanged with NORDITA.
	Dec.	The Agreement of Collaboration is exchanged with KEK as a new member entity of Japan.
2013	Jul.	The Board appoints Prof. Seunghwan Kim as the 5th President.
	Nov.	The Agreement of Collaboration is exchanged with IUPAP.
		Kazakhstan is admitted as a new member of APCTP
		Prof. Paul A. Pearce is elected as the 5th Chairperson of the Board.

2015	Apr.	APCTP is reconnected with APEC PPSTI as an APEC Endorsed Center.
	Jun.	The Board appoints Prof. Bum-Hoon Lee as the 6th President.
		The Agreement of Collaboration is exchanged with INP RK and IETP.
	Nov.	The Agreement of Collaboration is exchanged with RCNP.
2016	Mar.	APCTP 20th Anniversary Celebration Ceremony is held.
		Canada is admitted as a new member of APCTP. (The Agreement of Collaboration is exchanged in June)
	Apr.	The Agreement of Collaboration is renewed with IBS.
	Jun.	The 1st APEC PPSTI Centers Cooperation is held. (Pohang Declaration is adopted)
	Oct.	The Agreement of Collaboration is renewed with AAPPS.
	Nov.	The Agreement of Collaboration is renewed with IUPAP.
		The Agreement of Collaboration is exchanged with NUUz.
		The Agreement of Collaboration is exchanged with SCS.
		The Agreement of Collaboration is exchanged with IPM.
		The Board appoints Prof. Won Namkung as the 6th Chairperson of the Board and Acting President.
	Dec.	APCTP hosts AAPPS Headquarters.
2017	Apr.	The Membership Agreement is signed with WIPM-CAS.
		The Membership Agreement is signed with ANZAMP.
		The Membership Agreement is signed with MATRIX.
	Nov.	The Board appoints Prof. Noboru Kawamoto as the 7th Chairperson of the Board.
		The Board appoints Prof. Yunkyu Bang as the 7th President.
2018	Nov.	The Agreement of Collaboration is exchanged with CTP
	Dec.	The Agreement of Collaboration is exchanged with KITS

3. Organization Chart

- Board of Trustees: 15 Trustees and 2 Auditors
  - Chairperson (Noboru Kawamoto, Japan)
- General Council: Representatives from 16 member countries
- Science Council: 6 world-renowned scholars including President and Executive Director as Ex-Officio



4. APCTP Executive Members

Board of Trustees & Auditors

Position	Name	Nationality	Affiliation	Term
Chairperson	Noboru KAWAMOTO	Japan	Hokkaido University	Nov. 30, 2017 ~Nov. 25, 2019
President	Yunkyu BANG	Korea	POSTECH	Ex-Officio Nov. 30, 2017 ~Nov. 25, 2019
Trustee	Seogon KOH	Korea	Ministry of Science & ICT	Ex-Officio
Trustee	Bumhoon LEE	Korea	Korean Physical Society	Ex-Officio
Trustee	Doochul KIM	Korea	Institute for Basic Science	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Won NAMKUNG	Korea	POSTECH	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Sung-Chul SHIN	Korea	KAIST	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Moohyun CHO	Korea	NINT	Nov. 28, 2018 ~Nov. 27, 2021
Trustee	Hong-Sang JUNG	Korea	APEC Climate Center	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Mei-Yin CHOU	Taipei	Academia Sinica	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	NGUYEN Ba An	Vietnam	Vietnam Academy of Science and Technology	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Yue-Liang WU	Beijing	University of Chinese Academy of Sciences	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Paul A. PEARCE	Australia	University of Melbourne	Nov. 26, 2016 ~Nov. 25, 2019
Trustee	Eun Kyung SUK	Korea	ChonBuk National University -	Mar. 10, 2018 ~Mar 09, 2021
Trustee	Kwang Hwa CHUNG	Korea	KBSI	Mar. 10, 2018 ~Mar 09, 2021
Auditor	Han-Yong CHOI	Korea	Sungkyunkwan University	Nov. 30, 2017 ~Nov. 29, 2019
Auditor	Masani GOMITA	Japan	KEK	Nov. 30, 2017 ~Nov. 29, 2019

Executive Director

Name	Nationality	Affiliation	Term
Woo-Sung JUNG	Korea	POSTECH	Nov. 30, 2017~Nov. 25, 2019

General Council Members

Nationality	Name	Affiliation	Term
Australia	Omar FODA	University of Melbourne	Jan. 1, 2017~Dec. 31, 2019
Beijing	Gui Lu LONG	Tsinghua University	Jan. 1, 2017~Dec. 31, 2019
	Zhong-can OU-YANG	Chinese Academy of Sciences	Jan. 1, 2017~Dec. 31, 2019
	Yue-Liang WU	University of Chinese Academy of Sciences (UCAS)	Jan. 1, 2017~Dec. 31, 2019
Canada	Manu PARANJAPE	Université de Montréal	Jun. 15, 2016~Jun. 14, 2019
India	Indra DASGUPTA	Indian Association for the Cultivation of Science	Mar. 29, 2017~Mar. 28, 2019
Japan	Masaki OSHIKAWA	University of Tokyo	Jan. 1, 2017~Dec. 31, 2019
	Tetsuo HATSUDA	Program Director of iTHEMS, RIKEN	Jan. 1, 2017~Dec. 31, 2019
	Satoshi ISO	KEK	Jan. 1, 2017~Dec. 31, 2019
Kazakhstan	Medeu ABISHEV	National Academy of Sciences of the Republic of Kazakhstan	Jan. 1, 2017~Dec. 31, 2019
Korea	Sung-Won KIM	Ewha Womans University	Jan. 1, 2017~Dec. 31, 2019
	Sang-Pyo KIM	Kunsan National University	Jan. 1, 2017~Dec. 31, 2019
	Ha-Woong JEONG	KAIST	Jan. 1, 2017~Dec. 31, 2019
Lao PDR	TBA (Recommendation is under consideration)		
Malaysia	Kurunathan RATNAVELU	University of Malaya	Jan. 1, 2017~Dec. 31, 2019
Mongolia	TBA (Recommendation is under consideration)		
Philippines	Jose Perico ESGUERRA	University of the Philippines	Mar. 20, 2018~Mar. 19, 2021
Singapore	Kok Khoo PHUA	Nanyang Technological University, Singapore(NTU)	Jan. 1, 2017~Dec. 31, 2019
Taipei	Chong-Sun CHU	National Center for Theoretical Sciences	Mar. 20, 2018-Mar. 19, 2020
	Kin-Wang NG	Academia Sinica	Jan. 1, 2017~Dec. 31, 2019
Thailand	TBA (Recommendation is under consideration)		
Uzbekistan	Mirzayusuf MUSAKHANOV	Uzbekistan Academy of Sciences	Apr. 1, 2017~Mar. 31, 2020
Vietnam	NGUYEN Dai Hung	Vietnam Academy of Science and Technology	Jan. 1, 2017~Dec. 31, 2019

Science Council Members

Name	Nationality	Affiliation	Term
Yunkyu BANG	Korea	POSTECH	Ex-Officio
Woo-Sung JUNG	Korea	POSTECH	Ex-Officio
Steven G. LOUIE	USA	University of California at Berkeley	Jul.1, 2017~Jun.30, 2019
Naoto NAGAOSA	Japan	University of Tokyo	Nov. 12, 2018~Nov.25, 2019
Fu-Chun ZHANG	China	Kavli ITS	Nov. 12, 2018~Nov.25, 2019
Kiwoon CHOI	Korea	IBS	Nov. 12, 2018~Nov.25, 2019

KPS-APCTP Committee

Position	Name	Affiliation	Term
Chairperson	Bumhoon LEE	Sogang University	Jan. 1, 2019~Dec. 12, 2020
Member	Hawoong JEONG	KAIST	Jan. 1, 2017~Dec. 12, 2020
Member	Hyoung Joon CHOI	Yonsei University	Jan. 1, 2013~Dec. 12, 2020
Member	JINHEE YOON	Inha University	Jan. 1, 2015~Dec. 12, 2020
Member	Jae-Weon LEE	Jungwon University	Jan. 1, 2019~Dec. 12, 2020
Member	Gun Sang JEON	Ewha Womans University	Jan. 1, 2019~Dec. 12, 2020
Member	Kwon PARK	KIAS	Jan. 1, 2019~Dec. 12, 2020
Member	Ki-Seok KIM	POSTECH	Jan. 1, 2019~Dec. 12, 2020
Member	Piljin YI	KIAS	Jan. 1, 2019~Dec. 12, 2020
Member	Seok KIM	Seoul National University	Jan. 1, 2019~Dec. 12, 2020
Member	Nak-Woo KIM	Kyung Hee University	Jan. 1, 2019~Dec. 12, 2020
Member	Seong Chan PARK	Yonsei University	Jan. 1, 2019~Dec. 12, 2020

Program Coordinators

Name	Nationality	Affiliation	Term
Yongseok OH	Korea	Kyungpook National University	Sep. 1, 2017~Aug. 31, 2019
Soon-Hyung YOOK	Korea	Kyung Hee University	Aug. 1, 2018~Jul. 31, 2020
Nak-woo KIM	Korea	Kyung Hee University	Jul. 1, 2017~Jun. 30, 2019
Seung-Hoon JHI	Korea	POSTECH	Aug. 1, 2017~Jul. 31, 2019

Science Culture Committee

Name	Nationality	Affiliation	Term
Sang Wook KIM	Korea	Kyung Hee University	Jan. 1, 2019~Dec. 31, 2019
Myung-Hyun RHEE	Korea	Science Writer	Jan. 1, 2019~Dec. 31, 2019
Seung Woo SON	Korea	Hanyang University	Jan. 1, 2019~Dec. 31, 2019
Sungbin LEE	Korea	KAIST	Jan. 1, 2019~Dec. 31, 2019
Eun Hee LEE	Korea	Science Communicator	Mar. 1, 2019~Dec. 31, 2019

5. Member Countries and Membership Fees

Membership Overview (March 2017 ~ February 2019)

The Center has signed up a membership agreement with two institutions in Australia – Australian and New Zealand Association of Mathematical Physics (ANZAMP) and MATRIX, a mathematical research institute. It is expected that the two MoUs would contribute to the stable and sustainable relations between the Center and Australia.

Likewise, a new MoU with Wuhan Institute of Physics and Mathematics at the Chinese Academy of Sciences (WIPM-CAS) has been made. In addition to the existing membership with Chinese Physical Society (CPS), more productive academic relations are expected.

Member Countries and Entities/Institutes

- Australia
  - Australian and New Zealand Association of Mathematical Physics (ANZAMP)
  - Mathematical Research Institute (MATRIX)
- Beijing
  - Chinese Physical Society (CPS)
  - Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences (WIPM-CAS)
- Canada: Canadian Association of Physicists (CAP)
- India: India Association for the Cultivation of Science (IACS)
- Japan: Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization (IPNS/KEK)
- Kazakhstan: National Academy of Sciences of the Republic of Kazakhstan (NAS RK)
- Korea: National Research Foundation of Korea (NRF)
- Lao PDR: Research Institute of Science, Science Technology & Environment Agency (RIS-STEA)
- Malaysia: Malaysia Institute of Physics (MIP)
- Mongolia: Mongolian Academy of Sciences (MAS)
- The Philippines: National Research Council of the Philippines (NRCP)
- Singapore: Institute of Advanced Studies (IAS)
- Taipei: Academia Sinica (AS)
- Thailand
  - National Research Council of Thailand (NRCT)
  - Thai Physical Society (TPS)*

  *MOU is under discussion
- Uzbekistan: Uzbekistan Academy of Science (UAS)
- Vietnam: Vietnam Academy of Science and Technology (VAST)

Payment Status of Membership Fees

(Unit: USD)

Items	Australia						Beijing			
	ANU		ANZAMP		MATRIX		CPS		WIPM-CAS	
	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount
1996							May.21	10,000		
1997	Dec.02	10,000					May.28	10,000		
1998	Apr.24	10,000					Jan.22	10,000		
1999							Nov.23	10,000		
2000										
2001										
2002							Feb.14	20,000		
2003							May.30	10,000		
2004							Oct.04	10,000		
2005							May.10 Jul.28	20,000		
2006	Sep.08	10,000					May.22	10,000		
2007	May.20	10,000					Apr.23	10,000		
2008	May.30	10,000					May.20	10,000		
2009	May.13	10,000					May.22	10,000		
2010	Jun.03	10,000					Jun.01	10,000		
2011	May.16	10,000					Apr.25	10,000		
2012	Apr.24, 2013	10,000					May.24	10,000		
2013	May.19, 2014	10,000					May.10	10,000		
2014	Mar.26, 2015	10,000					Jul.23	10,000		
2015							Apr.16	10,000		
2016							Apr.25	10,000		
2017			Jun.14	2,500	Dec.20	7,500	Jun.14	10,000	May.26	3,000
2018			Apr.24	2,500			Sep.11	10,000	Jun.4	3,000
Total	122,500						236,000			

— *continued*

(Unit: USD)

Items	Japan		Lao PDR		Malaysia		Mongolia		Philippines	
	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount
1996	May.22	10,000								
1997	Aug.21	4,244								
1998	Jul.13	3,742			Mar.23	6,509				
1999	Oct.28	4,789							Jul.26	10,000
2000										
2001	Mar.08	4,178								
2002	Mar.13	10,000								
2003	Mar.24	10,000								
2004	Apr.13	10,000								
2005	Apr.11	10,000								
2006	Jul.04	10,000								
2007	Mar.29	10,000	exempted				exempted			
2008	Jan.18 Jun.09	20,000	exempted				exempted			
2009	May.22	10,000	exempted				exempted			
2010	Jun.04	10,000	exempted				exempted			
2011	Sep.30	10,000	exempted				exempted			
2012	May.11	10,000	exempted				exempted			
2013	Feb.22	10,000	exempted				exempted			
2014	Mar.25	10,000	exempted				exempted			
2015	Mar.23	10,000								
2016	May.25	10,000							Oct.23, 2017	901
2017	May.25	10,000								
2018	May.25	10,000								
Total	206,953		-		6,509		-		10,901	

— *continued*

(Unit: USD)

Items	Singapore		Taipei		Thailand		India	
	Date	Amount	Date	Amount	Date	Amount	Date	Amount
1996			Jul.15	10,000				
1997			Oct.13	10,000				
1998			May.20	10,000				
1999	Jan.09	2,500	Aug.19	10,000				
2000			Dec.07	10,000	Jun.29	10,000		
2001			Dec.19	10,000	Jan.05	6,945		
2002								
2003			Mar.07	20,000				
2004			Aug.04	10,000				
2005			Apr.25	10,000				
2006			Jul.12	10,000				
2007			Jun.05	10,000				
2008			Nov.14	10,000	Aug.20	6,945	Jun.20	10,000
2009			May.22	10,000	Jul.16	10,000		
2010			May.13	10,000	Jun.09	10,000	Aug.17	20,000
2011			May.20	10,000	Jun.09	10,000	Mar.30	10,000
2012	Feb.21, 2013	10,000	Jul.23	10,000	May.31	10,000	Mar.28	10,000
2013	Feb.21	10,000	Oct.04	10,000			May. 24	10,000
2014	Jul.23	10,000	Aug.07	10,000			Aug.11	10,000
2015	Mar.18, 2016	10,000	Mar.25	10,000			Aug.03	10,000
2016	Feb.24, 2017	10,000	Jul.04	10,000			Nov.08	10,000
2017	Oct.17	10,000	Sep.14	10,000			Dec.05	10,000
2018	May.6	10,000	May.14	10,000			Sep.7	10,000
Total	72,500		230,000		63,890		110,000	

Items	Vietnam		Uzbekistan		Kazakhstan		Canada		Total
	Date	Amount	Date	Amount	Date	Amount	Date	Amount	
1996	Jun.11	10,000							**40,000**
1997	Jul.26	10,000							**44,244**
1998	Jun.05	10,000							**50,251**
1999	May. 04	10,000							**47,289**
2000	Aug.11	10,000							**30,000**
2001	May. 31	10,000							**31,123**
2002	Apr.18	10,000							**40,000**
2003	May. 07	10,000							**50,000**
2004	Jul.01	10,000							**40,000**
2005	Jun.17	10,000							**50,000**
2006	Jun.14	10,000							**50,000**
2007	Apr.27	10,000							**50,000**
2008	Jun.19	10,000							**76,945**
2009	Jul.01	10,000							**60,000**
2010	Dec.10	10,000							**80,000**
2011	Jun.17	10,000	exempted						**70,000**
2012	Aug.31	10,000	exempted						**80,000**
2013	May. 28	10,000	exempted		exempted				**70,000**
2014	Jul.24	10,000	exempted		exempted				**70,000**
2015	Mar.23	10,000							**60,000**
2016	May. 10	10,000					Jul.07	5,000	**65,901**
2017	Jun.07	10,000			Nov.24	5,000	Jul.31	5,000	**83,000**
2018	Jun.7	10,000					Nov.9	5,000	**70,500**
Total	230,000		-		5,000		15,000		**1,309,253**

6. Partnerships

Partner Institutes

- ICTP (International Center for Theoretical Physics), Italy
- NCTS (National Center for Theoretical Science), Taipei
- PIMS (Pacific Institute for the Mathematical Sciences), Canada
- ECT* (European Centre for Theoretical Studies in Nuclear Physics and Related Areas), Italy
- ITP/CAS (Institute of Theoretical Physics, Chinese Academy of Sciences), Beijing
- MPI-PKS (Max Planck Institute for the Physics of Complex Systems), Germany
- JINR (Joint Institute for Nuclear Research), Russia
- IPNS/KEK (Institute of Particle and Nuclear Studies of High Energy Accelerator Research Organization), Japan
- YITP (Yukawa Institute for Theoretical Physics, Kyoto University), Japan
- IOP/CAS (Institute of Physics, the Chinese Academy of Sciences), Beijing
- ISSP (Institute for Solid State Physics of the University of Tokyo), Japan
- KPS (Korean Physical Society), Korea
- AAPPS (Association of Asia Pacific Physical Societies)
- IOP/VAST (Institute of Physics, Vietnam Academy of Science and Technology), Vietnam
- ThEP (Thailand Center of Excellence in Physics), Thailand
- IBS (Institute for Basic Science), Korea
- IUPAP (International Union of Pure and Applied Physics)
- INP RK (Institute of Nuclear Physics), Kazakhstan
- IETP (Scientific Research Institute of Experimental and Theoretical Physics), Kazakhstan
- RCNP (Research Center for Nuclear Physics), Japan
- Indonesian Physical Society, Indonesia
- National University of Laos, Lao PDR
- Myanmar Physical Society, Myanmar
- Mongolian Physical Society, Mongolia
- Vietnamese Physical Society, Vietnam
- NUUz (National University of Uzbekistan named after Mirzo Ulugbek), Uzbekistan
- SCS (State Committee of Science, Ministry of Education and Science, Republic of Armenia), Armenia
- IPM (Institute for Research in Fundamental Sciences), Iran
- CTP (Center for Theoretical Physics Seoul National University), Korea
- KITS (Kavli Institute for Theoretical Science), Beijing

II. Scientific Activities Report

1. Summary of Scientific Activities
2. Focus Research Programs
3. Academic Programs

1. Summary of Scientific Activities

2018 Number of Participants

Program Category		No. of Programs	Number of Participants			
			Total	Korea	Member Countries (Excl. Korea)	Non-Member Countries
Focus Research Programs	Focus Programs	2	95	66	18	11
	Topical Research Programs	10	756	689	24	43
FRP Total		12	851	755	42	54
Academic Programs	Schools	7	535	508	14	13
	Conferences &Workshops	13	1422	977	258	187
	External Activities	9	1467	72	1161	234
	Joint Activities	6	436	94	200	142
AP Total		35	3860	1651	1633	576
Total		**47**	**4,711**	**2,406**	**1,675**	**630**

Number of Participants by Gender and Academic Position

(Excluding External and Joint Activities)

Program Category		Total	Gender		Academic Position				
			Male	Female	Prof.	Researcher	Post-Doc	Student	Etc.
Focus Research Programs	Focus Programs	95	90	5	36	8	26	25	-
	Topical Research Programs	756	643	113	263	72	70	345	6
FRP Total		851	733	118	299	80	96	370	6
Academic Programs	Schools	535	452	83	98	37	44	347	9
	Conferences &Workshops	1,422	1,315	107	452	211	160	588	11
AP Total		1,957	1,767	190	550	248	204	935	20
Total		**2,808**	**2,500**	**308**	**849**	**328**	**300**	**1,305**	**26**

Number of Participants by Countries

(Excluding External and Joint Activities)

Region	Countries	No. of Participants
Member Countries	Korea	2,240
	Japan	109
	Beijing	94
	India	38
	Taipei	19
	Vietnam	17
	Thailand	12
	Philippines	11
	Australia	6
	Canada	2
	Mongolia	2
	Singapore	2
	Uzbekistan	2
Non-Member Countries	United States	73
	Italy	21
	Pakistan	17
	Germany	16
	France	15
	Russia	15
	United Kingdom	13
	Iran	12
	Indonesia	7
	Mexico	7
	Nepal	6
Sub total	**24**	**2,756**

Region	Countries	No. of Participants
Non-Member Countries	Israel	5
	Poland	4
	Spain	4
	Turkey	4
	Brazil	3
	Greece	3
	Ireland	3
	Romania	3
	Austria	2
	Czech	2
	Ethiopia	2
	Sweden	2
	Switzerland	2
	Tanzania	2
	Argentina	1
	Bangladeshi	1
	Belgium	1
	Colombia	1
	Croatia	1
	Denmark	1
	Hungary	1
	Netherlands	1
	Senegal	1
	Sudan	1
	Ukraine	1
Sub total	**25**	**52**

2. Focus Research Programs

Focus Programs

01 Strings, Branes and Gauge Theories
02 Holography and Geometry of Quantum Entanglement

Topical Research Programs (10 subjects, 28 mini-workshops)

01 Discussion Meeting on Polymer Physics Theory

- 01-1 Discussion Meeting on Polymer Physics Theory
- 01-2 Discussion Meeting on Polymer Physics Theory

02 Researches on Heavy flavors in Hadron Physics

- 02-1 Hadrons in various environments
- 02-2 Strong interactions in effective approaches

03 STATPHYS MONTHLY MEETING

- 03-1 The 103rd Statphys Monthly Meeting
- 03-2 The 104th Statphys Monthly Meeting
- 03-3 The 105th Statphys Monthly Meeting
- 03-4 The 106th Statphys Monthly Meeting
- 03-5 The 107th Statphys Monthly Meeting
- 03-6 The 108th Statphys Monthly Meeting

04 Strongly interacting quark-gluon plasma : from discovery to present

- 04-1 Every aspect of QCD matter at extreame conditions
- 04-2 Strongly interacting quark-gluon plasma; present
- 04-3 Strongly interacting QGP at RHIC and LHC : outlook

05 Quantum Geometry and Duality

- 05-1 Quantum Geometry and Duality
- 05-2 Quantum Geometry and Duality

06 Gravity and Cosmology

- 06-1 The 54th Workshop on Gravity and Cosmology
- 06-2 The 55th Workshop on Gravity and Cosmology

07 The Origin and Evolution of the Universe

07-1 The Origin and Evolution of the Universe
07-2 The Origin and Evolution of the Universe
07-3 The Origin and Evolution of the Universe

08 Innovative Workshop on Soft/Bio Materials

08-1 Soft Matter Summer School & Innovative Workshop on Bio/Soft Materials
08-2 Innovative Workshop on Soft/Bio Materials

09 Physics in Economic and Social System

09-1 Physics in Economic and Social System
09-2 Physics in Economic and Social System

10 Pursuing new particle physics through phenomenological approach

10-1 Baryogenesis for the origin of the matter
10-2 Charged Higgs Day
10-3 Basic collider physics
10-4 New probes of New physics

Pictures

[Focus Program]
Strings, Branes and Gauge Theories

[Topical Research Program]
Strongly interacting QGP at RHIC and LHC : outlook

Focus Research Programs 01

Strings, Branes and Gauge Theories

(1) Period
July 16 - 25, 2018

(2) Venue
APCTP Headquarters, Pohang

(3) Organizers
Nakwoo Kim (Kyung Hee University)
Sung-Soo Kim (UESTC Chengdu)
Rak-Kyeong Seong (Tsinghua University)

(4) Total Participants
34 persons

(5) Program Goal
String theory occupies a central position in the modern endeavors in theoretical physics. In particular, with this program we wish to put world experts on string theory and quantum field theory together and pursue the recent trends in international research community. With about 25 participants we are going to create a close knit atmosphere and cultivate creative environment.

(6) Research Performance
The participants could hear valuable results and we had enough time to have deeper discussions. We hope the participants started collaboration, and will hear about the result soon. This program is the first one of the series, and we started in 2018. Compared to other branches of research, String theory and gauge theories is a research topic on which Korean researchers are worldwide leading experts. Because of limited budget we invited only 2 people from USA, 1 from Japan and 1 from China. However they are all active researchers who recently produced noticeably significant results. If there were enough office places assigned - only one desk was given to our disposal - we could have benefited from more discussions.

Focus Research Program 02

Holography and Geometry of Quantum Entanglement

(1) Period
August 8 - 16, 2018

(2) Venue
Hanyang University, Seoul

(3) Organizers
Sang-Jin Sin (Hanyang Univeristy)
Ki-Seok Kim (POSTECH)
KeunYoung Kim (GIST)
Piljn Yi (KIAS)
Nakwoo Kim (Kyunghee Univeristy)
Koji Hashimoto (Osaka Univeristy)
Ioanis Papadomitriou (KIAS)

(4) Total Participants
61 persons

(5) Program Goal
We try to understand the principle of holography through the information theory basis and we also try to solve unsloved problems in condensed matter using the holography.

(6) Research Performance
Pisin Chen (National Taiwan U), Sang Mo Cheon (Hanyang U), Gil Young Cho (POSTECH), Jaeyoon Cho (APCTP), Eoin O Colgain (APCTP), Xian Hui Ge (Shanghai U), Koji Hashimoto (Osaka U), Michal P. Heller (Albert Einstein Institute), Ling-Yan Hung (Fudan U), Euihun Joung (KyungHee U), Isaac Kim (Stanford U), Keun-Young Kim (GIST), Ki-Seok Kim (POSTECH), Kyung Kiu Kim (Sejong U), Yan Liu (Beihang U), Masamichi Miyaji (Kyoto U), Mitsuhiro Nishida (GIST), Jaehyuk Oh (Hanyang U), Chanyong Park (GIST), Ioannis Papadimitrious (KIAS), YongHui Qi (Hanyang U), Dario Rosa (KIAS), Gordon W. Semenoff (UBC), Yunseok Seo (GIST), Sang-Jin Sin (Hanyang U), Tomonori Ugajin (OIST), Run-Qiu Yang (KIAS), Dong-Han Yeom (APCTP), Junggi Yoon (KIAS)

Through the talks by the speakers listed above, we tried to understand the principle of holography through the information theory basis and we also try to solve unsolved problems in condensed matter using the holography. Due to the participation of the internationally known speakers, many domestic researchers participated and it promoted the research standard of organizers as well as the domestic participants. I believe that the workshop also contributed to the fame of the APCTP to worldwide.

Topical Research Programs 01

String Theory and Cosmology

(1) Organizers
Jaeup Kim (UNIST)
YongSeok Jho (Gyeongsang National University)

(2) Activities
2 mini-workshops (total 60 participants)
- Discussion Meeting on Polymer Physics Theory
  - Date: July 19-21, 2018
  - Venue: Seoul Nat'l Univ., Pyeongchang
  - Participants: 42 persons
- Discussion Meeting on Polymer Physics Theory
  - Date: November 16-17, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants: 18 persons

(3) Program Goal
This group meeting covers general theory of polymers and other soft matters, including block copolymers, polyelectrolytes, biopolymers and other soft matter complex. Thanks to the support of APCTP, we have hosted these meetings for the years 2013~2018. For a few meetings, we received supporting fund from UNIST and KIAS. The 6th meeting was an international conference, and we also hosted 3 tutorial workshops.
Various theoretical methods and techniques are introduced in the meeting as a form of lecture, tutorial and/or research seminar. We encourage researchers in the meeting to find applications of the theory and to build collaboration network with theorists and/or experimentalists.

(4) Research Performance
In the 11th meeting, three self-consistent field theory (SCFT) specialists, Won Bo Lee, Yongjoo Kim and Jaeup Kim lectured on the theory and basic coding of SCFT, and they talked about their application to the real polymer system. Students and postdocs were the major audiences and the meeting provided them a good experience to become a polymer theorist.
In the 12th meeting, the major focus was on the soft material such as polyelectrolytes and liquid crystals. For the first time in this meeting, a student, So Jung Park made a presentation. She talked about the development of single chain in mean field (SCMF) method.
For the year 2018, our major focus was on the expansion of the local network between theorists in the polymer physics area, and we evaluate that such an objective was successfully fulfilled. In the 11th meeting, we had a tutorial about SCFT and we had 43 participants. In the 12th meeting, there were 4 talks and 18 participants were attended.

