2017 APCTP STATUS REPORT

March 06, 2018

APCTP
Asia Pacific Center for Theoretical Physics

Contents

Foreword

I became the new president of the APCTP in the last November in 2017. It is a great honor for me and at the same time a heavy duty on my shoulder to steer this important international organization to the right direction. During the last 22 years since its inauguration in 1996, our center has made a steady growth with the leadership of the previous presidents. In particular, during the presidency of Prof. Peter Fulde, our center has made a quantum jump of the status of our center. Prof. Peter Fulde has improved the financial status of the center and laid down a stable foundation to make the APCTP a truly international center of the theoretical physics. Among others, the center has established the good scale of in-house research groups – the JRG -- for the first time since its foundation. After the end of the presidency of Prof. Peter Fulde, a consensus was made that it is a time to have a Korean president so that we can have more efficient communication with the Korean government in order to make one more level up of the center. Indeed, we have successfully elected two excellent Korean presidents in recent years, Prof. Seunghwan Kim and Prof. Bum-Hoon Lee. Unfortunately, however, these two excellent presidents could not serve for their full terms because of the unexpected occurrences such as the government call for the other duty. During the last one year with the absence of the president, the center was excellently run under the guidance of the acting president Prof. Won Namgung and with the skillful management of the executive director Prof. Woo-Sung Jung.

Considering this recent history after Prof. Peter Fulde, my duty as the new president of the APCTP is very clear. Firstly, I should make a stronger relationship with the government and improve the stability of the center. Secondly, I should make the APCTP more visible in the Asia-Pacific region as well as in the international community.

As to the first goal, after a long discussion with the executive director, Prof. Woo-Sung Jung, our strategy is to emphasize the role of the APCTP as more in line with the government's new policy, namely, "Science Diplomacy" in broad concept. Incidentally, in November of last year, the Association of Asia Pacific Physical Societies (AAPPS) headquarter has finally settled in our center. Historically, the AAPPS (founded in 1989) and the APCTP have been intimately related since their foundations and both institutes largely share the common goal -- the promotion of the advancement of physics in the Asia-Pacific region. The APCTP is already publishing the AAPPS bulletin since 2011, started by Prof. Won Namkung. We will develop more of the joint scientific programs and activities together with the AAPPS, which will greatly benefit both institutes. Also after the reconnection with the APEC (Asia-Pacific Economic Cooperation) in 2014, our center is playing a central role in the APEC PPSTI (Policy Partnership on Science, Technology, and Innovation) meeting. We will develop more programs with the APEC such as the APEC-YST program, which will increase the number of our in-house researchers and is currently under discussion with the government. In this way, I will convince the government the unique and important role of the APCTP for the international cooperation in Science and Technology in the AP-region, under the concept of "Science Diplomacy".

For the second goal, we should improve the in-house research to be more coordinated and also need to develop new programs with which the member countries more actively participate and feel more directly

benefit. For these matters, I have a long discussion with the chairperson of the BOT, Prof. Noboru Kawamoto. The preliminary idea is to utilize senior scientist visiting program in conjunction with the in-house researchers such as the JRG leaders and post-docs. Secondly, we would like to experiment a new external school/conference program held in the member countries with the voluntary participation of the scholars from all member countries. The general council members can propose to hold this program in his/her country. These new programs will be experimented with the limited budget at the start, but I am willing to increase the budget in future. It is needless to say that we will continue the various forms of collaboration with our traditional partnership institutes such as the IBS centers, KIAS, ICTP, and many others.

In summary, I will try to emphasize the international role of the APCTP both in connection with the government policy as well as with the member countries. I believe that in this way we can more clearly define the identity of the APCTP and convince the government of the unique role of the APCTP as an international organization. Based on the acquired stability, we can pursue the excellence of the research quality of the center in the long run.

Finally, I am very happy that Prof. Peter Fulde had agreed to be the special advisor during my term. Having him again at the center is a great fortune not only for me but also for the whole center so that we can consult him for his advises and wisdom at any time. I would like to express my sincere thanks to Prof. Peter Fulde for his love and dedication to our center.

Yunkyu Bang
President

I. Overview

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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

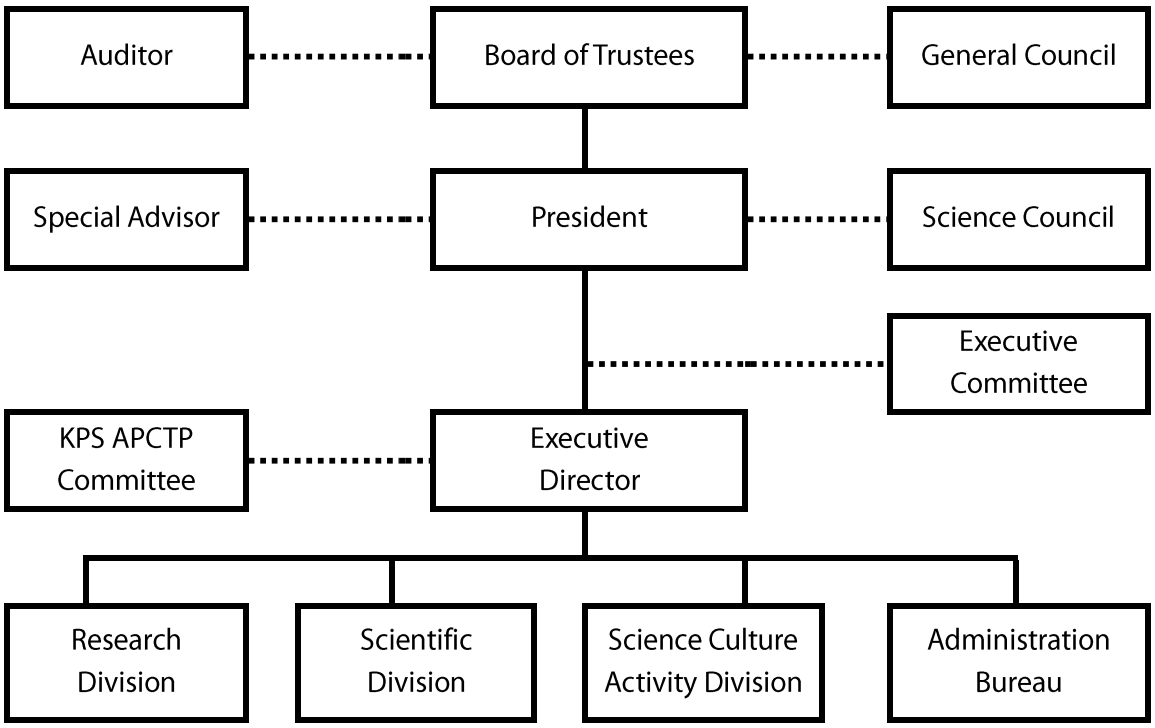
1993	Feb.	The International Planning Committee (IPC) is formed.
1994	May.	IPC recommends Korea as the host of the APCTP headquarters.
	Nov.	Association for Science Cooperation in Asia (ASCA) endorses the proposal to host the APCTP in Korea.
1995	Sep.	UNESCO PAC, IUPAP, and AAPPS endorse the proposal 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.
	Apr.	The Agreement of Collaboration is exchanged with IOP/VAST.
		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.

3. Organization Chart

- Board of Trustees: 13 Trustees and 2 Auditors
  - Chairperson (Noboru Kawamoto, Japan)
- General Council: Representatives from 16 member countries
- Science Council: 5 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	Jeongwon KIM	Korea	Ministry of Science & ICT	Ex-Officio
Trustee	Jae Il 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	POSTECH	Nov. 28, 2015 ~Nov. 27, 2018
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
Vacancy	-	-	-	-
Vacancy	-	-	-	-
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	Cristine VILLAGONZALO	University of the Philippines	Mar. 20, 2015~Mar. 19, 2018
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, 2015~Mar. 19, 2018
	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, 2014~Jun. 30, 2019
Spenta WADIA	India	International Center for Theoretical Sciences	Sep. 1, 2015~Aug. 31, 2018
Mahn Won KIM	Korea/USA	GIST	Mar. 1, 2013~Feb. 28, 2018

KPS-APCTP Committee

Position	Name	Affiliation	Term
Chairperson	Sung-Won KIM	Ewha Womans University	Jan.1, 2017-Dec.31, 2018
Vice Chairperson	Ha-Woong JEONG	KAIST	Jan.1, 2017-Dec.31, 2018
Secretary	Jun-Ho KIM	Incheon National University (INU)	Ex-Officio
Member	Kimyeong LEE	KIAS	Jan.1, 2017-Dec.31, 2018
Member	Byung Yoon PARK	Chungnam National University	Jan.1, 2017-Dec.31, 2018
Member	Inyong CHO	SEOULTECH	Jan.1, 2017-Dec.31, 2018
Member	Sang-Pyo KIM	Kunsan National University	Jan.1, 2017-Dec.31, 2018
Member	Hyoung Joon CHOI	Yonsei University	Jan.1, 2013-Dec.31, 2018
Member	Kicheon KANG	Chonnam National University	Jan.1, 2017-Dec.31, 2018
Member	Jin-Hee YOON	Inha University	Jan.1, 2015-Dec.31, 2018
Member	Keon-Ho YOO	Kyung Hee University	Ex-Officio
Member	Woo-Sung JUNG	POSTECH	Ex-Officio

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, 2016~Jul. 31, 2018
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, 2017~Dec. 31, 2018
Myung-Hyun RHEE	Korea	Science Writer	Jan. 1, 2017~Dec. 31, 2018
Seung Woo SON	Korea	Hanyang University	Jan. 1, 2017~Dec. 31, 2018
Sungbin LEE	Korea	KAIST	Sep. 1, 2017~Dec. 31, 2018
Eun Hee LEE	Korea	Science Communicator	Mar. 1, 2018~Feb. 28, 2019

5. Member Countries and Membership Fees

Membership Overview (March 2017 ~ February 2018)

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				Japan	
	ANU		ANZAMP		MATRIX		CPS		WIPM-CAS			
	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount
1996							May. 21	10,000			May. 22	10,000
1997	Dec.02	10,000					May. 28	10,000			Aug.21	4,244
1998	Apr.24	10,000					Jan.22	10,000			Jul.13	3,742
1999							Nov.23	10,000			Oct.28	4,789
2000												
2001											Mar.08	4,178
2002							Feb.14	20,000			Mar.13	10,000
2003							May. 30	10,000			Mar.24	10,000
2004							Oct.04	10,000			Apr.13	10,000
2005							May. 10 Jul. 28	20,000			Apr.11	10,000
2006	Sep.08	10,000					May. 22	10,000			Jul.04	10,000
2007	May. 20	10,000					Apr.23	10,000			Mar.29	10,000
2008	May. 30	10,000					May. 20	10,000			Jan.18 Jun. 09	20,000
2009	May. 13	10,000					May. 22	10,000			May. 22	10,000
2010	Jun.03	10,000					Jun.01	10,000			Jun.04	10,000
2011	May. 16	10,000					Apr.25	10,000			Sep.30	10,000
2012	Apr.24, 2013	10,000					May. 24	10,000			May. 11	10,000
2013	May.19, 2014	10,000					May. 10	10,000			Feb.22	10,000
2014	Mar. 26, 2015	10,000					Jul.23	10,000			Mar.25	10,000
2015							Apr.16	10,000			Mar.23	10,000
2016							Apr.25	10,000			May. 25	10,000
2017			Jun.14	2,500	Dec.20	7,500*	Jun.14	10,000	May. 26	3,000	May. 25	10,000
Total	120,000						223,000				196,953	

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(Unit: USD)

Items	Lao PDR		Malaysia		Mongolia		Philippines		Singapore		Taipei	
	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount	Date	Amount
1996											Jul.15	10,000
1997											Oct.13	10,000
1998			Mar.23	6,509							May. 20	10,000
1999							Jul.26	10,000	Jan.09	2,500	Aug.19	10,000
2000											Dec.07	10,000
2001											Dec.19	10,000
2002												
2003											Mar.07	20,000
2004											Aug.04	10,000
2005											Apr.25	10,000
2006											Jul.12	10,000
2007	exempted				exempted						Jun.05	10,000
2008	exempted				exempted						Nov.14	10,000
2009	exempted				exempted						May. 22	10,000
2010	exempted				exempted						May. 13	10,000
2011	exempted				exempted						May. 20	10,000
2012	exempted				exempted				Feb.21, 2013	10,000	Jul.23	10,000
2013	exempted				exempted				Feb.21	10,000	Oct.04	10,000
2014	exempted				exempted				Jul.23	10,000	Aug.07	10,000
2015									Mar.18, 2016	10,000	Mar.25	10,000
2016							Oct.23, 2017	901	Feb.24, 2017	10,000	Jul.04	10,000
2017									Oct.17	10,000	Sep.14	10,000
Total	-		6,509		-		10,901		62,500		220,000	

—continued

(Unit: USD)

Items	Thailand		India		Vietnam		Uzbekistan		Kazakhstan		Canada		Total
	Date	Amount	Date	Amount	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	Jun.29	10,000			Aug.11	10,000							**30,000**
2001	Jan.05	6,945			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	Aug.20	6,945	Jun.20	10,000	Jun.19	10,000							**76,945**
2009	Jul.16	10,000			Jul.01	10,000							**60,000**
2010	Jun.09	10,000	Aug.17	20,000	Dec.10	10,000							**80,000**
2011	Jun.09	10,000	Mar.30	10,000	Jun.17	10,000	exempted						**70,000**
2012	May. 31	10,000	Mar.28	10,000	Aug.31	10,000	exempted						**80,000**
2013			May. 24	10,000	May. 28	10,000	exempted		exempted				**70,000**
2014			Aug.11	10,000	Jul.24	10,000	exempted		exempted				**70,000**
2015			Aug.03	10,000	Mar.23	10,000							**60,000**
2016			Nov.08	10,000	May. 10	10,000					Jul.07	5,000	**65,901**
2017			Dec.05	10,000	Jun.07	10,000			Nov.24	5,000	Jul.31	5,000	**83,000**
Total	63,890		100,000		220,000		-		5,000		10,000		**1,238,753**

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

II. 2017 Highlights

1. Summary of 2017 APCTP Activities

2. 2017 Benjamin Lee Professorship

3. Cooperation with International Organization

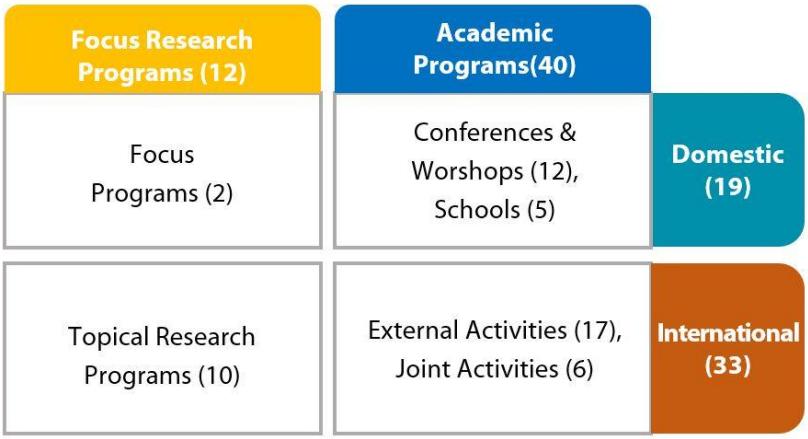
1. Summary of 2017 APCTP Activities

Scientific Activities

(1) Overview

The Center pursues the highest quality topical research in focused areas of theoretical physics and promotes cooperation among scientists from its member countries/regions and beyond. In order to promote the research activities and international cooperation, the Center supports Scientific Activities such as Focus Research Programs (Focus Programs, Topical Research Programs), Academic Programs (Conferences & Workshops, Schools and External and Joint Activities) on the current issues of physics societies.

(2) Number of Programs (total 52)



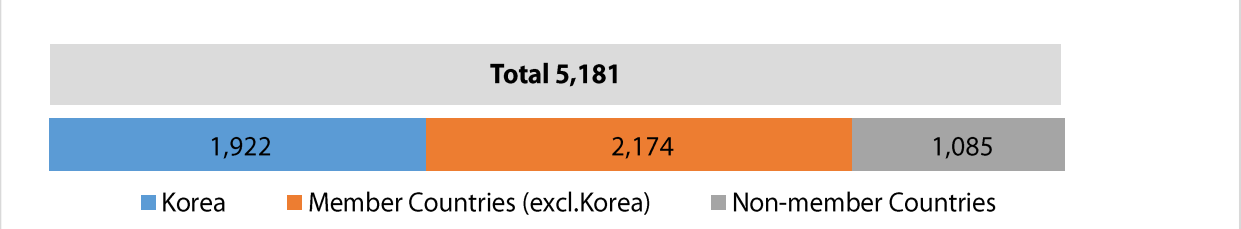
- External Activities in Australia(1), China(1), India(1), Japan(5), Kazakhstan(1), Malaysia(2), Singapore(1), Uzbekistan(2), and Vietnam(3)
- Joint Activities with BLTP JINR, IACS, ICTP, YITP, NCTS, and IUPAP

(3) Publications

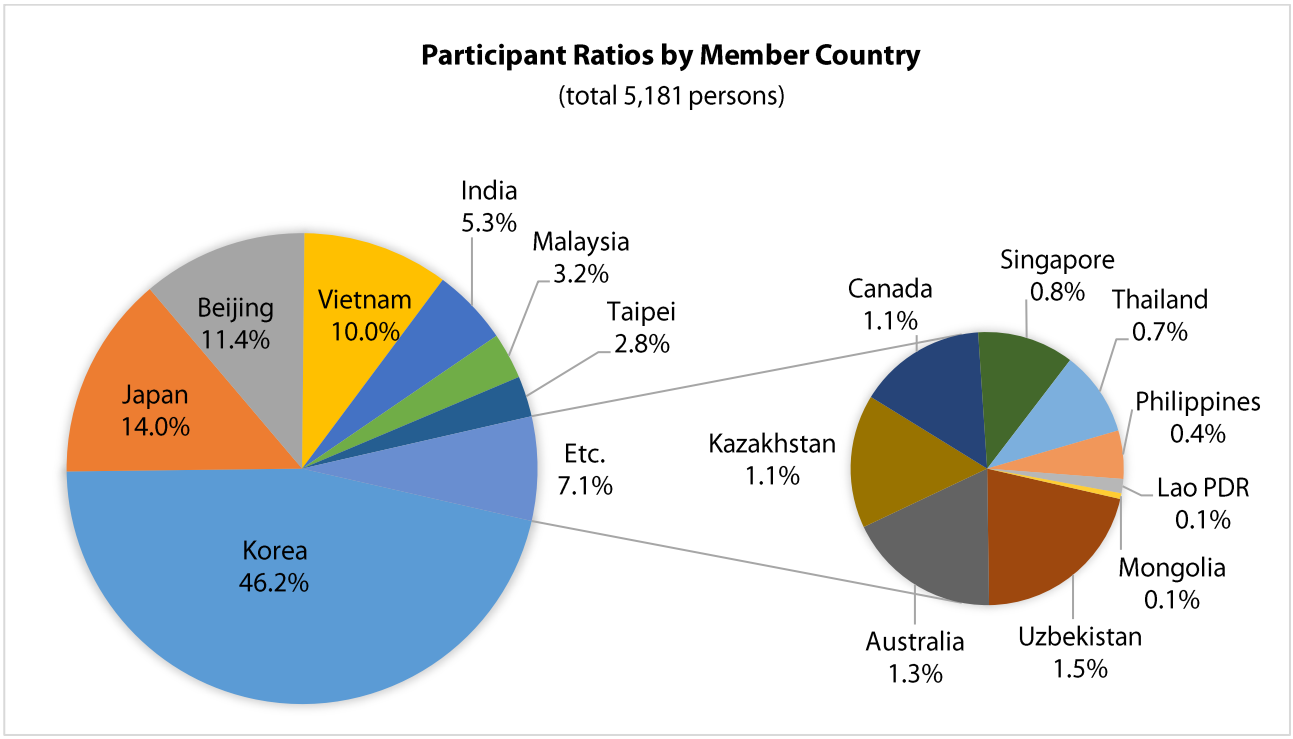
Numbers	SCI	Impact Factor
22	100 %	3.608

(4) Key Statistics

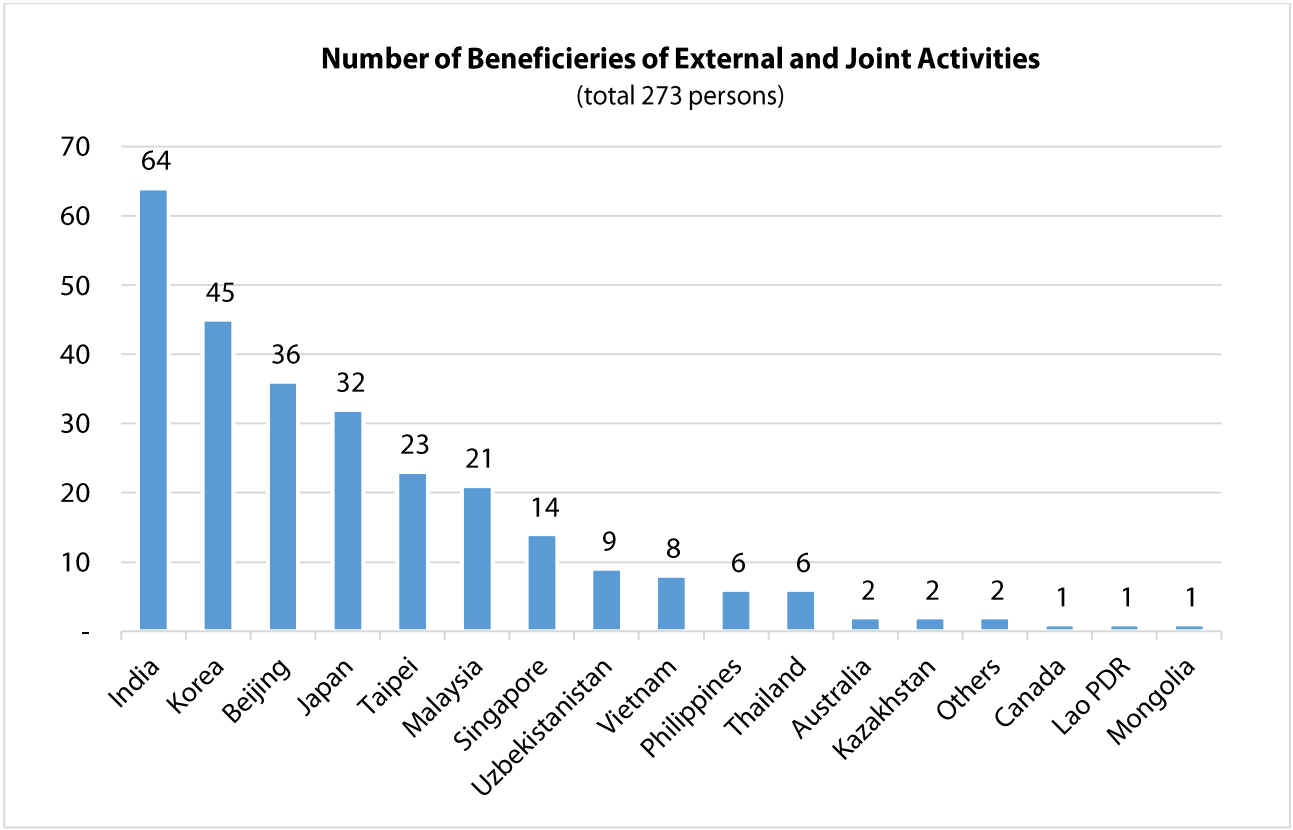
- Number of Participants by Membership



- Participant Ratios by Member Country



- Number of Beneficiaries of External and Joint Activities



* Others (Non-member Countries): Indonesia (1), USA (1)

Research Programs

(1) Overview

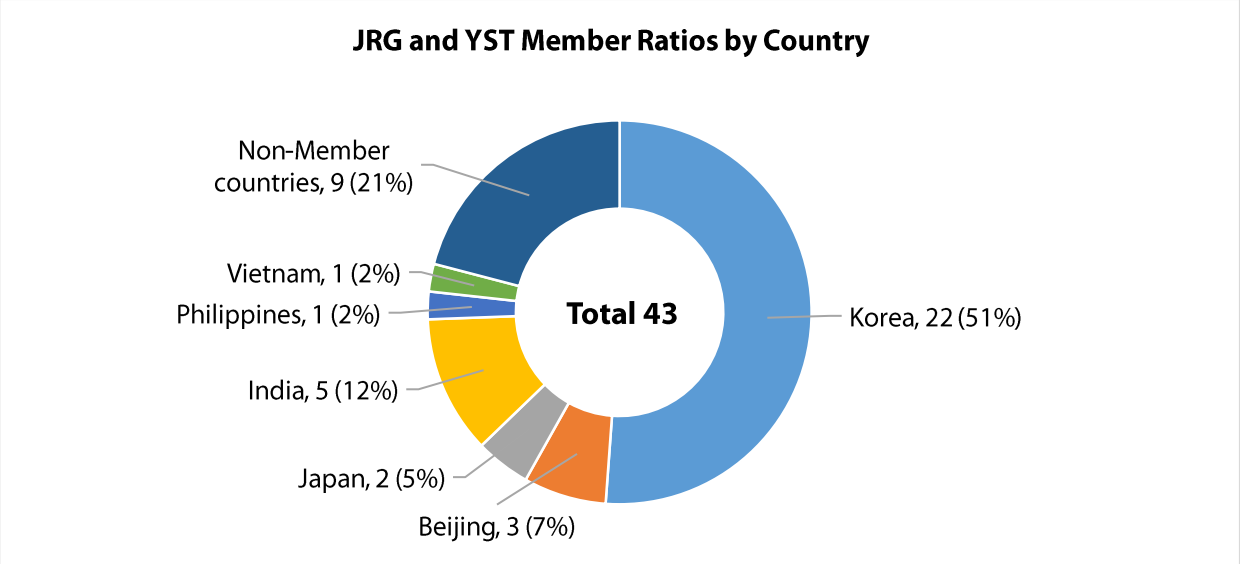
APCTP conducts research and training in advanced topics of theoretical physics and related areas through the following APCTP research programs.

- Junior Research Groups for pursuing joint research projects with scientific leaders of next generation
- Young Scientist Training Programs for training young scientists mainly of APCTP member countries
- Visitors Program for encouraging short and long-term visits

(2) Number of Faculty and Researchers

Program	Number of Faculty and Researchers			
	Prof.	Dr.	PhD. Stud.	Total
JRG	10	19	8	37
YST	-	6*	-	6
Total	10	25	8	43

* Not including Dr. Taeguen Song; transferred from JRG to YST



*Non-member countries: Brazil(1), Iran(3), Indonesia(1), Ireland(1), Italy(2), and Russia(1)

(3) Publications

Numbers	SCI	Impact Factor
57	100 %	4.632

Scientific Outreach Programs

(1) Objectives

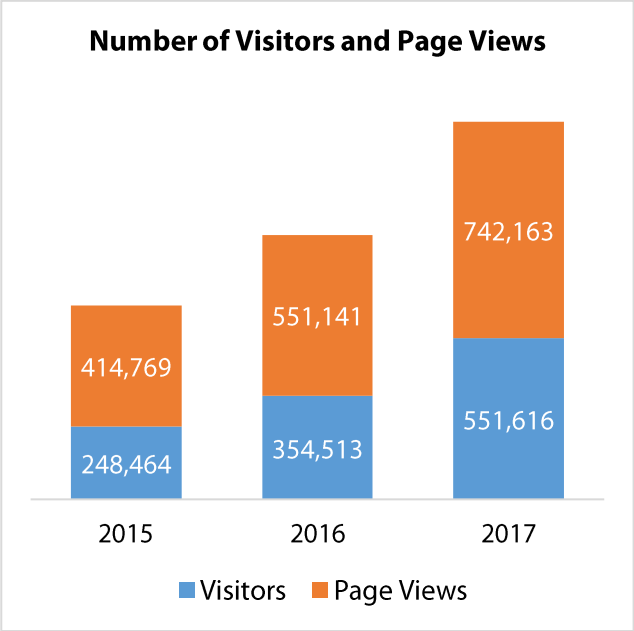
APCTP runs scientific outreach programs to:

- enhance the importance of basic science and attract more people to world of physics.
- provide a friendly atmosphere where the general public and scientists can interact with each other to promote popularization of physics.

(2) Programs

- Publication: a monthly online web-journal "Crossroads"
- Forums, Lectures, Schools, etc. (Total 18 programs)
  - Science Communication Forum/Lecture (14)
  - Science Communication School (1)
  - "Best Science Book 10" selected by APCTP (1)
  - Science in City Hall held with Pohang City (1)
  - Pohang Family Science Festival held with Pohang City (1)

(3) Statistics of Crossroads



2. 2017 Benjamin Lee Professorship

Overview

Benjamin Lee Professorship has been created in honor of Korea's foremost theoretical physicist, late Benjamin Lee, who had a distinguished career in particle physics theory. The program invites a theoretical physicist of international prominence to provide opportunities for the domestic scientists and graduate students to interact with a world-caliber theoretical physicist in their fields of study.

40th Anniversary of the late Benjamin W. Lee

Along with the 2017 Benjamin Lee Professorship, to commemorate the 40th anniversary of Benjamin W. Lee's death, various events including a commemorative exhibition and a special session were held from October 25-27, 2017 at HICO, Gyeongju.

At the exhibition, Benjamin Lee's academic achievements were introduced through the timeline wall and the relics exhibition room displayed his research notes and letters donated by Prof. Kang Joo Sang.

In the APCTP Benjamin Lee Special Session, Prof. Gerardus 't Hooft, Prof. Kazuo Fujikawa, Prof. Jewan Kim, Prof. Jihn E. Kim, Prof. Youngjoon Kwon, and Prof. Seong Youl Choi commemorated Benjamin Lee by sharing their memories with him and his excellent academic achievements. At the end of the session, the *'Critical Biography of Whiso Lee'* written by Prof. Kang Joo Sang was distributed to participants as a gift, republished through close cooperation with 'ScienceBooks'.

The winners of 2017 Benjamin Lee Professorship, Prof. Gerardus 't Hooft(Utrecht University, Winner of 1999 Nobel Prize in Physics) and Prof. Viatcheslav Mukhanov(Arnold Sommerfeld Center for Theoretical Physics), delivered insightful lectures to physicists at the KPS Fall meeting and to the public in Pohang. They also exchanged their academic opinions with APCTP researchers during the JRG Internal Seminar where research interests and results of each JRG group were presented.

Timeline Wall: Chronology of Benjamin W. Lee

Relics Exhibition Room

Program Schedule

<table>
<tr><th>Date</th><th colspan="2">Program Details</th></tr>
<tr><td>October 25</td><td>APCTP-KPS Keynote Speech
by Geradus 't Hooft</td><td rowspan="3">Commemorative Exhibition
- Timeline Wall
- Relics Exhibition Room
- APCTP Promotion Booth
- Cafe</td></tr>
<tr><td rowspan="2">October 26</td><td>APCTP Keynote Speech
by Viatcheslav Mukhanov</td></tr>
<tr><td>APCTP Special Session
by Gerardus 't Hooft, Kazuo Fujikawa,
Jewan Kim, Jihn E. Kim, Youngjoon Kwon
Seong Youl Choi</td></tr>
<tr><td rowspan="2">October 27</td><td colspan="2">POSTECH-APCTP Public Lecture
by Geradus 't Hooft</td></tr>
<tr><td colspan="2">JRG Internal Seminar
with Geradus 't Hooft and Viatcheslav Mukhanov</td></tr>
<tr><td>October 28</td><td colspan="2">Pohang-APCTP Public Lecture
by Viatcheslav Mukhanov</td></tr>
</table>

Lectures

- **APCTP-KPS Keynote Speech (Oct. 25)**
  - Speaker: Gerardus 't Hooft
  - Title: Quantum Black Holes and the Structure of Space and Time
  - Abstract: Theories of strings and D-branes can be used to describe objects that may be regarded as black holes or candidates thereof, but leave some properties of horizons and space-time structure underdeveloped. Yet one can also start off with black hole models using not much more than standard quantum field theory in combination with perturbative gravity. Then also, one can take gravitational back reaction into account, and find out where information is stored and how out-going particles are entangled. This yields a remarkably clear picture of the non-trivial space-time structure of black holes.

• APCTP Keynote Speech (Oct. 26)

- Speaker: Viatcheslav Mukhanov
- Title: Resolving Singularities in General Relativity
- Abstract: The simple modification of General Relativity at high curvatures which allows us to avoid singularities in contracting Friedmann universe, in anisotropic Kasner Universe and inside black holes.

- **APCTP Special Session (Oct. 26)**
  - Speaker: Gerardus 't Hooft
  - Title: The early days of the Standard Model - remembering Benjamin Lee
  - Abstract: In the 1960, the idea of renormalized quantum field theories was thought to be a difficult and confusing topic, so that most researchers were searching for more direct ways to understand the elementary particles. Yet there were several pioneers with a wider view on this subject, and Benjamin Lee was one of them. Then, in a rapid succession, new developments took place and new insights were found. Experimental and theoretical particle physics were still focusing on the same issues, so these were exciting times.

- **POSTECH-APCTP Public Lecture (Oct. 27)**
  - Speaker: Gerardus 't Hooft
  - Title: From Sub-atomic Particles to Black Holes, a World of Physics in a Bird's Eye View
  - Abstract: In the 1970s, the world of the tiny particles inside atoms was gradually cleared up by exciting new techniques in experimental observation as well as new theoretical insights.

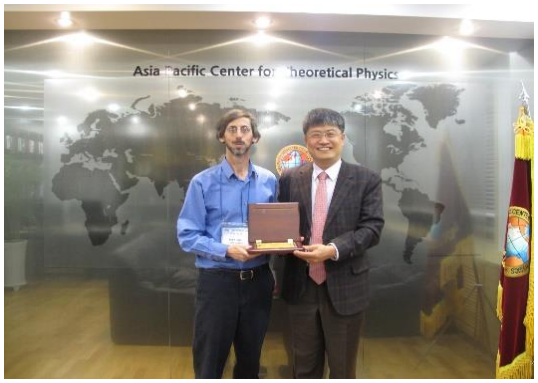
    This resulted in the "Standard Model", a precise description of the ways all known sub-atomic particles interact. Yet in spite of its elegance and accuracy, the Standard Model still has some dark corners. The gravitational forces must generate new structures at much tinier scales that we still do not understand. They could contain ultra tiny black holes. How does this work? Studying black holes and their relation with quantum particles should give us further clues. But how? Opinions and approaches differ. The human side of this endeavour is also interesting.

- **Pohang-APCTP Public Lecture (Oct. 28)**
  - Speaker: Viatcheslav Mukhanov
  - Title: The Quantum Universe
  - Abstract: A review on the recent development in cosmology and in particular, the relation between the measurements of Cosmic Microwave Background fluctuations and the theoretical predictions about quantum origin of galaxies made more than thirty years ago. Open problems and future possible developments will be briefly discussed.