Topical Research Programs 02

Researches on Heavy flavors in Hadron Physics

(1) Organizers

Jung-Keun Ahn (Korea University)
Myung-Ki Cheoun (Soongsil University)
Kyujin Kwak (UNIST)
Hyun-Chul Kim (Inha University)
Youngman Kim (RISP/IBS)
Seung-il Nam (Pukyong National University)

(2) Activities

2 mini-workshops (tota 39 participants)

- Hadrons in various environments
  - Date: October 19-20, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants: 20 persons
- Strong interactions in effective approaches
  - Date: November 9, 2018
  - Venue: Soongsil University, Seoul
  - Participants: 19 persons

(3) Program Goal

HaPhy meeting has been an only representative research meeting for nuclear and hadron physics in Korea for a decade. In 2018, we organized two meetings and performed discussions and exchanging ideas successfully. We had 19 speakers and 38 participants in total. Especially, we have encouraged young scientists to attend and to deepen their knowledge and experience in these valuable opportunities. We also focused on the collaboration between the low-energy nuclear and hadron physicists, who have a common basis in terms of strong interactions. Considering the future experimental facilities such as RAON, this kind of broad collaboration will shed light on the progress of the understandings on strong interactions.

(4) Research Performance

- 1st meeting: Hadrons in various environments

In this workshop, we invite active researchers working on various nuclear physics topics in terms of the hadrons at vacuum, finite temperature, and density. Topics from the hadron properties to nuclear scattering, we discuss them as a whole, being guided by QCD and equivalent approaches.

- 2nd meeting: Strong interactions in effective approaches

In this workshop, we invite researchers working on the low-energy nuclear physics and hadron physicists to share their ideas to deepen the understanding for the strong interactions in various scales. Especially, by having enough discussions, we would like to stimulate young scientists and lead to possible collaborations among the attendants.

Topical Research Programs 03

STATPHYS MONTHLY MEETING

(1) Organizers

Deok-Sun Lee (Inha University)

(2) Activities

6 mini-workshops (total 165 participants)

Title	Date	Venue	Participants
The 103rd Statphys Monthly Meeting	March 17, 2018	KIAS, Seoul	39
The 104th Statphys Monthly Meeting	May 19, 2018	KIAS, Seoul	20
The 105th Statphys Monthly Meeting	June 23, 2018	KIAS, Seoul	10
The 106th Statphys Monthly Meeting	September 7-8, 2018	APCTP Headquarters, Pohang	38
The 107th Statphys Monthly Meeting	November 17, 2018	KIAS, Seoul	22
The 108th Statphys Monthly Meeting	November 30, 2018	KIAS, Seoul	36

(3) Program Goal

We strongly believe that in order to catch up recent research achievements in statistical physics and related areas, regular meetings of scientists in statistical physics and related areas are very important. Through the present program, we provide a room for local scientists to construct a strong infrastructure for non-equilibrium complex system research and maintain close interactions to make a new development on the subjects. We invite two speakers each month during the semester and cover the various subjects in non-equilibrium complex systems including phase transitions and critical phenomena, renormalization group analysis, percolation, spin glasses, evolutionary dynamics, random walks, molecular dynamics and Monte-Carlo simulations, and so on. We also plan to invite scientists in other areas like biology, chemistry, economics, financial engineering etc, to provide broad perspective to domestic statistical physicists. The organizers of the program will have regular discussions and will decide speakers according to the current rapid development of the subjects. In addition to the domestic speakers, we are planning to invite international speakers in diverse regions and help the local scientists to develop close academic relationship with them. We hope to invite those foreign speakers who are visiting research institutes like KIAS and APCTP for other purposes.

(4) Research Performance

From the fundamental laws of statistical mechanics to the statistical physics of polymers and machine learning, various topics were addressed by the speakers of this year. The current status and the future direction of statistical physics research have been illuminated, which is believed to have contributed to developing research topics and

initiating and strengthening the interaction and collaboration among domestic scientists in the related fields. That the statistical physics monthly meeting provides opportunities to learn and catch up with the frontier of research in the field and foster collaboration is spreading over young researchers. A lot of graduate students and postdoctoral researchers attended the monthly meeting this year. Therefore the monthly meetings of statistical physics are playing a crucial role in the growth of the statistical physics research in Korea.

Topical Research Programs 04

Strongly interacting quark-gluon plasma : from discovery to present

(1) Organizers

Byungsik Hong (Korea University)
Ju-Hwan Kang (Yonsei University)
Eun-Joo Kim (Chonbuk National University)
Youngman Kim (Institute for Basic Science)
Min Jung Kweon (Inha University)
Young Il Kwon (Yonsei University)
Chang-Hwan Lee (Pusan National University)
Su Houng Lee (Yonsei University)
Kang Seog Lee (Chonnam National Univ)
June-Tak Rhee (Konkuk University)
Ghi Ryang Shin (Andong National University)
Sang-Jin Sin (Hanyang University)
In-Kwon Yoo (Pusan National University)
Jin-Hee Yoon (Inha University)
Inkyu Park (University of Seoul)
Yongseog Oh (Kyungpook National University)
Sungtae Cho (Kangwon National University)
Dong Ho Moon (Chonnam National University)

(2) Activities

3 mini-workshops (total 83 participants)

- Every aspect of QCD matter at extreame conditions
  - Date: May 25-26, 2018
  - Venue: Kangwon National University, Chuncheon
  - Participants: 25 persons
- Strongly interacting quark-gluon plasma; present
  - Date: July 3-4, 2018
  - Venue: Korea University, Seoul
  - Participants: 34 persons
- Strongly interacting QGP at RHIC and LHC : outlook
  - Date: November 23-24, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants: 24 persons

(3) Program Goal

The main purpose of the 2018 APCTP program was twofold: understanding the nature of Quantum Chromo-Dynamic (QCD) matter under extreme conditions, or the quark-gluon plasma (QGP) and establishing an internationally recognizable Korean heavy-ion physics community. We, members of the Korea relativistic heavy ion physics community having carried out faithfully the APCTP Topical Research Program for the last 13 years, continued our 2018 APCTP Topical Research Program following a tradition of the previous APCTP programs, and achieved the great success in the 2018 APCTP Topical Research Program. In order to keep pace with rising needs for the investigation on strongly interacting QCD mater, we had three academic meetings in the 2018 APCTP

topical research program for the discussion on the QCD matter at various temperatures and densities.

(4) Research Performance

During the past 20 years both theoretical studies and experimental measurements have been made in order to understand QCD matter at high temperature and densities. With the help of dedicated experiments at the Super Proton Synchrotron (SPS) at CERN and the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, some signatures for the existence of the strongly coupled quark-gluon could be found in 2003. Since then ten times more powerful collider than that at RHIC with its beam energy fflsNN = 2.76 and 5.02 TeV, the Large Hadron Collider (LHC) has been built at CERN, and nowadays provides us chances for more precise measurements on the QCD matter at extreme conditions. With these new experiments there arise needs for the investigation on various phenomena in heavy ion collisions, and therefore we focused on in the 2018 APCTP topical research program the strongly interacting QCD matter at various temperatures and densities.

Throughout our three academic meetings dedicated to discuss strongly interacting quark-gluon plasma, we looked back the important measurements at CERN and BNL supporting the existence of the strongly interacting quark-gluon plasma, and had in-depth discussions on every aspect of QCD matter at extreme conditions in both theories and experiments. Starting from the discussions on the development of theoretical ideas and calculations we could review current understanding of the strongly interacting quark-gluon plasma, and summarize its properties from a standard point of view in the QGP analysis. In addition, we tried to find what we miss in the study of QCD matter as well as what we need to look for in the future in order to clarify our understandings on the strongly interacting QGP.

Topical Research Programs 05

Quantum Geometry and Duality

(1) Organizers

Jaeup Kim (UNIST)
YongSeok Jho (IBS)
Kyung Kiu Kim (Sejong University)
O-Kab Kwon (Sungkyunkwan University)
Chanyong Park (GIST)
Sang-Jin Sin (Hanyang University)
Hyun Seok Yang (CQUeST/Sogang University)
Kanghoon Lee (IBS)
Euihun Joung (Kyung Hee University)
Kang-Sin Choi (Ewha University)
Hyeong-Chan Kim (Korea National University of Transportation)
Inyong Cho (SeoulTech)
Seok Kim (Seoul National University)
Jeong-Hyuck Park (Sogang University)
Soonkeon Nam (Kyung Hee University)
Yun Soo Myung (Inje University)
Hang Bae Kim (Hanyang University)

(2) Activities

2 mini-workshops (total 39 participants)

- Quantum Geometry and Duality
  - Date: April 14, 2018
  - Venue: APCTP Seoul Office
  - Participants : 21 persons
- Quantum Geometry and Duality
  - Date: November 29-30, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants : 18 persons

(3) Program Goal

During the preparation and the process of the program, productive discussions were made on important topics in string theory, gravity theory and quantum field theory, and other detailed topics. For example, we discussed on physical meaning of duality between supersymmetric field theory and supergravity solutions, entanglement entorpy in string theory and quantum field theory and understanding microstates of black holes through quantum field theories. These discussions are expected to contribute to creation of new topics in theoretical physics.

(4) Research Performance

This program consisted of two workshops that included active discussions to develop the theoretical quantum and classical gravity and non-perturbative approaches of quantum field theory. In detail, these workshops covered the following topics :

3d gauge theory / Double field theory / 5d and 6d CFT and supersymmetric field theory / Holography / Entanglement Entropy in String theory / Euclidean Wormhole / Dynamical Compactification / Large AdS Black hole / Higher spin gauge theory / ABJM theory and holography / Entanglement Entropy in Holography

The talks were related to very hot topics in string, gravity and field theories. Every attendant enjoyed active discussions. We expect many collaborations to be made though discussion at this work shop. Therefore, this workshop was very successful.

Topical Research Programs 06

Gravity and Cosmology

(1) Organizers

Inyong Cho (Seoul National University of Technology)
Gungwon Kang (Korea Institute of Science and Technology Information)
Heeil Kim (Seoul National University)
Hyeong-Chan Kim (Korea National University of Transportation)
Sang Pyo Kim (Gunsan National University)
Sung-Won Kim (Ewha Womans University)
Chang-Hwan Lee (Pusan National University)
Wonwoo Lee (CQUeST, Sogang University)
John. J Oh (National Institute for Mathematical Science)
Hyung Won Lee (Inje University)
Seokcheon Lee (Gyeongsang National University)
Kyoung Yee Kim (Inje University)
Bogeun Gwak (Sejong University)

(2) Activities

2 mini-workshops (total 25 participants)

- The 54th Workshop on Gravity and Cosmology
  - Date: May 25, 2018
  - Venue: APCTP Seoul Office
  - Participants: 9 persons
- The 55th Workshop on Gravity and Cosmology
  - Date: November 16-17, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants: 16 persons

(3) Program Goal

Intended for seminars and workshop by participating members on their latest work in progress, invited review talks by external experts on the subjects of interest in the field for the gravity and cosmology. Expect most participating members to attend these workshops. Domestic and foreign participants actively participate the workshops and they have been very successful and beneficial for all the participating members in the past. Then, we maintain this form of the program which is successfully organized in past years.

(4) Research Performance

In this year, 2018, there were two workshop on gravity and cosmology. The two workshops included developments of hydrodynamics and black hole in general relativity. Further, including inflation, large structure, and gravitatioanl wave, topics of cosmology were presented in the workshop. Especially, speakers were experts about these research areas, so this time of program was very productive and helpful to participants. Overall, this year of programs was well organized to collect recent researches and participants across country. We had discussed and talked about many interesting topics and researches in this program.

In this year, the program held three-day workshop and seminar to facilitate researches and discussions for domestic/international researchers in gravity and cosmology. Especially, improvements in this year; 1) there were many topics included in the program such as black hole, quantum gravity, numerical relativity, cosmology, and dark matter. 2) Due to the detection of the gravitational wave in LIGO, researches in gravity and cosmology become important, so we invited young researchers in our program to promote their researches and growth.

We hope that this program will provide a place for domestic researchers to introduce their research and discuss various researches, and to introduce the latest trends and actively developing fields and to establish a joint research field. It also expects to contribute to the foundation and continuous development of the domestic research environment.

Topical Research Programs 07

The origin and evolution of the Universe

(1) Organizers

Ki Young Choi (Sungkyunkwan University)
Kyungjin Ahn (Chosun University)
Chan-Gyung Park (Chonbuk National University)
Jinn-Ouk Gong (KASI)
Seokcheon Lee (Sungkyunkwan University)
Seoktae Koh (Jeju National University)

(2) Activities

3 mini-workshop (41 persons)

- The origin and evolution of the Universe
  - Date: June 15-16, 2018
  - Venue: Sungkyunkwan Univ., Suwon
  - Participants: 23 persons
- The origin and evolution of the Universe
  - Date: September 14-15, 2018
  - Venue: Tongyeong
  - Participants: 8 persons
- The origin and evolution of the Universe
  - Date: November 22-23, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants: 10 persons

(3) Program Goal

Our goal is to have a regular meeting of Cosmology group in Korea to exchange recent developments and informations in their reserach fields and promote the collaborations between each other. Especially we encourage the young postdoctral researchers and students to participate to make actual collaboration and in-depth study. Further we will invite foreign researchers in the Asia Pacific area to make internaitonal coopeartions.

(4) Research Performance

In 2018, we had three meetings at Sungkyunkwan University, Tonhyeong and APCTP. We discussed about "the formation of the first star and galaxy", "Gravitational waves from Binary Mergers of Sub-Solar Mass Dark Black Holes", "Constrained seesaw extended NMSSM", "Expanding Universe and Dynamical Compactification using Yang-Mills Instantons", and "Singlet fermonic dark matter".

We had meeting regularly and discussed about the new researches and ideas. Especially we invited experts on the cosmology and particle-astrophysics to give a seminar and workshop. It was helpful to get new idea and proceed to write a paper. The contribution from APCTP was very helpful to continue this meeting and contribute to the cosmology society in Korea.

Topical Research Programs 08

Innovative Workshop on Soft/Bio Materials

(1) Organizers

Myung Chul Choi (KAIST)
Changbong Hyeon (KIAS)
Fyl Pincus (UCSB)
Mahn Won Kim (KIAS)
Hyuk Kyu Pak (UNIST)

(2) Activities

2 mini-workshops (133 persons)

- Soft Matter Summer School & Innovative Workshop on Bio/Soft Materials
  - Date: July 2-6, 2018
  - Venue: KIAS, Seoul
  - Participants: 92 persons
- Innovative Workshop on Soft/Bio Materials
  - Date: November 30-December 1, 2018
  - Venue: APCTP Headquarters, Pohang
  - Participants: 41 persons

(3) Program Goal

The overall objective of "Innovative Workshop on Bio & Soft Materials" proposed program is to provide avenues for close interactions between international/domestic researchers in the field of Bio/Soft Matter Physics. It will also provide unique opportunities for the researchers to find collaborative projects and track the cutting-edge research results. Two workshops were held in KIAS (July), and APCTP headquarter at Pohang during 2018 (Nov). There was a focus topic each session, and four invited speakers in the field presented research results, followed by discussion sessions.

(4) Research Performance

Soft/Bio materials is the most fast growing interdisciplinary field, although the history of field is short and the community is small such that interactions between groups are lack. The goal of Innovative Workshop on Soft/Bio materials is to overcome this problem and further lead the field. Since Mahn Won Kim started the 1st Workshop on the fall of 2013, the 27th workshop was held on at APCTP (Pohang) on Nov 2018. The researchers working on many different fields such as Physics, Materials, Mechanical engineering, Medicine etc. are invited in the workshop and provide and share their current research interests. We also provided the field experiences and recent cutting-edge works to the undergraduate and graduate students who just start the research in soft/bio area.

Topical Research Programs 09

Physics in Economic and Social System

(1) Organizers

Gabjin Oh (Chosun univeristy)
Okyu Kwon (NIMS)
jaewoo lee (Inha university)

(2) Activities

2 mini-workshops (total 49 participants)

- Physics in Economic and Social System
  - Date: October 5-6, 2018
  - Venue: NIMS, Daejeon
  - Participants: 25 persons
- Physics in Economic and Social System
  - Date: November 16-17, 2018
  - Venue: Chosun Univ, Gwangju
  - Participants: 24 persons

(3) Program Goal

We built up the community and nurturing young scientists in econophysics and social physics, the emerging field in physics, through the TRP. Based on the Korean community, we established the activity hub of the field in the Asia-Pacific area.

(4) Research Performance

The TRP focused on the education activity through seminar and mini-workshop. Through the TRP, we would like to teach the basic theory and research tool as well as the strength and the capability as a physicist in the field. The lectures were provided by the scholars from academia as well as industry such as financial firms. We would like to strengthen the community activity and capability in Korea and the Asia-Pacific area.

Topical Research Programs 10

Pursuing new particle physics through phenomenological approach

(1) Organizers

Jeonghyeon Song (Konkuk University)
Seongchan Park (Yonsei University)
Hyun-Min Lee (Chung Ang University)
Sunghoon Jung (Seoul National University)

(2) Activities

4 mini-workshops (122 persons)

- Baryogenesis for the origin of the matter
  - Date: August 20, 2018
  - Venue: Chung-Ang University, Seoul
  - Participants: 49 persons
- Charged Higgs Day
  - Date: September 1, 2018
  - Venue: Konkuk University, Seoul
  - Participants: 25 persons
- Basic collider physics
  - Date: November 10, 2018
  - Venue: Konkuk University, Seoul
  - Participants: 20 persons
- New probes of New physics
  - Date: November 24, 2018
  - Venue: Yonsei University, Seoul
  - Participants: 28 persons

(3) Program Goal

We continue our program with APCTP in 2018 under the title of "Pursuing new particle physics theory". Our primary purpose is the open discussion about theoretical ideas for new physics beyond the standard model, in connection with the phenomenology of the LHC, future colliders, dark matter search experiments, and gravitational wave observation. Our focus is on the comprehensive understanding of the Universe, through the collider physics phenomenology, new dark matter theories of WIMP, SIMP and also WIMPZillas, and the implications of new physics theories on the gravitational wave observation. This TRP program shall help us to develop deep and keen insights on particle physics through analyzing the LHC results and the cosmological data and discuss their implications for new physics.

(4) Research Performance

We conclude that the participants, especially graduate student and young postdocs, have been able to carry their research in particle physics phenomenology through the snail series in 2018. Most of all, we have extended our interest from the collider phenomenology into dark matter experiment, cosmic ray experiment, and gravitational experiment. All of these fields are frontier physics. Snail lecture series was timely and useful to all of the participants. In 2018, we have improved the snail lecture series so that graduate students and young postdocs could get to know the frontier particle physics. Particularly we have tried a new form of snail lecture series, 'charged Higgs day'. We have focused on the charged Higgs boson only, and invited all of the theoretical and experimental experts in Korea. Six active presentations and discussions were very helpful to extend the idea about the charged Higgs boson. After the session, for example, Konkuk University and Seoul National University had started a collaboration on this subject.

3. Academic Programs

Program List

Schools	
01	The 15th KIAS-APCTP Winter School on Statistical Physics
02	22nd APCTP Winter School on Fundamental Physics
03	2018 Computational Neuroscience Winter School
04	The 7th School of Mesoscopic Physics
05	Nuclear Physics School 2018
06	2018 Summer School on Numerical Relativity and Gravitational Waves
07	2018 Biophysics School
Conferences & Workshops	
01	Quantum Materials Symposium 2018
02	International workshop for String theory, Gravitation and Cosmology (STGCOS) 2018
03	The Nature of Hadron Mass and Quark-Gluon Confinement from JLab Experiments in the 12-GeV Era
04	APCTP-KIAS Workshop on Motors and Engines
05	International Symposium on Recent Progress in Superconductivity
06	8th East-Asia School and Workshop on Laboratory, Space, and Astrophysical Plasmas
07	APCTP-CTPU-GSDC 2018 LHC Physics Workshop @Korea
08	Computational Approaches to Magnetic Systems 2018
09	8th International Symposium on Nuclear Symmetry Energy (NuSYM2018)
10	International Workshop on Disordered Systems (IWDS2018): from localization to thermalization and topology
11	Workshop on Spin-orbit Coupled Topological States
12	The 21st Asian Workshop on First-Principles Electronic Structure Calculations (ASIAN-21)
13	The 10th APCTP Workshop on Multiferroics

External Activities	
01	Abdildin readings
02	International Conference on Holography, String Theory and Discrete Approaches in Hanoi
03	24th VIETNAM SCHOOL OF PHYSICS
04	The 9th International Workshop on Advanced Materials Science and Nanotechnology (IWAMSN 2018)
05	International workshop “New aspects of the Hadron and Astro/Nuclear Physics”
06	Particles, gravitation and the Universe
07	The 10-th International Conference on Photonics and Application (ICPA-10)
08	8th International Conference on Quarks and Nuclear Physics
09	The 2nd Asia Pacific Workshop on Quantum Magnetism
Joint Activities	
01	Kavli Asian Winter School 2018
02	Spring School on Superstring Theory and Related Topics
03	Joint Canada Asia-Pacific Conference on General Relativity and Relativistic Astrophysics
04	12th APCTP-BLTP JINR Joint Workshop
05	The 1st APCTP-TRIUMF Joint Workshop
06	The 10th APCTP-IACS-KIAS Joint Conference on Eemergent Phenomena in Novel Oxide Materials and Low Demensional Systems

Pictures

[School]
2018 Computational Neuroscience Winter School

[Conference and Workshop]
Quantum Materials Symposium 2018

[External Activity]
International workshop “New aspects of the Hadron and Astro/Nuclear Physics”

[Joint Activity]
Joint Canada Asia-Pacific Conference on General Relativity and Relativistic Astrophysics

Schools 01

The 15th KIAS-APCTP Winter School on Statistical Physics

(1) Period
January 8 - 12, 2018

(2) Venue
POSCO International Center, Pohang

(3) Organizers
Cheol-Min Ghim (UNIST)
Hyunggyu Park (KIAS)
Jae Dong Noh (University of Seoul)
Soon-Hyung Yook (Kyunghee Univ & APCTP)

(4) Total Participants
138 persons

(5) Program Goal
The Winter School aims to provide graduate students and junior researchers with a foundational and working knowledge of machine learning in connection with the principles of statistical physics.

(6) Research Performance
Considering the recent surge of interest in machine learning and deep learning, it is timely and effective to review the fundamentals of machine learning and to provide the relevant hands-on training opportunities. Despite the apparent lack of international participants, we reckon that Winter School played a crucial role in empowering the local research community, which eventually overcompensates for the lack of internationalization.

Schools 02

22nd APCTP Winter School on Fundamental Physics

(1) Period
January 22 - 29, 2018

(2) Venue
APCTP Headquarters, Pohang

(3) Organizers
Chanju Kim (Ewha Womans University)
Nakwoo Kim (Kyunghee University)
Seok Kim (Seoul National University)
Kimyeong Lee (KIAS)
Soonkeon Nam (Kyunghee University)
Jaemo Park (POSTECH)
Chaiho Rim (Sogang University)
Hyeonjoon Shin (APCTP)
Sang-Jin Sin (Hanyang University)

(4) Total Participants
48 persons

(5) Program Goal
The objective of this school is to provide graduate students in theoretical high-energy physics in Asia-Pacific region, with indispensable knowledge needed for frontier research.

(6) Research Performance
This year Emparan gave elementary lectures on black hole physics, and Arutyunov gave also introductory lectures on integrability. And Yavartanoo presented detailed computational methods in the study of the trendy SYK (Sachdev-Yeh-Kitaev) model. The material presented this year is expected to be very useful when the participants starting their own research.

Schools 03

2018 Computational Neuroscience Winter School

(1) Period
January 5 - 8, 2018

(2) Venue
Daejeon Convention Center, Daejeon

(3) Organizers
Jaeseung Jeong (KAIST)
Se-Bum Paik (KAIST)
Taewook Ko (NIMS)
Sangwan Lee (KAIST)
Sung-Phil Kim (UNIST)

(4) Total Participants
99 persons

(5) Program Goal
This winter school was for teaching and training undergraduate/graduate students and young researchers in physics and related fields who are interested in theoretical and computational neuroscience.
The program was composed of lectures and group activites, and the purpose of this school is to introduce various approaches of theoretical physics that contribute to the study of brain and neural systems.

(6) Research Performance
This year, the lectures covered various topics in computational and systems neuroscience and the group activity offers hands-on experience in the tools of statistical mechanics, nonlinear dynamics and computational technics for data analysis, algorithm design in brain research.
Tutorial-level lectures mostly covered important issues on the theoretical physics and computational simulations to study the brain and neural systems, including these topics: Neural encoding & decoding, Neural network models, Neuroscience-inspired A.I., Reinforcement learning, Bayesian data analysis.
Each lecture introduced various approaches in computational brain science based on theoretical physics. Most up-to-date research technics of mathematical modeling and data analysis were also covered. These lectures and activities helped students to understand how experimental research in brain science can be helped and improved by mathematical approaches of theoretical physics.

Schools 04

The 7th School of Mesoscopic Physics

(1) Period
May 24 - 26, 2018

(2) Venue
POSCO International Center, Pohang

(3) Organizers
Heung-Sun Sim (KAIST)
Yong-Joo Doh (GIST)
Dohun Kim (SNU)
Myung-Ho Bae (KRISS)
Hyung-Kook Choi (Chonbuk Nat'l Univ.)
Junho Suh (KRISS)
Gil-Ho Lee (POSTECH)

(4) Total Participants
95 persons

(5) Program Goal
The 7th school of Mesoscopic Physics is a meeting to deliver the basic knowledge of mesoscopic physics to graduate students and to promote the information exchange, scientific discussions, and collaborations among scientists. The school has been annually held since 2012, each time inviting four or five experts in the field as lecturers. It is intended particularly for lectures rather than seminal talks as in usual conferences so that the participants can learn and discuss thoroughly the topics.

(6) Research Performance
The main audience in this Summer School should be a graduate student in Master Course or a senior undergraduate student majoring in physics. The level of the lectures will be set to the main audience, instead of the PI professors or researchers.
The number of registered participants has increased to ~109 in comparison with the number (~60) in last year. The increase was caused by more participants in Master Course level. Those younger students had asked lots of questions during the lectures, which is also a new change in this Summer School. We will also encourage the students' participation in the lecture in next year.

Schools 05

Nuclear Physics School 2018

(1) Period
June 25 - 29, 2018

(2) Venue
APCTP Headquarters, Pohang

(3) Organizers
Eun-Joo Kim (Chonbuk National University)
Byungsik Hong (Korea University)
Hee-Jung Lee (Chungbuk National University)
Jung Keun Ahn (Korea University)
Young Man Kim (RISP/IBS)
YongSeok Oh (Kyungpook National University)
Chang Ho Hyun (Daegu University)

(4) Total Participants
52 persons

(5) Program Goal
The 2018 Nuclear Physics School (NPS) was held from Monday June 25 through Friday June 29, 2018, at the APCTP headquarter, Pohang. The Nuclear Physics School has been held every year since 2001, hosted by Division of Nuclear Physics, Korea Physical Society. The school is open to graduate students and young researchers with a strong interest in experimental and theoretical nuclear physics. The lectures of the 2018 NPS reviewd on the physics of Generalized Parton Distributions, and selective topics in RHIC and EIC physics.

(6) Research Performance
A series of lectures on hadron physics and selective topics in Relativistic Heavy Ion Collider and Electron-Ion Collider for students and postdoc follows with intensive discussion were given in the period of school. For hadron physics with theoretical view, there were reviews on the detailed historical explanation from atoms and quarks, a basic lecture for Quantum Chromodynamics and Light-Front Quark Model, recent activity on hadron and nuclear structure study, and QMC model. For experimental reviews, a history of spin physics, Electron-Ion Collider (EIC) concept, and an introduction to the physics program of EIC were given. The lectures this year in the field of experimental and theoretical physics was very well connected to each other, and was well received by participants.
On the first day of the Nuclear Physics School, students from each institution introduced their lab and field of research, helping students share information. Our future goal is to find a way to encourage students' participation and make connections between each other.
This year's Nuclear Physics School normally had 2 sessions in the morning and 2 or 3 sessions in the afternoon. However, many participants commented that 5 sessions a day was a tight schedule for both the lecturers and the audience. Therefore, we plan to reduce the lecture time next year. Also, we plan to make sessions where students have a chance to discuss freely with lecturers or make their own calculations.