Benjamin Lee Professorship List

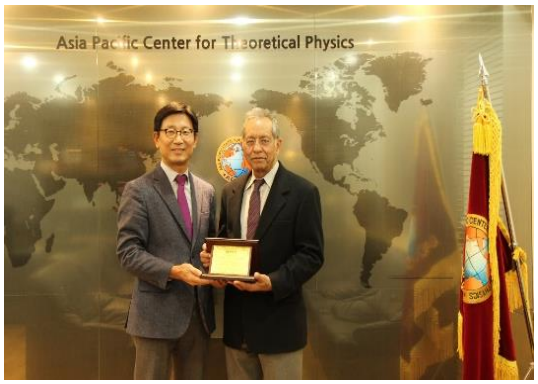
2012 Benjamin Lee Professorship

Naoto Nagaosa
The University of Tokyo
(Condensed Matter Theory)
Award: Nishina Memerial Prize(2005)



2013 Benjamin Lee Professorship

Eric Linder
University of California, Berkeley
(Cosmology)

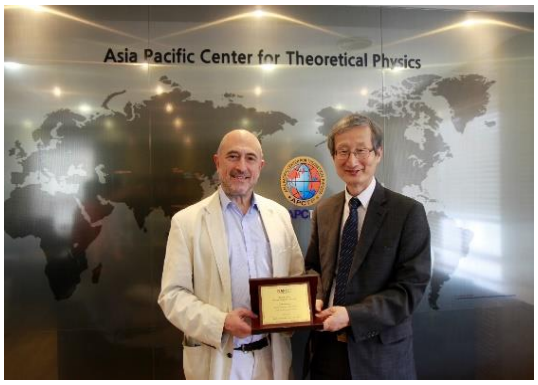


2014 Benjamin Lee Professorship

Chandra Varma
University of California, Riverside
(Theoretical Condensed Matter Physics)
Awards: Bardeen Prize (2012),
The Alexander von Humboldt Prize (2004)

2015 Benjamin Lee Professorship

Karlheinz Langanke
GSI
(Nuclear Astrophysics)
Award: Lise Meitner Prize of the European Physical Society (2012)



2016 Benjamin Lee Professorship

János Kertész
Central European University
(Statistical Physics)
Award: Szechenyi Award (2014)

2017 Benjamin Lee Professorship

Gerardus 't Hooft
Universiteit Utrecht
(Particle physics)
Award: Nobel Prize in Physics(1999)

2017 Benjamin Lee Professorship

Viatcheslav Mukhanov
Arnold Sommerfeld Center for Theoretical Physics
(Cosmology)
Award: Max Planck Medal (2015)

3. Cooperation with International Organization

Asia-Pacific Economic Cooperation (APEC)

The Center has operated YST program in cooperation with APEC since 2015 and has endeavoured to get more participation from APEC members. Since 2017 the Center has introduced a new recruitment process, which requires every APEC economy recommends at least one candidate.

8 candidates from 4 countries (Russia, China, Australia, and the Philippines) applied for the position and one promising scientist from the Philippines was successful. The progress report will be made at the PPSTI meeting.

Successful Applicant

- Name: Mikaela Irene Fudolig
- Nationality: The Philippines
- Education: PhD in Physics at the University of the Philippines-Diliman (2015)
- Research Area: Complex systems
- Period: 15 Jan 2018 ~ 14 Jan 2019
- Introduction

Dr. Mikaela Fudolig obtained her PhD in Physics from the University of the Philippines-Diliman in 2015, where she also obtained her bachelor's degree in physics, summa cum laude. Currently an Assistant Professor at the Ateneo de Manila University, she has also taught physics at her alma mater and has also worked as an R&D Specialist at a renewable energy firm. Her research interests include the application of mathematical techniques to social and biological phenomena. Her undergraduate thesis was on modeling language competition, while her doctoral dissertation was on the analytic treatment of consensus in opinion dynamics models. With her previous work mainly on theory, she hopes to expand her research areas into those involving real-world data, particularly in the field of complex systems.

- Acceptance Statement and Future Plan:

I am very happy to be accepted for a postdoctoral position at the Asia Pacific Center for Theoretical Physics under the APEC Young Scientist Training Program. I want to mentor students, not just by teaching them content, but by guiding them to make their own discoveries through scientific research. This fellowship will help me reach this goal.

I have always had several interests, and as a researcher, I have always wanted to explore social and biological phenomena using tools from physics and related fields. Handling students like myself with various interests is a challenging task because it requires not just familiarity with a broad range of topics, but also an appreciation of several disciplines and how they are related. At the APCTP, I hope to become a better researcher, not just in doing more research, but also in being exposed to new research philosophies and methodologies. With this, I can become a better mentor for our young researchers, especially those whose interests span multiple areas.

Association of Asia Pacific Physical Societies (AAPPS)

(1) Academic Activities of the AAPPS Divisions

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

Division	Support	Details
Division of Plasma Physics (DPP)	10,000K KRW	2017 AAPPS DPP Conference (Sep.18-22, Chengdu, China)
Division of Astrophysics, Cosmology and Gravitation (DACG)	10,000K KRW	International Conference on Gravitation: Joint Conference of ICGAC-XIII and IK15 (July.03-07, Seoul, Korea)

a. 2017 AAPPS DPP Conference

After formation of the first division in 2014, the division of Plasma Physics held a 1st Asia-Pacific Conference on Plasma Physics successfully. 482 invited speakers and participants visited Chengdu to have fruitful discussions and build a research network.

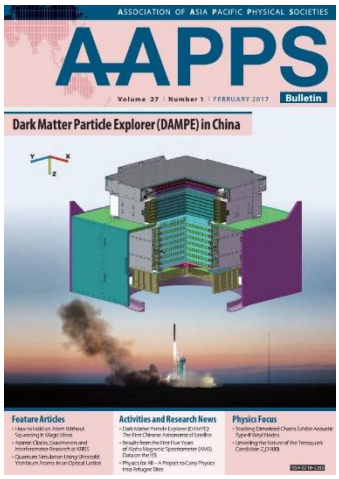
b. International Conference on Gravitation: Joint Conference of ICGAC-XIII and IK15

The conference organized by the division of Astrophysics, Cosmology and Gravitation also took place in 2017. 120 papers were presented, and 60 papers out of them were presented by foreigners or physicists in foreign institute in "International Conference on Gravitation: Joint Conference of ICGAC-XIII and IK15". 153 researchers participated and it was a good opportunity to get international collaboration and nationwide cooperation.

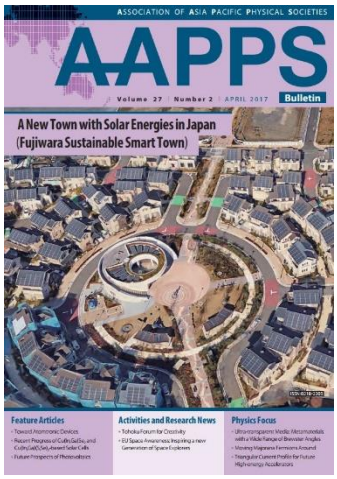
(2) Opening Ceremony for AAPPS Headquarters

After approval of the installation of the AAPPS Headquarters at the APCTP, the Opening Ceremony was held at the APCTP, Korea in November 28, 2017.

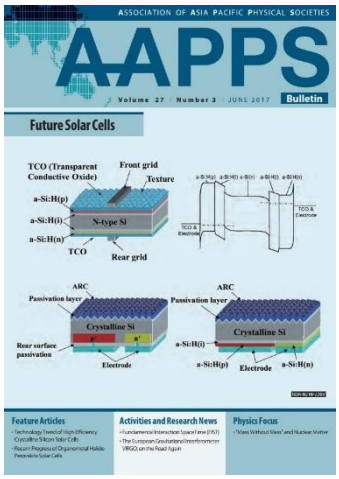
(3) Publication of the AAPPS Bulletin



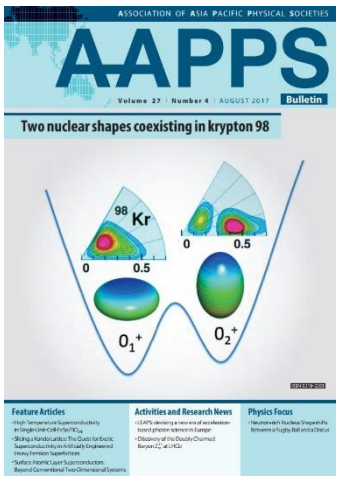
February Issue



April Issue

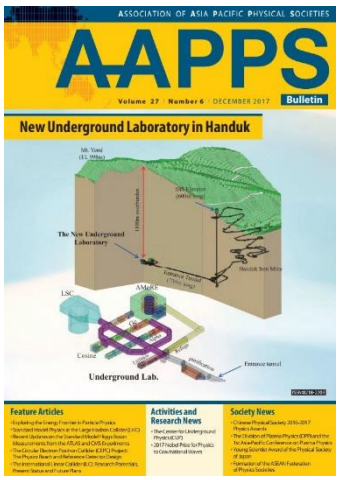


June Issue



August Issue

October Issue



December Issue

III. Scientific Activities Report

1. Summary of Scientific Activities

2. Focus Research Programs

3. Academic Programs

1. Summary of Scientific Activities

2017 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	92	36	44	12
	Topical Research Programs	10	815	756	27	32
FRP Total		12	907	792	71	44
Academic Programs	Schools	5	339	321	13	5
	Conferences &Workshops	12	980	635	174	171
	External Activities	17	2,336	131	1,756	449
	Joint Activities	6	619	43	160	416
AP Total		40	4,274	1,130	2,103	1,041
Total		**52**	**5,181**	**1,922**	**2,174**	**1,085**

Publications

Numbers	SCI	Impact Factor
22	100 %	3.608

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	92	89	3	47	9	21	15	-
	Topical Research Programs	815	699	116	324	59	95	331	6
FRP Total		907	788	119	371	68	116	346	6
Academic Programs	Schools	339	287	52	76	15	29	212	7
	Conferences &Workshops	980	883	97	366	100	131	363	20
AP Total		1,319	1,170	149	442	115	160	575	27
Total		**2,226**	**1,958**	**268**	**813**	**183**	**276**	**921**	**33**

Number of Participants by Countries

Region	Countries	No. of Participants
Asia-Pacific	**Korea***	**1,922**
	Japan*	**582**
	Beijing*	**473**
	Vietnam*	**417**
	India*	**219**
	Malaysia*	**132**
	Taipei*	**116**
	Uzbekistan*	**63**
	Australia*	**54**
	Kazakhstan*	**47**
	Iran	35
	Singapore*	**34**
	Thailand*	**30**
	Philippines*	**17**
	Israel	16
	Indonesia	13
	Hong Kong	12
	Pakistan	12
	Turkey	8
	Cambodia	7
	Armenia	5
	Bangladeshi	5
	Lao PDR*	**5**
	Nepal	4
	Kyrgyzstan	3
	Mongolia*	**2**
	New Zealand	2
	Qatar	2
	Yemen	2
	Afghanistan	1
	Iraq	1
	Myanmar	1
	Saudi Arabia	1
	Sri Lanka	1
Sub total	**34**	**4,244**

Region	Countries	No. of Participants
Europe	United Kingdom	106
	Germany	97
	Italy	86
	Russia	79
	France	66
	Switzerland	36
	Austria	22
	Poland	22
	Netherlands	21
	Spain	14
	Romania	9
	Ukraine	9
	Czech	8
	Belgium	7
	Hungary	7
	Sweden	7
	Finland	6
	Greece	6
	Ireland	5
	Slovenia	5
	Denmark	4
	Portugal	4
	Croatia	3
	Albania	2
	Azerbaijan	2
	Bulgaria	2
	Georgia	2
	Lithuania	2
	Serbia	2
	Belarus	1
	Macedonia	1
	Slovakia	1
Sub total	**32**	**644**

***Member Countries**

Region	Countries	No. of Participants
Africa	Egypt	7
	South Africa	7
	Nigeria	6
	Morocco	5
	Tanzania	5
	Burkina Faso	3
	Ethiopia	3
	Tunisia	3
	Zambia	3
	Cameroon	2
	Ghana	2
	Uganda	2
	Benin	1
	Burundi	1
	Congo, Democratic Republic of	1
	Kenya	1
	Sudan	1
Sub Total	**17**	**53**

Region	Countries	No. of Participants
America	United States	137
	Canada*	**45**
	Brazil	20
	Argentina	12
	Mexico	10
	Peru	6
	Colombia	5
	Ecuador	2
	Chile	1
	Panama	1
	Uruguay	1
Sub total	**11**	**240**
Total	**94**	**5,181**

***Member Countries**

2. Focus Research Programs

Program List

Focus Programs

01 Geometry and Holography for Quantum Criticality
02 Discrete Approaches to the Dynamics of Fields and Space-Time

Topical Research Programs (10 subjects, 31 mini-workshops)

01 String Theory and Cosmology

- 01-1 Classical and Quantum Theory of Gravity
- 01-2 2017 FRP Workshop for String Theory and Cosmology (2nd)

02 BSM Physics in the Post Higgs Era

- 02-1 Clockwork Theories
- 02-2 B physics Anomalies: R_X's
- 02-3 Focus Day on Gravitational Wave Physics
- 02-4 Lattice Calculation and Dark Matter Phenomenology

03 STATPHYS MONTHLY MEETING

- 03-1 The 97th Statphys Monthly Meeting
- 03-2 The 98th Statphys Monthly Meeting
- 03-3 The 99th Statphys Monthly Meeting
- 03-4 The 100th Statphys Monthly Meeting
- 03-5 The 101st Statphys Monthly Meeting
- 03-6 The 102nd Statphys Monthly Meeting

04 Physics in Economic and Social System

- 04-1 Physics in Economic and Social System
- 04-2 Physics in Economic and Social System

05 Discussion Meeting on Polymer Physics Theory

- 05-1 Discussion Meeting on Polymer Physics Theory
- 05-2 Discussion Meeting on Polymer Physics Theory & Innovative Workshop on Soft/Bio Materials
  *Joint workshop with '06 Innovative Workshops on Soft/Bio Materials' program

06 Innovative Workshop on Soft/Bio Materials

- 06-1 Innovative Workshop on Soft/Bio Materials
- 06-2 Discussion Meeting on Polymer Physics Theory & Innovative Workshop on Soft/Bio Materials
  *Joint workshop with '05 Discussion Meeting on Polymer Physics Theory' program

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 07-4 The Origin and Evolution of the Universe
08	Every Corner of QCD Phase Diagram
	08-1 Quark Matter from Small to Large Collision System 08-2 Exploration for QCD Phase Diagram *Joint workshop with '10 Understanding of the Hadrons in Various Environments' program 08-3 Joint Symposium on Nuclear, Particle & Field, and Astro Physics (SYNPA 2017) and Heavy-Ion Meeting (HIM)
09	Gravity and Cosmology
	09-1 The 53rd Workshop on Gravity and Cosmology 09-2 Seminar and Research Meeting on Gravity and Cosmology
10	Understanding of the Hadrons in Various Environments
	10-1 Exploration for QCD Phase Diagram *Joint workshop with '08 Every Corner of QCD Phase Diagram' program 10-2 Nuclear Physics in Various Environments 10-3 Brain Storming for Hadron Physics in Korea 10-4 Reactions and Structures in Nuclear and Hadron Physics

Pictures

[Focus Program] Geometry and Geometry and Holography for Quantum Criticality

[Topical Research Program] Discussion Meeting on Polymer Physics Theory & Innovative Workshop on Soft/Bio Materials

Geometry and Holography for Quantum Criticality

(1) Period

August 18 (Fri) ~ 26 (Sat), 2017

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Sang-Jin Sin (Hanyang Univeristy)
Ki-Seok Kim (Postech)
KeunYoung Kim (GIST)
Deog-Ki Hong (Pusan National Univeristy)
Piljin Yi (KIAS)
Nakwoo Kim (Kyunghee Univeristy)
Koji Hashimoto (Osaka Univeristy)

(4) Total Participants

44 persons

(5) Program Goal

Strongly interacting Many body systems include nuclear matter and high temperature superconductivity as examples and they have been investigated vigorously last a few decades without much progress since calculational tools are not available. Considering its academic and industrial importance, it should be considered as the most important unsolved problem in 21st century physics. Recently gauge/gravity dual idea was proposed as a calcuational tool for such system and was applied successfully for a few system. We want to investigate the problem in coherent manner by inviting the most prominent figures in this development. We will organize a summer school as a parallel program on string theory and theoretical condensed matter physics just before this focus workshop.

(6) Research Performance

5 main speakers are all foreign scholars currently very active. Aron Beekman, Mike Lukas, B. Gauteraux, Tomi Otsutki, K. Yoshida altogether gave 19 lectures. Half of the participants has foreigner. The workshop was very active as well as international one. Personally it was the most useful focus due to the focused lectures from which many new ideas were fruitfully materialized.

Focus Research Program 02

Discrete Approaches to the Dynamics of Fields and Space-Time

(1) Period

September 19 (Tue) ~ 23 (Sat), 2017

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Noboru Kawamoto (Chair, Hokkaido Univ.)
Hyun Seok Yang (Co-Chair, Sogang Univ.)
Seyong Kim (Sejong Uinv.)
Sang-Jin Sin (Hanyang Univ.)
Tsuguhiko Asakawa (Maebashi Institute of Technology)
Fumihiko Sugino (IBS, Daejeon)
So Matsuura (Keio Univ.)
Jun Nishimura (KEK)
Hiroshi Suzuki (Kyushu Univ.)
Yoshiyuki Watabiki (Tokyo Institute of Technology)
Satoshi Watamura (Tohoku Univ.)
Masanori Hanada (Kyoto Univ.)
Daisuke Kadoh (Keio Univ.)
Hiroyuki Fuji (Kagawa Univ.)
Masafumi Fukuma (Kyoto Univ.)
Shinsuke Nishigaki (Shimane Univ.)
Issaku Kanamori (Hiroshima Univ.)
Goro Ishiki (Tsukuba Univ.)
Asato Tsuchiya (Shizuoka Univ.)
Yuki Sato (Chulalongkorn Univ.)
Naoki Sasakura (Kyoto Univ.)

(4) Total Participants

48 persons

(5) Program Goal

Discrete approaches on space-time have been playing an important role for lattice gauge theory and dynamical triangulation of quantum gravity and other formulations. In formulating various non-perturbative formulations discrete approaches make numerical calculation possible. We consider that discrete approach would be indispensable even for a possible new formulation of standard model and

even for Planck scale physics. According to the developments of the nonperturbative formulation of superstring theory and in the gauge/gravity correspondence the discrete approaches to the dynamics of fields and space-time are getting increasingly important and they even have strong connection with condensed matter physics and quantum information theory.

In this workshop we aim to encourage that researchers who have mutually connected theme come together and discuss and exchange ideas for further new developments. As concrete subjects, we discuss: lattice gauge theory, large N gauge theory, lattice supersymmetry, field theories on non-commutative space-time, gauge/gravity correspondence, quantum gravity, matrix models of non-perturbative formulation of string theory, lattice gravity, tensor models, etc. Recent developments of condensed matter physics which are closely related to particle physics will be discussed as well.

This workshop is one of series of workshops, 2010 in YITP, 2012 RIKEN, 2013 KEK, 2014 Keio U., 2015 in Okayama Inst. Quantum Phys., 2016 Shizuoka U. This is the first trial of outside of Japan.

(6) Research Performance

Talks are all original works for the subjects: Entanglement related phenomena, lattice QCD related subjects, chiral random matrix for QCD, lattice supersymmetry, Bose-Einstein condensate, brane matrix model, non-commutative geometry and gravity, several approaches for sign problem such as complex Langevin, domain-wall fermion, tensor network, Lefschets thimbles, causal dynamical triangulation, Canonical tensor model, emergent space-time proposals, noncommutative scalar theory of renormalization and exact solutions. Integrable deformation, many-body localization in large-N set up, et. cet.

Almost all works are excellent original works on each subject. Since many of subjects have loose overlaps each other so that interaction among the speakers was very intensive. In this sense the workshop was very successful.

String Theory and Cosmology

(1) Organizers

Inyong Cho (SeoulTech)
Hang Bae Kim (Hanyang University)
Hyeong-Chan Kim(Korea National University of Transportation)
Kyung Kiu Kim (Yonsei University)
O-Kab Kwon (Sungkyunkwan University)
Jungjai Lee (Daejin University)
Yun Soo (Inje University)
Soonkeon Nam (Kyung Hee University)
Chanyong Park (APCTP)
Sang-Jin Sin (Hanyang University)
Hyun Seok Yang (CQUeST/Sogang University)

(2) Activities

2 mini-workshops (total 41 participants)

- Classical and Quantum Theory of Gravity
  - Date: May 12, 2017
  - Venue: College of Natural Sciences, Sejong Univ.
  - Participants: 19 persons
- 2017 FRP workshop for String Theory and Cosmology (2nd)
  - Date: November 24, 2017
  - Venue: APCTP Seoul Office
  - Participants: 22 persons

(3) Program Goal

The program is composed of two workshops and some sub-group activities. The workshops hold in May and November. This workshop includes several seminars and lectures on the subject of string cosmology, gauge/gravity duality, entropic gravity, dark matter and dark energy. The main goals of this activity are to make participants discuss and collaborate each other about interesting topics as well as to increase their general knowledge in string theory and cosmology.

(4) Research Performance

Since 2009 the workshop on string theory and cosmology have played important roles in this field and this year there were 2 mini workshops at May 12 and November 24. For the workshop at May 12, the main subject of the workshop was cosmology, gravity, and dark energy, and related topics. On the other hand, for the workshop at November 24, the main subject was string/M theory and gauge/gravity duality. As a result, there have been many discussion among attendants and this program gave young researchers opportunities for presenting their results. And also domestic researchers could know what other researchers are studying.

BSM Physics in the Post Higgs Era

(1) Organizers

Seongchan Park (Yonsei University)
Hyun Min Lee (Chung-Ang University)
Jeonghyeon Song (Konkuk University)
Tao Han (University of Pittsburgh)
Kyoungchul Kong (Kansas University)

(2) Activities

4 mini-workshops (total 134 participants)

- Clockwork theories
  - Date: June 24, 2017
  - Venue: Yonsei Univ.
- B physics anomalies: R_X's
  - Date: June 30, 2017
  - Venue: Yonsei Univ.
- Focus day on Gravitational wave physics
  - Date: September 23, 2017
  - Venue: Chungang Univ.
- Lattice calculation and Dark matter phenomenology
  - Date: December 1-2, 2017
  - Venue: Yonsei Univ.

(3) Program Goal

We continue our program with APCTP in 2017 under the title of "BSM physics in the post Higgs era" aiming to discuss theoretical ideas for Beyond the Standard Model(BSM) at the LHC and also future colliders, ILC and also 100 TeV machines. Our focus would be on extrapolation of the Standard model physics to a high scale and also its extension with TeV scale new physics. We also wish to discuss physics of new dark matter models including WIMP, SIMP and also WIMPZillas. Moreover, we will strengthen synergic effects by considering particle physics and cosmology all together when BSM physics is relevant. Therefore, timely setting up a Topical Research Program on phenomenological study on BSM physics in APCTP, we would like to develop the tools of analyzing the LHC results and the cosmological data and discuss their implications for new physics.

(4) Research Performance

The conventional ideas of WIMP dark matter confront danger due to precision measurements of direct detection experiments; available parameters are rapidly shrinking. In this regard, we review the new theoretical ideas of dark matter modeling and consider potential probe of these new ideas.

Lattice calculations provide strong tools for non-perturbative phenomena such as QCD. Recently its application to Dark matter physics has got wide attention in community. In this lecture, basics of lattice calculation will be introduced and its implication to Dark matter phenomenology will be discussed mainly for students who understand quantum mechanics and basics of quantum field theories.

STATPHYS MONTHLY MEETING

(1) Organizers

Youngkyun Jung (KISTI)
Hyunggyu Park (KIAS)
Jeong-Man Park (Catholic University)
Byungnam Kahng (Seoul Natinal University)
Hyuk-kyu Pak (UNIST)
Hyeong-Chai Jeong (Sejong University)
Jae Dong Noh (University of Seoul)
Beom Jun Kim (Sungkyunkwan University)
Soon-Hyung Yook (Kyunghee University)
Hyungtae Kook (Gachon University)
Hawoong Jeong (KAIST)
Kwang-Il Goh (Korea University)

(2) Activities

6 mini-workshops (total 181 participants)

Title	Date	Venue	Participants
The 97th Statphys Monthly Meeting	March 25, 2017	KIAS	30
The 98th Statphys Monthly Meeting	May 27, 2017	KIAS	34
The 99th Statphys Monthly Meeting	June 24, 2017	KIAS	20
The 100th Statphys Monthly Meeting	September 23, 2017	KIAS	32
The 101st Statphys Monthly Meeting	November 18, 2017	KIAS	29
The 102nd Statphys Monthly Meeting	December 9, 2017	KIAS	36

(3) Program Goal

We provide a room for local scientists to construct a strong infrastructure for statistical physics research and maintain close interactions to make a new development on the subjects. We will invite two speakers each month during the semester and cover the various subjects in statistical physics including phase transitions and critical phenomena, non-equilibrium fluctuation theorem, synchronization, percolation, evolutionary dynamics, random walks, polymer and biopolymer system, molecular dynamics and Monte-Carlo simulations, and so on.

(4) Research Performance

Based on 16 invited talks given at this meeting, recent research results have been presented. About 30 participants at each meeting have obtained the fundamental knowledge and built their power and vision to create new developments through a heated discussion.

Physics in Economic and Social System

(1) Organizers

Jae-Woo Lee (Inha University)
Beom Jun Kim (Sungkyunkwan University)
Woo-Sung Jung (POSTECH)
Gabjin Oh (Chosun University)

(2) Activities

2 mini-workshops (total 55 participants)

- Physics of Social Complexity I
  - Date: August 14 ~ 15, 2017
  - Venue: Pukyong National University
  - Participants: 30 persons
- Physics of Social Complexity I
  - Date: November 17 ~18, 2017
  - Venue: KAIST
  - Participants: 25 persons

(3) Program Goal

Society for Physics in Economic and Social System (PESS) was established in January, 2011. The PESS plans four meetings in the year of 2017 consisting of several sessions such as Tutorial, Seminar.

1. Tutorial session, will give lecture series on the long-needed training for econophysics and social physics tools such as complex network and agent-based model.
2. Seminar introduces the current research activities in econophysics and social physics field.

(4) Research Performance

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.

Discussion Meeting on Polymer Physics Theory

(1) Organizers

Jaeup Kim (UNIST)
YongSeok Jho (IBS)

(2) Activities

1 mini-workshop(26 persons) and 1 joint mini-workshop with TRP 06(50 persons)

- Discussion Meeting on Polymer Physics Theory
  - Date: June 2 ~ 3, 2017
  - Venue: DongGang CISTAR
  - Participants : 26 persons
- Discussion Meeting on Polymer Physics Theory & Innovative Workshop on Soft/Bio Materials (Joint mini-workshop)
  - Date: November 17 ~ 18, 2017
  - Venue: APCTP Headquarters, Pohang
  - Participants : 50 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 five years (2013~2017). Exceptionally larger group of people participated in the 10th meeting (fall 2017), jointed with the 25th Innovative Workshop on Soft/Bio Materials.

Various theoretical methods and techniques are introduced in the meeting as a form of lecture 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 9th meeting, two Molecular Dynamics specialists, Yongjoo Kim and Changbong Hyun lectured on the theory and basic coding of MD simulation, 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 10th meeting three experimentalists and three theorists lectured and the major focus was on the communication between the theory and experiment community. Jae-Hyung Jeon lectured on supperdiffusion, Jinhae Park explained defect theory in liquid crystal, Kahyun Hur lectured on nanostructures and metamaterials.

Innovative Workshop on Soft/Bio Materials

(1) Organizers

Myung Chul Choi (KAIST)
Mahn Won Kim (GIST)
Bopil Gim (KAIST)
Jaseung Koo (KAERI)
Ji-Yong So (KAERI)
Byung Mook Weon (Sungkyunkwan University)
Hyuk Kyu Pak (UNIST)

(2) Activities

1 mini-workshop(70 persons) and 1 joint mini-workshop with TRP 05(50 persons)

- The 24th Innovative Workshop on Bio/Soft Materials: Membranes
  - Date: July 3 ~ 7, 2017
  - Venue: KAIST
  - Participants: 70 persons
- The 25th Innovative Workshop on Bio/Soft Materials
  - Date: November 17 ~ 18, 2017
  - Venue: APCTP Headquarters, Pohang
  - Participants: 50 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 KAIST, APCTP headquarter at Pohang during 2017 (July and 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

A. Scientific excellence: excellent
Though innovative workshop, domestic and international leading research groups were participated and shared the most important scientific problems such as water and interfaces. In addition, participants discussed informally without time limitation.

B. Research cooperation: excellent
This workshop provided various ways for finding great co-works, who may have different backgrounds of research but have similar research interests. It was also great opportunities for finding complementary researcher between experimentalist and theorists.

C. Networking with global groups: excellent
We invited researchers in international leading groups as speakers and attending participants such that domestic researchers can make the connection to global groups.

D. Output (article): very good
Five SCI papers was published or will be submitted in 2017, which has been addressed in the above.

The Origin and Evolution of the Universe

(1) Organizers

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

(2) Activities

4 mini-workshops (total 52 participants)

- The Origin and Evolution of the Universe
  - Date: May 12 ~ 14, 2017
  - Venue: Jeju National University
  - Participants: 16 persons
- The Origin and Evolution of the Universe
  - Date: August 16 ~ 17, 2017
  - Venue: Chonbuk National Universtiy
  - Participants: 7 persons
- The Origin and Evolution of the Universe
  - Date: October 13-14, 2017
  - Venue: Sungkyunkwan University
  - Participants: 17 persons
- The Origin and Evolution of the Universe
  - Date: November 30, 2017
  - Venue: Sungkyunkwan University
  - Participants: 12 persons

(3) Program Goal

The goal of our program is to have a regular meeting of Cosmology group in Korea to exchange recent developments and informations in their research topics to 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 invite foreign researchers in the Asia Pacific area to make international cooperations.

(4) Research Performance

In the year 2017 we had 4 mini-workshops.

The first one was in May at the Jeju National University organized by Prof. Seoktae Koh, one of the member of the project. This mini-workshop was a joint meeting with Japanese cosmological groups and the purpose to communicate between Korea-Japan researchers and to enhance the collaborations. Through this meeting we made a decision to submit an international collaboration proposal to NRF and it was made. Next year we promised to have a mini-workshop at Japan.

The second mini-workshop was held at the Chonbuk National University organised by Prof. Changyoung Park, also a member of the project. In this meeting, we invited the domestic researchers and discussed on the recent researches. We gave more time to the speakers to make more auestions and discussion. It was good time to learn and discuss.

The third meeting was at Sungkyunkwan University. This time we focused on the early time cosmology, including the primordial gravitational wave and dark energy.

The fourth one was also at Sungkyunkwan University. In this mini-workshop we mainly focused on the review on the cosmology about the problems and the recent progress to make a new idea from the first.

Every Corner of QCD Phase Diagram

(1) Organizers

Youngman Kim (IBS)
Sungtae Cho (Kangwon Nat'l Univ.)
Tetsuo Hatsuda (Univ. of Tokyo)
Masayasu Harada (Nagoya Univ.)
Byungsik Hong (Korea Univ.)
Sangyong Jeon (McGill Univ.)
Ju-Hwan Kang (Yonsei Univ.)
Eun-Joo Kim (Chonbuk Nat'l Univ.)
Teiji Kunihiro (Yukawa Institute)
Min Jung Kweon (Inha Univ.)
Young Il Kwon (Yonsei Univ.)
Chang-Hwan Lee (Pusan Nat'l Univ.)
Kang Seog Lee (Chonnam Nat'l Univ.)
Su Houng Lee (Yonsei Univ.)
Yasuo Miake (Univ. of Tsukuba)
Dong Ho Moon (Chonnam Nat'l Univ.)
Yongseog Oh (Kyungpook Nat'l Univ.)
Inkyu Park (Univ. of Seoul)
June-Tak Rhee (Konkuk Univ.)
Mannque Rho (CEA Saclay, France)
Ghi Ryang Shin (Andong Nat'l Univ.)
Kwang-Souk Sim (Korea Univ.)
Sang-Jin Sin (Hanyang Univ.)
Enke Wang (Huazhong Normal Univ.)
Xin-nian Wang (LBNL,USA)
Nu Xu (LBNL, USA)
In-Kwon Yoo (Pusan Nat'l Univ.)
Jin-Hee Yoon (Inha Univ.)

(2) Activities

2 mini-workshops(113 persons) and 1 joint mini-workshop with TRP-10(39 persons)

- Quark matter from small to large collision system
  - Date: April 21 ~ 22, 2017
  - Venue: IBS 3F Auditorium, Daejeon
  - Participants: 32 persons

- Exploration for QCD Phase Diagram (Joint mini-workshop)
  - Date: May 26 ~ 27, 2017
  - Venue: College of Natural Science 1, Pukyong Nat'l University
  - Participants: 39 persons
- Joint Symposium on Nuclear, Particle & Field, and Astro Physics (SYNPA 2017) and Heavy-Ion Meeting (HIM)
  - Date: November 17 ~ 18, 2017
  - Venue: Cosmos Hall, Chonnam National University
  - Participants: 81 persons

(3) Program Goal

The main purpose of this program is twofold: to understand the nature of matter under extreme conditions and to establish an internationally recognizable Korean heavy-ion physics community. In addition, to get renowned we will renew a set of activities that are focused on realizing more concrete outcome of domestic as well as international collaborations and enhancing our expertise on focused topics. We also plan to make a concerted effort to engage people in high-energy physics and astrophysics in active discussions. It will broaden our interest on the physics topics related to the rare-isotope accelerator experiments to be built in Korea.

(4) Research Performance

Workshop-1: Quark matter from small to large collision system:

We have had an in-depth discussion on proton-proton, proton-heavy ion, and heavy ion–heavy ion collisions both in theory and in experiments. We have tried to understand physics associated with those collisions from small to large systems.

Workshop-2: Exploration for QCD Phase Diagram

We have discussed how to deal with theoretically and experimentally first order phase transition and also big data. In addition, we discussed direct photon elliptic flow at RHIC and LHC.

Workshop-3: Joint Symposium on Nuclear, Particle & Field, and Astro Physics (SYNPA 2017) and Heavy-Ion Meeting (HIM)

Leading physicists in Korea have reviewed the recent research trends in nuclear, particle & field, and astrophysics and discuss together.

The topics include gravitational wave, QCD, exotic hadrons, rare isotope physics, deep learning and physics, neutron star and compact objects, astrophysical particles, dark matter, dark energy and inflation.

Topical Research Programs 09

Gravity and Cosmology

(1) Organizers

Inyong Cho (SeoulTech)
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 23 participants)

- The 53rd Workshop on Gravity and Cosmology
  - Date: November 2 ~ 4, 2017
  - Venue: Sejong University, Seoul
  - Participants: 17
- Seminar and Research Meeting on Gravity and Cosmology
  - Date: November 23, 2017
  - Venue: Sejong University, Seoul
  - Participants: 6

(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, 2017, there were one workshop and one seminar and research meeting on gravity and cosmology. The three-day workshop included developments of hydrodynamics and black hole in general relativity. Further, including inflation, large structure, and gravitational 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. One seminar was about project about gravitational wave in Korean research group. Although this was very small seminar about specific topic, many participants come to seminar room. 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.

Topical Research Programs 10

Understanding of the Hadrons in Various Environments

(1) Organizers

J.K. Ahn (Korea University)
M.K. Cheoun (Soongsil University)
E. Hiyama (RIKEN)
D. Jido (Tokyo Metropolitan University)
H.-Ch. Kim (Inha University)
Y. Kim (RISP/IBS)
J. Meng (Peking University)
S.i. Nam (Pukyong National University)
B.S. Zou (ITP)
K.J. Kwak (UNIST)

(2) Activities

3 mini-workshops(31 persons) and 1 joint mini-workshop with TRP-08(39 persons)

- Exploration for QCD Phase diagram (Joint mini-workshop)
  - Date: May 26 ~ 27, 2017
  - Venue: Department of Physics, Pukyong National University
  - Participants: 39 persons
- Nuclear physics in various environments
  - Date: October 13 ~ 14, 2017
  - Venue: APCTP headquarters, Pohang
  - Participants: 15 persons
- Brain storming for hadron physics in Korea
  - Date: December 01 (Fri), 2017
  - Venue: APCTP Seoul office
  - Participants: 11 persons
- Reactions and structures in nuclear and hadron physics
  - Date: December 8, 2017
  - Venue: Department of Physics, Pukyong National University
  - Participants: 5 persons

(3) Program Goal

Hadron physics has been studied and understood in terms of quantum chromodynamics (QCD) as the 1st principle for the strongly interacting systems. In the low-energy regions, the conventional

perturbation method cannot be applied simply, due to the transmutation of the scale in QCD. Moreover, in describing resonance states of hadrons, the confinement seems to play an important role. To overcome those huddles, many distinctive approaches have been suggested. In principle, all the physical observable are represented in terms of the certain ratio of the intrinsic QCD parameter, saying Lambda QCD. Being based on this, many effective models have been introduced, such as the Nambu—Jona-Lasinio (NJL) model, chiral perturbation theory, instanton QCD vacuum, operator-product expansion (OPE), etc. Simultaneously, the computer-powered simulations for hadrons, i.e. lattice QCD, has shed light on the ultimate understanding of hadron properties, although it suffers from the notorious sign problem. Although, for a couple of decades, the hadron physics has been developed successfully, we still have many unknowns and unsatisfied understandings. Hence, we would like to focus on the three topics for the HaPhy2017 program.