Schools 06

2018 Summer School on Numerical Relativity and Gravitational Waves

(1) Period
July 23 - 27, 2018

(2) Venue
NIMS, Daejeon

(3) Organizers
John J. Oh (NIMS)
Sanghoon Oh (NIMS)
Gungwon Kang (KISTI)
Hyung Mok Lee (SNU)
Hyun Kyu Lee (Hanyang Univ.)
Hyung Won Lee (Inje Univ.)
Chunglee Kim (KASI)
Edwin Son (NIMS)
Chan Park (KISTI)
Jinho Kim (KASI)
Sanghyeon Ahn (KASI)
Hwansun Kim (NIMS)
Young-Min Kim (UNIST)
Piljong Jung (GIST)
Keun-Young Kim (GIST)
Heeil Kim (DasanData/SNU)

(4) Total Participants
57 persons

(5) Program Goal
The purpose of this summer school is aiming to train graduate students, postdoctoral researchers, and experts who are of interest in gravitational-wave physics/astronomy and numerical relativity. The lecture is consist of 1) basics of general relativity and astrophysics and 2) technical details of numerical methods for computational simulation and data analysis. The lectures after the common session are composed of two parallel sessions -- one is numerical relativity, another is gravitational-wave data analysis, in which theoretical overview, technical methods, and interactive exercises are covered.

(6) Research Performance
In the common session of the summer school, two lectures are given -- 1) general relativity 2) GW theory basics. After that, there are two parallel sessions with numerical relativity and gravitational wave data analysis. In NR course, theories on NR and BH simulations are presented with technical exercises. While GWDA course is presented from the LIGO GW school with the materials in LIGO Open Data Workshop -- lectures and exercises.
In addition, deep learning methodology and its application to GWDA and from expert of multi messenger astronomy, special lecture on the fields are given.

Schools 07

2018 Biophysics School

(1) Period
July 9 - 11, 2018

(2) Venue
APCTP Headquarters, Pohang

(3) Organizers
Junghyo Jo (KIAS)
Jong-Bong Lee (POSTECH)
Seunghwan Kim (POSTECH)
Chang Yong Song (POSTECH)
Jae-Hyung Jeon (POSTECH)
Woo-Sung Jung (POSTECH)
Wokyung Sung (POSTECH)

(4) Total Participants
46 persons

(5) Program Goal
We live in an exciting era for life science. Advanced tools for observing life and accumulated information of biological systems give great opportunities for unveiling what life is. This school aims to encourage the next generation of biophysicists by introducing fundamental questions in life, experimental tools for observing life, and theoretical/computational methods for integrating data.

(6) Research Performance
Since ‘life’ becomes one important topic of physics, biophysics has been actively contributing to provide deep insights of what life is. Therefore it is very important to introduce biophysics to the next generation of biophysicists. Unfortunately, however, we did not have good programs for undergraduate students in Korea. Our school is contributing to introduce them about life science, theoretical / computational / experimental biophysics since 2014. Many students have applied to participate our program since now this program becomes pretty popular among Korean undergraduate students. Until now, about 200 students have completed this summer program for the last five years.

Conferences & Workshops 01

Quantum Materials Symposium 2018

(1) Period
February 24 – March 1, 2018

(2) Venue
Muju Deogyusan Resort, Muju

(3) Organizers
Jaejun Yu (Seoul National Univ.)
Kee Hoon Kim (Seoul National Univ.)
Hyung Joon Choi (Yonsei Univ.)
Yunkyu Bang (APCTP)
Jung Hoon Han (Sungkyunkwan Univ.)
Gun Sang Jeon (Ewha Womans Univ.)
Youngjung Jo (Kyungpook National Univ.)
Changyoung Kim (Seoul National Univ.)
Jun Sung Kim (POSTECH)
Tae-Hwan Kim (POSTECH)
Tuson park (Sungkyunkwan Univ.)
Jae-Hoon park (POSTECH)
Je-Geun park (Seoul National Univ.)
kwon park (KIAS)
Chan-Ho Yang (KAIST)

(4) Total Participants
157 persons

(5) Program Goal
Quantum Materials Symposium 2018 (QMS18) is organized by the Korean condensed matter physics community of strongly correlated electron systems (SCES) and sponsored by various organizations in Korea including Asia-Pacific Center for Theoretical Physics (APCTP), Korea Institute for Advanced Study (KIAS), IBS (Institute of Basic Science) Center for Correlated Electron Systems (IBS-CCES) and IBS Center for Artificial Low Dimensional Electronic Systems (IBS-CALDES). We intend to bring world-renowned researchers in various frontiers in condensed matter physics.

(6) Research Performance
The QMS 2018 symposium has been successfully held in Muju, Deokyou mountain resort, from Feb. 24 (sat) to Mar. 1 (Friday) with a total of ~150 participants at least from approximately 10 different countries (korea, germany, UK, US, china, japan, taiwan, iran, india, france…). Numerous attendants have expressed the idea that high quality scientific sessions have been organized with very comfortable and relaxed atmosphere. It turned out that the symposium has been more than a success than previous years. The food was excellent and the session discussions were quite useful. In particular, we have promoted young researchers by including several oral speeches with 25 min long in addition to the 40 min long invited speeches. Furthermore, about 51 posters were presented by young students and postdocs, out of which 10 poster awards have been given with a prize of 100 dollars each. Overall, the symposium has been quite successful.

Conferences & Workshops 02

International workshop for String theory, Gravitation and Cosmology (STGCOS) 2018

(1) Period
June 18 ~ 20, 2018

(2) Venue
APCTP Headquarters, Pohang

(3) Organizers
Yun Soo Myung (Inje University)
Hyeong-Chan Kim (Korea National University of Transportation)
Wonwoo Lee (CQUeST, Sogang University)
Kyoung Yee Kim (Inje University)
Gungwon Kang (Korea Institute of Science and Technology Information)
Kyung Kiu Kim (Sejong University)
Yoonbai Kim (Sungkyunkwan University)
Wontae Kim (Sogang University)
O-Kab Kwon (Sungkyunkwan University)
Hyung Won Lee (Inje University)
Jae-Weon Lee (Jungwon University)
Jaehyuk Oh (Hanyang University)
Chan Park (Korea Institute of Science and Technology Information)
Chanyong Park (APCTP)
Miok Park (KIAS)
Mu-In Park (Sogang University)
Sang-Jin Sin (Hanyang University)
Dong-han Yeom (APCTP)
Sang-Heon Yi (University of Seoul)
Rong-Gen Cai (Institute of Theoretical Physics, Chinese Academy of Sciences)
Yungui Gong (Huazhong University of Science and Technology)
Qing-Guo Huang (Chinese Academy of Sciences)
Leonardo Modesto (Southern University of Science and Technology)
Nobuyoshi Ohta (Kindai University)

(4) Total Participants
42 persons

(5) Program Goal
This program is a continuation of the annual international workshop which has lasted for the last 9 years.
The scope of the workshop is focussed on string theory, gravitation and theoretical cosmology. In particular, it pursues the inter-communication between those three fields. Also a few of observational cosmologists will be invited to report the recent observational results. In doing so, the theorists can come up with the observational constraints in building the theoretical models. The speakers present their recent

progress and have intensive discussions from which the participants can build up collaborations in these fields. The contents of the workshop will provide young postdocs and students with a good opportunity of tutorial for their research work.

(6) Research Performance

There were 31 oral presentations and 2 poster presentations. They consisted of gravitation including gravitational wave as a hot issue in recent years, cosmology and quantum gravity. And some presentations were related with quantum entanglement.

STGCOS 2018 was held in APCTP, Pohang. A total of 42-44 participants from five countries, including Korea, China, Japan, the United States and Russia. There were 31 oral presentations and 2 poster presentations. Due to the limitations of period and budget, some participants were not able to present their research works. For this reason, we want to hold the upcoming workshop, STGCOS 2019, at APCTP, Pohang for four days in the next year. We would like to thank APCTP for their financial and administrative supports.

Conferences & Workshops 03

The Nature of Hadron Mass and Quark-Gluon Confinement from JLab Experiments in the 12-GeV Era

(1) Period

July 1 - 4, 2018

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Volker Burkert (JLab)
Daniel S. Carman (JLab)
Latifa Elouadrhiri (JLab)
Ralf W. Gothe (Univ. of South Carolina)
Chueng Ryong Ji (North Carolina State Univ.)
Hyon-Suk Jo (Kyungpook National University)
Kyungseon Joo (Univ. of Connecticut)
Viktor Mokeev (JLab)
Herve Moutarde (Saclay)
Carlos Munoz (Orsay)
Yongseok Oh (Kyungpook National University)
David G. Richards (JLab)
Craig D. Roberts (Argonne National Lab)

(4) Total Participants

44 persons

(5) Program Goal

This workshop aims to develop plans and collaborations through which existing and foreseen experiments at JLab (location: Newport News, Virginia, USA) can provide insights into the two most important unsolved problems within the Standard Model; namely, the origin of hadron mass and the confinement of gluons and quarks. Duality between the quark-gluon fundamental degrees of freedom and the meson-baryon effective degrees of freedom will be exploited among the experts in various QCD motivated theoretical approaches to come up with the unified phenomenological description both for the hadron resonances and the hard exclusive processed. It will canvass a wide range of experiment and theory, e.g.

(a) nuclear femtography with computation and measurement of the momentum and spatial distributions of partons inside a hadron using new opportunities from semi-inclusive DIS, DVCS and DVMP experiments in the 12 GeV era, and diverse array of methods in order to expose emergent phenomena via quasiparticle formation,

(b) exploring the dynamics and impacts of hadron mass generation with hadron elastic and transition form factors,

(c) prospects for contributions from lattice- regularized QCD.

The potential for a combined experiment-theory effort to gather the information necessary to provide the hadron imaging with hard processes and solve the problems

of mass generation and confinement has recently been demonstrated in the successful description of JLab data on pion and nucleon elastic form factors, and a number of nucleon resonance electroexcitation amplitudes using continuum bound-state methods. This analysis has unified a large body of experimental results on hadron elastic and transition form factors within a single framework and thereby provided strong evidence to support universality of the dynamically generated dressed-quark mass function, whose existence and behavior are predicted by both continuum and lattice methods.

In the absence of quantum effects, the appearance of the non-zero, dynamically generated mass for the proton and other hadrons in the chiral limit of QCD is impossible. Hence, experiment-theory connections that provide confirmation of its existence are plausibly the best means to probe the strong dynamics that lie at the heart of mass generation. JLab is the only facility in the world today (and for the foreseeable future) that is capable of unravelling the structure of ground- and excited-state hadrons. Indeed, with its 12-GeV electron beam, JLab can utilize a remarkable range of hadron structure parameters that are interpretable in QCD and extracted from experiment– elastic and transition form factors, and a host of parton distributions – that can be used to chart the transition from the Standard Model's perturbative domain, characterized by weak interactions among gluons and quarks, into the domain of strong-QCD, a phase within which all measurable phenomena are emergent and the origin of 98% of the visible mass in the Universe is to be found. Crucially, theory that can directly connect these measurements with QCD is now reaching maturity, so that the data can be mined for the information need to solve the Standard Model's most pressing questions. A remarkable synergy currently exists between the capacities and interests of experiment and theory; and the purpose of this workshop, therefore, is to gather world-class experimentalists and theorists in order to capitalize on existing successes and foster new collaborative efforts that will lead JLab through the 12-GeV era, and also explore novel avenues for physics at a future electron ion collider (EIC) with nuclear femtography.

Existing JLab collaborations, e.g. between JLab and ANL (USA), Indiana Univ. (USA), the Univ. of South Carolina (USA), Irfu/SPhN, CEA, Saclay (France), CNRS/IN2P3, Orsay (France), INFN of Genova (Italy), INFN of Roma (Italy), Giessen Univ. (Germany), Tuebingen Univ. (Germany), Yerevan Physics Institute (Armenia), Moscow State Univ. (Russia), Boskovic Institute (Croatia), and the Asia Pacific Center for Theoretical Physics (Korea) that includes many institutions in Korea and the Asia-Pacific region will be strengthened and new teams will be built, involving scientists from Korean universities and research institutes, in particular. We expect the discussions to be lively and productive, and we will encourage the participation of early-career researchers, whose future depends heavily on the successes we can achieve now and build upon with an EIC.

(6) Research Performance

During the workshop, many discussions were made by participants to initiate collaborations. In particular, the following topics were discussed in depth.

1. Electron Ion Collider (EIC) project: This is the new project of the USA in hadron physics to understand the structure of nuclei. Many physical motivations and current ideas were presented.

2. Generalized Parton Distributions (GPD) has been a major research topic of JLab. New data and theoretical ideas were presented and discussed.

3. Hadron reactions and spectra: These are crucial to understand the strong interactions at the hadronic scale. New data as well as new theoretical tools were presented and suggested.

Among 36 presentations, 10 of them were reported by domestic researchers while 26 presentations were reported by the researchers outside Korea: 3 in Japan, 5 in Europe, 2 in South America, and 16 in the USA. So, 72% of the presentations were given by researchers outside Korea. This was the first workshop dedicated to JLab physics in APCTP. JLab is the world-leading facility in studying hadron structure and this became a good chance to foster collaboration by introducing this field to the AP region as many experts from JLab attended this workshop.

Conferences & Workshops 04

APCTP-KIAS Workshop on Motors and Engines

(1) Period
June 25 ~27, 2018

(2) Venue
KIAS, Seoul

(3) Organizers
Yong Woon Kim (KAIST)
Juyeon Yi (PNU)
Peter Talkner (Univ. of Augsburg)
Hyunggyu Park (KIAS)

(4) Total Participants
59 persons

(5) Program Goal
The rapid recent development of experimental tools for the control, manipulation and observation of processes on the nano-scale has also triggered the curiosity on the side of theory and has lead to the emergence of so-called stochastic and quantum thermodynamics. These novel fields have been very active but also controversial, in particular when it comes to apply familiar macroscopic notions as work and heat to situations when thermal or quantum fluctuations dominate the dynamics. The investigations of nano-engines ranging from biological motors to single electron engines are of central interest both in view of applied issues and of basic research. This workshop is intended to provide a general understanding of the subject and to introduce the most recent research results. Topics to be covered are motors in bio-molecular systems, quantum motors, classical/quantum heat engines and their fundamental limits.

(6) Research Performance
As it was an only three-day workshop, research was not performed at the conference site during the workshop. However, a number of collaborations and new ideas are expected to come through the presentations and interactions at the workshop. For instance, we proposed a new idea on a generalization of trade-off relation between efficiency and power of the heat engine, which is under current investigation.
The workshop was considered to be very successful and fruitful, based on the following points: 1) about 80% of invited speakers came from abroad, representing internationalization of the meeting 2) had 60 participants more than expected, which reflects great interest in the topics covered in the workshop 3) had a number of positive feedbacks from participants; they evaluated this workshop as very interesting and inspiring because many active researchers were brought together and because all the presentations are well organized to deliver recent results on the focused topic and at the same time to help audiences to get broad perspectives.

Conferences & Workshops 05

International Symposium on Recent Progress in Superconductivity

(1) Period
July 8 - 11, 2018

(2) Venue
Yongpyong Resort, Pyeongchang

(3) Organizers
Yunkyu Bang (Chonnam National Univ.)
Hanyong Choi (Sungkyunkwan Univ.)

(4) Total Participants
98 persons

(5) Program Goal
The international Workshop on recent progress in superconductivity (IWRS 201) will provide an exciting opportunity to discuss recent progress in superconducting materials and its pairing mechanism. Major topics that will be treated in the symposium will include, but not limited to
- New superconducting materials
- Cu/Fe-based high-Tc superconductivity
- Heavy fermions superconductivity (quantum critical superconductivity)
- Superconductivity in low-dimensional compounds
- Recent progress in theory on superconductivity.

(6) Research Performance
IWRS 2018 held 8 scientific sessions and have 21 invited speakers. On Tuesday afternoon, a 2 minute oral presentation was prepared before the poster session so that young scientists and graduate students could present their recent results, leading to an opportunity to discuss research with world-renowned scientists. We expect that these interactions provided by the conference would produce foundation for future research collaboration.
The international workshop on recent progress in superconductivity was an avenue to discuss various forefront research topics among world renowned scholars and local Korean reserchers in a friendly, relaxed environment. There were many pariticipants from the nations in the Asia-Pacific rims such as China, Japan, United States of America, and Korea, providing a unique opportunity to begin or enhance collaborative research among participants.
Applied science in Korea has been very strongly supported, but research on the superconductivity and strongly correlated quantum matter was very rare because its importance has been less well represented. This workshop provided an excellent opportunity to expose not only the importance of superconductivity and complex quantum matter, but also the important role of international collaboration.

Conferences & Workshops 06

8th East-Asia School and Workshop on Laboratory, Space, and Astrophysical Plasmas

(1) Period
July 30 - August 3, 2018

(2) Venue
Chungnam National University, Daejeon

(3) Organizers
Jungyeon Cho (Chungnam National University)
Dongsu Ryu (UNIST)
Hui Li (LANL, USA)
Ryoji Matsumoto (Chiba Univ., Japan)
Quanming Lu (Univ. of Science & Technology of China)

(4) Total Participants
91 persons

(5) Program Goal
Plasma physical processes play an important role in various laboratory, space, and astrophysical environments, including fusion experiment, Earth magnetosphere, Sun, interstellar medium, and intergalactic medium. This summer school intends to 1) introduce basic physics of laboratory, space, and astrophysical plasmas and provide training to young scientists; 2) bring scientists from laboratory physics, space physics, and astrophysics together and exchange ideas and latest results; 3) foster future collaborations especially in the East-Asian region and also around the world.
Topics includes 1) Reconnection, 2) Turbulence, 3) Dynamo, 4) Momentum transport and particle accelerations, 5) MHD, PIC, or GK codes.

(6) Research Performance
Participants introduced their recent research results through 12 80-min lecturers, 17 invited talks, 12 oral contributed talks, and 9 posters. The number of participants is more than expected. Most participants are from the Far-Eastern region. Students participation from China and Japan is lower than expected. It is encouraging that there are 2 students from Taiwan.

Conferences & Workshops 07

APCTP-CTPU-GSDC 2018 LHC Physics Workshop @Korea

(1) Period
August 7 – 9, 2018

(2) Venue
Konkuk University, Seoul

(3) Organizers
Soonkeon Nam (Kyunghee University)
Jihn E Kim (Seoul National University)
Eung Jin Chun (KIAS)
Deog-Ki Hong (Pusan National University)
Sun Kun Oh (Konkuk University)
Yongkyung Kwon (Konkuk University)
Jeonghyeon Song (Konkuk University)
Toru Sugitate (Hiroshima University)
Kiwoon Choi (IBS-CTPU)
Inkyu Park (University of Seoul)
Bum Hoon Lee (APCTP & Sogang University)
Frank Zimmermann (CERN)
Hwidong Yoo (Seoul National University)
Youngjoon Kwon (Yonsei University)

(4) Total Participants
87 persons

(5) Program Goal
The most important aim of the program committee was to set the characteristic of our workshop be distinguishable from other academic activities that take place before and after our workshop.
Thus, the program committee has tried to emphasize the distinctive character of our workshop from others. However, the summer of this year was so crowded with a number of heavy-weight international conferences as to make our workshop squeezingly sandwiched in between them. The program of our workshop inevitably overlapped with more than one of them.
Hence, we have opened the program to included any subject that are relevant with high energy physics. It is worthwhile to notice that we have invited an expert on science poliy from STEPI to get in touch with the policy perspective of Moon government.

(6) Research Performance
The experiences over more than 10 years have established a well-organized schedule. The time table of each day starts from 09:00 or 09:30 in the morning with two coffee breaks and a lunch break until 17:30 or 18:00 for three days. Each day, there have been 12 talks of 30 minutes, and in total, 36 talks in three days. Chiarpersons of each session

have been successfully assigned. The group of student assistants helped the workshop very remarkably.

As this workshop is mainly composed of oral presentations of recent researches, most of them have been published elsewhere.

Conferences & Workshops 08

Computational Approaches to Magnetic Systems 2018

(1) Period

August 27 – 28, 2018

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Kyoo Kim (Max Planck POSTECH/Korea center)
Bongjae Kim (Kunsan national University)
Cesare Franchini (University of Vienna)
Byung Il Min (POSTECH)

(4) Total Participants

47 persons

(5) Program Goal

Magnetism in the condensed matter has been a continuous issue of interests. Through this workshop on “Computational approaches to magnetic systems”, we plan to discuss the current status of various computational and theoretical methods to magnetic systems. The topic will include various approaches which include density functional theory (DFT), dynamical mean-field theory (DMFT), coherent potential approximation (CPA), exact diagonalization (ED), renormalization group (RG) etc. Wide range of systems will be covered from conventional metal to correlated oxides. We hope this workshop can be a stepping stone for the future collaboration of various groups in the field.

(6) Research Performance

In this 2 days mini workshop, with 15 outstanding in their field and mostly young speakers, we had intensive and extensive discussion on the research of magnetism and magnetic materials using computational method ranging from classical Monte Carlo in the classical spin system, to field theoretical approach to Majorana fermions in quantum magnetism systems. Dispites the diverse methodology and systems, we had very active discussions on these subjects. Students are encouraged to present their current researches in the poster session to get feedback from researchers and professors. Overall impression for this workshop is very successful. We had discussion about the future of workshop, and agreed to make this workshop annual.

Conferences & Workshops 09

8th International Symposium on Nuclear Symmetry Energy (NuSYM2018)

(1) Period
September 10 - 13, 2018

(2) Venue
Hanwha Resort, Haeundae, Busan

(3) Organizers
Myung Ki Cheoun (Soongsil University)
Byungsik Hong (Korea University)
Youngman Kim (IBS)
Kyujin Kwak (UNIST)
Chang-Hwan Lee (Pusan National University)
Yongseok Oh (Kyungpook National University)
Jeonghyeok Park (Korea University)
Myung Ki Cheoun (Soongsil University)
Byungsik Hong (Korea University)
Youngman Kim (IBS)
Kyujin Kwak (UNIST)
Chang-Hwan Lee (Pusan National University)
Yongseok Oh (Kyungpook National University)
Jeonghyeok Park (Korea University)

(4) Total Participants
90 persons

(5) Program Goal
NuSYM2018 will concentrate on the advances in experimental and theoretical studies of the nuclear Equation of State of asymmetric nuclear matter. An important role of this symposium is to unite the efforts of the nuclear physics and astrophysics communities in solving their common problems. The program will cover the current state of research and the anticipated development trends in various centers and facilities in the world. The symposium will provide a convenient space and time for discussions of burning experimental and theoretical problems and of the future directions as well as to form collaborations and to advance inter-related research fields.

(6) Research Performance
NuSYM2018 discussed recent theoretical and experimental results on nuclear equation of state and symmetry energy. Especially, the most recent results on the nuclear symmetry energy and neutron stars, including the recent observation of the gravitational wave due to the collision between neutron stars by LIGO and current status of NICER, were presented. In addition, the development of the nuclear transport models and ab initio nucleon density functional were presented. Finally, the construction and plan of the various radioactive ion beam (RIB) facilities were also reorted.

Conferences & Workshops 10

International Workshop on Disordered Systems (IWDS2018) : from localization to thermalization and topology

(1) Period
September 3 - 7, 2018

(2) Venue
PCS IBS, Daejeon

(3) Organizers
Rudo Roemer (University of Warwick)
Lea Santos (Yeshiva University)
Ki-Seok Kim (POSTECH)

(4) Total Participants
71 persons

(5) Program Goal
The scientific topics covered were
- Transport and localization in disordered systems
- Thermalization and many-body localization
- Quantum dynamics in many-body systems
- Topological phases of matter and their properties

The workshop provided a stimulating and motivating scientific atmosphere to learn about the most recent advances in the field and to foster further collaborations between the participants. Although the programme of the workshop contained many talks, there was still good time for the participants to discuss, exchange information, and conduct some research. The workshop was particularly useful in introducing the emerging Asian community of disordered systems researchers to the state of the field and to showcase their talents to the international experts. The workshop also included a poster prize, awarded and sponsored by Physica E – low-dimensional systems and nano-structures, and judged by three invited speakers.

(6) Research Performance
The workshop overall succeeded in providing a platform to discuss the physics of many-body localization, thermalization and topology to an audience of experts in traditionally mainly single-particle localization physics. It is clear that the role of interactions will become ever more important in the future of the field. Nevertheless, it was also clear how the many approaches developed in single-particle localization physics now provide a very fruitful basis for these currently ongoing many-body developments.

A particular highlight of the workshop was the outreach into other areas of physics where quantum interference and many-body aspects are important. Here we just wish to point to talks on superconductivity, machine learning, scanning gate techniques,

renormalization groups, glasses and transport in complex electric power grids. This diversity highlights the uniquely successful appeal of the field to other areas of physics. A considerable part of the conference was also given to applications of classical waves such as microwaves and light where localization physics provides an area of application while still retaining many open questions of fundamental importance.

Looking into the future, it is clear that the workshop participants were hoping that the workshop series will continue. At the meeting, two proposals for holding the next event emerged and at present this is scheduled to take place in 2020 at Morelia in Mexico. While it is still a bit too early to discuss specifics, it is already clear that the workshop's tradition to reach out to exciting and new topical areas of the field will continue in 2020 as well.

We should also mention that this workshop had a very good number of female participants, with 6 talks given by women. A very nice outcome of this gathering was that some of these women are now trying to collaborate among them and will be visiting each other already during this year. A suggestion for the future could be to explicitly ask organizers to try to make sure their workshops count with a certain minimum number of female participants, such as at least 20-25%.

Feedback from the participants, on the high quality of the premises, the hotel accommodation and the workshop excursion, was unanimously very positive. The overall organization of the event, before and during IWDS, was of excellent quality. As scientific organizers, we did not receive a single negative comment from a participant regarding any organisational matter.

Workshop on Spin-orbit Coupled Topological States

(1) Period

October 1 - 5, 2018

(2) Venue

POSCO International Center, Pohang

(3) Organizers

Jeehoon Kim (POSTECH)
Sungdae Ji (MPK)
Alexei Andreanov (IBS-PCS)
Jae Hoon Park (POSTECH)
Ki-Seok Kim (POSTECH)
Alireza Akbari (APCTP)
Yunkyu Bang (POSTECH)
Hyunwoo Lee (POSTECH)
EunGook Moon (KAIST)
Kwon Park (KIAS)
Taehwan Kim (POSTECH)
Suk Bum Chung (UOS)
Keun Su Kim (Yonsei)
Jungdae Kim (Ulsan)
Gil Ho Lee (POSTECH)
Gil Young Cho (POSTECH)

(4) Total Participants

128 persons

(5) Program Goal

In the field of topological physics, which has recently attracted the attention of many researchers, we have invited 40 distinguished speakers and shared their expertise on topological insulators, spin liquid systems, to explore the expansion of the research scope of the new topological materials and the activation of joint research.

(6) Research Performance

The workshop was composed of 15 organizers and 39 invited speakers. The total number of registered members of the workshop is about 140. The conference was highly participated by so many researchers throughout the conference period. The invited speakers have delivered all of the latest research results that have not been announced yet, and some of the videos of the presentations are being made available to various researchers upon request. Most foreign speakers first visited APCTP and POSTECH, were impressed with the research facilities and personnel of Pohang, and discussed the possibility of collaborative research. The main profit was that many future collaborations and personnel exchanges are expected with regard to topological materials and new materials near future.

It was the first large-scale conference on topological material physics supported by the APCTP main sponsor, which was a meaningful workshop by delivering the latest research to Korean topological materials researchers and providing opportunities for collaborative research with prominent overseas researchers.

Conferences & Workshops 12

The 21st Asian Workshop on First-Principles Electronic Structure Calculations (ASIAN-21)

(1) Period
October 29 - 31, 2018

(2) Venue
KAIST, Daejeon

(3) Organizers
Yong-Hyun Kim (KAIST)
Hyunju Chang (KRICT)
In-Ho Lee (KRISS)
Yong-Hoon Kim (KAIST)
Myung Joon Han (KAIST)
Hyoung Joon Choi (Yonsei University)
Young Woo Son (KIAS)
Chul Hong Park (Busan National University)
Seung-Hoon Jhi (POSTECH)
Noejung Park (UNIST)
Seungwu Han (Seoul National University)
Young-Kyun Kwon (Kyung Hee University)
Sung-Hoon Lee (Kyung Hee University)
Cheol-Hwan Park (Seoul National Univ.)
Byungchan Han (Yonsei Univ.)

(4) Total Participants
343 persons

(5) Program Goal
This workshop is an annual series starting in 1998 to provide a forum for discussing all the important issues in computational condensed matter physics and materials science. The principal purpose of the workshop is to offer an opportunity for exchanging ideas and enjoying in-depth discussion both in the methodology in computational physics and chemistry and its application to materials. This workshop consists of invited talks and contributed poster presentations. The majority of the participants are active scientists and researchers in electronic structure theory from all Asian countries. Scientists and researchers from other areas are also very welcome to join us. The official language is English.

(6) Research Performance
There are 5 international plenary speakers, 21 asian invited speakers, and 120 poster presentation.
Recent progress in electronic structure calculations has been discussed during the workshop via plenary/invited talks and poster presentations. The subject includes physics of low-dimensional materials, novel 2D materials, state-of-the-art computation,

energy materials, phonon effect, electron correlation, defects in semiconductors, novel electronic states, machine learning & TDDFT, topological materials, and etc. There are 343 participants including 114 foreign scholars and students from 18 different countries (Japan, China, Taiwan, Thailand, USA, etc.)

The workshop was very successful in discussing recent issues in electronic structure calculations, and also showing how much KAIST elaborates on science and technology. Many participants from foreign countries showed their satisfaction after the workshop. Therefore, we self-evaluate that the workshop was 100% successful in every aspect.

Conferences & Workshops 13

The 10th APCTP Workshop on Multiferroics

(1) Period

November 11 - 13, 2018

(2) Venue

KAIST, Daejeon

(3) Organizers

Chan-Ho Yang (KAIST)
Myung Joon Han (KAIST)
Sungbin Lee (KAIST)
Je-Geun Park (SNU)
Yoon Hee Jeong (POSTECH)

(4) Total Participants

165 persons

(5) Program Goal

The scope of the program includes various fields such as magnetism, ferroelectrics, spintronics, topological structures, correlated and spin-orbit coupled systems. This workshop serves as a catalyst for finding new directions that go beyond the traditional magnetoelectric coupling in multiferroics with active scientists in each field.

(6) Research Performance

The specific themes of the workshop - domain textures, materials and mechanisms, spin & orbital, collective excitations, 2D & hybrid structures – were concretely chosen after receiving the abstracts of the invited speakers. Many researchers gave talks about topological structures and transitions such as electric/magnetic skyrmions, bi-merons, and unusual textures. Dynamic motion/excitations beyond the static structures were discussed as an important direction for future research. Conducting domain walls can be an essential ingredient for future nanocircuitry. New materials and mechanisms for large ME coupling were also reported based on experimental observations as well as theoretical predictions. The materials were also expanded from the conventional inorganic solid crystals to 2D materials, liquid crystals, and hybrid structures. Theoretical approach using second principles calculation can be effective for understanding the topological textures and domain walls for which the unit-cells are hardly defined. Advanced microscopic techniques such as scanning TEM and NV center microscope are being quickly developed for high-resolution visualization of crystalline and magnetic structures. A new concept of the orbital Hall effect was proposed. Since it can be induced by an electric field rather than a current, the orbital Hall effect can be found in dielectric materials as well. Two invited talks reported topological Hall effects in a manganite thin film and an oxide heterostructure, respectively. Many speakers reported experimental findings of collective excitations associated with magnon, electromagnons, acoustic waves, and electronic structures in multiferroics.

External Activities 01

Abdildin readings

(1) Period
January 8 ~ 18, 2018

(2) Venue
Ramanujan Lecture Hall, ICTS Bangalore

(3) Organizers
Minxin Huang (ICTS, University of Science and Technology of China)
Sangmin Lee (Seoul National University, South Korea)
Sungjay Lee (Korea Institute for Advanced Study, Korea)
R. Loganayagam (ICTS-TIFR, Bangalore)
Suvrat Raju (ICTS-TIFR, Bangalore)
Tadashi Takayanagi (YITP, Japan)
Masahito Yamazaki (Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), The University of Tokyo)
Gang Yang (Institute of Theoretical Physics, Chinese Academy of Sciences)

(4) Total Participants
223 persons

(5) Activity Evaluation
The School had an outstanding set of lectures and the courses were on cutting edge areas in String Theory and related subjects. It was very gratifying that a number of students from china were also able to participate. The school consisted of 29 lectures of 1.5 hours each. There were discussion sessions of half an hour duration during the last three days of the School. The School also had a Kavli Distinguished Lecture by David Gross (Jan. 8th), Vishveshwara Lecture by Kip Thorne (Jan. 11th), Infosys-ICTS Chandrasekhar Lectures by Nathan Seiberg (Jan. 8th, 9th, 11th and 12th) and ICTS Distinguished Lecture by Hirosi Ooguri (Jan. 15th).

(6) Comments
High benchmark set for the Asian Winter Schools should continue in the years to come.

External Activities 02

International Conference on Holography, String Theory and Discrete Approaches in Hanoi

(1) Period
August 6 ~ 10, 2018

(2) Venue
Duy Tan University, Vietnam

(3) Organizers
Hai-Qing Zhang (Beihang Univ., China)
Phung Van Dong (IOP, VAST)
Shingo Takeuchi (Duy Tan Univ.)
Vu Xuan Quang (Duy Tan Univ.)

(4) Total Participants
25 persons

(5) Activity Evaluation
In this conference, the following points would be very problematic:
· Quite extremely uncooperativeness of the secretary in Institute of Physics (IOP), Hanoi, Ms. Duong Thai Man. Always saying “that’s not my work” and “I am Busy”, she has denied all the help I ask to orgaznize the conference (e.g. reservation of hotel, setting of the venue).

One thing I could not forget is that, when I needed to use a printer in IOP to print out the receipts towqrd the registration fee that each person pays, she demanded me to pay the cost for each paper and ink ! (where number of papers I will use at that time is about 25.)

Regarding this point, since it is too bad, I have said to Prof. Phung Van Dong(vice director in IOP). Then, I could use the printer without paying the cost to her.

· Irresponsibility of Phung Van Dong, the person above, who allowed her such ehaviors would be also a critical problem.
· It is unclear and I have no idea why they took such attitude to me!
· As written in the supporting letter which IOP wrote, this conference should have been planned with their corporation. Despite of this, thy helped almost nothing.
· No (or very late) reply of the person in charge of “supporting letter”, Prof. Dai Hung Nguyen, to me request for the “supporting letter” would have been a problem, which arose various vain hard works for me. His delay in his reply would seem close to the abandonment of office.

After all, I cannot do anyting on the ones above, however at least I would like to remain those by writing as above.

(6) Comments

· In the last September, I obtained the “supporting letter” from him with very great pains. In this September, Prof. Dai Hung Nguyen told me that he cannot write it for the following reason:

Since APCTP allocates only 10,000 USD to the activities in Vietnam in 2019, he needs to confirm the number of activities he will ask APCTP for the financial support in 2019, which is 5. Those 5 have been already determined.

So, this September, I could not apply for the program-4.

Since his reply was just before the deadline of the submission day of the application, I had written the application form and made various preparatioin, which all got into vain.

· At any rate, I wonder why I had to have such a great trouble to just get reply, as the problem before he undertake to write the “supporting letter” or not.

· I wish APCTP to tell Porf. Dai Hung Nguyen to properly make a reply toward my requests for the “supporting letter”, if he undertakes the charge of “supporting leter”.

· Since I am going to apply for the program-4 in my activity in 2020, I am going to tell him that.

I wish he could also include my activity in the activities which he considers to support. I wish he does not make decision without any inquiring to me, otherwise I would not be able to appy for program-4 again in 2019 (and eternally).

In addition, if no response from his (as usual in the case of him), since I have to proceed with the preparation, and finally enormous energy and effort would be vain.

· If possible, I wish APCTP to rethink the institution of the “supporting letter”.

*** As a result of that I have considered variously, I would like to submit this document with this description.

External Activities 03

24th VIETNAM SCHOOL OF PHYSICS

(1) Period

August 20 ~ 31, 2018

(2) Venue

International Center for Interdisciplinary Science and Education, Quy Nhon, Vietnam

(3) Organizers

Duc Ninh LE(IFIRSE)
Sabine Kraml(LPSC Grenoble, France)
Thi Nhung Dao(IFIRSE)

(4) Total Participants

37 persons

(5) Activity Evaluation

Vietnam School of Physics (VSOP), created in 1994, is now a recognized international school of physics. For 24 years the VSOP has proved to be an activity for science, friendship and collaboration between physicists from different generations and from different countries in the region and in the world. This year the school was devoted for particle physics and cosmology and were attended by 21 Vietnamese participants and 16 foreign ones.

The school scientific program started with introductory lectures on the Standard Model (SM), Experimental Physics (Exp), and Cosmology and Dark matter (C&DM) in the first week. And then, lectures on QCD, Beyond the SM (BSM), and Monte-Carlo Event Generators (MC) followed in the second week.

The program was organized in the way that more fundamental and “easier-to-be-understood” lectures were scheduled in the first week, and then followed by more advanced lectures in the second week. The lectures were of different content and style but were coordinated with each other and covered important topics of particle physics, cosmology and experimental methods at the LHC experiments (mainly ATLAS and CMS). The lectures on SM, QCD and BSM were given using blackboard with lecture-note files provided to the participants. These files can be obtained from the school website. The cosmology lectures were presented using both computer presentation and blackboard. The other lectures on experimental methods and Monte-Carlo Event Generators were presented using computer presentation. For SM, Exp, C&DM, QCD and BSM lectures, several exercises were provided as homework to the students. This help to deepen their understanding and encouraged discussion among students and between students and lecturers. Indeed, we have divided all students into five groups, each with a group leader. This worked very well as they worked together to do a lot of homework. The MC lecturer provided a hands-on tutorial on how to use the MC generator Herwig and on MC method to do phase space integration.

The students were active, asked a lot of questions and did a lot of exercises. Many of them went on the blackboard to present their solutions for the SM, QCD and BSM lectures.

Besides the lectures, the school program also contained four seminar sessions where students gave 17 talks (each talk lasted 15 minutes) on the topics of their interest or research. The seminar sessions were highly appreciated by the students as they gave them an opportunity to present (for the first time for some students) a scientific work in English before an international audience. Most of these seminars were very professionally prepared and presented. The organizers and lecturers had very good impressions of the talks.

A full-day excursion on Sunday between the two working weeks was organized. All participants joined in. We had a wonderful day. This activity enhanced the interactions and understanding between participants as well as discovering the beauty of Binh Dinh province.

The school, VSOP-24, was a great success. All six lecturers gave excellent lectures, from introductory up to research level, to meet the large spectrum of participants. All lectures were well prepared, clearly presented, and interesting. All students participated in every lecture. At the end, many of them expressed that they had enjoyed VSOP-24 very much, and have benefited a lot from the school. Lecturers have also communicated to the organizers that they were very happy and satisfied with the school.

All three organizers (Thi Nhung DAO, Sabine KRAML, Duc Ninh LE) present at the school are very happy with this success. We saw that the school went very well, the scientific program is very good with important and hot topics. The selection of participants, organization, and timetable were quite optimal. We therefore want to continue our efforts to use this framework for future VSOPs.

External Activities 04

The 9th International Workshop on Advanced Materials Science and Nanotechnology (IWAMSN 2018)

(1) Period

November 7 ~ 11, 2018

(2) Venue

Ninh Binh City, Ninh Binh Province, Vietnam

(3) Organizers

Le si Dang (IN, France)
Kazuhito Hashimoto (Nims, Japan)
Nguyen Quang Liem (IMS, Vietnam)

(4) Total Participants

443 persons

(5) Activity Evaluation

IWAMSN2018 was organized to promote opportunities for joining discussions, sharing knowledge, and establishing collaboration between Vietnamese and foreign scientists in order to develop the field of advanced materials science and nanotechnology.

IWAMSN2018was organized very successfully with high quality of scientific results presented, large number of participants, a wide variety of discussed topics, promising new collaborations established. On behalf of the organizers, we would like to express our sincere thanks to Asia Pacific Center for Theoretical Physics for your constant support for many years and for coming years.

External Activities 05

International workshop “New aspects of the Hadron and Astro/Nuclear Physics”.

(1) Period
November 5 ~ 10, 2018

(2) Venue
National University of Uzbekistan, Tashkent, Uzbekistan

(3) Organizers
Bakhodir Irgaziev (NUU, Tashkent)
Zokirjon Kanokov (NUU, Tashkent)
Yousuf Musakhanov (NUU, Tashkent)
Hyun-Chul Kim (Inha University)
Ulugbek Yakhshiev (Inha University)
Rakhim Yarmukhamedov (NUU, Tashkent)

(4) Total Participants
45 persons

(5) Activity Evaluation
In general the workshop passed smoothly. The percentage of foreign participants was 33%. From APCTP member countries participated 39 participants and 9 of them from abroad. The scientific part was passed as planned and very smoothly with the intensive discussions. In particular, uzbek scientists were very satisfied with scientific discussions. We think that the main goal of the workshop is achieved.

External Activities 06

Particles, gravitation and the Universe

(1) Period
December 10 ~ 14, 2018

(2) Venue
Vietnam academy of science and technology (VAST), Hanoi, Viet Nam

(3) Organizers
Nguyen Anh Ky (Institute of Physics, VAST)
Misao Sasaki (Kavli IPMU, University of Tokyo)
Dinh Van Trung (Institute of Physics, VAST)
Nguyen Thi Hong Van (Institute of Physics, VAST)

(4) Total Participants
94 persons

(5) Activity Evaluation
- Internationalization ratio of participants: 41/94.
- Internationalization ratio of invited reports: 18/19,
- Internationalization ratio of contributed reports: 15/21,
- Internationalization ratio of summary reports: 2/2,
- Internationalization ratio of the APCTP contribution: 574 USD / 1000 USD

External Activities 07

The 10-th International Conference on Photonics and Application (ICPA-10)

(1) Period
November 11 ~ 15, 2018

(2) Venue
Halong city, Quang Ninh province, Vietnam

(3) Organizers
Hung Dai Nguyen (VPS & VAST)
Hakuta Kohzo (UEC, Tokyo)
SUK HYYONG (APRI, GIST, R. Korea)
Bourguignon Bernard (ISMO Orsay. France)
Lap Van Dao (Swinburne Tech. Uni., Australia)
Sarukura Nobuhiko (Osaka Uni., Japan)
Valentin A Orlovich (IOP, NAS Belarus)
Hieu Van Nguyen (VAST)
Brechignac Philippe (Paris-11 University. France)
Kato Yoshiaki (Hamamatsu, Japan)
Nickles Viktor Peter (MBI. Berlin, Germany)
Yuri Kivshar (Australian National Uni., Australia)
Ueda Ken-Ich (UEC. Tokyo, Japan)
Zadkov Victor N (Moscow State Uni., Russia)
Chardonnet Christian (CNRS France)
Kodama Ryosuke (ILE, Osaka Uni., Japan)
Lee Tak Yong (APRI, GIST. R. Korea)
Dat Thanh Huynh (VNU HoChiMinh)
Binh Thanh Nguyen (IOP, VAST)
Binh The Nguyen (HUS, VNU Hanoi)
Hoi Van Pham (IMS VAST)
Khoa Xuan Dinh (Vinh University)
Trung Van Dinh (IOP, VAST)
Bang Huy Nguyen (Vinh University)
TuanHung Vu Le (Uni. Nat. Sciences, VNU HCM)
Vinh Quang Lam (Uni. Nat. Sciences, VNU HCM)
Hieu Chi Hoang (Uni. Nat. Sciences, VNU HN)
Dinh Nang Nguyen (Uni. & Eng. & Technology, VNU HN)
Thang Duc Pham (Uni. & Eng. & Technology, VNU HN)
Hai Hoang Le (Uni. Le Quy Don)
Minh Van Nguyen (Uni. Edu. HN)
Hoang Huy Luc (Uni. Edu. HN)
Ha Lien Thi Nghiem (IOP, VAST)
Tien Quoc Tran (IMS, VAST)
Minh Quang Nguyen (IMS, VAST)
Tuan Hong Pham (Nacentec, MOST)
Son Manh Nguyen (Hue University)
Tuan Van Ta (VPS)
Bich Thi Vu (IOP, VAST)
Minh Hong Pham (IOP, VAST)
Khanh Van Thi Nguyen (IOP, VAST)

(4) Total Participants
308 persons

(5) Activity Evaluation
90 International scientists. 46 scientists are APCTP members. 219 Vietnamese scientists.
Vietnamese participants 219, International participants: 90 (from Japan (16), France (14) ,Belarus (8), Thailand (8), R. Korea (7), Philippines (5), Austria, Laos (2), Cambodia (2), Myanmar (4), Malaysia (2), Indonesia (4) Russia, Poland, Taiwan, Canada, Italy, Germany, Spain, New Zealand, ...)

External Activities 08

8th International Conference on Quarks and Nuclear Physics

(1) Period
November 13 ~ 17, 2018

(2) Venue
Tsukuba, Japan

(3) Organizers
Shunzo Kumano (KEK / J-PARC)
Shinya Sawada (KEK / J-PARC)

(4) Total Participants
216 persons

(5) Activity Evaluation
We had a large number of participants from the APCTP related countries (more than 150) to this conference, and many of them are theorists. About 40% of the participants are young students and postdocs. It is good to learn about recent progress for them in the wide areas of hadron and nuclear physics. The APCTP support was distributed mostly to young scientists, and the support was valuable for their participation. We received very good evaluations on speaker selections and appropriate topics by participants according to personal communications.

External Activities 09

The 2nd Asia Pacific Workshop on Quantum Magnetism

(1) Period
November 29 ~ December 7, 2018

(2) Venue
International Centre for Theoretical Sciences, Bengaluru - 560 089, India

(3) Organizers
Subhro Bhattacharjee (ICTS, Bangalore)
Gang Chen (Fudan University, China)
Ying-Jer Kao (National Taiwan University, Taiwan)
SungBin Lee (Korea Advance Institute of Science and Technology, Republic of Korea,)
Nic Shannon (Okinawa Institute of Science and Technology, Japan)
Arnab Sen (Indian Association for the Cultivation of Science, India,)
Zenji Hiroi (University of Tokyo, Japan)
Kedar Damle (Tata Institute of Fundamental Research, India,)
Jason Gardner (National Synchrotron Radiation Research Center, Taiwan)
Yong Baek Kim (University of Toronto, Canada)
Roderich Moessner (MPI-PKS, Dresden)
Je-Geun Park (Seoul National University, Republic of Korea)
Subhro Bhattacharjee (ICTS, Bangalore)
Gang Chen (Fudan University, China)
Ying-Jer Kao (National Taiwan University, Taiwan)
SungBin Lee (Korea Advance Institute of Science and Technology, Republic of Korea,)
Nic Shannon (Okinawa Institute of Science and Technology, Japan)
Arnab Sen (Indian Association for the Cultivation of Science, India,)
Zenji Hiroi (University of Tokyo, Japan)
Kedar Damle (Tata Institute of Fundamental Research, India,)
Jason Gardner (National Synchrotron Radiation Research Center, Taiwan)
Yong Baek Kim (University of Toronto, Canada)
Roderich Moessner (MPI-PKS, Dresden)
Je-Geun Park (Seoul National University, Republic of Korea)
Subhro Bhattacharjee (ICTS, Bangalore)
Gang Chen (Fudan University, China)

Ying-Jer Kao (National Taiwan University, Taiwan)
SungBin Lee (Korea Advance Institute of Science and Technology, Republic of Korea,)
Nic Shannon (Okinawa Institute of Science and Technology, Japan)
Arnab Sen (Indian Association for the Cultivation of Science, India,)
Zenji Hiroi (University of Tokyo, Japan)
Kedar Damle (Tata Institute of Fundamental Research, India,)
Jason Gardner (National Synchrotron Radiation Research Center, Taiwan)
Yong Baek Kim (University of Toronto, Canada)
Roderich Moessner (MPI-PKS, Dresden)
Je-Geun Park (Seoul National University, Republic of Korea)

(4) Total Participants
76 persons

(5) Activity Evaluation
The second Asia-Pacific meeting on frustrated magnetism was a step towards organizing the Asia-pacific community working in this area to foster discussion on the active areas of research and explore possible research collaborations. The meeting received participation from a large number of active researchers in the area, both theorists and experimentalists, from different parts of the asia-pacific region including students and postdoctoral fellows from India. The organisers and the speakers (on enquiry from the organisers) felt that the meeting was largely successful in achieving its goal and this is partly reflected in interest to continue this next year so that this becomes an annual feature. It was also felt by the organisers that in future the meeting would try to incorporate more representation from experimental researchers as well as researchers from under-represented countries in the asia-pacific region.

Joint Activities 01

Kavli Asian Winter School 2018

(1) Period
January 8 – 18, 2018

(2) Venue
ICTS-TIFR, Bangalore, India

(3) Organizers
Minxin Huang (ICTS, University of Science and Technology of China)
Sangmin Lee (Seoul National University)
Sungjay Lee (KIAS)
R. Loganayagam (ICTS-TIFR)
Suvrat Raju (ICTS-TIFR)
Tadashi Takayanagi (YITP)
Masahito Yamazaki (Kavli IPMU, The University of Tokyo)
Gang Yang (Institute of Theoretical Physics, Chinese Academy of Sciences)

(4) Total Participants
118 persons

(5) Activity Evaluation
The School had an outstanding set of lectures and the courses were on cutting edge areas in String Theory and related subjects. It was very gratifying that a number of students from china were also able to participate. The school consisted of 29 lectures of 1.5 hours each. There were discussion sessions of half an hour duration during the last three days of the School. The School also had a Kavli Distinguished Lecture by David Gross (Jan. 8th), Vishveshwara Lecture by Kip Thorne (Jan. 11th), Infosys-ICTS Chandrasekhar Lectures by Nathan Seiberg (Jan. 8th, 9th, 11th and 12th) and ICTS Distinguished Lecture by Hirosi Ooguri (Jan. 15th).

(6) Comments
High benchmark set for the Asian Winter Schools should continue in the years to come.

Joint Activities 02

Spring School on Superstring Theory and Related Topics

(1) Period
March 14 - 22, 2018

(2) Venue
ICTP, Trieste, Italy

(3) Organizers
Atish Dabholkar (ICTP)
Edi Gava (ICTP)
Veronika Hubeny (UC Davis)
Zohar Komargodski (Weizmann Inst. & SCGP Stony Brook)
Kumar Narain (ICTP)

(4) Total Participants
130 persons

(5) Activity Evaluation
An excellent school, touching on the most exciting recent developments, with very high quality lectures and enthusiastic participation of students.

(6) Comments
Excellent program. Should be continued.

Joint Activities 03

Joint Canada Asia-Pacific Conference on General Relativity and Relativistic Astrophysics

(1) Period
June 25 - 29, 2018

(2) Venue
University of Alberta, Edmonton, Canada

(3) Organizers
Dmitri Pogosian (University of Alberta)
Sang Pyo Kim (Kunsan National Univesrity)
Manu Paranjapee (Universite de Montreal)
Richard Sydora (University of Alberta)

(4) Total Participants
50 persons

(5) Activity Evaluation
In my opinion and the feedback I heard from participants the conference was a significant success having opened canadian General Relativity community to interaction with colleagues from Asia Pacific region. The format of the conference allowed every participant to present an oral talk (40 min for invited speakers and 20 minuts for contributed talk) which led to condensed and informative sessions where both established scientists and scientist at the beginning of their careers, including graduate students, could equally participate. We expect the conference to continue on bi-annual cycle, expanding the dialogue of the Relativity communities in our region, in particular between member countries of APCTP.

(6) Comments
We are currently discussing the place and venue for the JCAP-CGRRA 2020, in two year time period. Among ideas is to hold it this time outside of Canada, in one other APCTP member country.

Joint Activities 04

12th APCTP-BLTP JINR Joint Workshop

(1) Period

August 20 - 24, 2018

(2) Venue

Centum Premier Hotel, Busan

(3) Organizers

Wooyoung Kim (Kyungpook National Univ.)
Chang-Hwan Lee (Pusan National Univ.)
N. Kochelev (BLTP, JINR)
Yongseok Oh (Kyungpook National Univ.)
Hee-Jung Lee (Chungbuk National Univ.)
V. Voronov (BLTP, JINR)
A. Gladishev (BLTP,JINR)
S. Bondarenko (BLTP,JINR)
A. Hosaka (RCNP)
Pngming Zhang (IMP)
Emiko Hiyama (RIKEN)
Byungsik Hong (Korea Univ.)
Chang Ho Hyun (Daegu Univ.)
Dmitri Kazakov (BLTP,JINR)
Hyunchul Kim (Inha Univ.)
Victor Kim (St. Petersburg INP)
Youngman Kim (Institute for Basic Science)
Jie Meng (Peking Univ.)
Seung-il Nam (Pukyong National Univ.)
Makato Oka (Japan Atomic Energy Agency)
Qiang Zhao (IHEP)
Shan-Gui Zhou (ITP)
Bing-Song Zou (ITP)

(4) Total Participants

49 persons

(5) Activity Evaluation

The APCTP-BLTP JINR Joint Workshop was originally initiated to promote cooperation between researchers of Korea and Russia under the cooperation of the APCTP and BLTP of JINR in 2007 and is now recognized as a regular workshop. Since the 7th Joint Workshop, which was held under the title “Modern problems in nuclear and elementary particle physics” at Bolshiye Koti, Irkutsk Region, Russia, in July, 2013, we have made an effort to make the Joint Workshop internationally more recognized by inviting more physicists from other countries. In the 7th Joint Workshop, actually, 3 researchers from Japan joined. In the 8th Joint Workshop, which was held at Jeju Island in June, 2014, 10 researchers from China and Japan joined. From this workshop, the both sides agreed to enlarge the scope of the workshop by including more member countries of APCTP and of JINR. The researchers from China and Japan who joined this workshop also agreed on the purpose of the Joint Workshop. Thanks to the success of this series of Joint Workshops, we could set up collaboration programs. In fact, we already produced publications from the results of the collaboration and could win exchange programs such as the Brain Pool project. All these activities could be initiated by the Joint Workshop. In order to enlarge the scope of the workshop continuously, we had the 9th workshop at Institute of Nuclear Physics, Almaty, Kazakhstan, the 10th workshop at RIKEN in Japan and the 11th workshop at St. Petersburg in Russia, 2017.

Following the effort in the previous workshops, we had the 12th workshop from August 20 to August 24 at Busan in Korea, 2018. The number of the participants from Korea, Russia, China, Japan, and Spain were 47 and the number of talks were 35 as shown in the scientific program in the previous part of this report. During the workshop, the intensive talks on modern nuclear and elementary particle physics were given and many discussions in the participants were done. So, it is expected that this Joint Workshop could initiate another international collaboration among the participants.

Additionally, it looks that this series of Joint Workshops provide a very unique atmosphere among the participants and help understand both sides in physics and in culture. Therefore, we could conclude that this workshop was very successful in this year and this Joint Workshop is beneficial to the both sides of APCTP and BLTP JINR.

Joint Activities 05

The 1st APCTP-TRIUMF Joint Workshop

(1) Period
September 14 - 19, 2018

(2) Venue
APCTP Headquarters, Pohang, Korea

(3) Organizers
Sonia Bacca (TRIUMF)
Jason Holt (TRIUMF)
Yongseok Oh (Kyungpook National Univ.)
Manu Paranjape (Montreal Univ.)
Michael Pearson (Montreal Univ.)
Chang Ho Hyun (Daegu University)
Hyun-Chul Kim (Inha University)

(4) Total Participants
40 persons

(5) Activity Evaluation
This workshop is the first joint workshop of APCTP and TRIUMF since Canada became a member country of APCTP. In physics community, the meaning of this workshop is two-fold. First, this is a unique workshop which connects the Skyrme soliton model and energy density functional where Skyrme contributed to by developing so called the Skyrme force model. There is a strong consensus on the continuation of this kind of meeting and after discussion with organizing committee members and participants, the agreement for having the second workshop at TRIUMF in June 2020 was made. This is the other important meaning of this workshop. This will cause strong cooperation between APCTP and TRIUMF that represents Canadian physics community.

Joint Activities 06

The 10th APCTP-IACS-KIAS Joint Conference on Eemergent Phenomena in Novel Oxide Materials and Low Demensional Systems

(1) Period
October 1 - 3, 2018

(2) Venue
Sheraton Grand Hotel, Incheon, Korea

(3) Organizers
Kwon Park (KIAS)
Jaejun Yu (Seoul National Univ)
Yunkyu Bang (APCTP)
Indra Dasgupta (IACS)
Dipankar Das Sarma (IISc)
Kwon Park (KIAS)
Jaejun Yu (Seoul National Univ)
Yunkyu Bang (APCTP)
Indra Dasgupta (IACS)
Dipankar Das Sarma (IISc)

(4) Total Participants
49 persons

(5) Activity Evaluation
This program has been providing benefits to the APCTP community via an enduring collaboration between Korea and India, which are the member countries of APCTP. I think that this workshop has proved that the benefits are particularly great since this program has been running for 10 years by this year, establishing the tradition of APCTP contributing the international collaboration in Physics.