(4) Research Performance

I. QCD at finite temperature and density

Especially, the hadron properties in matter are very important to understand the genuine structure of the QCD vacuum. Recent developments in heavy-ion colliders and neutron-star researches revealed various interesting signals of the changes of the hadronic properties inside the hot and dense matter. In addition to the present experimental facilities, CBM (cold baryonic matter) experiment in GSI and the program for the hadron at finite density in J-PARC will help us to understand the new land of the hadron physics. From the theoretical point of view, the (partial) restoration of spontaneous chiral symmetry breaking in matter has been discussed intensively, although it is still difficult to draw a concrete answer. It is worth mentioning that the effects of electromagnetic fields affects the properties of hadrons in medium. QCD phase diagram, hadron-property changes in medium, especially inside the neutron star, QCD matters produced in the heavy-ion collision experiments, etc. will be addressed during the program. We also focus on the evolution of stars in terms of hadronic degrees of freedom.

II. Heavy-flavor physics

Although the understanding for the light-flavor hadrons, such as the nucleons and pions, are not perfect, we are now in a stage to handle those hadrons quite well. We have relatively good understanding for the strangeness in hadrons as well. Thus, a terra incognita in the flavor physics must be the charm and bottom quark physics, since the top quark lies far beyond the nonperturabtive QCD scale ~ 1 GeV. Many experimental facilities are working on and plan to measure heavy hadrons: BES, Belle, LHCb, J-PARC (future), etc. The recent finding of heavy pentaquark from LHCb must be one of the reasons to study the heavy-flavor physics. In theory, we can employ non-relativistic QCD (NRQCD), heavy-quark effective field theory (HQEFT), and so on to attack the heavy-flavor physics. We want to explore various related subjects, such as the heavy-quark symmetry, structure functions of heavy-flavored hadrons, and so on.

III. Hadron productions

The study on the hadron productions is one of the most conventional approach to reveal the hadron properties via scattering processes. By analyzing the production reaction process, one can understand the production mechanisms based on the various symmetries, such as the Lorentz invariance, gauge symmetry, crossing symmetry, TCP invariance, etc. The experimental anomalies can be studied by the theoretical calculations as well. We focus on the photon and pseudo-scalar meson beams off the nucleon targets, resulting in two-body or three-body (Dalitz) final states. Complicated interference effects occurring in the Dalitz processes will be explored extensively. We are also interested in the heavy-hadron productions, such as the Lambda_c, and D meson, which will be an important subject at J-PARC in the near future. Model-independent ways of determining hadron quantum numbers are of importance as well.

Through the workshops, we attempted to organize the collaborations between the attendants. In addition, we stimulate young scientists have new ideas and working motivation. As a result, as shown below, we were able to publish four SCI papers.

3. Academic Programs

Program List

Schools	
01	21st APCTP Winter School on Fundamental Physics
02	2017 Computational Neuroscience Winter School
03	14th KIAS-APCTP Winter School on Statistical Physics
04	2017 Summer School on Numerical Relativity and Gravitational Waves
05	2017 Biophysics School
Conferences & Workshops	
01	APCTP-Quantum Materials Symposium 2017
02	The 19th International Conference on Recent Progress in Many-Body Theories
03	International Workshop on Recent Progress in Superconductivity
04	Nuclear Physics School 2017
05	APCTP-CTPU-GSDC 2017 LHC Physics Workshop @Korea
06	International Workshop for String Theory and Cosmology 2017
07	The 6th School of Mesoscopic Physics: Electron Correlations in Quantum Devices
08	1st Asia Pacific Workshop on Quantum Magnetism 2017 (APWQM 2017)
09	Physics and Applications of Nanoelectronic and Nanomechanical Systems
10	15th International Conference on Squeezed States and Uncertainty Relations (ICSSUR 2017)
11	Tensor Network States
12	Nonlinear Effects Short-time Dynamics in Novel Superconductors and Strong Spin-orbit Coupled Systems
External Activities	
01	The 9th APCTP Workshop on Multiferroics
02	The 20th Asian Workshop on First-Principles Electronic Structure Calculations
03	International Conference on Relativistic Quantum Information North 2017 (RQI-N 2017)
04	School and Conference on Frustrated Magnetism
05	The 9th Conference of the Asian Consortium on Computational Materials Science (ACCMS-9)
06	Summer Institute on Phenomenology of Elementary Particles and Cosmology (SI2017)
07	14th International Conference on Intersubband Transitions in Quantum Wells (ITQW 2017)
08	5th International Conference on Cosmology, Relativistic and Nuclear Astrophysics (ICCRNA 2017)
09	Fourth Dynamics Days Central Asia: Focus on Complex Network and Statistical Physics
10	International Symposium on Cosmology and Particle Astrophysics 2017 (CosPA2017)
11	Asia-Pacific Conference and Workshop on Quantum Information Science (APCWQIS)

12	International School on Strangeness in Nuclear Physics (SNP school) and International Workshop on Hadron Nuclear Physics (HNP)
13	The 6th International Workshop on Nanotechnology and Application (IWNA 2017)
14	The International Symposium on Physics of Unstable Nuclei 2017 (ISPUN17)
15	The 5th Conference on Applied and Engineering Physics (CAEP-5)
16	5th International Meeting on Frontiers of Physics
17	Integrability in Low-Dimensional Quantum Systems

Joint Activities

01	Spring School on Superstring Theory and Related Topics
02	Joint ICGEB-ICTP-APCTP Workshop on Systems Biology and Molecular Economy of Microbial Communities
03	11th APCTP-BLTP JINR-PINP NRC KI-SPbSU Joint Workshop "Modern problems in nuclear and elementary particle physics"
04	9th IACS APCTP Joint Activity on Novel Quantum Phases in Oxide Materials and Low Dimensional Systems
05	2017 Asian-Pacific School and Workshop on Gravitational and Cosmology
06	2017 International Conference Women in Physics (ICWIP)

Pictures

[School] 2017 Summer School on Numerical Relativity and Gravitational Waves

[Conference and Workshop] APCTP-Quantum Materials Symposium 2017

[External Activity] 5th International Meeting on Frontiers of Physics

[Joint Activity] 9th IACS APCTP Joint Activity on Novel Quantum Phases in Oxide Materials and Low Dimensional Systems

21st APCTP Winter School on Fundamental Physics

(1) Period

January 19 ~ 25, 2017

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Nakwoo Kim (Kyunghee University)
Chanju Kim (Ewha Womans University)
Seok Kim (Seoul National University)
Jaemo Park (POSTECH)
Jeong-Hyuck Park (Sogang University)
Sang-Jin Sin (Hanyang University)

(4) Total Participants

55 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 event is basically for educating graduate students, so it is not directly related to research achievement directly. However this year Prof. Sungjay Lee's lectures on 3 dimensional quantum field theory dualities are mildly related to recent research activities, so we hope the participants make progress.

2017 Computational Neuroscience Winter School

(1) Period

February 6 ~ 10, 2017

(2) Venue

POSCO International Center, POSTECH, Pohang

(3) Organizers

Jaeseung Jeong (KAIST)
Se-Bum Paik (KAIST)
Sang Wan Lee (KAIST)
Tak-Wook Ko (NIMS)

(4) Total Participants

58 persons

(5) Program Goal

The brain is one of the most challenging complex systems in both the dynamical and the structural aspects. Theoretical and computational studies of the brain have attracted explosive attention of physicists. As the study of the brain is interdisciplinary, the lectures in the school covers all the area of theoretical modeling, biological experiments, and engineering applications. We expect that the winter school will serve to promote young physicists to communicate with the biologists, the medical scientists, and the engineers to solve the common question: how the brain functions.

(6) Research Performance

Tutorial-level lectures in the fields of computational and theoretical brain science were provided. Student participants performed a team project as a group assignment.

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.

14th KIAS-APCTP Winter School on Statistical Physics

(1) Period

January 9 ~ 13, 2017

(2) Venue

High 1 Resort, Jeongseon

(3) Organizers

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

(4) Total Participants

86 persons

(5) Program Goal

The winter school aims to provide graduate students and junior researchers with a series of lectures on the stochastic processes in pure and applied physics, which are not comprehensively covered in undergraduate and graduate curricula.

(6) Research Performance

Statistical Physics Division of Korean Physical Society has been putting its best effort to provide next-generation scholars and researchers with up-to-date training opportunities. As a major academic event to this end, Winter School had been annually organized for varying thematic research topics. As the 14th event, Division has chosen stochastic processes in pure and applied physics.

Stochastic process underlies a wide variety of physicochemical phenomena. At the same time, it comprise a conceptual framework for multidisciplinary efforts centered around biological and social sciences.

2017 Summer School on Numerical Relativity and Gravitational Waves

(1) Period

June 25 ~ 30, 2017

(2) Venue

Hongik University, Seoul

(3) Organizers

John J. Oh (NIMS)
Sang Hyeon Ahn (KASI)
Hyung Mok Lee (Seoul National Univ.)
Gungwon Kang (KISTI)
Hyunkyu Lee (Hanyang Univ.)
Chang-Hwan Lee (Pusan National Univ.)
Hyung Won Lee (Inje Univ.)
Hee Il Kim (Seoul National Univ. & ZettaHPC)
Seoktae Koh (Jeju National Univ.)
Sang Hoon Oh (NIMS)
Chunglee Kim (KASI)
Edwin J. Son (NIMS)
Young-Min Kim (Pusan National Univ.)
Hwansun Kim (NIMS)
Youngbok Bae (KASI)
Chan Park (KISTI)

(4) Total Participants

84 persons

(5) Program Goal

The main goal of this school is to training graduate students, junior and/or senior post-docs and researchers who are interested in numerical relativity and gravitational waves physics and astronomy. The lectures of this school are on (1) the basics of general relativity and astrophysics, and (2) numerical methods and technical details for numerical simulation and data analysis. In addition, the school includes one-day mini-workshop at which some participants present their research works on the fields. Such workshop provides them with good chances to know what other colleagues in the East Asian regions are working on, resulting in collaborations sometimes.

We have been holding this school annually since 2005. The school became international in format from the year of 2008 with increasing number of participants from East Asian countries, e.g., Japan, China, Taiwan and Korea as well as achieving better stability. The school has been organized through close communications by the international organizers in those four countries. Due to the demands by participants and the self-evolution of the school, we expanded the school in 2011. Some of the main improvements were i) to extend the period from five days to seven days, ii) to prepare very basic introductory lecture sessions for students and beginning researchers with tutorials, iii) to include more technical details in the advanced programs with computer lab sessions so that some advanced level students and researchers can get practical helps from the experts, and iv) to make a short session at which physicists can learn basic knowledge on the astronomical or astrophysical systems which are relevant in numerical relativity and gravitational wave detection experiments. In 2016, we are planning to hold the school basically in the same format.

From 2016, advanced gravitational wave detectors such as advanced LIGO and KAGRA will start the science observation for detecting gravitational waves. Furthermore, we are celebrating the centennial year of the general relativity until 2016. For this reason, this school will be much more a special meaning, which will be helpful for promoting the school.

This summer school aims to train domestic graduate students and junior level of researchers that have a special interest in gravitational-wave physics and astronomy, numerical relativity, and computational skills in these fields. The lectures are mainly consist of two parallel programs in gravitational-wave data analysis and numerical relativity. Each program covers theoretical overview, technical methodologies, and practical exercises. Each program covers in detail:

1) Numerical Relativity
   - General Theory of Relativity
   - Numerical Analysis
   - Programming Techniques
   - BSSN/ADM Formalism
   - Black Hole Simulation
   - GR Hydrodynamics
   - Post-Newtonian Theory
2) Gravitational Wave Data Analysis
   - Gravitational Wave Theory
   - GW Astronomy & Astrophysics
   - Astro-statistics
   - Programming Techniques
   - Signal Processing & GW Data Analysis
   - Machine Learning and its Application
   - Computing Skills

(6) Research Performance

We expect that this summer school is on the 1st upgrade stage of gravitational-wave(GW) and numerical relativity(NR) schools supported by APCTP during the past few years. A great change in environment after the detection of gravitational-wave last year requires more specialized efforts and services to students and researchers in Korea, elaborating their curiosity and passions on the advanced knowledge of GW and its related topics of sciences. We felt that the 2nd phase transition of the past summer school for preparing a new era of GW astronomy should be strongly needed, and we are ready to transfer the knowledges to domestic researchers with an advanced level.

Last year, 2016, we held the 1st GWSSNR with above 80 participants and we found that their thirsty on GW astronomy was much more strong enough, which will be the most powerful motivation of maintaining this school. If supported by various aspects including APCTP programs, this school will be evolved as the most excellent program to encourage domestic research ecology.

2017 Biophysics School

(1) Period

July 3 ~ 5, 2017

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Seunghwan Kim (POSTECH)
Wokyung Sung (POSTECH)
Changyong Song (POSTECH)
Jong-Bong Lee (POSTECH)
Jae-Hyung Jeong (POSTECH)
Woo-Sung Jung (POSTECH/APCTP)
Junghyo Jo (APCTP)

(4) Total Participants

56 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/experimental biophysics since 2014. This year, many students applied to participate our program since the school seems to be known to undergraduate students in Korea. Furthermore, following last year, we helped them to develop their academic career by providing opportunities of lab tour and individual meeting during the school.

APCTP Quantum Materials Symposium 2017
in conjunction with 17th Korea-Taiwan-Japan Workshop on SCES & APW

(1) Period

February 19 ~ 24, 2017

(2) Venue

Yongpyong Resort, Pyeongchang

(3) Organizers

Tuson Park (Chair, Sungkyunkwan Univ.)
Kee-Hoon Kim (Vice Chair, Seoul National Univ.)
Yunkyu Bang (Chonnam National Univ.)
Gun-Sang Jeon (Ewha Womans Univ.)
Younjung Jo (Kyungpook National Univ.)
Jung Hoon Han (Sungkyunkwan Univ.)
Changyoung Kim (Seoul National Univ.)
Jun Sung Kim (IBS-CALDES, POSTECH)
Tae-Hwan Kim (POSTECH)
Jae-Hoon Park (POSTECH)
Je-Geun Park (Seoul National Univ.)
Kwon Park (KIAS)
Chan-Ho Yang (KAIST)
Jaejun Yu (Seoul National Univ.)

(4) Total Participants

195 persons

(5) Program Goal

APCTP-Quantum Materials Symposium 2017 (QMS17) is organized by the Korean condensed matter physics community of strongly correlated electron systems (SCES). We intend to bring world-renowned researchers in various frontiers in condensed matter physics. During the six-day symposium, we hope to cover various topics in condensed matter physics such as quantum magnetism, unconventional superconductivity, heavy fermion, quantum phase transition, low-D electronic materials, etc.

(6) Research Performance

This international symposium on condensed matter physics was an avenue to discuss various forefront research topics among world renowned scholars and local Korean researchers in a friendly, relaxed environment. There were many participants 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.

The 19th International Conference on Recent Progress in Many-Body Theories

(1) Period

June 25 ~ 30, 2017

(2) Venue

POSCO International Center, POSTECH, Pohang

(3) Organizers

Jong Eun Han (SUNY at Buffalo)
Kiseok Kim (POSTECH)

(4) Total Participants

75 persons

(5) Program Goal

The conference series "The International Conference on Recent Progress in Many-Body Theories" has started through collaboration between subfields of the particle-nuclear and the condensed matter theories in the late 1970s. The conference has the main mission of fostering the exchange of ideas and techniques among physicists working in diverse areas of applications of many-body techniques as quantum fluids, condensed matter physics, nuclear and subnuclear physics, and quantum field theory, astrophysics, atomic and molecular physics, quantum chemistry, complex systems, strongly correlated electron systems, quantum magnetism, ultracold atoms, and quantum information theory. The conference series has been held bi-annually in recent years and the 19thconference, mainly sponsored by the APCTP, is the first one hosted by an institution in the East Asian region.

(6) Research Performance

During the conference, 49 talks and 15 posters have been presented. All oral presentations were 30 minutes long including the discussion time. Diverse topics from the above 6 sub-fields have been covered with particular emphasis on the topological insulators, time-dependent computational methods, reflecting the intense interest in today's research. In particular, the program contained two invited talks from the experimental groups (Dr. H.W.Yeom and Dr. U. Bovensiepen) which have led to inspired discussions among theorists. The newly installed subfield "Transport and Nanostructures" has injected new perspectives in the expanding roles of quantum many-body theory in the cross-road of fundamental and applied physics.

International Workshop on Recent Progress in Superconductivity

(1) Period

July 3 ~ 5, 2017

(2) Venue

Yongpyong Resort, Pyeongchang

(3) Organizers

Yunkyu Bang (Chonnam Univ.)
Tuson Park (Sungkyunkwan Univ.)

(4) Total Participants

102 persons

(5) Program Goal

The international Workshop on recent progress in superconductivity(IWRS 2017) 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 2017 held 8 scientific sessions and have 21 invited speakers. On Tuesday morning, there was a poster session where young scientists and graduate students presented their recent results and had an opportunity to discuss research with world-renowned scientists. We expect that these interactions provided by the conference would lead to foundation for future research collaboration.

IWRS 2017 highly encouraged participation of students and postdoctoral researchers who are early in their careers. In order to achieve the goal, the workshop 1) invited young scientists for oral talks, and 2) gave students poster awards for excellent presentations and research quality. Even though the number of the poster presentations has increased from seven to twelve this year, it is imperative to encourage students or postdoctoral researchers to be more involved in the discussion and presentations in the future workshop.

Nuclear Physics School 2017

(1) Period

June 19 ~23, 2017

(2) Venue

APCTP Headquarters, Pohang

(3) Organizers

Jung Keun Ahn (Korea University)

(4) Total Participants

54 persons

(5) Program Goal

The school focused current hot issues in theoretical and experimental approaches to hadron physics, which could bring us a new idea on the future experiments envisioned at the rare isotope accelerator project RAON.