III. Research Programs Report

1. Summary of Research Programs
2. Scientific Reports of Junior Research Groups

1. Summary of Research Programs

Junior Research Groups (JRG)

(Mar. 2018 – Feb. 2019)

No.	Group	Leader
1	**Many-body Theory and Correlated Systems**	**Alireza Akbari**
2	**Quantum Information and Many-Body Theory**	**Jaeyoon Cho**
3	**Supergravity and String Theory**	**Eoin O colgain**
4	**Statistical Physics of Complex Dynamics**	**Hang-Hyun Jo**
5	**Electronic Structure and Magnetism**	**Igor Di Marco**
6	**Physics beyond the Standard Model and its Phenomenology**	**Hiroshi Okada**
7	**Physics of matter at non-equilibrium**	**Yuji Hirono**
8	Classical and Quantum Theory of Gravity*	Dong-han Yeom

* Research period ended in February 2019
NB. Current groups are emboldened.

Young Scientist Training Program (YST)

(Mar. 2018 – Feb. 2019)

No.	Name	Nationality	Research Field
1	Sangho Kim*	Korea	Nuclear Physics
2	**Parada Hutauruk**	**Indonesia**	**Nuclear Physics**
3	Yun-Long Zhang**	China	Astrophysics/Cosmology
4	**Kiesang Jeong**	**Korea**	**Nuclear Physics & Particle Physics**
5	**Heetae Kim**	**Korea**	**Statistical Physics**
6	**Ilya Bakhmatov**	**Russia**	**Particle Physics/Quantum Field Theory & Other Physics (Theory of gravity/Mathematical physics)**
7	**Mikaela Irene Dimaano Fudolig**	**The Philippines**	**Statistical Physics**
8	**Ujjal Kumar Dey**	**India**	**Particle Physics/Quantum Field Theory**
9	**Carlos Baldo III**	**The Philippines**	**Condensed Matter Physics**
10	**Kyunghyun Baek**	**Korea**	**Atomic/Molecular Physics, Optics (Quantum information/Quantum optics)**
11	**Hyungjoo Kim**	**Korea**	**Nuclear Physics & Particle Physics**

* Research period ended in September 2018
** Research period ended in October 2018
NB. Current members are emboldened.

Visitor Programs

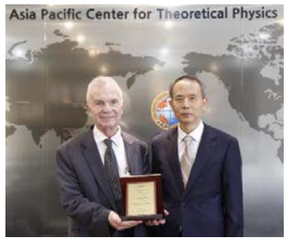
Total	Member Country		Non Member Country
	Korea	Others	
22	7	8	7

Unit: number of visits

Benjamin Lee Professorship

The program is intended to invite a theoretical physicist of international prominence to stay at APCTP for an extended period and provide opportunities for the domestic scientists interact with a world-caliber theoretical physicist in their fields of study.

- Winners
  - Herry Eugene Stanley : Boston University
- Period: October 22 ~ October 24
- Research Activities
  - APCTP Colloquium: Are Organizing Principles from Physics of Relevance to Economic and Social Sciences? (Oct. 23)
  - JRG Internal Seminar & Consuling Session (Oct. 23)
  - APCTP-KPS Keynote Speech (Oct. 24)



2. Scientific Reports of Junior Research Groups

Report List

Yearly Report

01 Many-body Theory and Correlated Systems
02 Quantum Information and Many-Body Theory
03 Supergravity and String Theory
04 Statistical Physics of Complex Dynamics
05 Electronic Structure and Magnetism
06 Physics beyond the Standard Model and its Phenomenology
07 Physics of matter at non-equilibrium

Final Report

01 Classical and Quantum Theory of Gravity

Yearly Report 01

Many-body Theory and Correlated Systems

Group Information

- Leader : Prof. Alireza Akbari (PhD., IASBC, Iran (2007))
- Period : Dec. 1, 2014~Nov. 30, 2019
- Members

Name	Nationality	Period
Prof. Alireza Akbari	**Iran**	**Dec. 1, 2014 ~ Nov. 30, 2019**
Dr. Fabrizio Cossu	**Italy**	**May 27, 2016 ~ May 26, 2018**
Dr. Mehdi Biderang	**Iran**	**Jun. 2, 2016 ~ Nov. 30, 2019**
Ms. Moloud Tamadonpour	**Iran**	**Jan. 1, 2019 ~ Apr. 15, 2019**
Dr. Utkarsh Mishra*	India	Mar. 4, 2016 ~ Oct. 31, 2018
Dr. Nimisha Raghuvanshi	India	Jul. 1, 2017 ~ Jun. 30, 2018

* Jointly employed by Jaeyoon Cho group
NB. Current members are emboldened.

Scientific Scope

Correlations in many-body systems arising from interactions between electrons and electrons, electrons and phonons, and so on, can give rise to a variety of broken symmetry phases such as magnetism, superconductivity, and other ordered states. In our group we investigate the physics of such systems focusing especially on unconventional and high TC superconductors, observed for example in the Fe-pnictides, cuprates, and heavy fermion compounds, as well as trying to understand the close link between magnetism and superconductivity. We also investigate the physics of topological insulators and superconductors, which are distinguished from normal insulators by conducting edge states but are insulating in the bulk. We are particularly interested in those states protected by time-reversal symmetry, which can be detected via various spectroscopic techniques.

Overview

Our main area of expertise is in theoretical condensed matter physics and statistical physics. We use many-body techniques based on the Green's function approach to investigate the dynamics of various broken symmetry states in strongly correlated systems. We also apply non-equilibrium methods such as the density-matrix method to understand ultrafast dynamics in superconductors and magnetic materials observed in pump-probe spectroscopy. In the following we shortly present our current research activities including the future plans and proposals. The main objective of our work is a theoretical investigation of the ordered phases and their ordering parameters in unconventional superconductors and strong spin-orbit coupled systems such as topological insulators and topological superconductors.

Research Highlights

(i) Spin-orbit coupling, minimal model and potential Cooper pairing from repulsion in BiS2-superconductors

We develop the realistic minimal electronic model for recently discovered BiS2 superconductors including the spin-orbit coupling based on first-principles band structure calculations. Due to strong spin-orbit coupling, characteristic for the Bi-based systems, the tight-binding low-energy model necessarily includes px, py, and pz orbitals. We analyze a potential Cooper-pairing instability from purely repulsive interaction for the moderate electronic correlations using the so-called leading angular harmonics approximation (LAHA). For small and intermediate doping concentrations we find the dominant instabilities to be dx2−y2-wave, and s3-wave symmetries, respectively. At the same time, in the absence of the sizable spin fluctuations the intra and interband Coulomb repulsion are of the same strength, which yields the strongly anisotropic behavior of the superconducting gaps on the Fermi surface in agreement with recent ARPES findings. In addition, we find that the Fermi surface topology for BiS2 layered systems at large electron doping can resembles the doped iron-based pnictide superconductors with electron and hole Fermi surfaces with sufficient nesting between them. This could provide further boost to increase Tc in these systems (see Fig. 1). The result of this research is going to be published in New J. Phys 2018.

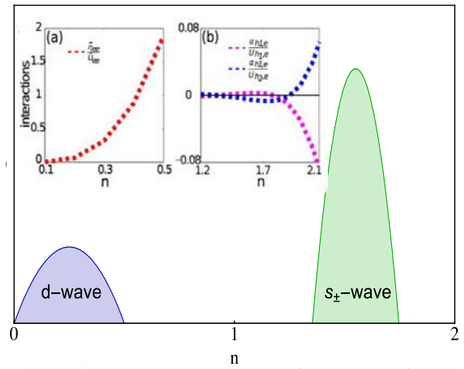


Fig1. Putative superconducting phase diagram arising from the repulsive interactions. Onset:
(a) Evolution of the cos 4φk cos 4φk′ angular dependence of the pair-scattering between electron pockets with increasing doping. (b) Evolution of the cos 2φk angular dependence between electron and hole pockets with increasing

(ii) Mach Mixed-pairing superconductivity in 5d Mott insulators with antisymmetric exchange: Application to Sr2IrO4

We investigate the potential existence of a superconducting phase in 5dMott insulators with an eye to hole doped Sr2IrO4. Using a mean-field method, a mixed singlet-triplet superconductivity, d+p, is observed due to the antisymmetric exchange originating from a quasi-spin-orbit-coupling. Our calculation on ribbon geometry shows possible existence of the topologically protected edge states, because of nodal structure of the superconducting gap. These edge modes are spin polarized and emerge as zero-energy flat bands, supporting a symmetry protected Majorana states, verified by evaluation of winding number and $\mathbb{Z}2$ topological invariant. At the end, a possible experimental approach for observation of these edge states and determination of the superconducting gap. The symmetry is discussed based on the quasi-particle interference (QPI) technique (See Fig2). Results of this research have been published in Phys. Rev. B 96, 205156 (2017).

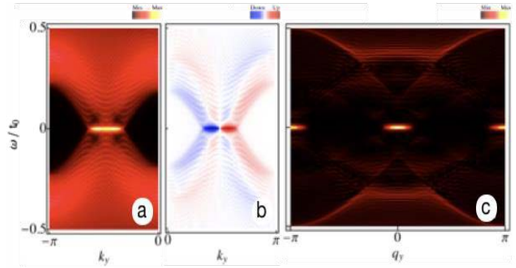


Fig2: (a,b) The intensity plots of the momentum- and spin-resolved local density of states along the Γ-Y momentum direction, respectively. The up and down helical states in (b) correspond to the states with the winding numbers +1 and −1, respectively. (c) Intensity of the QPI dispersion (absolute value) at the edge for the Y-Γ-Y momentum direction.

(iii) Surface state tunneling signatures in two-component superconductor UPt3

We extended the QPI method to three-dimensional superconductors and analyze the expected spectrum for the two-component heavy-fermion superconductor UPt3 whose gap structure is still controversial. Starting from a 3D electronic structure and the three proposed chiral gap models E1g,u or E2u, we perform a slab calculation that simultaneously gives extended bulk states and topologically protected in-gap dispersionless surface states. We show that the number of Weyl arcs and their hybridization with the line node provides a fingerprint that may finally determine the true nodal structure of the UPt3 superconductor. The corresponding result was published in PRL (Phys. Rev. Lett. 118, 087004, 2017). These are initial works in this subject and we believe our calculation combining their experimental result can solve this long time question of the gap symmetry in this compound (See Fig.4)

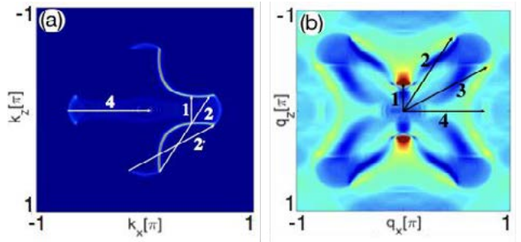


Fig4: (a) Surface Density of states contour plot for E1g with Weyl arcs type surface state and (b) its corresponding QPI patterns, in which the main scattering wave vectors indicated by qi for the possible topological superconducting states in UPt3.

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

We study the influence of antisymmetric spin-orbit coupling 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. This research has been published in Phys. Rev. B 98, 014524 (2018).

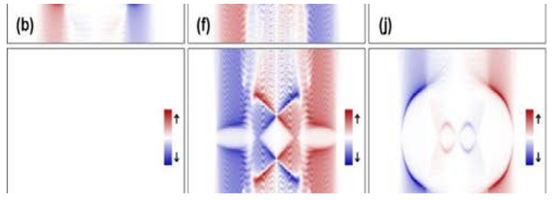


Fig5: Energy dispersion of the momentum-resolved and spin-resolved spectral functions for a triplet-dominant noncentrosymmetric superconductor for the s + p pairings, in the case of the pure, mixed Rashba and Dresselhaus, and pure Dresselhaus SOCs, respectively.

Quantum Information and Many-Body Theory

Group Information

- Leader : Jaeyoon Cho (PhD., KAIST, Korea (2005))
- Period : Nov. 1, 2015 ~ Oct. 31, 2020
- Members

Name	Nationality	Period
Prof. Jaeyoon Cho	**Korea**	**Nov. 1, 2015 ~ Oct. 31, 2020**
Dr. Zhongtao Mei	**China**	**Aug. 1, 2018~Jul. 31, 2019**
Dr. Wali Hossain*	**India**	**Sep. 1, 2016 ~ Oct. 16, 2019**
Dr. Utkarsh Mishra**	**India**	**Mar. 4, 2016~Oct. 31, 2018**
Dr. Jiang Long***	**China**	**Mar. 1, 2019 ~ Feb. 28, 2020**
Mr. Yongjin Lee	Korea	Nov. 1, 2015 ~Jul. 31, 2018
Dr. Chae-Yeun Park	Korea	May 1, 2017~May 31, 2018

* Jointly employed by Eoin O Colgain group
** Jointly employed by Alireza Akbari group
*** Will join after the end of Dong-han Yeom group
NB. Current members are emboldened.

Scientifics Scope

We study quantum many-body phenomena---especially those of strongly-correlated systems---from the perspective of quantum information theory. Our main, but not sole, interest is to study the nature of entanglement in many-body ground states (static features) and the evolution of entanglement in disordered or quenched systems (dynamical features). We are also interested in proposing experimental schemes to study such properties in atomic/quantum optical systems.

Overview

We have focused on examining the relation between correlations (in the conventional sense) and entanglement in many-body systems. In the first work below, we have studied how correlations affect the entanglement. To be specific, we have rigorously proven that in one dimension, a finite correlation length implies a constant bound on the entanglement entropy, called the entanglement area law. In the second work below, on the other hand, we have studied how entanglement affects the correlations. To be specific, we have performed various case studied as to how bipartite entanglement of many-body states is manifested in the correlation of local measurement outcomes.

Research Highlights

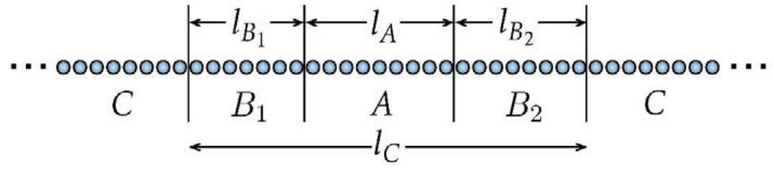
(i) Realistic area-law bound on entanglement from exponentially decaying correlations

Understanding the universal nature of strongly-correlated many-body systems is one of the central topics in theoretical physics. Even though strongly-correlated systems are generally intractable, it is possible to unfold the universal relationship between their characteristic attributes, providing a guiding principle for studying specific model Hamiltonians. For example, the existence or absence of a spectral gap, a finite or diverging correlation length, and the behavior of entanglement entropies are commonly studied attributes, which find intriguing mutual connections.

One of the prominent open problems in this context is whether the ground states of gapped Hamiltonians always obey the area law for entanglement entropy in any dimension, i.e., whether the entanglement between a subregion and its complement scales as the boundary size of the chosen region or can grow faster, e.g., as the volume of the region. The underlying idea is that the existence of a gap significantly restricts the correlation that the ground state can accommodate. There is a well-established theorem, namely, the exponential clustering theorem, which states that the existence of a spectral gap implies a finite correlation length in the ground state. Indeed, a seminal work by Hastings and several ensuing works have given proofs of the area law in one-dimensional gapped systems, wherein the area law means a constant bound on the entanglement entropy. In higher dimensional cases, however, only partial results are present. Originally spawned by the Bekenstein-Hawking entropy, the area law has arrested a huge interest thanks to its widespread relevance, e.g., to frameworks based on tensor network states, topological entanglement entropies, the holographic formula based on the AdS/CFT correspondence, the Hamiltonian complexity theory, and so on.

Since the proof for one-dimensional gapped systems, a naturally ensuing question was whether a finite correlation length alone can imply the area law. Albeit likely at first glance, serious doubt was cast upon its possibility due to unfavorable examples such as quantum data-hiding states and quantum expander states, for which a small correlation and a large entanglement can coexist. Amid such uncertainty, the proof that a finite correlation length indeed implies the area law in one dimension was a remarkable achievement. However, the physical relevance of that proof is highly questionable because the obtained upper-bound of the entanglement entropy is ridiculously huge to such an extent that it is never reachable in any physically sensible situation (having a constant of $\sim 10^8$ in the exponent, the bound easily surpasses the estimated number of atoms in the whole universe!). Consequently, we are still facing a quite unsatisfactory situation: under the condition of a finite correlation length alone, does the upper-bound of entanglement entropies exist only in such a hypothetical limit? Answering this question is important in truly confirming our picture on one-dimensional systems: in one dimension, a finite gap implies exponential decay of correlations, which in turn implies the area law. Here, the aforementioned unfavorable examples again seem to suggest that this picture might be misleading in reality.

In this work, we have given a proof of the one-dimensional entanglement area law from exponentially decaying correlations, which dramatically reduces the previously obtained bound, bringing the bound into a realistic regime. As well as the involved constants, our bound also improves the functional dependence on the correlation length. With ξ being the correlation length, we obtain the bound of $\sim(\log\xi)2^{(\mathrm{const})\xi}$, while the previous proof gives $\sim\xi^{(\mathrm{const})\xi}$. In fact, the exponential dependency of the bound is unavoidable in general. Our bound thus leaves only little room for improvement. Interestingly, the dependence on ξ is even more favorable than that of Hastings' original proof for gapped systems, which reads $\sim\xi(\log\xi)2^{(\mathrm{const})\xi}$, although this bound was significantly improved by an ensuing work (for gapped systems).



Moreover, compared to the previous one, our proof is remarkably simpler and more straightforward. The proof directly addresses the internal structure of the states with exponentially decaying correlations using elementary quantum information tools. Such a direct nature allows us to envisages a clear and intuitive picture on the encountered situation. The central part of the proof is to show that when the length scale is increased as $l \to \mathrm{x}l \to \mathrm{x}^2 l \to \ldots \to \mathrm{x}^n l$ with x>0, the upper-bound of the mutual information $I(A{:}C)$ in the above figure initially increases indefinitely, but saturates at some point, and then decreases exponentially in n. Combined with a simple renormalization-like construction, this behavior of the mutual information accounts not only for the entanglement area law, but also for why the area-law bound is exponentially large in the correlation length and how the common intuition---with a finite correlation length, the entanglement of a large region is determined by the correlations around the boundary---indeed makes sense.

Thus, the present work makes our view on one-dimensional systems quite solid and consistent. We hope that our proof offers a more direct and detailed insight into the situation and becomes an important step towards the understanding of the area law in higher dimensions.

(ii) Correlations in local measurements and entanglement in many-body systems

Entanglement is a distinctive feature of quantum mechanics, which exposes fundamental differences between quantum and classical physics and can be exploited as a resource for quantum information processing. Entanglement is also a useful tool for characterizing quantum states in many-body systems. For example, ground states of gapped Hamiltonians typically follow an area law, whereas random states follow a volume law of entanglement. Amid experimental developments in engineering many-body quantum states, a great deal of interest has been generated in examining such features of many-body entanglement in real experiments. For example, there have been several proposals for measuring Renyi α=2 entanglement entropies and their experimental realizations. Generally speaking, however, it is very hard to directly measure the entanglement as it is a nonlinear function of the state itself, not an observable. In order to measure the entanglement, one needs to obtain the density matrix through a quantum state tomography or find the appropriate relations to other measurable quantities, which are nontrivial in many-body systems.

In this work, we have studied the many-body entanglement in terms of the correlation in local measurements. To be specific, we have considered a bipartite separation of many-body spin states and positive-operator valued measures (POVMs) acting on each party

separately. We have then investigated the correlation in such local POVM measurements, which is quantified by the statistical distance (total variation distance) between the joint probability distribution of the measurement outcome and the product of its marginal distributions. Formally, given a quantum state ρ_{AB} of a composite system A⊗B and local POVMs $\{M_i\}$ and $\{N_i\}$ acting on the subsystem *A* and *B*, respectively, we have considered

$$\Delta_D(\{M_i\},\{N_i\}) \equiv \frac{1}{2}\sum_{i,j}|\mathrm{Tr}[M_i \otimes N_i(\rho_{AB} - \rho_A \otimes \rho_B)]|,$$

where $\rho_A = \mathrm{Tr}_B \rho_{AB}$ and $\rho_B = \mathrm{Tr}_A \rho_{AB}$. Letting

$$P_A(i) = \mathrm{Tr}[(M_i \otimes I_B)\rho_{AB}],$$

$$P_B(j) = \mathrm{Tr}\left[\left(I_A \otimes N_j\right)\rho_{AB}\right],$$

$$P_{AB}(i,j) = \mathrm{Tr}\left[\left(M_i \otimes N_j\right)\rho_{AB}\right],$$

this quantity can be written more straightforwardly as

$$\Delta_D(\{M_i\},\{N_i\}) \equiv \frac{1}{2}\sum_{i,j}|P_{AB}(i,j) - P_A(i)P_B(j)|.$$

For convenience, we call this quantity a correlation in local measurements (CLM). Apparently, for general mixed state ρ_{AB}, the CLM does not necessarily capture the entanglement between A and B. On the other hand, if the state ρ_{AB} is guaranteed to be pure, the CLM should be nonzero for properly chosen POVMs if and only if ρ_{AB} is an entangled state. Our aim is to study such relation between the CLM and the entanglement in a quantitative manner under the condition that ρ_{AB} is a pure many-body spin state. By definition, the CLM has a direct relevance to real experimental situations. Furthermore, The CLM is different from conventional correlation functions of two local operators like $Tr[O_A \otimes O_B(\rho_{AB} - \rho_A \otimes \rho_B)]$ as the CLM is defined by the probability distribution of the measurement outcome, not by the expectation values of general operators. There have been earlier works that studied correlation measures involving local measurements. However, the main focus of them was on investigating quantum correlations that are not captured by local measurements. Our focus, on the other hand, is on how far one access the quantum correlation only using local POVM measurements, especially, in many-body systems.

We have investigated the relation between the CLM and other correlation and entanglement measures that have been studied before. We have then examined the CLM for several examples---Haar random states, spin squeezed states, and the ground state of the Heisenberg XXZ chain---under the restriction that local measurements are performed in the basis of a collective spin operator. We have generalized the CLM to the case of imprecise measurement and found its relation to the concept of quantum macroscopicity. We have further investigated how the imprecise measurement affects Bell's inequalities

Yearly Report 03

Supergravity & String Theory

Group Information

- Leader : Eoin O Colgain (PhD., Imperial College London, UK (2007))
- Period : Dec. 1, 2015 ~ Nov. 30, 2020
- Members

Name	Nationality	Period
Prof. Eoin O Colgain	**Ireland**	**Nov. 1, 2015 ~ Oct. 31, 2020**
Dr. Wali Hossain*	**India**	**Aug. 1, 2018~Jul. 31, 2019**
Dr. Ilya Bakhmatov**	**Russia**	**Sep. 1, 2016 ~ Oct. 16, 2019**
Dr. Thiago Araujo	**Brazil**	**Mar. 4, 2016~Oct. 31, 2019**

*Jointly employed by Jaeyoon Cho group.
**YST Member
NB. Current members are emboldened.

Scientific Scope

We are working on classical gravity, broadly defined. In a formal application we are fleshing out the correspondence we identified between the Classical Yang-Baxter Equation, a hallmark of integrability, and supergravity. In a separate direction, we are exploring tension in the Hubble constant through studies of type Ia supernovae data.

Results

Since arriving at APCTP, my group has published of order 20 papers and my personal google scholar citations in 2018 hit 300 citations. This is largely due to our publications that have rewritten Yang-Baxter deformations in terms of a simple high-school level matrix inversion. Further impact comes from our recent paper connecting the de Sitter Swampland conjecture of Vafa et al. to the tension in the Hubble constant. Independently, both are suggesting that the current cosmological model is incorrect at low redshift.

On the basis of this work Thiago Rocha will be moving to Bern, Switzerland and an unexpected outcome of our workshop on H0 tension is that Robert Brandenburger made an offer to Suddhasattwa Brahma so that he can join McGill University. So activities of my group have been responsible for two APCTP researchers getting new positions.

Yearly Report 04

Statistical Physics of Complex Dynamics

Group Information

- Leader : Hang-Hyun Jo (PhD., KAIST, Korea (2006))
- Period : May 1, 2017 ~ Apr. 30, 2020
- Members

Name	Nationality	Period
Prof. Hang-Hyun Jo	**Korea**	**May 1, 2017 ~ Apr. 30, 2020**
Dr. Takayuki Hiraoka	**Japan**	**Jul. 1, 2017 ~ Jun. 30, 2019**
Dr. Byoung-Hwa Lee	**Korea**	**Jun. 1, 2017 ~ Feb. 28, 2019**
Dr. Jin Xu	**China**	**May 1, 2017 ~ Feb. 28, 2019**
Mr. Taekho You	**Korea**	**Oct. 1, 2017 ~ Dec. 31, 2019**
Mr. Min-Young Lee	**Korea**	**Feb. 1, 2019 ~ Dec. 31, 2019**
Dr. Juyong Song	Korea	Mar. 1, 2013 ~ Dec. 31, 2018
Mr. Min-Woo Ahn	Korea	Feb. 1, 2018 ~ Jan. 31, 2019

NB. Current members are emboldened.

Scientific Scope

For the analysis and modeling of complex systems, we adopt the notion of temporal networks where the links are considered existent only at the moment of interaction between elements of the systems. These interacting behaviors generically show inhomogeneous, non-Poissonian temporal patterns. Our group focuses on the development of the analysis framework for such non-Poissonian temporal patterns as well as for the temporal networks, and eventually their applications to the real world problems such as epidemic spreading in a population.

Overview

We have studied the properties and effects of correlations between inter-event times, often called correlated bursts, in inhomogeneous temporal patterns, which have been observed in various empirical datasets, e.g., earthquakes, neuronal firings, and human activities. The correlations between inter-event times can be measured in memory coefficient and burst size distributions.

We first studied the effect of burst size distributions on the scaling relation between the power-law exponent of inter-event time distribution and the decaying exponent of autocorrelation function. Then we found that the memory coefficient has a limit to properly measure the correlations between inter-event times when the burst size distributions show power-law behaviors.

Research Highlights

(i) Analytic framework for the bursty temporal patterns and its applications

Temporal inhomogeneities in event sequences of natural and social phenomena have been characterized in terms of interevent times (IETs) and correlations between IETs. The inhomogeneities of IETs have been extensively studied, while the correlations between IETs, often called correlated bursts, are far from being fully understood. For measuring the correlated bursts, two relevant approaches were suggested, i.e., memory coefficient and burst size distribution. Here a burst size denotes the number of events in a bursty train detected for a given time window. Empirical analyses have revealed that the larger memory coefficient tends to be associated with the heavier tail of the burst size distribution. In order to comprehend these observations, we derive the analytical form of the memory coefficient as a function of parameters describing IET and burst size distributions. Our analytical result can explain the general tendency of the larger memory coefficient being associated with the heavier tail of burst size distribution.

Reference: H.-H. Jo and T. Hiraoka, Limits of the memory coefficient in measuring correlated bursts, Physical Review E 97, 032121 (2018)

We studied the relation between power-law IET distribution and algebraically decaying autocorrelation functions. Temporal inhomogeneities have often been characterized in terms of scaling behaviors in the autocorrelation function with a decaying exponent γ, the IET distribution with a power-law exponent α, and the burst size distributions. To understand such temporal scaling behaviors implying a hierarchical temporal structure, we devise a hierarchical burst model by assuming that each observed event might be a consequence of the multilevel causal or decision-making process. By studying our model analytically and numerically, we confirm the scaling relation $\alpha+\gamma=2$, established for the uncorrelated IETs, despite of the existence of correlations between IETs. Our modeling approach for the hierarchical temporal structure can help us better understand the underlying mechanisms behind complex bursty dynamics showing temporal scaling behaviors.

Reference: B.-H. Lee, W.-S. Jung, and H.-H. Jo, Hierarchical burst model for complex bursty dynamics, Physical Review E 98, 022316 (2018)

More recently, we derived an analytic form of the autocorrelation function as a function of the memory coefficient between two consecutive IETs for an arbitrary form of the IET distribution, by adopting the Farlie-Gumbel-Morgenstern copula for the joint probability distribution of two consecutive IETs. Our analytic results are confirmed by numerical simulations for exponential and power-law IET distributions. For the power-law case, we find the tendency of the steeper decay of the autocorrelation function for the stronger correlation between IETs. Our analytic approach enables us to better understand long-term temporal correlations induced by the correlations between IETs.