(6) Research Performance

The NPS 2017 has been ended up with a great success in delivering fundamental techniques in nuclear physics experiments such as trigger and data acquisition system, and also in providing lucid lectures on the introduction to the non-relativisitc quark model and the hadron photoproduction reaction.

APCTP-CTPU-GSDC 2017 LHC Physics Workshop @Korea

(1) Period

August 1 ~ 3, 2017

(2) Venue

Konkuk University, Seoul

(3) Organizers

Sun Kun Oh (Konkuk University)

(4) Total Participants

98 persons

(5) Program Goal

This workshop has started in 2007 in parallel with the Korea-CERN Coordination Programme, which has also started in the same year to support systematically on long-term based plan those Korean participants in the CMS and ALICE experiments at the LHC in CERN. Later, the Korea-CERN Coordination Programme included computing facility issues and theorists as well.

The workshop has provided for the last ten years a very unique venue for those Korean scientists who participated in the LHC experiments to share not only their achievements but also some experiences and tips for administrative procedure in connection with CERN.

Recently, the scope of the workshop has become broad and wide to include Belle, SHiP, DUNE, RENO and other high energy experiments as well as LHC experiments. Further, nuclear physics, cosmology, string theories are also included within the workshop as important subjects for presentation.

(6) Research Performance

I would like to mention that we have had two remarkable talks this year. Unlike the conventional/ordinary research talks in high energy physics, Prof. Soonkeon Nam of Kyunghee University gave a talk on "Deep Learning and Particle Physics" and Dr. Wonsamg Cho of SNU on "Can Machines Learn High Energy Physics?"

These two talks were both impressive and suggestive in the sense that they have dealt with the Artificial Intelligence, Machine Learning, and Big Data Science with respect to the high energy physics which recently produce tens of Petabytes of experimental data.

These two talks may herald the oncoming of the related studies in high energy physics.

Some administrative issues with respect to the budget are under consideration.

International Workshop for String Theory and Cosmology 2017

(1) Period

August 23 ~ 25, 2017

(2) Venue

Haeundae Grand Hotel, Busan

(3) Organizers

Jae-Hyuk Oh (Hanyang University)

(4) Total Participants

36 persons

(5) Program Goal

String Theory, AdS/CFT, Theoretical and Observational Cosmology, Quantum gravity

(6) Research Performance

We invite 33 speakers studying on quantum gravity, phenomenological gravity, string inspired gravity and theoretical/observational cosmology. Especially, this year, 4 talks about quantum gravity field are presented and they are rare to learn. Also we invite an observational cosmologist to probe the current development of the observational data to refresh ourselves studying theoretical issues mostly.

The 6th School of Mesoscopic Physics: Electron correlations in Quantum Devices

(1) Period

May 25 ~ 27, 2017

(2) Venue

POSCO International Center, Pohang

(3) Organizers

Heung-Sun Sim (KAIST)
Myung-Ho Bae (KRISS)
Mahn-Soo Choi (Korea Univ.)
Yunchul Chung (Pusan National Univ.)
Yong-Joo Doh (GIST)
Kicheon Kang (Jeonnam National Univ.)
Ju-Jin Kim (Jeonbuk National Univ.)
Dohun Kim (Seoul National Univ.)
Hee Chul Park (IBS-PCS)

(4) Total Participants

65 persons

(5) Program Goal

With development in nanoscale integration, material quality, and measurement precision, quantum mechanical coherence and correlations are now routinely measured in artificial quantum devices. In this summer school, we suggest to learn, with excellent lecturers, the basic theoretical and experimental aspects of quantum coherent manipulation and correlation measurements in (1) two dimensional electron gas-based semiconductor quantum dots, (ii) defect centers in diamond, and (iii) superconducting devices.

(6) Research Performance

Beginning with the introduction of the fundamental and qubit experiment of two-dimensional semiconductor quantum dot devices, electron correlations in solid-based quantum devices, diamond nitrogen vacancy defects, topological super-conductors, and superconducting devices were introduced as well as the basic concept of quantum computation.

1st Asia Pacific Workshop on Quantum Magnetism 2017 (APWQM 2017)

(1) Period

August 28 ~ 30, 2017

(2) Venue

Seoul National University, Seoul

(3) Organizers

SungBin Lee (KAIST, Korea)
Ying-Jer Kao (National Taiwan University, Taiwan)
Nic Shannon (OIST, Japan)
Subhro Bhattacharjee (International Centre for Theoretical Science, India)
Gang Chen (Fudan University, China)

(4) Total Participants

58 persons

(5) Program Goal

This workshop aims to bring together physicists working on various aspects of frustrated magnetism to exchange and discuss ideas on the recent at the frontiers of both theoretical as well as experimental research. The meeting is organized by people from five different countries Korea, Japan, China, Taiwan and India which brings together material scientists, chemists and experimental and theoretical physicists working in mostly different Asian academic institutes.

(6) Research Performance

In this workshop, total 58 number of researchers have participated, sharing their recent research and discussing the future topics in quantum magnetism. Within three days of workshop, there are 31 oral presentations and 15 poster sessions. In addition to the invited speakers, there are many Ph.D students who participate both from abroad and domestic and we encourage active collaborations.

Physics and Applications of Nanoelectronic and Nanomechanical Systems

(1) Period

August 28 ~ 30, 2017

(2) Venue

Yongpyong Resort, Pyeongchang

(3) Organizers

Sang Wook Lee (Ewha Womans University, Korea)

(4) Total Participants

39 persons

(5) Program Goal

The research area of nano-mechanics has developed rapidly in recent years following drastic improvements in device fabrication and measurement methods as well as in theory and modeling. Research about nano-mechanical systems is not only concerned with fundamental physics such as the mechanical control of single electron charge and spin transport, optical control and cooling of the mechanical degrees of freedom, electromechanical systems that approach or attain the mechanical quantum ground state, and electrical systems that control photons and phonons at the quantum level, but it also aims to develop applications like ultra sensitive mass detectors, chemical & biological sensors, quantum information technology and so on. This workshop will build on the success of two previous nano-mechanics workshops supported by APCTP in 2012 and 2015. Well established researchers from all over the world and young scientists will meet together and share their most recent results on the physics and applications of nano-mechanical systems.

(6) Research Performance

The invited talks are composed of 8 theoretical works and 8 experimental ones. It was very well balanced between theory and experiment so that all of the participants have deep discussion on each subject. All presentations dealt with the newest results of NEMS research field. Even though the common interest of our workshop is NEMS, the subjects discussed in this workshop were expanded to various interesting fields such as, quantum computing, quantum heat engine, quantum interferences, high sensitive optomechanical sensors and so on.

15th International Conference on Squeezed States and Uncertainty Relations (ICSSUR 2017)

(1) Period

August 28 ~ September 1, 2017

(2) Venue

Ramada Plaza Hotel Jeju, Jeju

(3) Organizers

Hyunseok Jeong (Seoul National University, Korea)

(4) Total Participants

150 persons

(5) Program Goal

- To build up a strong international network in quantum information and quantum optics and to lead the future research directions in the field.
- To build up an efficient research network centered on Asia-Pacific area with invited researchers in the area including Singapore, Japan, China, and Australia.

(6) Research Performance

- Up-to-date research results in the field of quantum optics and quantum information have been presented through 34 invited talks, 40 contributed talks, and 47 posters.
- Successfully built up a strong international network in quantum information and quantum optics.
- Future research directions have been suggested in the areas of quantum macroscopicity and quantum metrology

Tensor Network States

(1) Period

August 28 ~ 31, 2017

(2) Venue

Hongik University, Seoul

(3) Organizers

Myung-Hoon Chung (Hongik University)
Ji-Woo Lee (Myongji University)

(4) Total Participants

21 persons

(5) Program Goal

The goal of "Tensor Network States" was aimed at introducing the numerial and analytical methods using tensor network states to the domestic researchers and students by the foreign invited speakers and also at promoting the interchange of ideas by the presentation of domestic researchers with invited speakers for the future cooperation.

(6) Research Performance

On the first day, Dr. Ian Mcllouch gave a lecture on the infinite-size Density Matrix Renormalization Group(DMRG) and finite-size DMRG method. This research differs from the old DMRG suggested by Prof. Steve White in that it uses Matrix Product States(MPS) rather than the quantum basis. He also brought Python code implementation of iDMRG to the audience and they had a chance to run the program on their computers.

On the second day, Prof. Masaki Oshikawa explained the general property of a symmetry protected states like Haldane phase and the effect of that property on MPS.

On the third day, Prof. Zhiyuan Xie explained various "Tensor Renormalization Group" (TRG) theory. Especially, he explained about the spin liquid using TRG.

On the last day, Prof. Min-Chul Cha reported his research on the one-dimensional Fermion Hubbard model. Especially he calculated the "central charge" and compared his result with the analytic calculations. Dr. Jaeyoon Cho explained the relation among the spectral gap, exponential clustering, and the entanglement area law in the perspective of quantum information theory. Prof. Ji-Woo Lee explained his research on the one-dimensional XXZ spin chain, two-species boson system, and soft-core boson system in the perspective of quantum phase transitions.

Nonlinear Effects and Short-time Dynamics in Novel Superconductors and Correlated Spin-orbit Coupled Systems

(1) Period

September 18 ~ 23, 2017

(2) Venue

IBS Center for Theoretical Physics of Complex Systems, Daejeon

(3) Organizers

Alireza Akbari (APCTP, Korea)
Ilya Eremin (Ruhr-Universität Bochum, Germany)
Takami Tohyama (Tokyo University of Science, Japan)

(4) Total Participants

87 persons

(5) Program Goal

The workshop focused on the ultrafast dynamics and non-linear effects in strongly correlated systems ranging from Mott insulators to unconventional superconductors. The goal of the meeting was to present the state of the art in experimental investigation and theoretical understanding of strongly excited states far from equilibrium. The workshop planned to have an exchange of ideas between experimental and theoretical approaches, which are used to investigate the excited state, its relaxation, and in particular the interactions that mediate this relaxation in Mott insulators and High-Tc superconductors. Our goal was to bring together leading experimental and theoretical experts working in this field, and have open and constructive discussion about recent developments and open questions in this rapidly developing branch of experimental and theoretical condensed matter physics.

The topics of workshop include the following keywords:

- Ultrafast dynamics in strongly correlated systems
- Topological insulators and topological superconductors
- High temperature superconductivity
- Correlated spin-orbit coupled systems

(6) Research Performance

In conclusion, the workshop clearly responded to its main goals to bring together leading scientists working in the field of Short-time Dynamics to discuss the recent advances in these fields, and to visualize further research prospects and to promote new research collaborations, as well as, to bring together top level scientists and young researchers in order to stimulate lively interaction and exchange of ideas between them.

Two main results of the Workshop are (i) a focused exchange of ideas on the recent experimental and theoretical developments in the field of pump-probe spectroscopy in correlated electron systems, and (ii) an involvement of young scientists in the discussion which has stimulated new research collaborations.

External Activities 01

The 9th APCTP Workshop on Multiferroics

(1) Period

November 9 ~ 11, 2017

(2) Venue

Kashiwa campus, University of Tokyo, Japan

(3) Organizers

[Local Organization Committee]
Tsuyoshi Kimura (Univ. of Tokyo)
Taka-hisa Arima (RIKEN/Univ. of Tokyo)
Masashi Tokunaga (Univ. of Tokyo)

[International Organization Committee]
Yoon Hee Jeong (POSTECH)
Sang-Wook Cheong (Rutgers University)
Daniel Khomskii (University of Köln)

(4) Total Participants

124 persons

(5) Activity Evaluation

The APCTP Workshop on Multiferroics started at the headquarters of APCTP at Pohang in 2008 and has continued as an annual event for the last several years, growing steadily over the years in terms of both participation and its international impact and visibility. (1st-Pohang, 2nd-Taiwan, 3-Tokyo, 4-Beijing, 5-Singapore, 6-Pohang, 7-Bangalore, 8-Shanghai). It has successfully brought together the most active members in the field of multiferroics and continues to enhance the strength of collaboration in the international community, particularly in APCTP member countries. Also the positive impact of this workshop on multiferroics on young generation of each member country should not be regarded lightly. The itinerancy of the present workshop among the member countries has been having particularly positive effects in terms of advertising the role of APCTP as an organization enhancing international collaboration. In 2007, we held the 9th workshop at Kashiwa campus, University of Tokyo, Japan on Nov. 9th(Thu) -11th(Sat).

We had 23 invited talks (14 from APCTP member countries and 9 from non-APCTP member countries), 6 contributed talks (4 from Japan and 2 from non-APCTP member countries), and 55 poster presentations mainly by graduate students and young researchers. During the three days, participants of the workshop actively discussed various topics related to multiferroic research such as fundamental understandings of known multiferroics, syntheses of new multiferroics, fabrications of

multiferroics/ferroelectrics with new functionalities, multiferroic domain engineering, and explorations of new functionalities (e.g., electric control of magnetism and nonreciprocal phenomena) in multiferroics. Furthermore, we had a special session during the reception (evening of the first day) where all the participants frankly discussed the future direction of multiferroic research.

(6) Comments

During and after the workshop, I received a number of positive comments from the participants. Some of them mentioned that they are going to start collaboration work with other participants. Some young participants from APCTP countries acknowledged our financial supports (or no registration fee). From these comments from participants, we consider to achieve the purpose of the APCTP workshop on multiferroics. In this 9th APCTP workshop, we also invited more than 5 distinguished scientists from non-APCTP countries, which enhanced the scientific quality of the workshop and also lead to the increase of the number of young participants from APCTP countries. This also caused an effective advertisement of the activity of APCTP to USA and European countries. Furthermore, during the workshop, we decided to hold a next workshop at Daejeon, Korea in 2018 to continue the fruitful collaborative activity.

The 20th Asian Workshop on First-Principles Electronic Structure Calculations

(1) Period

October 30 ~ November 1, 2017

(2) Venue

Technology Building, Nanjing University, China

(3) Organizers

[International Organizing Committees]
Kee Joo Chang (Korea Advanced Institute of Science and Technology)
Meiyin Chou (Academia Sinica)
Zhong Fang (Chinese Academy of Sciences)
Xingao Gong (Fudan University)
Guangyu Guo (National Taiwan University)
Jisoon Ihm (Seoul National University)
Tamio Oguchi (Osaka University)
Atsushi Oshiyama (University of Tokyo)
Isao Tanaka (Kyoto University)
Satoshi Watanabe (University of Tokyo)
Jaejun Yu (Seoul National University)

[Local Organizing Committees]
Xiangang Wan (Nanjing University) (Chair)
Haijun Zhang (Nanjing University) (Co-Chair)
Dajun Shu (Nanjing University)
Jianxin Li (Nanjing University)
Dingyu Xing (Nanjing University)

(4) Total Participants

319 persons

(5) Activity Evaluation

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 a wide variety of materials having not only fundamental significance and but also industrial importance.

This workshop in held in Nanjing has more than 230 participants. In the period of the workshop, these participants enjoyed the scientific talks and energetically attend the discussion on the topics of first-principles calculations and its applications. We believe that this workshop provides a great platform for participants to learn the frontier of the computational condensed matter physics, to exchange the ideas and to make cooperation. It is very helpful to promote the development of first-principles calculations society, especially in Asia.

(6) Comments

The support of APCTP is very helpful for us to hold this workshop! The process is not too complex.

International Conference on Relativistic Quantum Information North 2017 (RQI-N 2017)

(1) Period

July 4 ~ 7, 2017

(2) Venue

Yukawa Institute of Theoretical Physics, University of Kyoto, Japan

(3) Organizers

Tadashi Takayanagi (Yukawa Institute of Theoretical Physics, Kyoto University)
Yu Watanabe (YITP)
Yasusada Nambu (Nagoya University)
Izumi Tsutsui (KEK Theory Center)
Beni Yoshida (Perimeter Institute)
Doyeol (David) Ahn (Univ. of Seoul/Florida Atlantic University)
Shih-Yuin Lin (Changua University, Taiwan)
Masahiro Hotta (Tohoku University)

(4) Total Participants

105 persons

(5) Activity Evaluation

The RQI-N 2017 conference was the 8th conference in a series of international conferences held previously in Taiwan in 2010, Spain in 2011, Canada 2012, UK 2013, South Korea 2014 USA 2015 and Canada2016. These conferences have been the single most important platform in the field of Relativistic Quantum Information. During this 4-Day conference an interdisciplinary community of 105 researchers at the interface of quantum information science and technology on one side and the general relativistic quantum field theory on the other side were gathered at Yukawa Institute of Theoretical Physics, Kyoto University. The conference covered talks and discussions about new mathematical techniques as well as about opportunities for experimental advances, both for finding quantum gravity effects and applications of relativistic quantum information methods for quantum technologies. This conference provided an ideal setting for the communities of researchers in gravity, quantum field theory, quantum information to meet and to share their expertise and to develop new collaborations. Topics that covered at the conference include relativistic effects in quantum information theory and quantum information processing, quantum optics, implementations in quantum metrologies as well as more fundamental topics. The scientific excellence of this conference can be very well manifested by the talks by leading scientists such as William Unruh and Don Page.

(6) Comments

RQIN 2017 was aimed to bring researchers in quantum information and general relativity together in an inderdisciplinary field of relativisitic quantum information. The highlight of the conference was the presentation by William Unruh who showed that the Cosmological constant may be related to the high matter vacuum energy. He argued that the large vacuum energy directly causes the low measure expansion rate by a process of very weak parametric resonance with spacetime on the small scale being highly dynamic. Bringing string theorist such as Tadashi Takayanagi and N. W. Kim can be considered another meaningful success of this conference.

School and Conference on Frustrated Magnetism

(1) Period

School: April 3 ~ 9, 2017
Conference: April 10 ~ 12, 2017

(2) Venue

Institute of Mathematical Sciences, Chennai, India

(3) Organizers

Rajesh Narayanan (Indian Institute of Technology-Madras)
Ganesh Ramachandran (Institute of Mathematical Sciences)
Arnab Sen (Indian Association for the Cultivation of Science)
Prabuddha Chakraborty (Indian Statistical Institute-Chennai)
Bohm-Jung Yang (Seoul National University)

(4) Total Participants

90 persons

(5) Activity Evaluation

The School and Conference on frustrated magnetism was heavily modelled on the School on Quantum Disordered Systems that some of us had earlier organized in Chennai in 2016. Thus, consistent with the structure that we felt worked very well in the previous edition we designed the program to have a school with a very large pedagogical component wherein some of the leading experts in the field of frustrated magnetism would give easily accessible lectures to the next generation of researchers in this field. The school was followed by a conference on Frustrated magnetism where leading scientists could share their latest results with each other and also with the students who attended the school.