Reference: H.-H. Jo, Analytically solvable autocorrelation function for correlated interevent times [arXiv:1901.00982]

Finally, we studied the impact of correlated bursts in the collective dynamics such as spreading in the temporal networks. Spreading dynamics has been considered to take

place in temporal networks, where temporal interaction patterns between nodes show non-Poissonian bursty nature. The effects of inhomogeneous IETs on the spreading have been extensively studied in recent years, yet little is known about the effects of correlations between IETs on the spreading. In order to investigate those effects, we study two-step deterministic susceptible-infected (SI) and probabilistic SI dynamics when the interaction patterns are modeled by inhomogeneous and correlated IETs, i.e., correlated bursts. By analyzing the transmission time statistics in a single-link setup and by simulating the spreading in Bethe lattices and random graphs, we conclude that the positive correlation between IETs slows down the spreading. We also argue that the shortest transmission time from one infected node to its susceptible neighbors can successfully explain our numerical results.

Reference: T. Hiraoka and H.-H. Jo, Correlated bursts in temporal networks slow down spreading, Scientific Reports 8, 15321 (2018)

(ii) Modeling interaction networks for complex systems and related issues

Apart from the temporal patterns, the network structure itself provides the information on the interaction structure of complex systems. We focus on the social networks as we find a number of real-world datasets and important issues, which are applicable to other physical and biological complex systems. In a social network the individuals or nodes connect to other nodes by choosing one of the channels of communication at a time to re-establish the existing social links. We develop a general setting to get insight and understand the class of network sampling models, where the probability of sampling a link in the original network depends on the attributes of its adjacent nodes. We derive exact analytic expressions of the sampled network for such network characteristics as the degree distribution, degree correlation, and clustering spectrum. Based on our analysis, we find that the sampled network may have sampling-induced network properties that are absent in the original network, which implies the potential risk of a naive generalization of the results of the sample to the entire original network.

Reference: Y. Murase, H.-H. Jo, J. Torok, J. Kertesz, and K. Kaski, Sampling networks by nodal attributes [arXiv:1902.04707]

We also introduce a model for the formation of social networks, which takes into account the homophily or the tendency of individuals to associate and bond with similar others, and the mechanisms of global and local attachment as well as tie reinforcement due to social interactions between people. We generalize the weighted social network model such that the nodes or individuals have F features and each feature can have q different values. Here the tendency for the tie formation between two individuals due to the overlap in their features represents homophily. We find a phase transition as a function of F or q, resulting in a phase diagram. For fixed q and as a function of F the system shows two phases separated at Fc. For F<Fc large, homogeneous, and well separated communities can be identified within which the features match almost perfectly (segregated phase). When F becomes larger than Fc, the nodes start to belong to several communities and within a community the features match only partially (overlapping phase). Several quantities reflect this transition, including the average degree, clustering coefficient, feature overlap, and the number of communities per node.

Reference: Y. Murase, H.-H. Jo, J. Torok, J. Kertesz, and K. Kaski, Structural transition in social networks: The role of homophily [arXiv:1808:05035]

Topological heterogeneities of social networks have a strong impact on the individuals embedded in those networks. One of the interesting phenomena driven by such heterogeneities is the friendship paradox (FP), stating that the mean degree of one's neighbors is larger than the degree of oneself. Alternatively, one can use the median degree of neighbors as well as the fraction of neighbors having higher degree than oneself. Each of these reflects on how people perceive their neighborhoods, i.e., their perception models, hence how they feel the peer pressure. In our paper, we study the impact of perception models on the FP by comparing three versions of the perception model in networks generated with a given degree distribution and a tunable degree-degree correlation or assortativity. We numerically find that the network-level peer pressure is not necessarily negatively correlated with the assortativity in the case with the mean-based perception model. By simulating the opinion formation where the opinion adoption probability of an individual is given as a function of the individual peer pressure, we find that it takes the longest times to reach consensus when individuals adopt the median-based perception model, compared to other versions. Our findings suggest that one needs to consider the proper perception model for better modeling human behaviors and social dynamics.

Reference: E. Lee, S. Lee, Y.-H. Eom, P. Holme, and H.-H. Jo, Impact of perception models on friendship paradox and opinion formation [arXiv:1808.04170]

In order to get more insight into the real-world properties of social networks, we analyze a large-scale mobile phone call dataset with the metadata of the mobile phone users, including age, gender, and billing locality, to uncover the nature of relationships between peers or individuals of similar ages. We show that in addition to the age and gender of users, the information about the ranks of users to each other in their egocentric networks is crucial in characterizing intimate and casual relationships of peers. The opposite-gender pairs in intimate relationships are found to show the highest levels of call frequency and daily regularity, consistent with small-scale studies on romantic partners. This is followed by the same-gender pairs in intimate relationships, while the lowest call frequency and daily regularity are observed for the pairs in casual relationships. We also find that older pairs tend to call less frequently and less regularly than younger pairs, while the average call durations exhibit a more complex dependence on age. We expect that a more detailed analysis can help us better characterize the nature of peer relationships and distinguish various types of relations, such as siblings, friends, and romantic partners, more clearly.

Reference: M.I.D. Fudolig, D. Monsivais, K. Bhattacharya, H.-H. Jo, and K. Kaski, Uncovering intimate and casual relationships from mobile phone communication [arXiv:1808.10166]

Finally, understanding the mechanisms behind human mobility patterns is crucial to improve our ability to optimize and predict traffic flows. Two representative mobility models, i.e., radiation and gravity models, have been extensively compared to each other against various empirical data sets, while their fundamental relation is far from being fully understood. In order to study such a relation, we first model the heterogeneous population landscape by generating a fractal geometry of sites and then by assigning to each site a population independently drawn from a power-law distribution. Then the radiation model on this population landscape, which we call the radiation-on-landscape (RoL) model, is compared to the gravity model to derive the distance exponent in the gravity model in terms of the properties of the population landscape, which is confirmed

by the numerical simulations. Consequently, we provide a possible explanation for the origin of the distance exponent in terms of the properties of the heterogeneous population landscape, enabling us to better understand mobility patterns constrained by the travel distance.

Reference: I. Hong, W.-S. Jung, and H.-H. Jo, Gravity model explained by the radiation model on a population landscape [arXiv:1803.09067]

(iii) Temporal patterns in biological systems

We also studied the temporal patterns in biological systems by looking at the circadian clock. Circadian clocks play a pivotal role in orchestrating numerous physiological and developmental events. Waveform shapes of the oscillations of protein abundances can be informative about the underlying biochemical processes of circadian clocks. We derive a mathematical framework where waveforms do reveal hidden biochemical mechanisms of circadian timekeeping. We find that the cost of synthesizing proteins with particular waveforms can be substantially reduced by rhythmic protein half-lives over time, as supported by previous plant and mammalian data, as well as our own seedling experiment. We also find that previously enigmatic, cyclic expression of positive arm components within the mammalian and insect clocks allows both a broad range of peak time differences between protein waveforms and the symmetries of the waveforms about the peak times. Such various peak-time differences may facilitate tissue-specific or developmental stage-specific multicellular processes. Our waveform-guided approach can be extended to various biological oscillators, including cell-cycle and synthetic genetic oscillators.

Reference: H.-H. Jo, Y.J. Kim, J.K. Kim, M. Foo, D.E. Somers, and P.-J. Kim, Waveforms of molecular oscillations reveal circadian timekeeping mechanisms, Communications Biology 1, 207 (2018)

Yearly Report 05

Electronic Structure and Magnetism

Group Information

- Leader : Igor Di Marco (PhD., Radboud University Nijmegen, Netherlands (2009))
- Period : Dec. 4, 2017 ~ Dec. 3, 2020
- Members

Name	Nationality	Period
Prof. Igor Di Marco	**Italy**	**Dec. 4, 2017 ~ Dec. 3, 2020**
Dr. Arya Subramonian	**India**	**Apr. 1, 2018 ~ Feb. 28, 2020**
Dr. Sagar Sarkar	**India**	**Nov. 1, 2018 ~ Oct. 31, 2019**

NB. Current members are emboldened.

Scientific Scope of the Unit

Electron-electron interaction in solids gives rise to many exotic phenomena, which are (or have the potential to be) exploited in modern technology. Our group develops and applies computational tools to describe those systems where the electron-electron interaction has a primary role. The methods we focus on include density-functional theory (DFT), dynamical mean-field theory (DMFT) and their combination (DFT+DMFT). Systems of interest are the itinerant ferromagnets, as e.g. Fe and Ni, Heusler compounds, complex transition metal oxides, as e.g. NiO or Fe_3O_4 (magnetite), and lanthanides-based systems. In addition, we intend to investigate more novel systems, including magnetically doped topological insulators and two-dimensional materials.

Period of Reference

This reports includes activities and achievements from March 2018 to February 2019.

Overview of activities

The present research group was established in December 2017, and this report covers 12 months of activities. The group leader was on leave of absence, due to a severe illness, from mid April to the end of July. Dr. Arya Subramonian joined the JRG in April, after having completed her PhD studies at the Institute of Mathematical Sciences, in Chennai (India), under the supervision of Prof. S. R. Hassan. Sagar Sarkar joined the JRG in November, just after his VIVA defence. His doctoral studies were undertaken at the S. N. Bose National Centre for Basic Sciences in Kolkata, India, under the supervision of Prof. Priya Mahadevan. Unfortunately, the recruitment of this second researcher took longer than expected, due to a previously selected candidate who accepted this position in May, but then changed idea in June. In this initial phase, the group has been working on five major topics. First, we have investigated the properties of the dilute magnetic semiconductor Mn-doped GaAs, which has a key importance in the development of spin-based electronics (spintronics). Second, we have worked on the theoretical aspects of ultrafast magnetism, focusing on how to connect experimental results to theoretical modeling. In particular, we addressed whether a linear proportionality between magnetic asymmetry and sample magnetization exists or not. Third, we have been investigating charge density waves in the monolayer of

$NbSe_2$, with a special focus on the role of strain and impurities. Fourth, we investigated the arising of exotic magnetism on the surfaces of Heusler semiconductors. Our fifth line of research is focused on lanthanides-based systems.

Publications in the period of reference (in chronological order)

1. Jan Minár, **I. Di Marco**, and Jindřich Kolorenč; "Implementation of Exact Diagonalization in KKR + DMFT" in "Multiple Scattering Theory for Spectroscopies", Springer (2018)
2. Slavomír Nemšák, Mathias Gehlmann, Cheng-Tai Kuo, Shih-Chieh Lin, Christoph Schlueter, Ewa Mlynczak, Tien-Lin Lee, Lukasz Plucinski, Hubert Ebert, **Igor Di Marco**, Ján Minár, Claus M. Schneider, and Charles S. Fadley; "Element- and momentum-resolved electronic structure of the dilute magnetic semiconductor $Ga_{1-x}Mn_xAs$", Nat. Comm. **9**, 3306 (2018)
3. Fabrizio Cossu, Ali G. Moghaddam, Kyoo Kim, Hassan A. Tahini, **Igor Di Marco**, Han-Woong Yeom, and Alireza Akbari; "Unveiling hidden charge density waves in single-layer $NbSe_2$ by impurities", Phys. Rev. B **98**, 195419 (2018)

Received Grants

1. Igor Di Marco
   a. European Union COST Action MAGNETOFON (co-applicant)
   b. Psi-k funds for organizing the "Workshop and hands-on school on the FP-LMTO method and DMFT", Santo Stefano di Sessanio, Italy, 04-08 June 2018
   c. Medium-scale SNAC allocation for computational resources, Sweden (150K core-h per month, for 12 months)
2. Arya Subramonian
   a. none
3. Sagar Sarkar
   a. none

Other achievements and activities

1. Igor Di Marco
   a. main organizer of the "Workshop and hands-on school on the FP-LMTO method and DMFT", Santo Stefano di Sessanio, Italy, 04-08 June 2018
   b. invited talk for the Chemistry Colloquium at UNIST, Ulsan, 27 March 2018
   c. member of the management committee for the EU-COST Action MAGNETOFON
   d. adjunct professor at POSTECH, South Korea
   e. invited talk at the international CECAM Workshop on "Ab Initio Spin Modelling", Lausanne, Switzerland, 26-28 November 2018
   f. poster presentation at the "21st Asian Workshop on first-principle electronic structure calculations", KAIST, Daejeon, 29-31 October 2018
2. Arya Subramonian
   a. participation at the "Workshop on Quantum Many-Body states", KAIST, Daejeon, 27-28 April 2018
   b. contributed talk at the "Workshop and hands-on school on the FP-LMTO method and DMFT", Santo Stefano di Sessanio, Italy, 04-08 June 2018
   c. research visit at L'Aquila University, Italy, 09-15 June 2018
   d. participation at the workshop on "Computational approach to magnetic systems (CAMS) 2018", APCTP, Pohang, 27-28 August 2018
   e. participation at the "Autumn school on correlated electrons", Forschungszentrum Julich, Germany, 17-21 September 2018
   f. research visit at Uppsala University, Sweden, 24-28 September 2018
   g. participation at the "21st Asian Workshop on first-principle electronic structure calculations", KAIST, Daejeon, 29-31 October 2018
   h. contributed talk at the IBS-PCS retreat, Hadong, 23-25 January 2019
3. Sagar Sarkar
   a. contributed talk at the IBS-PCS retreat, Hadong, 23-25 January 2019
4. Invited Guests at APCTP
   a. Dr. Alberto Marmodoro, Ludwig-Maximilians University, Munich (Germany), 17-20 December 2018

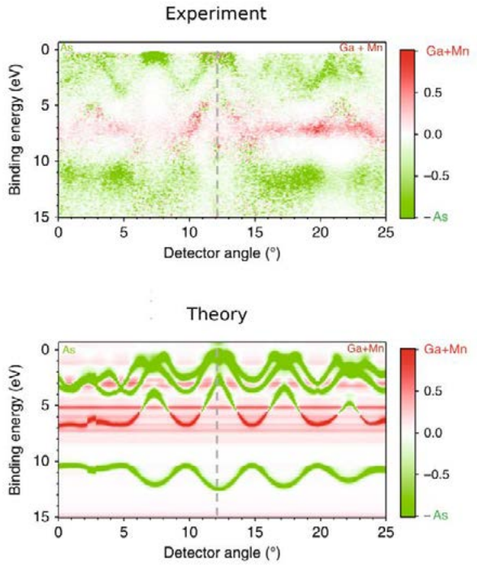
Research Highlights

(i) Strong electronic correlations in $Ga_{1-x}Mn_xAs$

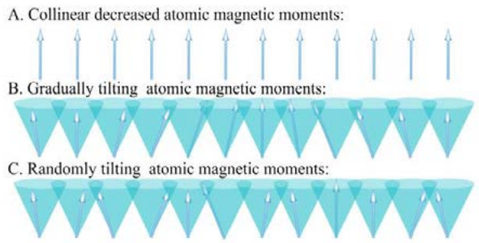
Dilute magnetic semiconductors are standard semiconductors that acquire a ferromagnetic order after having been doped with a small amount of magnetic impurities. Their discovery, at the end of the nineties, has fueled a great enthusiasm in the scientific community, as they found immediate application in technological devices where both the spin and charge of electrons are exploited. Unfortunately, the rise of this new "spintronics" has proven to be more elusive than expected, due to the difficulties in stabilizing the ferromagnetic order observed at low temperatures up to room temperature. These problems partly originate from the fact that the mechanisms driving the formation of the long range order remains uncertain in various classes of dilute magnetic semiconductors. We have been recently collaborating with prominent experimental scientists at the Berkeley National Laboratories (USA) to investigate the electronic properties of this material, and their implication on its magnetism. This project took advantage of a new technique, based on the combination of standing wave excitations with angle-resolved hard X-ray photoemission spectroscopy (SW-HARPES). The data obtained with SW-HARPES provide both element-resolved and momentum-resolved electronic excitations, as illustrated in the top panel of the Figure above. We performed various DFT+DMFT calculations to interpret these experimental data. Disorder was treated within the coherent-potential approximation (CPA) and electronic transitions were considered only with respect to a free electron state. The color-map shown in the bottom panel of the Figure above clearly illustrates that theory and experiment are in good agreement with each other, and they both locate the Mn-3*d* states in the range 3-7 eV and (to a less extent) in the close region around the Fermi level. This electronic structure implies a physical picture where magnetism originates from a coexistence of *p*-*d* exchange and double-exchange mechanisms. Future research will be focused on a direct calculation of the magnetic properties, and in particular the ordering temperature, via a multi-scale approach where DFT+DMFT results are used as input for simulations of atomistic spin dynamics. This analysis requires the theoretical treatment of various concentrations of dopants on the same footing and with the same accuracy, which in turn requires important technical advances. In the future, joint theoretical and experimental work based on SW-HARPES may also be used to investigate other important classes of materials, where element-

specific electronic structure is needed. A full account of our results can be found in Nature Communications **9**, 3306 (2018).

(ii) Ultrafast magnetism in Fe and Ni



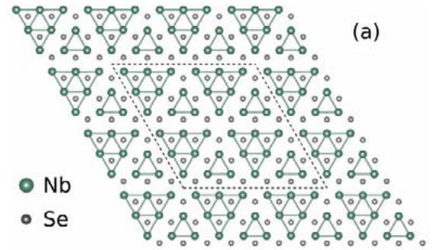
For many decades, scientists have been probing magnetic states in matter through light, in both reflectivity or transmission experiments. At the end of the nineties, the progressive increase of available photon energies led to the discovery that an intense laser pulse can decrease the magnetization of a Ni sample of about 40% in a few hundred femtoseconds. This discovery opened the field of ultrafast magnetism, which has attracted a vast interest, in the hope of controlling the magnetization in the sub-picosecond timescale. Despite many progresses, driven mainly by advances in experimental techniques, a fundamental understanding of ultrafast magnetism is still lacking. A difficulty in this field is the lack of connection between quantities measured in experiments and microscopic degrees of freedom. In the past, the present JRG leader has worked on formulating a model of spectroscopic response after the ultrafast magnetic dynamics has taken place [Phys. Rev. B **92**, 064403 (2015)]. Recently, we have tried to extend this model to the transient regime. A key quantity in experiments of ultrafast magnetism is the magnetic asymmetry A(E), which is defined as the normalized difference between the reflectivity I3(E), measured for opposite magnetization directions 3 at various photon energies. The reflectivity can be obtained directly in experiments using the transverse magneto-optical Kerr effect (T-MOKE). We can obtain its theoretical counterpart by first calculating the electronic structure of Fe in DFT or DFT+DMFT and then using the dielectric tensor to solve the Fresnel equations for the correct geometry. In collaboration with an experimental group at Uppsala University (Sweden), we have been investigating how the magnetic asymmetry evolves just after a laser pulse and how it relates to the microscopic state of the system. To this aim, we considered several magnetic configurations, grouped in the families illustrated in the Figure on the right. We can calculate magnetic asymmetries for various systems and in various geometries. Our analysis disproves one of the major assumption of the field of ultrafast magnetism, i.e. that there is a linear proportionality between the magnetic asymmetry at a given energy and the total magnetization of the sample. This proportionality does not universally hold even for the simplest scenario, which is the presence of gradually tilting moments. As expected, more complicated scenarios give rise, to even less linear relations, further supporting our point. We hope that our main statement will help bringing clarity to the field of ultrafast magnetism, where conclusions on the microscopic states were often drawn from



experimental measurements without a proper theoretical justification. We are currently preparing a manuscript for Physical Review B.

(iii) Charge density waves in NbSe2

Transition metal dichalcogenides are van der Waals layered materials which show a wide range of interesting phenomena and applications, due to the tunability of their electronic structure. Moreover, they can host exotic phases, such as superconductivity, charge density waves, and even topologically non-trivial states. These exotic phenomena are expected to become even more interesting when one goes from the bulk material to the monolayer. In fact, over the past decade, synthesis and exploration of atomically thin two-dimensional materials have almost revolutionized our common understandings of condensed matter systems. In this context, we started a collaboration with the JRG led by Prof. Alireza Akbari and with Prof. Han-Woong Yeom at IBS to analyse the formation of charge density waves in monolayer $NbSe_2$. Our calculations show that the pure monolayer of $NbSe_2$ has three stable charge density waves phases, the most stable one being composed by triangular Nb-Nb clusters, as depicted in the Figure on the right. Transition metal adatoms, such as Co and Mn, change the energetic order of the various phases, making the phase composed by hexagonal Nb-Nb clusters as the most favourable structure. This result explains recent experimental findings, which found evidence of a phase that does not have the previously assumed triangular symmetry. We also explore the effects due to other adsorbates that are likely to be used in experiments, like K and Ga. We found that both these elements do not alter the energetic hierarchy observed in the clean monolayer. We also perform a Fourier analysis of the charge density, in order to emphasize the changes induced by the impurities. A full account of these results can be found in Phys. Rev. B **98**, 195419 (2018).



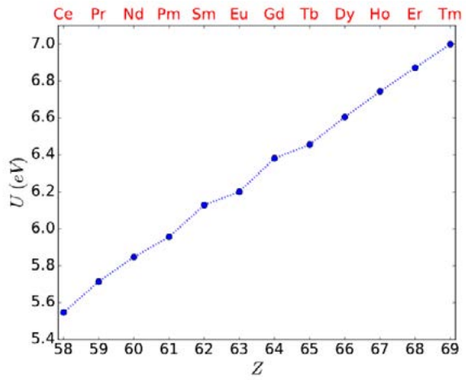
(iv) many-body effects and surface magnetism in selected Heusler compounds

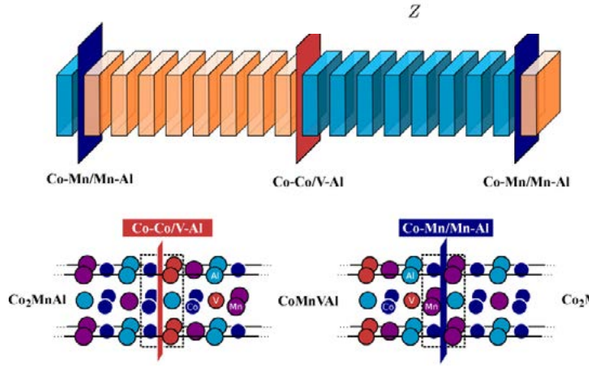
Heusler compounds are a family of intermetallic compounds with a face centered cubic structure. They have been extensively studied in the last decades, due to their varied physical properties and, especially, high tunability. In a recent work [Phys. Rev. B **97**, 035105 (2018)] we investigate the many-body effects characterizing the Co_2MnAl/CoMnVAl heterostructure (see Figure below). This heterostructure is composed by alternating layers of a half-metallic ferromagnetic Heusler compound and an “almost gapless” semiconducting Heusler compound. This system is interesting as it was predicted by previous first-principle calculations as a possible candidate for spin-injecting devices. We perform several DFT and DFT+DMFT calculations of the bulk materials and the heterostructure. We find that two interfaces, Co-Co/V-Al and Co-Mn/Mn-Al (see Figure below), preserve the half-metallic character, with and without including electronic correlations. This is a non trivial result, since non-quasi particle states appear in the excitation spectrum, but they do not fall within the minority spin gap, and therefore do not destroy the half-metallic character. We also analyze the magnetic exchange interactions in the bulk and at the interfaces. At the Co-Mn/Mn-Al interface, competing magnetic interactions are likely to favor the formation of a non-collinear magnetic order, which is detrimental for the spin polarization. Due to these interesting magnetic properties found for the heterostructure, we decided to perform a deeper investigation of the bulk and surface magnetism of the family of quaternary Heusler compounds that behave as almost gapless semiconductors. We select CoMnVAl, CoCrTiP and FeMnTiP as representative

systems of this kind. We find that all these systems become ferromagnetic and metallic at the surfaces, which is a very interesting phenomenon. The analysis of the inter-atomic exchange interactions also show that there are both ferromagnetic and anti-ferromagnetic components, which makes the magnetic order tunable via composition and substrates. A manuscript illustrating these last results is currently under preparation and will be soon submitted to Physical Review B.

(v) atomic physics in lanthanides-based systems

Lanthanides possess a partially filled shell of 4f electrons that tend to be localized around the nuclei. This localization prevents the usage of standard computational methods such as DFT with local or semi-local functionals, which limits the possibility of theoretical investigations. The most common way to address this deficiency is to use model Hamiltonians, constructed with a limited number of parameters. Even in this simplified case, however, one still faces the problem of determining the required parameters without experimental input. Our JRG formulated a new method to obtain Coulomb interaction parameters for the 4f manifold, which is the crucial part of any model Hamiltonian. By combining open-core calculations with Herring's definition, we can obtain the average strength of the Coulomb interaction, *U*, for the whole series of elemental lanthanides (see Figure on the right). Most importantly, a full account of the multipolar expansion of the Coulomb interaction can be obtained by assuming a screening in the form of a Yukawa potential. This approach allows us to obtain robust data for the full Coulomb interaction vertex, which is a crucial information, especially for systems with a reduced dimensionality. We are currently writing a manuscript on this study. Alongside this project, we are also investigating the electronic and magnetic properties of isolated rare-earth adatoms on top of graphene. Our main interest consists in determining the landscape of spin excitations, which arises from the interplay of strong electronic correlations, crystal field effects and hybridization. Determining these energies is very important for understanding, and possibly manipulating, magnetism at the atomic scale [see e.g. Science **317**, 1199 (2007)]. This project is based on a collaboration between our JRG, theoretical groups at Bennett University (India) and Uppsala University (Sweden), and the experimental group of Prof. Harald Brune at EPFL (Switzerland).





Yearly Report 06

Physics beyond the Standard Model and its Phenomenology

Group Information

- Leader : Hiroshi Okada (PhD., Kanazawa University, Japan (2007))
- Period : Jun. 1, 2018 ~ May 31, 2021
- Members:

Name	Nationality	Period
Prof. Hiroshi Okada	**Japan**	**Jun. 1, 2018 ~ May 31, 2021**
Dr. Haing Cai	**China**	**Oct. 1, 2018 ~ Sep. 30, 2019**

NB. Current members are emboldened.

Scientific Scope

We focus on model buildings of neutrino(quark) physics, dark matter candidates, and their related phenomenologies such as lepton flavor violations(LFVs), muon anomalous magnetic moment(muon g-2), Z boson decays, and collider physics that can be tested by Large Hadron Collider. Through the model buildings, we try to construct all the phenomenologies can be explained by as a minimal way as possible.

Overview

We have achieved several types of neutrino and quark models that lead to several predictions of their neutrino oscillation data and masses as well as quark mixing and their masses. In order to realize these models, we have often introduced Abelian or Non-Abelian groups as flavor symmetries. Also we have sometimes included discussions of dark matter candidate, LFVs, muon g-2. and collider physics.

Research Highlights

1) An inverse seesaw model with global $U(1)_H$ symmetry
By Ujjal Kumar Dey, Takaaki Nomura, Hiroshi Okada.
arXiv:1902.06205 [hep-ph].

2) Dark matter and B-meson anomalies in a flavor dependent gauge symmetry
By Parada T.P. Hutauruk, Takaaki Nomura, Hiroshi Okada, Yuta Orikasa.
arXiv:1901.03932 [hep-ph].

3) CP violation of quarks in A_4 modular invariance
By Hiroshi Okada, Morimitsu Tanimoto.
arXiv:1812.09677 [hep-ph].
10.1016/j.physletb.2019.02.028.
Phys.Lett. B791 (2019) 54-61.

4) Linear seesaw model with hidden $SU(2)_H \times U(1)_X$ gauge symmetry
By Takaaki Nomura, Hiroshi Okada.

arXiv:1812.08473 [hep-ph].

5) One-loop neutrino mass model with $SU(2)_L$ multiplet fields
By Takaaki Nomura, Hiroshi Okada.
arXiv:1812.08016 [hep-ph].

6) Resolving B-meson anomalies by flavor-dependent gauged symmetries
$\displaystyle \prod_{i=1}^3U(1)_{B_i-L_i}$
By Chao-Qiang Geng, Hiroshi Okada.
arXiv:1812.07918 [hep-ph].

7) A neutrino mass model with hidden $U(1)$ gauge symmetry
By Haiying Cai, Takaaki Nomura, Hiroshi Okada.
arXiv:1812.01240 [hep-ph].

8) Inverse seesaw model with large $SU(2)_L$ multiplets and natural mass hierarchy
By Takaaki Nomura, Hiroshi Okada.
arXiv:1809.06039 [hep-ph].

9) One-loop neutrino mass model without any additional symmetries
By Takaaki Nomura, Hiroshi Okada.
arXiv:1808.05476 [hep-ph].

10) An inverse seesaw model with natural hierarchy at TeV scale
By Takaaki Nomura, Hiroshi Okada.
arXiv:1807.04555 [hep-ph].

11) A predictive model of radiative neutrino mass with gauged $U(1)_{B-2L_{\ell_2}-L_{\ell_1}}$ symmetry
By Takaaki Nomura, Hiroshi Okada.
arXiv:1806.09957 [hep-ph].

12) A Linear seesaw model with hidden gauge symmetry
By Takaaki Nomura, Hiroshi Okada.
arXiv:1806.07182 [hep-ph].

13) An inverse seesaw model with $U(1)_R$ gauge symmetry
By Takaaki Nomura, Hiroshi Okada.
arXiv:1806.01714 [hep-ph].
10.31526/LHEP.2.2018.01.
LHEP 1 (2018) no.2, 10-13.

14) Predictive neutrino mass textures with origin of flavor symmetries
By Tatsuo Kobayashi, Takaaki Nomura, Hiroshi Okada.
arXiv:1805.07101 [hep-ph].
10.1103/PhysRevD.98.055025.
Phys.Rev. D98 (2018) no.5, 055025.

Yearly Report 07

Physics of matter at non-equilibrium

Group Information

- Leader : Yuji Hirono (PhD., The University of Tokyo, Japan(2014))
- Period : Sep. 1, 2018 ~ Aug. 31, 2021
- Members

Name	Nationality	Period
Prof. Yuji Hirono	**Japan**	**Sep. 1, 2018 ~ Aug. 31, 2021**

NB. Current members are emboldened.

Scientific Scope

QCD matter exhibits a rich variety of phases at finite temperatures and densities. We aim at understanding the dynamical aspects of QCD matter at finite temperatures and densities, through various techniques including those of quantum field theories and effective theories such as hydrodynamics and kinetic theories. We also aim at extending the analysis to a wider variety of systems including Dirac/Weyl semimetals where similar methodologies apply.

Overview

The group settled and started in September of 2018, and we are right now in the process of searching suitable members. In 2018, we studied the consequences of the transport phenomena induced by the chiral anomaly. We also analyzed the phase structure of dense QCD matter from the view point of higher-form symmetries.

Research Highlights

"Dynamics of Vortices in Chiral Media: The Chiral Propulsion Effect" [Phys. Rev. Lett. 121, 142301]

Macroscopic transport effects arising from the chiral anomaly has attracted much attention. One of such phenomena is the so-called Chiral Magnetic Effect (CME). In this work, we examined the role of dynamical electromagnetism in the motion of thin filaments of magnetic fields.

We showed that the dynamics of such filaments are governed by a modified version of the localized induction equation in the parity-breaking background. The helical solitonic excitations on vortices in a parity-breaking medium are found to carry an additional energy flow along the vortex in the direction dictated by the sign of chirality imbalance; we call this the Chiral Propulsion Effect (CPE). This is a novel transport phenomenon that is realized by an interplay of chiral anomaly and dynamical electromagnetism. We also analyzed several solutions of the EOM, and discussed how the anomalous transport affects the nature of the fluctuations around the solutions.

"Quark-hadron continuity beyond Ginzburg-Landau paradigm" [arXiv:1811.10608]

Phases of matter has been conventionally classified by Ginzburg-Landau (GL) theory based on local order parameters. It is known by now that the GL description is not sufficient to classify phases; there are orders that can only detected using non-local order parameters, and they are called topological orders. The topologically ordered phases are characterized by emergent higher-form symmetries at low energies and their subsequent spontaneous breaking.

We examined the phase structure of dense QCD matter from the view point of topological order. There is a proposal about the phase diagram of dense QCD called quark-hadron continuity scenario, which states that the color superconducting phase can be continuously connected with superfluid phase of nucleons without phase transitions. We derived a dual gauge theory which has a form of the topological BF theory coupled with massless Nambu-Goldstone (NG) bosons.

We showed that there is an emergent discrete two-form symmetry, and illustrated that it leads to fractional statistics between vortices and quasiparticles. However, the symmetry is not broken because of the confining force between vortices mediated by massless NG modes. Consequently, the color superconducting phase has the same topological structure as the nucleon superfluid phase. This indicates that the continuity scenario extends beyond the Ginzburg-Landau theory.

There are not many experimental or observational clues as to the phase diagram of dense QCD matter. This work is an example where higher-form symmetries provide us with useful information constraining the QCD diagram.

Final Report 01

Classical and Quantum Theory of Gravity

Group Information

- Leader : Dong-han Yeom (PhD., KAIST, Korea (2011))
- Period : Sep. 1, 2017 ~ Feb. 28, 2019
- Members

Name	Nationality	Period
Prof. Dong-han Yeom	Korea	Sep. 1, 2017 ~ Feb. 28, 2019
Dr. Brahma Suddhasattwa*	India	Oct. 12, 2017 ~ Sep. 30, 2019
Dr. Jiang Long**	China	Sep. 1, 2018 ~ Feb. 28, 2019
Dr. Daeho Ro	Korea	Jan. 1, 2018 ~ Oct. 31, 2018
Dr. Alexey Golovnev	Russia	Jan. 1, 2018 ~ May 31, 2018

* Will be financially supported by Dong-han Yeom until the end of his contract
** Will join Jaeyoon Cho group from March 1, 2019

Scientific Scope

In our group, we investigate classical and quantum aspects of gravity. We are interested in three issues: (1) theoretical motivations of quantum and semi-classical gravity models, (2) experimental implications of various gravitational models, and (3) technical improvements of important theoretical tools, including Euclidean path-integral approach and double-null formalism for dynamical black holes.

Research Highlights

(i) Published papers

- ***Why concave rather than convex inflaton potential?*** (Eur.Phys.J. C78 (2018) no.10, 863)

The Planck data on cosmic microwave background indicates that the Starobinsky-type model with concave inflation potential is favored over the convex-type chaotic inflation. Is there any reason for that? Here we argue that if our universe began with a Euclidean wormhole, then the Starobinsky-type inflation is probabilistically favored. It is known that for a more generic choice of parameters than that originally assumed by Hartle and Hawking, the Hartle-Hawking wave function is dominated by Euclidean wormholes, which can be interpreted as the creation of two classical universes from nothing. We show that only one end of the wormhole can be classicalized for a convex potential, while both ends can be classicalized for a concave potential. The latter is therefore more probable.

- ***Suppression of long-wavelength CMB spectrum from the no-boundary initial condition*** (Eur.Phys.J. C78 (2018) no.11, 930)

The lack of correlations at the long-wavelength scales of the cosmic microwave background spectrum is a long-standing puzzle and it persists in the latest Planck data. By considering the Hartle-Hawking no-boundary wave function as the initial condition of the inflationary universe, we propose that the power suppression can be the consequence of a massive inflaton, whose initial vacuum is the Euclidean instanton in a compact manifold. We calculate the primordial power spectrum of the perturbations, and find that as long as the scalar field is moderately massive, the power spectrum is suppressed at the long-wavelength scales.

- ***Tunneling decay of false vortices with gravitation*** (JHEP 1711 (2017) 028)

We study the effect of vortices on the tunneling decay of a symmetry-breaking false vacuum in three spacetime dimensions with gravity. The scenario considered is one in which the initial state, rather than being the homogeneous false vacuum, contains false vortices. The question addressed is whether, and, if so, under which circumstances, the presence of vortices has a significant catalyzing effect on vacuum decay. After studying the existence and properties of vortices, we study their decay rate through quantum tunneling using a variety of techniques. In particular, for so-called thin-wall vortices we devise a one-parameter family of configurations allowing a quantum-mechanical calculation of tunneling. Also for thin-wall vortices, we employ the Israel junction conditions between the interior and exterior spacetimes. Matching these two spacetimes reveals a decay channel which results in an unstable, expanding vortex. We find that the tunneling exponent for vortices, which is the dominant factor in the decay rate, is half that for Coleman-de Luccia bubbles. This implies that vortices are short-lived, making them cosmologically significant even for low vortex densities. In the limit of the vanishing gravitational constant we smoothly recover our earlier results for the decay of the false vortex in a model without gravity.

- ***Pre-Hawking radiation cannot prevent the formation of apparent horizon*** (Phys.Rev. D97 (2018) no.6, 064045)

As an attempt to solve the black hole information loss paradox, recently there has been the suggestion that, due to semi-classical effects, a pre-Hawking radiation must exist during the gravitational collapse of matter, which in turn prevents the apparent horizon from forming. Assuming the pre-Hawking radiation does exist, here we argue the opposite. First we note that the stress energy tensor near the horizon for the pre-Hawking radiation is far too small to do anything to the motion of a collapsing shell. Thus the shell will always cross the apparent horizon within a finite proper time. Moreovall, the amount of energy that can be radiated must be less than half of the total initial energy (if the particle starts at rest at infinity) before the shell becomes a null shell and cannot radiate any more without becoming tachyonic. We conclude that for any gravitational collapsing process within Einstein gravity and semi-classical quantum field theory, the formation of the apparent horizon is inevitable. Pre-Hawking radiation is therefore not a valid solution to the information paradox.

- ***Tunneling from the past horizon*** (Phys.Rev. D97 (2018) no.8, 086011)

We investigate a tunneling and emission process of a thin-shell from a Schwarzschild black hole, where the shell was initially located beyond the Einstein-Rosen bridge and finally appears at the right side of the Penrose diagram. In order to obtain such a solution, we should assume that the areal radius of the black hole horizon increases after the tunneling. Hence, there is a parameter range such that the tunneling rate is exponentially enhanced, rather than suppressed. We may have two interpretations regarding this. First, such a tunneling process from the past horizon is improbable by physical reasons; second, such a tunneling is possible in principle, but in order to obtain a stable Einstein-Rosen bridge, one needs to restrict the parameter spaces. If such a process is allowed, this can be a non-perturbative contribution to Einstein-Rosen bridges as well as eternal black holes.

- ***How can we erase states inside a black hole?*** (J.Korean Phys.Soc. 73 (2018) no.19, 1420-1430)

  Selected as JKPS Highlight for November 2018

We investigate an entangled system, which is analogous to a composite system of a black hole and Hawking radiation. If Hawking radiation is well approximated by an outgoing particle generated from pair creation around the black hole, such a pair creation increases the total number of states. There should be a unitary mechanism to reduce the number of states inside the horizon for black hole evaporation. Because the infalling antiparticle has negative energy, as long as the infalling antiparticle finds its partner such that the two particles form a separable state, one can trace out such a zero energy system by maintaining unitarity. In this paper, based on some toy model calculations, we show that such a unitary tracing-out process is only possible before the Page time while it is impossible after the Page time. Hence, after the Page time, if we assume that the process is unitary and the Hawking pair forms a separable state, the internal number of states will monotonically increase, which is supported by the Almheiri-Marolf-Polchinski-Sully (AMPS) argument. In addition, the Hawking particles cannot generate randomness of the entire system; hence, the entanglement entropy cannot reach its maximum. Based on these results, we modify the correct form of the Page curve for the remnant picture. The most important conclusion is this: if we assume unitarity, semi-classical quantum field theory, and general relativity, then the black hole should violate the Bekenstein-Hawking entropy bound around the Page time at the latest; hence, the infinite production arguments for remnants might be applied for semi-classical black holes, which seems very problematic.

- ***Tunneling decay of self-gravitating vortices*** (EPJ Web Conf. 168 (2018) 03004)

We investigate tunneling decay of false vortices in the presence of gravity, in which vortices are trapped in the false vacuum of a theory of scalar electrodynamics in three dimensions. The core of the vortex contains magnetic flux in the true vacuum, while outside the vortex is the appropriate topologically nontrivial false vacuum. We numerically obtain vortex solutions which are classically stable; however, they could decay via tunneling. To show this phenomenon, we construct the proper junction conditions in curved spacetime. We find that the tunneling exponent for the vortices is half that for Coleman-de Luccia bubbles and discuss possible future applications.

- ***Effective line elements and black-hole models in canonical loop quantum gravity*** (Phys.Rev. D98 (2018) no.4, 046015)

Canonical quantization is often used to suggest new effects in quantum gravity, in the dynamics as well as the structure of space-time. Usually, possible phenomena are first seen in a modified version of the classical dynamics, for instance in an effective Friedmann equation, but there should also be implications for a modified space-time structure. Quantum space-time effects, however, are often ignored in this setting because they are not obvious: they require a careful analysis of gauge transformations and the anomaly problem. It is shown here how modified space-time structures and effective line elements can be derived unambiguously, provided an off-shell anomaly-free system of modified constraints exists. The resulting effective line elements reveal signature change as an inescapable consequence of non-classical gauge transformations in the presence of

holonomy modifications. The general framework is then specialized to black-hole models in loop quantum gravity. In contrast to previous studies, a self-consistent space-time structure is taken into account, leading to a new picture of black-hole interiors.

- ***On singularity-resolution in mimetic gravity*** (Phys.Lett. B782 (2018) 280-284)

Recently, it was shown that modified mimetic gravity, with a f(□ϕ) term, results in a singularity-free model of gravity, for both cosmological and black hole spacetimes [1, 2]. In this work, we analyze this model further and show that, since the function f was tuned to vanish rapidly for small values of the argument, the non-singular bounce relies heavily on a subtle branch changing mechanism for the multi-valued function f. Furthermore, this mechanism has interesting implications for the proposed link between this model and loop quantum cosmology.

- ***Effective black-to-white hole bounces: The cost of surgery*** (Class.Quant.Grav. 35 (2018) no.20, 205007)

We investigate possible geometries allowing transitions from a black hole to a white hole spacetime, by placing a space-like thin shell between them. Such proposals have been advanced recently to account for singularity-resolution in black-hole spacetimes. This space-like shell can be extended to be outside the event horizon and, thereby, reproduce some of the features of these proposals. On the other hand, if the space-like shell is confined fully within the horizon, then it results in a bounce near a space-like singularity inside the black hole. For both cases, the null energy condition is necessarily violated, at least effectively, due to introduction of quantum effects. If the shell, with a non-trivial negative tension, extends beyond the event horizon, then one can see effects of quantum gravity modifications even outside the horizon as a cost of such a space-like surgery. Naturally, one needs to consider whether these types of manufactured spacetimes violates any known laws of nature, allowing for reasonable assumptions. After critically comparing our results with several models in the literature, we reiterate a new way to avoid such black-hole singularities without leaving a white-hole remnant via a quantum bounce.

- ***Black hole factory: a review of double-null formalism*** (Int.J.Mod.Phys. D28 (2018) no.03, 1930006)

  Invited review for Int.J.Mod.Phys. D.

In this review paper, we comprehensively summarize numerical applications of double-null formalism for studying dynamics within the theory of gravity. By using the double-null coordinates, we can investigate dynamical black holes and gravitational phenomena within spherical symmetry, including gravitational collapse, formation of horizons and singularities, as well as evaporations. This formalism can be extended to generic situations, where we can change dimensions, topologies, the gravity sector, as well as the matter sector. We also discuss its possible implications for black hole physics and particle astrophysics. This strong numerical tool will have lots of future applications for various research areas including general relativity, string theory, and various approaches to quantum gravity.

- ***No-boundary wave function for loop quantum cosmology*** (Phys.Rev. D98 (2018) no.8, 083537)

Proposing smooth initial conditions is one of the most important tasks in quantum cosmology. On the other hand, the low-energy effective action, appearing in the semiclassical path integral, can get nontrivial quantum corrections near classical singularities due to specific quantum gravity proposals. In this article, we combine the well-known no-boundary proposal for the wavefunction of the universe with quantum modifications coming from loop quantum cosmology (LQC). Remarkably, we find that the restriction of a `slow-roll' type potential in the original Hartle-Hawking proposal is considerably relaxed due to quantum geometry regularizations. Interestingly, the same effects responsible for singularity-resolution in LQC also end up expanding the allowed space of smooth initial conditions leading to an inflationary universe.

- ***Regular instantons in the Eddington-inspired-Born-Infeld gravity: Lorentzian wormholes from bubble nucleations*** (JCAP 1810 (2018) no.10, 056)

The O(4)-symmetric regular instanton solutions are studied within the framework of the Eddington-inspired-Born-Infeld gravity (EiBI). We find that the behavior of the solution would deviate from that in Einstein gravity when the kinetic energy of the scalar field is sufficiently large. The tunneling probability is calculated numerically in different parameter space. We find that the tunneling probability would increase with the Born-Infeld coupling constant, which is assumed to be positive in this paper. Furthermore, we discover a neck feature in the physical instanton solutions when the kinetic energy of the scalar field is sufficiently large. This feature can be interpreted as a Lorentzian time-like wormhole geometry formed during the bubble materialization.

- ***On the geometry of no-boundary instantons in loop quantum cosmology*** (Universe 5 (2019) no.1, 22)

We study the geometry of Euclidean instantons in loop quantum cosmology (LQC) such as those relevant for the no-boundary proposal. Confining ourselves to the simplest case of a cosmological constant in minisuperspace cosmologies, we analyze solutions of the semiclassical (Euclidean) path integral in LQC. We find that the geometry of LQC instantons have the peculiar feature of an infinite tail which distinguishes them from Einstein gravity. Moreover, due to quantum-geometry corrections, the small-a behaviour of these instantons seem to naturally favor a closing-off of the geometry in a regular fashion as was originally proposed for the no-boundary wavefunction.

(ii) Preprints

- ***Hawking radiation as instantons*** (arXiv:1806.03766)

There have been various interpretations of Hawking radiation proposed based on the perturbative approach, and all have confirmed Hawking's original finding. One major conceptual challenge of Hawking evaporation is the associated black hole information loss paradox, which remains unresolved. A key factor to the issue is the end-stage of the black hole evaporation. Unfortunately by then the evaporation process becomes non-perturbative. Aspired to provide a tool for the eventual solution to this problem, here we introduce a new interpretation of Hawking radiation as the tunneling of instantons. We study instantons of a massless scalar field in Einstein gravity. We consider a complex-valued instanton that connects an initial pure black hole state to a black hole with a scalar field that represents the Hawking radiation at future null infinity, where its action depends only on the areal entropy difference. By comparing it with several independent approaches to Hawking radiation in the perturbative limit, we conclude that Hawking radiation may indeed be described by a family of instantons. Since the instanton approach can describe non-perturbative processes, we hope that our new interpretation and holistic method may shed lights on the information loss problem.

- ***Quantum creation of traversable wormholes ex nihilo in Gauss-Bonnet-dilaton gravity*** (arXiv:1808.01103)

We investigate a nucleation of a Euclidean wormhole and its analytic continuation to Lorentzian signatures in Gauss-Bonnet-dilaton gravity, where this model can be embedded by the type-II superstring theory. We show that there exists a Euclidean wormhole solution in this model by choosing a suitable shape of the dilaton potential. After the analytic continuation, this explains a quantum creation of a time-like traversable wormhole. Finally, we discuss relations to the information loss problem and the current literature.

- ***Causal structures and dynamics of black-hole-like solutions in string theory*** (arXiv:1901.06857)

We investigate spherically symmetric solutions in string theory. Such solutions depend on three parameters, one of which corresponds to the asymptotic mass while the other two are the dilaton and two-form field amplitudes, respectively. If the two-form field amplitude is non-vanishing, then this solution represents a trajectory of a singular and null hypersurface. If the dilaton and two-form field amplitudes are non-vanishing but very close to zero, then the solution is asymptotically the same as the Schwarzschild solution, while only the near horizon geometry will be radically changed. If the dilaton field diverges toward the weak coupling regime, this demonstrates a firewall-like solution. If the dilaton field diverges toward the strong coupling limit, then as we consider quantum effects, this spacetime will emit too strong Hawking radiation to preserve semi-classical spacetime. However, if one considers a junction between the solution and the flat spacetime interior, this can allow a stable star-like solution with reasonable semi-classical properties. We discuss possible implications of these causal structures and connections with the information loss problem.

- ***Comment on "Quantum transfiguration of Kruskal black holes"*** (arXiv:1902.07874)

After examining the asymptotic structure of the quantum black holes proposed in Phys. Rev. Lett. 121, 241301 (2018) and Phys. Rev. D 98, 126003 (2018), we found that the solution is not asymptotically flat. Since the property of asymptotic flatness has been explicitly invoked in their calculations, for instance in their finding of a relation between the black hole and the white hole masses, it thereby raises a serious concern about the consistency of their solution in the classical limit.

(iii) Work in progress

The following topics are the present active research topics based on domestic or international collaborations.

1. ***Further investigations of the no-boundary wave function***

   A. Applications for further theories, e.g., loop quantum cosmology or modified gravity *(Collaboration with S. Brahma, etc.)*

   B. Observational consequences for CMB power spectrum, etc. *(Collaboration with P. Chen, H.-H. Yeh, etc.)*

   C. Extensions to non-compact instantons, e.g., Euclidean wormholes *(Collaboration with D. Ro, P. Chen, etc.)*

2. ***Non-perturbative aspects of black holes and the information loss problem***

   A. Further study on Hawking radiation and instantons *(Collaboration with P. Chen, M. Sasaki, etc.)*

   B. Quantum gravitational analysis for inside the black hole using the Wheeler-DeWitt wave function *(Collaboration with P. Chen, C.-Y. Chen, M. Bouhmadi-Lopez, etc.)*

   C. Applications of loop quantum cosmology and singularity resolution inside a horizon *(Collaboration with S. Brahma, P. Chen, C.-Y. Chen, M. Bouhmadi-Lopez, etc.)*

3. ***Numerical modeling of various physical problems***

   A. Semi-classical black holes and astrophysical applications *(Collaboration with C. Park, etc.)*

   B. Numerical computation of entanglement entropy and information *(Collaboration with H. Zoe, etc.)*

Final Comments

Since September of 2017, I have been the leader of the Junior Research Group "Classical and Quantum Theory of Gravity". In this extraordinary research circumstances, I could continue various research activities. I believe that I could obtain successful research outcomes. During one and a half years, I have published 14 papers, completed 4 preprints, and there are more active research projects. Based on this experience, I could find a new position at Pusan National University.

Among numerous good things of APCTP, the best opportunity of mine was to collaborate with good postdoctoral colleagues. Apart from the number of publications, I could learn various things from various young experts; also, I could get many help to pursue my research interests. I am happy that some of our group members could find a better next position after they leave APCTP. Also, APCTP could be a good herb of research communications. Thanks to this, I could easily collaborate domestic and international collaborators through the base of APCTP.

As many colleagues commented and I myself agreed, the research environment of APCTP is very good, but the potential problem is that the contraction is non-permanent. This also made me stress to find the next position as soon as possible. Someday, I hope that scientists could do their own research interests without any stress from outside the research, although at this moment, there is no such an ideal institute in the real world.

IV. Cooperation with International Organization Report

IV. Cooperation with International Organization Report

Association of Asia Pacific Physical Societies (AAPPS)

(1) Academic Activities of the AAPPS Divisions

There are three academic activities supported by the APCTP as below.

Division	Support	Details	No. of participants
Division of Plasma Physics (DPP)	10,000K KRW	2nd Asia-Pacific Conference on Plasma Physics (Nov. 12-16, Kanazawa, Japan)	682 (620 talks)
Division of Astrophysics, Cosmology and Gravitation (DACG)	10,000K KRW	CosPA 2018 (Nov. 19-23, Yang Zhou, China)	143 (63 talks)
Division of Nuclear Physics (DNP)	10,000K KRW	ANPhA (=AAPPS-DNP) Board Meeting / Symposium 2018 in Beijing (Sep. 13-14, Beijing, China)	35 (12 talks)

a. 2nd Asia-Pacific Conference on Plasma Physics

This conference is the second annual conference of AAPPS-DPP (AAPPS-DPP2018). AAPPS-DPP2018 made important advanced compared with the first one (AAPPS-DPP2017) in number of participants (~500 in 2017 to 682 in 2018), establishment of financial responsibility by AAPPS-DPP, creation of student (U30) award, creation of poster prize, increase of publication to AAPPS-DPP's official journal RMPP (Reviews of Modern Plasma Physics) (10 for 2018 to 31 for 2019). Especially poster sessions were of great success as compared with 1st conference. We believe AAPPS-DPP annual conference becomes comparable with EPS-DPP and can be one of three central regional plasma conferences (APS-DPP, EPS-DPP and AAPPS-DPP).

b. CosPA 2018

CosPA 2018 is the 17th symposium, which has been organized in Asia Pacific region annually as an activity of the Asia Pacific Organization of Cosmology and Particle Astrophysics. The event was attended by about 150 faculties and graduate students from over 10 countries. In this symposium, the researchers from the observational, computer simulation and theoretical sides working in cosmology, astrophysics and astroparticle physics gathered to discuss the current situation as well as prospects for future improvements. Some original novel ideas are brought forth.

c. ANPhA (=AAPPS-DNP) Board Meeting / Symposium 2018 in Beijing

The ANPhA2018 is the 12th ANPhA Board meeting and the 10th ANPhA Symposium. The talks were well organized and presented mainly by senior scientists in Asia, which focused on the latest progress and future plans of nuclear science facilities and nuclear physics research in Asia. This is a great chance for communication and study for young people attending this symposium.

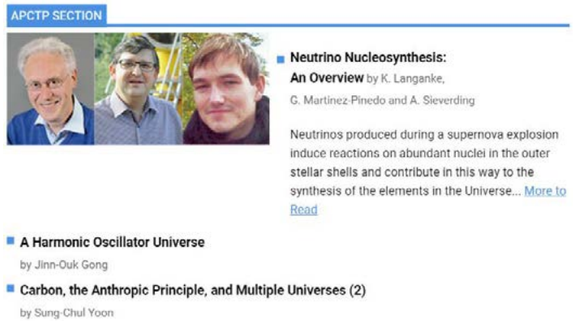
(2) Efforts to increase the brand awareness of the AAPPS Bulletin

a. Publication of the special issue: Collection of Scientific Articles in 2018

To attract more readers, the APCTP published a special issue titled “Collection of Scientific Articles in 2018” and distributed the hard copies to domestic and international physics community.

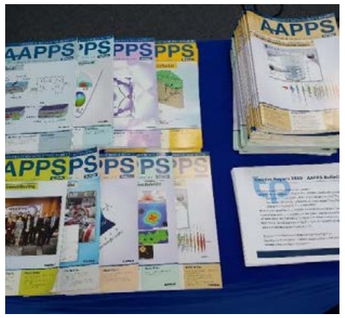
b. Increasing accessibility with online newsletter

Online newsletter in an easy-to-access format has been sent out to 23 countries including the APCTP member entities and the AAPPS member societies from 2018.



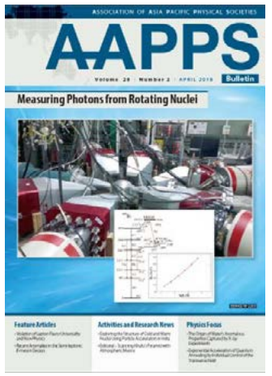
c. Exhibition booth at the Physical Societies’ official meeting in AP region

APCTP publicized the AAPPS Bulletin at the official meeting of the Korean Physical Society (KPS) and the Japan Society of Applied Physics (JSAP) and encouraged potential authors to submit the scientific papers to the AAPPS Bulletin.



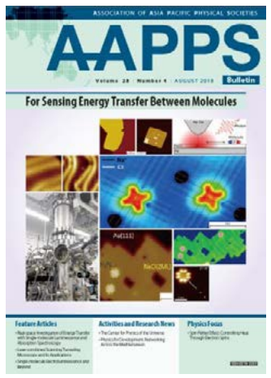
(3) Publication of the AAPPS Bulletin

February Issue



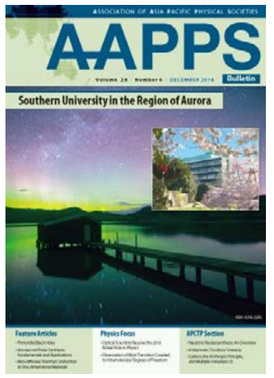
April Issue

June Issue



August Issue

October Issue



December Issue

V. Scientific Outreach Programs Report

1. Web Journal ‘Crossroads’
2. Forums, Lectures, Schools, etc.

1. Web Journal 'Crossroads'

Crossroads creates and distributes of high-quality scientific literary contents by the Asia-Pacific scientist network.

(1) Goal

Lead the Vision for Science, Future and Humanity

- Build up a network for scientist in the Asia-Pacific region and set an example of science web-journal
- Expand the base of science and lead its popularization by communicating with scientists

(2) Publication

- online journal published monthly in Korean:
  Volume 14, Issue 1 ~ Issue 12
- number of articles by section (total 96 articles):
  APCTP People(4), APCTP Plaza(12), Cross Street(22), Book Review(11), SF Review(13), Science Fiction(12), APCTP Everywhere(22)

(3) Number of visitors and page views

Item	2016	2017	2018
Visitors	354,513	551,616	526,555
Page Views	551,141	742,163	590,830

(4) Number of visitors worldwide

Year	2016	2017	2018
USA	175,747	216,785	211,095
Korea	113,591	197,248	179,071
Canada	28,958	50,738	49,339
Beijing	3,815	7,507	11,237
UK	3,067	5,773	6,387
Japan	990	3,659	1,793
Germany	982	773	695
Etc.	27,363	69,133	66,938
Total	**354,513**	**551,616**	**526,555**

2. Forums, Lectures, Schools, etc.

Science Communication Forum/Lecture

Science Communication Forums/Lectures demonstrate hot scientific issues of the year to the public. Physicists and Scientists are invited to share their research and discuss scientific issues.