Evaluation of the School:

Frustrated Magnetism is one of the frontier areas of research in modern condensed matter. However, new entrants to this cutting edge area of research are usually frustrated due to the formidable array of techniques, and methodologies that they have to master. This particularly vexing task is made doubly difficult as there is a particular dearth of pedagogical material from which the students can familiarize themselves with the latest results in this fast-paced area of research. Thus, the central aim of the school was to have leading experts in the field give lectures on this frontier topics that are accessible to both students and post-doctoral fellows. As attested to by the list of topics appended below, these lectures were designed in such a manner so as to gently introduce the students of the school into techniques and methodologies that are currently in-vogue in the field. Thus, keeping in mind this goal our lecturers and topics were chosen.

The lecturers and topics are:
(1)Prof. John Chalker (University of Oxford)
Topic: An Introduction to Frustrated Magnetism.
(2)Prof. Anders Sandvik (Boston University)
Topic: Numerical Approaches to Frustrated Magnetism
(3)Prof. Diptiman Sen (Indian Institute of Science)
Topic: The Kitaev Model
(4)Prof. Subhro Bhattacharjee (ICTS)
Topic: Spin Liquids
(5)Prof. Shigeki Onoda (RIKEN)
Topic: Quantum Spin Ice
(6)Prof. Karlo Penc (Hungarian Academy of Sciences)
Topic: Novel Phases in Frustrated Magnetism

The program was designed in consultation with the lecturers. The number of lectures that was assigned to each of the lecturers were done so in consultation with them and keeping in mind the scope and breadth of the topics they were supposed to lecture on. The lectures were of one and a half hour duration which gave ample time to the students to assimilate the information given in an un-hurried fashion. The lecturers were encouraged to use the chalk-board as much as possible so that intermediate steps in deriving key results were appreciated by the students. Experimental and numerical results were projected by using the over-head projection system. As can be seen from the attached schedule, the program was so designed such that there were enough gaps in the program wherein students could approach the lecturers and clarify their doubts in one-on-one sessions. Apart from the lectures we had two colloquiums delivered by Prof. John Chalker and Prof. Anders Sandvik and a special seminar delivered by Prof. Kedar Damle (TIFR). These special lectures were designed to give a broad based holistic over-view of the field to the students and also to a broad general audience of physicists. The first three days of the program was devoted generally to cover mostly introductory material in the field. Building up on the material covered in the first three days, the last three days concerned itself to the coverage of more advanced topics. Wherever possible the lecturers of the school pointed out possible applications to real material systems.

The lectures were judged to be amazingly useful by both young Theorists and Experimenters. The lectures were recorded and are now being hosted at the Institute of Mathematical Sciences You Tube Channel, (see, https://www.youtube.com/playlist?list=PLhkiT_RYTEU3Q06ytIMV0RwAOaaKTdUWw). These lectures can now be used as resource material for future generation of Condensed Matter Physicists.

Evaluation of the conference:

The conference followed the school and was held over the three days spanning 10th April 2017 to 12th April 2017. The conference had leading researchers in the field presenting their latest results. The conference speakers were predominantly drawn from leading research groups from Germany, India, Japan, Hungary, United Kingdom, and the United States of America. The talks were designed to be of thirty minute duration with an additional ten minutes designated for a question and answer session. This format led to very interactive sessions. The speakers in the conference were drawn from all

academic levels: There were very senior Professors, mid-level Associate Professors, and starting Assistant Professors who were invited to give the talks in the conference. Furthermore, our speaker list included a few young post-doctoral fellows who should be very shortly be moving onto faculty positions in leading Institutions. Thus, the conference presented these younger researchers an invaluable platform to present their results on an International platform. The talks were extremely interactive and was extremely beneficial for all the researchers. Due to the fact that there was a preceding school, the younger students also could appreciate and understand the latest results being presented in the school. Apart from these technical talks we also organized a special colloquium that was delivered by Prof. Ronny Thomale of the University of Wuerzburg. The colloquium served the important function of outreach where once again some of the most important latest results in the field was presented to a diverse audience of physicists thus helping to popularize the field. Such colloquiums are important as it leads importantly to cross-talk between physicists working in different areas. The colloquium by Prof. Thomale accomplished exactly this function.

Goals accomplished by the Program:

One of the primary aims of the program was that of man-power training: The training of future generation of condensed matter physicists in the field of Frustrated Magnetism. The extremely high quality lectures by our team of renowned lecturers accomplished just that. The talks in the conference helped push the boundaries of their knowledge in the field as they became familiar to the latest results in this contemporary area of research. The school and conference also afforded the students the opportunity to interact scientifically with some of the leading researchers in this frontier area of research. To facilitate interactions between the students and senior researchers we had organized a poster session that ran through out the program. Using the medium of the poster sessions the students could interact and seek input from senior researchers on their research. The conference also played an important role of providing a platform of fostering new collaborations and furthering existing co-operations between leading research groups in the area.

(6) Comments

As can be gleaned from above the goals of the program were well met. The lectures in the school and the conference talks were consistently of very high quality. The students who attended the program were some of the best students from top quality graduate programs in India. Thus, the combination of these two factors resulted in a program that was considered absolutely top-notch by the participants. There was significant cross-talk between the theorists, the numerical experts, and the experimentalists. This led to certain new collaborations being seeded. Even though we consider the program to be very successful, there are certain aspects of the program that we would like to improve on. They are:

1. We would like to increase the number of women participants especially among the invited speakers.
2. We would like to further the ratio of experimentalists as compared to the theorists among the invited speakers.
3. In this program we predominantly had students coming from top graduate programs in India. In the next program we would like to change this and make this program truly international. More specifically, we would like to have more students from APCTP member countries other than India represented among our student participants.

The 9th Conference of the Asian Consortium on Computational Materials Science (ACCMS-9)

(1) Period

August 8 ~ 11, 2017

(2) Venue

Berjaya Time Square Hotel, Kuala Lumpur, Malaysia

(3) Organizers

Chew Khian-Hooi (University of Malaya)

(4) Total Participants

223 persons

(5) Activity Evaluation

ACCMS-9 attracted 223 delegates from 17 countries and regions. The largest percentage of overall conference attendance came from Asia. The delegates were from Australia, Canada, P. R. China, Hong Kong, India, Indonesia, Japan, Kazakhstan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, United States, United Kingdom and Vietnam. The top two countries with the largest representation were Malaysia (the host country) (29%) and Japan (25 %), followed by Thailand, Taiwan and South Korea. Among them, the participants from Indonesia and Philippines were the two new countries that represented this conference series of ACCMS.

The ACCMS-9 meeting features 3 plenary lectures, over 100 invited speeches, 30 oral talks scheduled in 3 parallel sessions and 1 poster session with 50 poster presentations on 8 major areas of interest in the studies of computational materials science, and related areas.

The 3 plenary lectures were delivered by Prof. Enge Wang of Peking University (P. R. China), Prof. Kaoru Ohno of Yokohama National University (Japan) and Prof. Mei-Yin Chou of Academia Sinica (Taiwan). List chronologically, these plenary talks were:

1. "Chemical Reactions of Iron Corrosion", Prof. Kaoru Ohno of Yokohama National University
2. "Nature of Water on Surface", Prof. Enge Wang of Peking University
3. "Computational Studies of Novel Two-Dimensional Materials and Their Heterostructures", Prof. Mei-Yin Chou of Academia Sinica

Dr Liew Chee Sun who lead the UM Data-intensive Computing Centre (DICC) of University of Malaya delivered a special talk on "Facilitating Scientific Knowledge Discovery Using High Performance and Data-intensive Computing". There were 5 industry talks given by major companies including Biolin Scientific & Kulim Hi-Tech Sdn. Bnd., Krüss Gmbh & Ficher-Intermass (M) Sdn. Bhd., Denova Sciences Pte. Ltd, Anton Paar Malaysia Sdn. Bhd., and Agilent Technologies & LabAlliance Sdn. Bhd.

In addition to the main conference of ACCMS-9, a full-day pre-conference workshop on first-principles all-electron mixed basis calculations with the Tohoku Mixed-Basis Orbitals ab-initio (TOMBO) code was held on A ugust 8, 2017 at the Berjaya Time Square Hotel, Kuala Lumpur. The TOMBO workshop was attended by about 40 participants from Australia, Japan, Malaysia, Taiwan and Vietnam. Prof. Yoshiyuki Kawazoe of Tohoku University, Prof. Kaoru Ohno of Yokohama National University and Dr Ryoji Sahara of National Institute for Materials Science were the main speakers of TOMBO workshop. There were also oral presentations delivered by TOMBO users in the workshop. The next TOMBO workshop aims to be a two-day event with more TOMBO users sharing their recent results using TOMBO codes.

In the ACCMS-9 meeting, the ACCMS Mid-career award was presented to Dr. Hiroshi Mizuseki of Korea Institute of Science and Technology (Korea) for his outstanding scientific contribution in the area of computational material science. The winners for best oral presentation awards were Dr Sek Peng Chin (best presentation) of University of Malaya (Malaysia), Dr Maaouia Souissi of National Institute for Materials Science (Japan), and Ms Hadieh Monajemi of University of Malaya (Malaysia). Mr Pongdet Netrattana (best poster award) of Kasetsart University (Thailand), Mr Wonseok Jeong of Seoul National University (Korea) and Mr Wei Lim Chong of University of Malaya (Malaysia) won the poster presentation awards or the Kawazoe prizes.

(6) Comments

We would like to express our sincere gratitude to the University of Malaya, our Patron, the Vice-Chancellor, National and International Advisory committees. Special thanks to Prof. Kawazoe for his support in all aspects related the ACCMS-9 meeting. We acknowledge the financial support from APCTP, and other sponsors. We thank all local organizing committee and helpers, plenary and invited speakers, and all the participants for the support to great success of this event.

Summer Institute on Phenomenology of Elementary Particles and Cosmology (SI2017)

(1) Period

August 25 ~ 31, 2017

(2) Venue

Human Resource Development Center "Fuji Calm", Japan

(3) Organizers

[Local Organizer]
Takehiko Asaka (Niigata Univ.)
Mayumi Aoki (Kanazawa Univ.)
Koji Ishiwata (Kanazawa Univ.)
Jisuke Kubo (Kanazawa Univ.)

[International Organizer]
Chuan-Ren Chen (National Taiwan Normal Univ.)
Kiwoon Choi (IBS)
Koici Hamaguchi (Tokyo Univ.)
Tao Han (Tsinghua Univ.)
Gerge Hou (National Taiwan Univ.)
Jihn E. Kim (Kyung Hee Univ.)
Kingman Cheung (National Tsing Hwa Univ.)
Pyungwon Ko (KIAS)
Otto Kong (National Central Univ.)
Jisuke Kubo (Kanazawa Univ.)
Taichiro Kugo (Kyoto Sangyo Univ.)
Takeshi Kurimoto (Toyama Univ.)
Jae Sik Lee (Chonnam National Univ.)
Cai-Dian Lu (IHEP)
Nobuhiro Maekawa (Nagoya Univ.)
Shigeki Matsumoto (IPMU)
Shugang Su (Arizona Univ.)
Morimitsu Tanimoto (Niigata Univ.)
Tzu-Chiang Yuan (Academia Sinica)

(4) Total Participants

83 persons

(5) Activity Evaluation

This year's Summer Institute was the 23rd of the series and was held in Fuji-Yoshida, Japan, which is so to say home of the Summer Institute.

We invited five lecturers; Porf. S. Petcov for neutrino physics, Prof. S. Kuroyanagi for gravitational waves, Prof. K. Nakamura for Large Hadron Collider (LHC), Prof. S. Park for collider phenomenology and Prof. T. Konstandin for particle cosmology. Except for Prof. Nakamura, the lecturers gave lectures for 2.5 hours in total, while Prof. Nakamura gave a lecturer of 1.5 hours. All of them delivered well-prepared lectures, and there were many questions not only from senior participants, but also from young participants. In addition to the lecturer, there were 30 short talks and 19 poster presentations. Most of them dealt with current topics in particle physics and particle cosmology.

(6) Comments

According to the idea of the Summer Institute, between 13:00 and 16:30 (during the afternoon break) and also in the night, many international small groups were formed to discuss the current problems and exchange their ideas in particle physics and particle cosmology. To summarize it can be said that it was also a successful summer institute. Finally we made an official announcement that the Summer Institute in 2018 will be held in China and the host university is Nankai University.

14th International Conference on Intersubband Transitions in Quantum Wells (ITQW 2017)

(1) Period

September 10 ~ 14, 2017

(2) Venue

Sands Expo and Convention Center, Marina Bay Sands, Singapore.

(3) Organizers

Qijie Wang (Nanyang Technological University) (Chair)
Jongwon Lee (Ulsan National Institute of Sciencen and Technology)
Kok Khoo Phua (Nanyang Technological University) (Advisory Committee)
Miriam Vitiello (Consiglio Nazionale delle Ricerche, Italy) (Co-Chair)
Mikhail Belkin (University of Texas at Austin) (Co-Chair)
Carlo Sirtori (University Paris Diderot) (Co-Chair)

(4) Total Participants

156 persons

(5) Activity Evaluation

The ITQW was successfully organized and well received by most, if not all, participants. The ITQW 2017 conference was held at the "Marina Bay Sands" in Singapore. ITQW successfully brought together leading academic scientists and researchers from all over the world including Asian countries to exchange and share their experiences on all topics related to intersubband transition phenomena and devices. The conference covers a wide range of topics from physics experiments to fully functional devices and applications. ITQW presents with a mixture of oral presentations and vibrant poster sessions. it provided plenty of opportunity to mix and network outside of the lecture theatre with planned free time and social events, and bring together academia and industry together. At the end of the programme, it establishes many fruitful collaborations among various partners, generates novel ideas and exchange students/research staff.

Both Nanyang Technological University and Semiconductor Optoelectronics Society in Singapore are very satisfied with the high quality of the event and are willing to continue to support similar events in the future.

(6) Comments

The ITQW 2017 conference was successfully organized by bringing together leading academic scientists and researchers from all over the world including Asian countries to exchange and share their experiences on all topics related to intersubband transitionphenomena and devices. The strong support from APCTP is really important and timely and greatly help the success of the conference. Both Nanyang Technological University and Semiconductor Optoelectronics Society in Singapore are very satisfied with the high quality of the event and are willing to continue to support similar events in the future.

5th International Conference on Cosmology, Relativistic and Nuclear Astrophysics (ICCRNA 2017)

(1) Period

October 31 ~ November 4, 2017

(2) Venue

Al-Farabi Kazakh National University, Kazakhstan

(3) Organizers

Nurgali Takibayev (Kazakhstan) - Cochair
Remo Ruffini (Italy) - Cochair
Sung-Won Kim (Korea) – Cochair
Tolegen Kozhamkulov (Kazakhstan)
Tlekkabul Ramazanov (Kazakhstan)
Mirzayusuf Musakhanov (Uzbekistan)
Hernando Quevedo (Mexico)
Leonid Chechin (Kazakhstan)
Medeu Abishev (Kazakhstan)
Kyoshi Kato (Japan)
Chingis Omarov (Kazakhstan)
Claudio Spitalieri (Italy)
Viktor Vasilevski (Ukraina)
Vladimir Ivaschuk (Russia)
Vladimir Dzhunushaliev (Kyrgyzstan)
Sayabek Sakhiev (Kazakhstan)
Bobomurad Akhmetov (Uzbekistan)
Yernazar Abdikamalov (Kazakhstan)
Ratbay Myrzakulov (Kazakhstan)

(4) Total Participants

68 persons

(5) Activity Evaluation

We believe that the conference was a success, we increase number of participants more than two time and involve students to conference as listeners. Also there was good experience in organizing reports by web-conference (from Japan, Russia, Ukraina). We are planning to publish proceedidngs in per revied conference series journal.

(6) Comments

V-th International Conference on on Cosmology, Relativistic and Nuclear Astrophysics (ICCRNA 2017) was dedicated to promote high level studies on hot topics and to encourage young physicists on these fields and to review recent progress in one of the most advanced fields of scientific research in Cosmology, Relativistic and Nuclear Astrophysics. It also provided an important venue for facilitating international scientific collaborations. This meeting taken place in the base of leading university in Central Asia the Al-Farabi Kazakh National University in Almaty, Kazakhstan and promoted cooperation among young scientists from Central Asia countries (more than 65% of participants was young scientists). Conference was supported by APCTP, IETP, NAS RK and KPS. Reports was listened by over 30 master and PhD students of Al-Farabi Kazakh National University.

Fourth Dynamics Days Central Asia: Focus on Complex Network and Statistical Physics

(1) Period

October 21 ~ 23, 2017

(2) Venue

Bukhara State University, Bukhara, Uzbekistan

(3) Organizers

Matrasulov Davronbek (Turin Polytechnic University in Tashkent)
Giulio Casati (Universita' degli Studi dell' Insubria)

(4) Total Participants

59 persons

(5) Activity Evaluation

International Conference "Fourth Dynamics Days Central Asia" was organized under guidance of Giulio Casati from Universita' degli Studi dell' Insubria (Italy) and Davron Matrasulov from Turin Polytechnic University in Tashkent (Uzbekistan) in close cooperation with the regular International Advisory Board. . This International Conference was 3-days activity that brought together recognized experts working on different aspects of complex systems and nonlinear dynamics with broad spectrum of interdisciplinary topics.

Two types of talks, invited lectures (35-minutes) and short (20-minutes) talks by young scholars have been presented during 3 days.

All participants agreed that the meeting was excellent and well organized. Also, they recommended to organize it regularly, in different cities of Uzbekistan and neighboring Central Asian countries.

(6) Comments

It was our fourth conference supported by and organized in cooperation with APCTP. We found that APCTP program is quite effective to support conferences. We are interested to cooperate with the APCTP in our future conferences to be organized in Uzbekistan.