Topic	Period	Speaker	Participants
Science Books Lectures (Venue: Seodaemun Museum of Natural History)			
Science Books Lectures(I)	Mar.2	Hang Bae Kim(Hanyang Univ.)	80
Science Books Lectures(II)	Mar.8	Jae Jun Yu(Seoul Nat'l Univ.)	51
Science Books Lectures(III)	Mar.15	Junga Hwang (Korea Astronomy and Space Science Institute)	68
Science Books Lectures(IV)	Mar.22	Sang Wook Kim (Kyung Hee Univ.)	52
Science Books Lectures(V)	Mar.29	Minryung Song (Korea Advanced Institute of Science and Technology)	62
Science Books Lectures(VI)	Jul.5	Seung-sup Kim (Korea Univ.)	56
Science Books Lectures(VII)	Jul.12	HanEum Lee (Science Writer)	52
Science Books Lectures(VIII)	Jul.19	Dae-Ik Jang (Seoul Nat'l Univ.)	51
Science Books Lectures(IX)	Aug.9	Kang-hwan Lee (Seodaemun Museum of Natural History)	58
Science Books Lectures(X)	Aug.14	Dae Yeol Lee (Yale Univ.)	64
Communication of Science, Culture and Art (Venue: Sobaeksan Optical Astronomy Observatory)			
Communication of Science, Culture and Art(I)	Jul.4-6	Tae-Hoon Lim(DGIST) & Soyo Lee(Bio Artist)	20
Communication of Science, Culture and Art(II)	Nov.1-3	Jae Hyuk Kim(Korea Foundation for the Advancement of Science and Creativity) & SangJoon Park(Korea Science Fiction Assosiation)	26

Welcome Physics Teachers to Master Class (Venue: APCTP Headquarters, Pohang)			
Welcome Physics Teachers to Master Class(1)	Jan.15-26	Suk-Min Chung(POSTECH)	9
Welcome Physics Teachers to Master Class(2)	Aug.6-10	Suk-Min Chung(POSTECH)	8
Public Lecture (Venue: POSCO International Center)			
Public Lecture	Dec.15	Taegeun Song (POSTECH)	103
Total			**760**

Science Books Lectures

Communication of Science, Culture and Art

Welcome Physics Teachers to Master Class

Public Lecture

“Best Science Book 10” selected by APCTP (November 2018)

The best science books are selected and promoted by APCTP for a wide readership. To announce the list and to express congratulations on being included in the list, the ‘Celebration of the Best Science Book 10 Selected by APCTP’ was held on November 27, 2018 at Science Bookshop GALDAR, Seoul.

No	Title	The date of Issue	Author
1	Quantum Physics	Dec. 8, 2017	Sang Wook Kim
2	A Crude Look at the Whole	Nov. 22, 2017	John. H. Miller
3	Spin	Jan. 2, 2018	Kang Young Lee
4	Postgenomic Era	Oct. 15, 2018	Kiwon Song
5	You Call that Science?	Mar. 19, 2018	Jaeyong Park
6	A Beautiful Questions	Jun. 15, 2018	Frank Wilczek
7	How to be a Scientist	Jul. 25, 2018	Sok NamKung
8	Cultural History of the 20th Century Technology	Apr. 30, 2018	Myong-Jin Kim
9	Birds Flying through the Water	Sep. 21, 2018	Won Young Lee
10	Scientific Factors Proven at the Front Page of the History	Sep. 14, 2018	Hong Pyo Kim

Science Communication School

Science Communication School provides the university students with science writing class and debating & presentation programs at the Center.

- Topic: CRISPR
- Period: January 31 ~ February 2, 2018
- Venue: APCTP Headquarters, Pohang
- Participants: 20 persons

Science in City Hall

Science in City Hall is held with Pohang City which includes high quality science lectures and programs combining Science, Education, Art, and Experience.

- Topic: Galaxy
- Period: October 27, 2018
- Venue: POSCO International Center
- Speaker: Soyeon Yi (Astronaut, Researcher) and 4 speakers
- Participants: 376 persons

Pohang Family Science Festival

Pohang Family Science Festival is held with Pohang City to stimulate interest in science through wider participation and to nurture science leaders from the local area.

- Topic: Science for the Future
- Period: December 8 ~ 9, 2018
- Venue: Pohang Sports Complex Indoor Stadium
- Participants: around 40,000 persons

VI. List of Scientific Papers

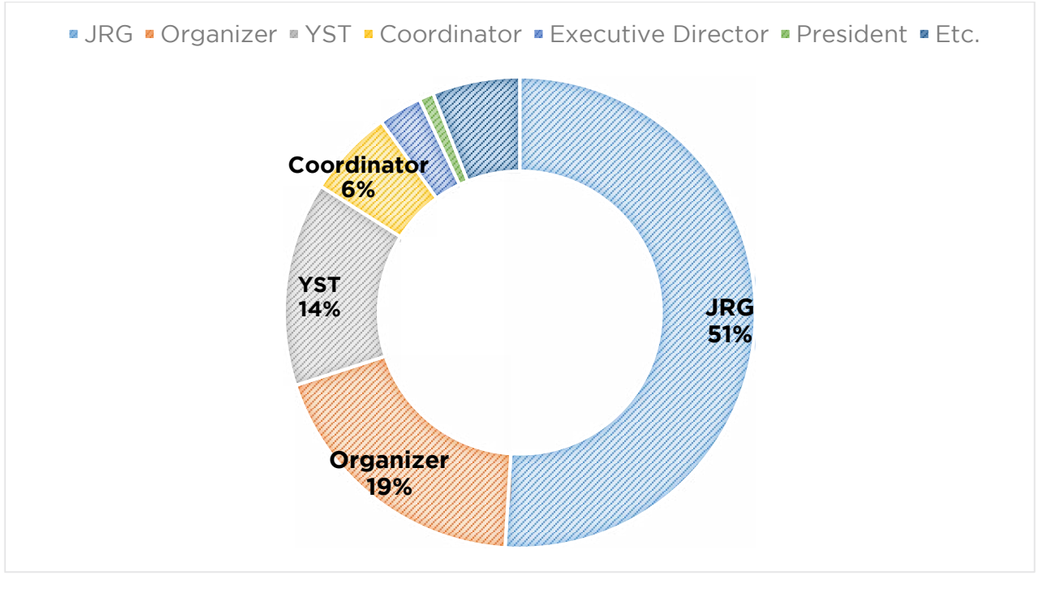
1. Scientific Papers Summary
2. Scientific Papers
3. Scientific Papers with Acknowledgement of APCTP

1. Scientific Papers Summary

Number of Scientific Papers

Scientific Papers	No. of Scientific Papers			SCI	Impact Factor
	Total	Author Category	No.		
Scientific Papers	83	President	1	100 %	4.2544
		Executive Director	3		
		Coordinator	7		
		JRG	59		
		YST	16		
		Organizer	1		
		Etc.	7		
Scientific Papers with Acknowledgement of APCTP	21	Organizer	21	100 %	4.8823
Total	104	-	115	100 %	4.5683

Ratios by Author Category



2. Scientific Papers

Number of Publications: 83

No.	Category	Journal	Authors	Article
1	JRG	International Journal of Modern Physics A	**Jung Hun Lee, Chanyong Park**	Nucleon form factors in nuclear medium
2	JRG	Journal of High Energy Physics	**Chanyong Park, Daeho Ro and Jung Hun Lee**	c-theorem of the entanglement entropy
3	JRG, YST	Journal of High Energy Physics	Sunly Khimphun, Bum-Hoon Lee, **Chanyong Park, Yun-Long Zhang**	Rindler fluid with weak momentum relaxation
4	JRG	Physical Review B	**Mehdi Biderang**, Andreas Leonhardt, **Nimisha Raghuvanshi**, Andreas P. Schnyder and **Alireza Akbari**	Drumhead surface states and their signatures in quasiparticle scattering interference
5	JRG	Physical Review A	**Utkarsh Mishra**, Hadi Cheraghi, Saeed Mahdavifar, R. Jafari and **Alireza Akbari**	Dynamical quantum correlations after sudden quenches
6	JRG	Physical Review B	**Mehdi Biderang**, H. Yavari, M.H. Zare, P. Thalmeier, **Alireza Akbari**	Edge currents as a probe of the strongly spin-polarized topological noncentrosymmetric superconductors
7	JRG	Physical Review B	P. Thalmeier, **Alireza Akbari**	Heavy quasiparticle bands in the underscreened quasiquartet Kondo lattice
8	JRG, Etc.	Physical Review B	**Dheeraj Kumar Singh, Alireza Akbari**, and Pinaki Majumdar	Quasi-one-dimensional nanoscale modulation as sign of nematicity in iron pnictides and chalcogenides
9	JRG	New Journal of Physics	Sergio Cobo-Lopez, M. S. Bahramy, R. Arita, **Alireza Akbari**, I. Eremin	Spin-orbit coupling, minimal model and potential Cooper-pairing from repulsion in BiS2-superconductors

No.	Category	Journal	Authors	Article
10	JRG	physical Review B	**Fabrizio Cossu**, Ali G. Moghaddam, Kyoo Kim, Hassan A. Tahini, **Igor Di Marco**, Han-Woong Yeom, and **Alireza Akbari**	Unveiling hidden charge density waves in single-layer NbSe2 by impurities
11	JRG	Physics of Particles and Nuclei	B.-H. Lee, **Chanyong Park, and Sunyoung Shin**	Walls of Nonlinear Sigma Models on SO(2N)/U(N) with N > 3
12	JRG	Physical Review A	**Chae-Yeun Park, Jaeyoon Cho**	Correlations in local measurements and entanglement in many-body systems
13	JRG	Physical Review X	**Jaeyoon Cho**	Realistic area-law bound on entanglement from exponentially decaying correlations
14	JRG	Physics Letters A	Anindita Bera, **Utkarsh Mishra**, Sudipto Singha Roy, Anindya Biswas, Aditi Sen(De), Ujjwal Sen	Benford analysis of quantum critical phenomena: First digit provides high finite-size scaling exponent while first two and further are not much better
15	JRG, YST	Physical Review D	**Ilya Bakhmatov**, Ö. Kelekci, **E. Ó Colgáin**, and M. M. Sheikh-Jabbari	Classical Yang-Baxter Equation from Supergravity
16	JRG, YST	Journal of Physics A-Mathematical and Theoretical	**Thiago Araujo, Ilya Bakhmatov, Eoin Ó Colgáin**, Jun-ichi Sakamoto, Mohammad M Sheikh-Jabbari, Kentaroh Yoshida	Conformal twists, Yang–Baxter σ-models & holographic noncommutativity
17	JRG	European Physical Journal C	**Thiago Araujo, Eoin Ó. Colgáin,** Hossein Yavartanoo	Embedding the modified CYBE in supergravity
18	JRG	Journal of High Energy Physics	**Ilya Bakhmatov**, **E. Ó Colgáin,** M. M. Sheikh-Jabbari, H. Yavartanoo	Yang-Baxter deformations beyond Cosets Spaces (a slick way to do TsT)

No.	Category	Journal	Authors	Article
19	JRG	Journal of Cosmology and Astroparticle Physics	Bikash R. Dinda, **Md. Wali Hossain** and Anjan A Sen	Observed galaxy power spectrum in cubic Galileon model
20	JRG	Physical Review D	**Thiago Araujo**	Remarks on BMS (3) invariant field theories: correlation functions and nonunitary CFTs
21	JRG	Scientific Reports	**Takayuki Hiraoka, Hang-Hyun Jo**	Correlated bursts in temporal networks slow down spreading
22	JRG, Executive Director	Physical Review E	**Byoung-Hwa Lee, Woo-Sung Jung, and Hang-Hyun Jo**	Hierarchical burst model for complex bursty dynamics
23	JRG	Physical Review E	**Hang-Hyun Jo, Takayuki Hiraoka**	Limits of the memory coefficient in measuring correlated bursts
24	JRG	Physica A-Statistical Mechanics and its Applications	**Hang-Hyun Jo**, Y. Murase, J. Török, J. Kertész, and K. Kaski	Stylized facts in social networks: Community-based static modeling
25	JRG	International Journal of Modern Physics D	Nakonieczna, Anna, Lukasz Nakonieczny, **Dong-han Yeom**	Black hole factory: A review of double-null formalism
26	JRG	Classical and Quantum Gravity	**Suddhasattwa Brahma, Dong-han Yeom**	Effective black-to-white hole bounces: The cost of surgery
27	JRG	Physical Review D	Martin Bojowald, **Suddhasattwa Brahma and Dong-han Yeom**	Effective line elements and black-hole models in canonical loop quantum gravity
28	JRG	Physical Review D	Subeom Kang, **Dong-han Yeom**	FuzzyEuclideanwormholesinanti-deSitterspace
29	JRG	Physical Review D	**Suddhasattwa Brahma, Dong-han Yeom**	No-boundary wave function for loop quantum cosmology

No.	Category	Journal	Authors	Article
30	JRG	Physics Letters B	**Suddhasattwa Brahma, Alexey Golovnev, Dong-han Yeom**	On singularity-resolution in mimetic gravity
31	JRG	Physical Review D	Pisin Chen, William G. Unruh, Chih-Hung Wu, **Dong-han Yeom**	Pre-Hawking radiation cannot prevent the formation of apparent horizon
32	JRG	Journal of Cosmology and Astroparticle Physics	Mariam Bouhmadi-López, Che-Yu Chen, Pisin Chen and **Dong-han Yeom**	Regular instantons in the Eddington-inspired-Born-Infeld gravity: Lorentzian wormholes from bubble nucleations
33	JRG	Physical Review D	Subeom Kang, **Dong-han Yeom**	Tunneling from the past horizon
34	JRG	European Physical Journal C	Pisin Chen, **Dong-han Yeom**	Why concave rather than convex inflaton potential?
35	JRG	Physics Letters B	**Suddhasattwa Brahma,** Michele Ronco	Constraining the loop quantum gravity parameter space from phenomenology
36	JRG	Physical Review D	Jibril Ben Achour, **Suddhasattwa Brahma**	Covariance in self-dual inhomogeneous models of effective quantum geometry: Spherical symmetry and Gowdy systems
37	JRG	Physical Review D	M Bojowald, **Suddhasattwa Brahma**, Umut Buyukcam, Michele Ronco	Extendinggeneralcovariance:Moyal-typenoncommutativemanifolds
38	JRG	Physical Review Letters	Martin Bojowald, **Suddhasattwa Brahma**	Loops Rescue the No-Boundary Proposal
39	JRG	Physical Review D	Martin Bojowald, **Suddhasattwa Brahma**	Signature change in two-dimensional black-hole models of loop quantum gravity

No.	Category	Journal	Authors	Article
40	JRG	Physical Review Letters	Martin Bojowald, **Suddhasattwa Brahma**, Umut Büyükçam, Jonathan Guglielmon and Martijn van Kuppeveld	Small Magnetic Charges and Monopoles in Nonassociative Quantum Mechanics
41	JRG	International Journal of Geometric Methods in Modern Physics	**Alexey Golovnev**	Algebraic aspects of massive gravity
42	JRG	Physics Letters B	**Alexey Golovnev**	Beyond dRGT as mimetic massive gravity
43	JRG	Nature Communications	Slavomír Nemšák, **Igor Di Marco,** et al.	Element- and momentum-resolved electronic structure of the dilute magnetic semiconductor manganese doped gallium arsenide
44	JRG	Physical Review D	Tatsuo Kobayashi, Takaaki Nomura, and **Hiroshi Okada**	Predictive neutrino mass textures with origin of flavor symmetries
45	JRG	Physical Review Letters	**Yuji Hirono**, Dmitri E. Kharzeev and Andrey V. Sadofyev	Dynamics of Vortices in Chiral Media: The Chiral Propulsion Effect
46	YST	Physical Review C	**Parada T. P. Hutauruk**, Wolfgang Bentz, Ian C. Cloët, and Anthony W. Thomas	Charge symmetry breaking effects in pion and kaon structure
47	YST, Coordinator, Etc.	Physical Review D	**Parada T. P. Hutauruk**, **Yongseok Oh, and K. Tsushima**	Impact of medium modifications of the nucleon weak and electromagnetic form factors on the neutrino mean free path in dense matter
48	YST, Coordinator	Journal of High Energy Physics	**Kie Sang Jeong**, Su Houng Lee and **Yongseok Oh**	Analysis of the b1 meson decay in local tensor bilinear representation

No.	Category	Journal	Authors	Article
49	YST	Physical Review C	Su Houng Lee, Jesuel Marques L., Aaron Park, R. D. Matheus, and **Kie Sang Jeong**	QCD sum rules for the Δ isobar in neutron matter
50	YST	JOURNAL OF CLEANER PRODUCTION	Masoud Behzad, **Heetae Kim**, Mehdi Behzad, Hadi Asghari Behambari	Improving sustainability performance of heating facilities in a central boiler room by condition-based maintenance
51	YST, Coordinator	Scientific Data	**Heetae Kim**, David Olave-Rojas , Eduardo Álvarez-Miranda & **Seung-Woo Son**	In-depth data on the network structure and hourly activity of the central chilean power grid
52	YST, Coordinator	New Journal of Physics	**Heetae Kim**, Sang Hoon Lee, Jörn Davidsen and **Seung-Woo Son**	Multistability and variations in basin of attraction in power-grid systems
53	YST	Journal of High Energy Physics	**Ilya Bakhmatov**, David S. Berman, Axel Kleinschmidt, Edvard T. Musaev, Ray Otsuki	Exotic Branes in Exceptional Field Theory: the SL(5) duality group
54	YST	Journal of High Energy Physics	Rong-Gen Cai, Sichun Sun and **Yun-Long Zhang**	Emergent dark matter in late time universe on holographic screen
55	YST	Journal of High Energy Physics	Yanyan Bu, Rong-Gen Cai, Qing Yang and **Yun-long Zhang**	Holographic charged fluid with chiral electric separation effect
56	YST, Coordinator	Physics of Particles and Nuclei	**Sang-Ho Kim, Yongseok Oh** and Alexander I. Titov	Decay Angular Distributions of K* and D* Mesons as a Tool for the Dynamics of Open Strange and Charm Production
57	YST	physical Review C	H. Kohri, **Sang-Ho Kim,** et al.	Differential cross section and photon-beam asymmetry for the γ - p→Ⓟ+n reaction at forward Ⓟ+ angles at Eγ=1.5 -2.95 GeV
58	YST	Physics Letters B	**Sang-Ho Kim**, Hyun-Chul Kim	KΟΛ photoproduction off the neutron with nucleon resonances

No.	Category	Journal	Authors	Article
59	JRG	Physical Review D	Deog Ki Hong, Du Hwan Kim and **Chang Sub Shin**	Clockwork graviton contributions to muon g - 2
60	JRG	Physics Letters B	Seong Chan Park, **Chang Sub Shin**	Clockwork seesaw mechanisms
61	JRG	Journal of Cosmology and Astroparticle Physics	**Jinn-Ouk Gong**, Min-Seok Seo	Consistency relations in multi-field inflation
62	Coordinator	Physical Review D	Yeunhwan Lim, Chang-Hwan Lee, and **Yongseok Oh**	Effective interactions of hyperons and mass-radius relation of neutron stars
63	JRG	Journal of High Energy Physics	Kiwoon Choi, Sang Hui Im and **Chang Sub Sin**	General continuum clockwork
64	Etc.	Current Applied Physics	Ki-Seok Kim, **Jae-Ho Han**	Interplay between chiral magnetic and Kondo effects in Weyl metal phase
65	JRG	Scientific Reports	**Seunghyeon Kim**, Michael F. Fenech & **Pan-Jun Kim**	Nutritionally recommended food for semi- to strict vegetarian diets based on large-scale nutrient composition data
66	JRG	Journal of High Energy Physics	Kwang Sik Jeong, **Chang Sub Shin**	Peccei-Quinn relaxion
67	Etc.	Journal of High Energy Physics	Jaemo Park, **Hyeonjoon Shin**	1/2-BPS D-branes from covariant open superstring in AdS4 × CP3background
68	Executive Director	Physica A-Statistical Mechanics and its Applications	**Woo-Sung Jung**	Analysis on the urban street network of Korea: Connections between topology and meta-information
69	Etc.	Physical Review B	**Jae-Ho Han**, Ki-Seok Kim	Boltzmann transport theory for many-body localization

No.	Category	Journal	Authors	Article
70	JRG	Physical Review A	Hyukjoon Kwon, **Chae-Yeun Park**, Kok Chuan Tan, Daekun Ahn, and Hyunseok Jeong	Coherence, asymmetry, and quantum macroscopicity
71	JRG	Physics Letters B	**Naoya Kitajima**, Toyokazu Sekiguchi, Fuminobu Takahashi	Cosmological abundance of the QCD axion coupled to hidden photons
72	Etc.	Physical Review B	**Hyun-Jung Lee**, Ki-Seok Kim	Hartree-Fock study of the Anderson metal-insulator transition in the presence of Coulomb interaction: Two types of mobility edges and their multifractal scaling exponents
73	JRG	PLoS One	Byunghwee Lee, Daniel Kim, Seunghye Sun, **Hawoong Jeong**, Juyong Park	Heterogeneity in chromatic distance in images and characterization of massive painting data set
74	President	Physics Letters B	D.G. Pak, **Bum-Hoon Lee**, Youngman Kim, Takuya Tsukioka, P.M. Zhang	On microscopic structure of the QCD vacuum
75	JRG	Physical Review B	S. Sold, G. Lefkidis, **B. Kamble**, J. Berakdar, and W. Hübner	Thermal emergence of laser-induced spin dynamics for a Ni4 cluster
76	Coordinator	Physical Review E	S, M. Oh, **S.-W. Son** and B. Kahng	Suppression effect on the Berezinskii-Kosterlitz-Thouless transition in growing networks
77	JRG	European Physical Journal C	**Moonju Hong, Yoonsoo Kim and Eoin O Colg´ain**	On non-Abelian T-duality for non-semisimple groups
78	Etc.	Physical Review B	**Singh, D.K,** Majumdar, P.	Drude weight anisotropy in the doped iron pnictides: The primary role of orbital weight redistribution along the reconstructed Fermi surfaces
79	JRG	Journal of the Korean Physical Society	**Junha Hwang, Hyosub Park, Heeseung Zoe and Dong-han Yeom**	How Can We Erase States Inside a Black Hole?
80	Executive Director	Journal of the Korean Physical Society	**Min-Woo Ahn, Woo-Sung Jung**	A Study on the Performance of Similarity Indices and its Relationship with Link Prediction: a Two-State Random Network Case
81	JRG	European Physical Journal C	**Pisin Chen, Yu-Hsiang Lin and Dong-han Yeom**	Suppression of long-wavelength CMB spectrum from the no-boundary initial condition
82	JRG	Chinese Physics C	Linping Mu, **Hiroshi Okada** and Chao-Qiang Geng	A model with flavor-dependent gauged U(1)B−L1 × U(1)B−L2−L3 symmetry
83	Organizer	Physical Review D	Jung Keun Ahn, **Seung-il Nam**	Ξ(1690)−production in the K−p→K+K−Λ reaction process near threshold

3. Scientific Papers with Acknowledgement of APCTP

Number of Publications: 21

No.	Category	Journal	Authors	Article
1	Organizer	Journal of High Energy Physics	Hyun-Sik Jeong, Chao Niu and **Keun-Young Kim**	Linear-T resistivity at high temperature
2	Organizer	Journal of High Energy Physics	Run-Qiu Yang, Chao Niu, Cheng-Yong Zhang and **Keun-Young Kim**	Comparison of holographic and field theoretic complexities for time dependent thermofield double states
3	Organizer	Journal of High Energy Physics	Hyun-Sik Jeong, Yongjun Ahn, Dujin Ahn, Chao Niu, Wei-Jia Li and **Keun-Young Kim**	Thermal diffusivity and butterfly velocity in anisotropic Q-lattice models
4	Organizer	Physical Review D	Eunseok Oh, I. Y. Park and **Sang-Jin Sin**	Complete Einstein equations from the generalized First Law of Entanglement
5	Organizer	ACS Macro Letters	Peter J. Chung, Chaeyeon Song, Joanna Deek, Herbert P. Miller, Youli Li, **Myung Chul Choi,** Leslie Wilson, Stuart C. Feinstein and Cyrus R. Safinya	Comparison between 102k and 20k Poly(ethylene oxide) Depletants in Osmotic Pressure Measurements of Interfilament Forces in Cytoskeletal Systems
6	Organizer	Physical Review B	GiBaik Sim, **SungBin Lee**	Discovery of a new type of magnetic order on pyrochlore spinels
7	Organizer	Journal of the Korean Physical Society	Pil-Jong Jung, Keun-Young Kim, Young-Min Kim, **John J. Oh**, Sang Hoon Oh and Edwin J. Son	Sensing and Vetoing Loud Transient Noises for the Gravitational-wave Detection
8	Organizer	AIP Advances	Youngmin Oh, Hyung Ju Hwang, Michael Leconte, Minwoo Kim and **Gunsu S. Yun**	Effect of time-varying flow-shear on the nonlinear stability of the boundary of magnetized toroidal plasmas
9	Organizer	Physical Review D	Brice Bastian, Stefan Hohenegger, Amer Iqbal and **Soo-Jong Rey**	Triality in little string theories
10	Organizer	Physics of the Dark Universe	**Ki-Young Choi**, Jongkuk Kim, Osamu Seto	Thermal production of light Dirac right-handed sneutrino dark matter
11	Organizer	European Physical Journal C	**O-Kab Kwon,** Dongmin Jang, Yoonbai Kim, D. D. Tolla	Holography of massive M2-brane theory: non-linear extension
12	Organizer	Journal of High Energy Physics	**Kyung Kiu Kim, O-Kab Kwon**	Janus ABJM models with mass deformation
13	Organizer	Journal of High Energy Physics	**O-Kab Kwon**, Dongmin Jang, Yoonbai Kim and D.D. Tolla	Gravity from entanglement and RG flow in a top-down approach
14	Organizer	Entropy	**Bogeun Gwak**	Thermodynamics and Cosmic Censorship Conjecture in Kerr–Newman–de Sitter Black Hole
15	Organizer	Classical and Quantum Gravity	**Chen-Te Ma**	Theoretical properties of entropy in a strong coupling region
16	Organizer	Journal of High Energy Physics	Lasma Alberte, Martin Ammon, **Matteo Baggioli,** Amadeo Jim´enez and Oriol Pujol`as	Black hole elasticity and gapped transverse phonons in holography
17	Organizer	Journal of High Energy Physics	Tomas Andrade, **Matteo Baggioli,** Alexander Krikunc and Napat Poovuttikul	Pinning of longitudinal phonons in holographic spontaneous helices
18	Organizer	NANO LETTERS	Ganbat Duvjir, Byoung Ki Choi, Iksu Jang, Søren Ulstrup, Soonmin Kang, Trinh Thi Ly, Sanghwa Kim, Young Hwan Choi, Chris Jozwiak, Aaron Bostwick, Eli Rotenberg, Je-Geun Park, Raman Sankar, **Ki-Seok Kim**, Jungdae Kim and Young Jun Chang	Emergence of a Metal–Insulator Transition and High-Temperature Charge-Density Waves in VSe2 at the Monolayer Limit

No.	Category	Journal	Authors	Article
18	Organizer	NANO LETTERS	Ganbat Duvjir, Byoung Ki Choi, Iksu Jang, Søren Ulstrup, Soonmin Kang, Trinh Thi Ly, Sanghwa Kim, Young Hwan Choi, Chris Jozwiak, Aaron Bostwick, Eli Rotenberg, Je-Geun Park, Raman Sankar, **Ki-Seok Kim**, Jungdae Kim and Young Jun Chang	Emergence of a Metal–Insulator Transition and High-Temperature Charge-Density Waves in VSe2 at the Monolayer Limit
19	Organizer	Physical Review D	Masato Arai, **Anastasia Golubtsova**, Chanyong Park and Sunyoung Shin	Vacua and walls of mass-deformed Kähler nonlinear sigma models on Sp(N)/U(N)
20	Organizer	New Journal of Physics	M. Sasaki, A. Ohnishi, Nabyendu Das, **Ki-Seok Kim** and Heon-Jung Kim	Observation of the possible chiral edge mode in Bi1-xSbx
21	Organizer	Journal of High Energy Physics	**Kyung Kiu Kim**, Seoktae Koh, Hyun Seok Yang	Expanding universe and dynamical compactification using Yang-Mills instantons