International Symposium on Cosmology and Particle Astrophysics 2017 (CosPA2017)

(1) Period

December 11 ~ 15, 2017

(2) Venue

Yukawa Institute for Theoretical Physics, Kyoto University, Japan

(3) Organizers

Misao Sasaki (Yukawa Institute for Theoretical Physics, Kyoto University) (Chair)
Jun'ichi Yokoyama (Research Center for the Early Universe, the University of Tokyo) (Secretariat)
Kunihito Ioka (Kyoto University)
Hideo Kodama (Kyoto University)
Takahiro Tanaka (Kyoto University)
Teruaki Suyama (The University of Tokyo)
Masahide Yamaguchi (Tokyo Institute of Technology)

(4) Total Participants

159 persons

(5) Activity Evaluation

We had 30 plenary talks by distinguished speakers from all over the world as well as promising youths of the Asia Pacific region. This combination served to enhance the activities in the research in cosmology and particle astrophysics of the region significantly. In the afternoon we had a poster session on Monday and parallel sessions on Tuesday, Wednesday, and Thursday where more than 100 oral presentations were made. We also had a reception with poster discussion, evening excursion to Arashiyama Hanatouro where participants enjoyed pleasant walk in bamboo tree pathways with spectacular illumination as well as a banquet at a historic Japanese restaurant in Kyoto whose garden was made in 1611. During the symposium we also had an annual face-to-face meeting of AAPPS-DACG where we discussed our future plan toward 2018 and APPC in 2019.

The conference was as a whole great success.

(6) Comments

This conference was a full-scale conference that covered practically all the important topics in contemporary cosmology and astrophysics, and the participants were much impressed with the advancement of the relevant fields contributed by researchers in the region. We decided to continue this series of symposium next year in Yangzhou in China and then Taipei in 2019.

Asia-Pacific Conference and Workshop on Quantum Information Science (APCWQIS)

(1) Period

September 26 ~ 28, 2017

(2) Venue

Khorezm Mamun Academy, Khiva, Uzbekistan

(3) Organizers

Jambul Yusupov (Turin Polytechnic University in Tashkent)
Choo Hiap Oh (National University of Singapore)

(4) Total Participants

38 persons

(5) Activity Evaluation

This Asia-Pacific Conference and Workshop were 3-days activity that brought together recognized experts working on the quantum information and IT – and related technologies. The talks of lectures (45-minutes) by invited speakers have been presented during these days. All participants agreed that the meeting was excellent and well organized.

(6) Comments

It was the first experience on cooperation with APCTP. We are interested to cooperate with the APCTP in our future conferences to be organized in Uzbekistan.

International School on Strangeness in Nuclear Physics (SNP School) and International workshop on Hadron Nuclear Physics (HNP)

(1) Period

SNP School: December 14 ~ 16, 2017
HNP Workshop: December 18 ~ 22, August 8 ~ 11, 2017

(2) Venue

SNP School: KEK Tokai branch, Tokai, Ibaraki, Japan
HNP Workshop: RIKEN, Wako, Japan

(3) Organizers

SNP School:
Atsushi Hosaka (RCNP) (Chair)
Satoshi N. Nakamura (Tohoku Univ.) (Chair)
Akinobu Dote (KEK)
Emiko Hiyama (RIKEN)
T. Nakano (RCNP)
Hiroyuki Noumi (RCNP)
H.Ohnishi (ELPH)
Makoto Oka (TITECH/JAEA)
K.Ozawa (KEK)
T. Suda (ELPH)
Toshiyuki Takahashi (KEK)
Hirokazu Tamura (Tohoku Univ.)
K.Tanaka (KEK)
M.Yoshoi (RCNP)

HNP Workshop:
[Chair]
Makoto Oka (TIT)
Atsushi Hosaka (RCNP)
Emiko Hiyama (Kyushu Univ./RIKEN)
[Local Organizing Committee]
Takumi Doi (RIKEN)
Tetsuo Hyodo (YITP)
Yoichi Ikeda (RCNP)
Masahiro Isaka (RCNP)
Takayuki Myo (OIT)

Hideko Nagahiro (NWU)
Hajime Togashi (RIKEN)

(4) Total Participants

135 persons

(5) Activity Evaluation

As a general impression, there are many young scientists including graduate students and postdoc researchers attending both of the SNP school and HNP workshop. In both events, young scientist sessions were arranged where they gave presentations and enjoyed discussions. As attempts to widen our scope we attempt to invite speakers not In the SNP school, not only the nuclear-hadron

To summarize, the events were very successful and useful to all participants. I appreciate strong support from APCTP without which we could not achieve the success.

(6) Comments

This is the second time that I have kindly received support from APCTP for external activities; the previous one was for "International workshop: The 10th APCTP-BLTP/JINR-RCNP-RIKEN Joint Workshop on Nuclear and Hadronic Physics, RIKEN, Wako, Japan, August 17(Wed) - 21(Sun), 2016. For both events, the support from APCTP is essential to encourage young people from Asian countries. Both events were successfully done and we heard many thankful and satisfactory voices from the participants.

The 6th International Workshop on Nanotechnology and Application (IWNA 2017)

(1) Period

November 8 ~ 11, 2017

(2) Venue

Ocean Dunes Resort, Phan Thiet, Vietnam

(3) Organizers

[Local Organizing Committee]
Dang Mau Chien (Institute for Nanotechnology, VNUHCM (Chairman))
Lam Quang Vinh (Dept. of Science and Technology, VNUHCM)
Le Thanh Long (Department of International Relations, VNUHCM)
Vu Dinh Thanh (Ho Chi Minh City University of Technology)
Mai Thanh Phong (Ho Chi Minh City University of Technology)
Tran Linh Thuoc (Ho Chi Minh City University of Science)
Tran Van Man (Ho Chi Minh City University of Science)
Vo Van Toi (Ho Chi Minh City International University)
Le Hoai Quoc (Saigon HighTech Park)
Duong Minh Tam (R&D Center, Saigon HighTech Park)
Nguyen Quang Liem (IMS, Vietnam Academy of Science and Technology)
Le Quoc Minh (Vietnam Materials Research Society)
Nguyen Huu Duc (Vietnam National University - Hanoi)
Nguyen Viet Ha (UET, Vietnam National University)
Nguyen Trong Giang (Hanoi University of Science and Technology)
Nguyen Duc Chien (IEP, Hanoi University of Science and Technology)
Vu Ngoc Hung (ITIMS, Hanoi University of Science and Technology)
Pham Thanh Huy (AIST, Hanoi University of Science and Technology)

[Secretary]
Doan Duc Chanh Tin (Institute for Nanotechnology, VNUHCM) (Chairman)
Dang Thi My Dung (Institute for Nanotechnology, VNUHCM)
Le Duy Dam (Institute for Nanotechnology, VNUHCM)
Nguyen Thanh Tuyen (Institute for Nanotechnology, VNUHCM)
Bui Thanh Tung (Institute for Nanotechnology, VNUHCM)
Nguyen Nhu Ngoc (Institute for Nanotechnology, VNUHCM)
Le Van Thang (Ho Chi Minh City University of Technology)
Phan Bach Thang (INOMAR, Vietnam National University - Ho Chi Minh City)

(4) Total Participants

251 persons

(5) Activity Evaluation

The 6th International Workshop on Nanotechnology and Application (IWNA 2017) opened an opportunity for international & national scientists to exchange knowledge on various aspects of nanotechnology. Moreover, the broad network for international collaboration in research and education on nanotechnology could be established as the productive results of the Workshops.

The Workshop has been highlighted with 3 plenary invited talks, 23 parallel oral sessions together with poster and exhibition session. 160 papers (out of 200 papers registered) have been presented, covering almost every aspect in nanotechnology, varying from theoretical and computational nanoscience, nanofabrication techniques, nanomaterials and nanodevices to applications of Micro-Nanotechnology. Selected papers will be refereed for publication in the International Journal of Nanotechnology (IJNT) and the electronic journal Advances in Natural Sciences: Nanoscience and Nanotechnology (ANSN).

As a part of the Workshop, the Forum on Business opportunities of Micro-Nanotechnology industry in Vietnam was organized for the scientists, researchers and business community to exchange business opportunities in Micro-Nanotechnology field in Vietnam. Moreover, several cooperation meetings between INT and some institutions were held to enhance the joint research projects and exchanged staff training.

(6) Comments

The Workshop IWNA 2017 brought a good chance for domestic and foreign scientists, researchers, students, companies to meet and exchange updated knowledge on micro-nanotechnology and applications. From the feedbacks of all the participants, we can conclude that the Workshop was well-organized and took place successfully. The contributions of the sponsors including APTCP are highly appreciated. The organizer would like to thank all the invited speakers, authors of the submitted papers and participants, members of the program, organizing, advisory and publication committees, staff of the secretariat, all supporters and sponsors of the Workshop. We hope all the participants will continue joining the IWNA 2019 and we shall receive the support and sponsorship of all the sponsors in the next Workshop in 2019.

The International Symposium on Physics of Unstable Nuclei 2017 (ISPUN17)

(1) Period

September 25 ~ 30, 2017

(2) Venue

Halong City, Vietnam

(3) Organizers

Dao Tien Khoa (INST Hanoi)
Nguyen Van Giai (IPN Orsay
Fadi Ibrahim (IPN Orsay)
Phan Viet Cuong (IOP Hanoi)
Alexandre Obertelli (IRFU, CEA Saclay)
Le Hong Khiem (IOP Hanoi).

(4) Total Participants

149 persons

(5) Activity Evaluation

The talks at the conference cover all aspect of the modern nuclear physics both in theory and experiment such as: structure of the exotic nuclei, nuclear reaction induced by stable and radioactive ion beam, astro-nuclear physics, updated news of nuclear facilities and projects. All the presentations are very good. The conference was a very good occasion for the nuclear physicist all over the world to discuss about the collaboration. It opened many chances for young scientist, especially for Vietnamese student. This also had a very good impact to Vietnam nuclear physics community.

(6) Comments

The conference was very well organized and great successful. We would like to ask that APCTP to support us for the next ISPUN which is planning to organize in 2020.

The 5th Conference on Applied and Engineering Physics (CAEP-5)

(1) Period

October 2 ~ 4, 2017

(2) Venue

Dalat University, Dalat City, Vietnam

(3) Organizers

Nguyen Van Hieu (Honour Chair)
Le Hong Khiem (Vietnam Academy of Science and Technology)
Nguyen Dai Hung (Vietnam Academy of Science and Technology)
Nguyen Duc Hoa (Dalat University)
Huynh Thanh Dat (Vietnam National University HoChiMinh City)
Le Hung Lan (Nacentech, Ministry of Science and Technology)
Huynh Viet Dung (Center of Biomedical Physics, Military Academy of Science and Technology)

(4) Total Participants

219 persons

(5) Activity Evaluation

The Conference on Applied & Engineering physics (CAEP-5) meeting has a great success. The number of presentations and their scientific qualities are considerably increased in respect to the preceding one. All contribution and presentations at CAEP-5 were comprehensive and were well – evaluated and presented the diverse and current research topics in Applied & Engineering physics. Experts from various research areas from different countries were given the chance to discuss and interact with each other, thereby leading to possible avenues for future collaboration.

(6) Comments

The Conference on Applied & Engineering physics (CAEP) series has received the financial support from APCTP since 2015 as APCTP External Activities. They have been successfully directed and organized by the international board of famous scientists in the fields of Physics and Applied & Engineering physics. The CAEP-5 meeting was effectively supported by national and international institutions, especially from APCTP. The number of presentations and their scientific qualities are considerably increased. The conference is an excellent venue for future collaborations between scientists coming from diverse locations and research fields to share and report new advances. CAEP-5 showed very well the rapid development of applied physics science and engineering and their potential great impact on other scientific and technologic fields and the participants in the region.

5th International Meeting on Frontiers of Physics

(1) Period

December 3 ~ 7, 2017

(2) Venue

Pullman Kuala Lumpur Bangsar, Malaysia

(3) Organizers

Kurunathan Ratnavelu (University of Malaya) (Chairman)
Hasan Abu Kassim (University of Malaya) (Co-Chairman)
Shahidan Radiman (The National University of Malaysia)
Sithi V. Muniandy (University of Malaya)
Hishamuddin Zainuddin (University Putra Malaysia)
Chin Oi Hoong (University of Malaya)
Faidz Abdul Rahman (Tunku Abdul Rahman University College)
Norhasliza Yusof (University of Malaya)
Yong Thian Khok (Tunku Abdul Rahman University College)
Woo Haw Jiunn (University of Malaya)
Chin Jia Hou (University of Malaya)
Melody Tan (University of Malaya)

(4) Total Participants

99 persons

(5) Activity Evaluation

The Malaysian Institute of Physics has successfully organized the 5th International Meeting on Frontiers of Physics (IMFP2017) on the 3-7 December 201 in Kuala Lumpur. IMFP2017 was the fifthin the series of IMFP organized by the Institute. The Meeting attracted 104 participants with more than 30% were participants from overseas. It was organized in cooperation with the Physics Department, University of Malaya. The scientific objective of the Meeting was to provide a forum for interaction involving world-renowned researchers so as to stimulate and enhance interest in Frontiers of Physics around the Asia Pacific region. The meeting was supported by the APCTP.

The IMFP 2017 spanned 3 days of active scientific discourse with plenary sessions (40 minutes), special sessions with invited talks (30 minutes) and parallel sessions with invited talks and contributed talks (20 & 15 minutes). The special sessions were organized along the following topics:

The IMFP2017 was considered moderately successful and extremely well organized by many of the participants. Most participants commended on the quality and contents of the scientific sessions. Based on the feedbacks from the participants, the Local Organizing Committee concluded that the 5th of IMFP

series had achieved the main objective in providing a forum for interaction involving world- renowned researchers so as to stimulate and enhance interest in Frontiers of Physics around the Asia Pacific region.

- The format of IMFP (plenary sessions and parallel sessions with special sessions on focused areas) was well received. The programme was considered to be well designed, and the speakers were well chosen.
- Topics of plenary and invited speakers were balanced. On the whole, Participants were very happy with the quality of the conference.
- Majority of the participants from the host country have benefited from the interactions between researches from abroad which would certainly open up new prospects for collaborations.
- The conference attracted a large number of contributed papers from local researchers.
- There is strong interaction between local researchers and scientists from overseas. Local researchers were exposed to new areas of research, and collaborative efforts were discussed during the conference.

Initiated during the conference are the following:

- Visit to the Malaysian Nuclear Agency by the Invited Speakers of the Nuclear Physics Division of AAPPS on 5th Dec 2017.
- Networking between Asian-Australia physicists in Plasma, Atomic & Molecular Collision Physics.

(6) Comments

The Local Organizing Committee of IMFP2017 wishes to thank the members of International Advisory Committee for their suggestions and recommendations to make this event highly successful. Special thanks are also extended to APCTP, for their financial as well as logistic support. Last but not least, we thank the participants of IMFP2017 for their contributions in the scientific programme and the members of Local Organizing committee for their hard work.

Integrability in Low-Dimensional Quantum Systems

(1) Period

June 26 ~ July 21, 2017

(2) Venue

MATRIX Research Institute, Creswick Campus, University of Melbourne, Australia

(3) Organizers

Murray Batchelor (Australian National University)
Patrick Dorey (Durham University)
Clare Dunning (Kent University)
Paul Pearce (University of Melbourne)
Chaiho Rim (Sogang University)

(4) Total Participants

59 persons

(5) Activity Evaluation

Scientifically, by all accounts, this was an excellent workshop at the leading edge of international research in integrable quantum systems in low-dimensions. A significant proportion of the active world-wide community working on quantum integrability was in attendance.

In addition to small group collaborations, the program consisted of 54 presentations:

- 90 minute Introductory Lectures:5
- 60 minute Invited Lectures (Week 3 Embedded Conference): 15
- 45 minute Specialized Seminars: 34

Total Number of Presentations: 54

Of the 54 talks, 42 are available on the workshop web page and several presentations will appear in the Matrix Proceedings to be published by Springer.

Some highlights, among many of the meeting, include the announcement of (i) the analytic calculation of the conformal partition functions of two-dimensional critical percolation, (ii) the demonstration of the quantum toroidal integrability behind the AGT corrspondence as well as (iii) some striking progress on the mathematical description of fusion within the affine Temperly-Lieb algebra.

Some major new directions making rapid progress during the meeting include (i) a collaboration explaining the mysteries of Baxter's Q-matrix for sl(2) models at roots of unity and (ii) a collaboration deriving analytically the correlation functions and conformal weights of critical dense polymers. Many physical applications to quantum quenches, ultracold atoms and matter-light interaction were also showcased during the meeting.

The true output of the meeting will only become clear over the coming year as the results of the various collaborations between workshop participants are written up and published.

(6) Comments

This was a highly successful meeting and the MATRIX facilities are first class. The APCTP has strongly funded this community over many years and it is much appreciated. It has led to a larger, stronger and more vibrant community. The area of quantum integrability continues to be an active area of current research with many new and exciting developments. The formal (via a circulated survey) and informal feedback on the workshop from participants was extremely positive!

Spring School on Superstring Theory and Related Topics

(1) Period

March 16 ~ 24, 2017

(2) Venue

ICTP, Trieste, Italy

(3) Organizers

Nima Arkani-Hamed (IAS)
Atish Dabholkar (ICTP)
Edi Gava (INFN)
Rajesh Gopakumar (ICTS-TIFR)
Kumar S. Narain (ICTP)

(4) Total Participants

140 persons

(5) Activity Evaluation

An excellent school with very high quality lectures and enthusiastic participation of students.

(6) Comments

Excellent program. Should be continued.

Joint ICGEB-ICTP-APCTP Workshop on Systems Biology and Molecular Economy of Microbial Communities

(1) Period

July 3 ~ 7, 2017

(2) Venue

ICTP, Trieste, Italy

(3) Organizers

Daniel Segre' (Boston University)
Simon Levin (Princeton University)
Vittorio Venturi (ICGEB)
Pan-Jun Kim (KAIST)
Matteo Marsili (ICTP) (Local Organiser)

(4) Total Participants

117 persons

(5) Activity Evaluation

Most speakers in this workshop are renowned scientists in the field of microbial community. The workshop featured a blend of theorists and experimentalists, both juniors and seniors. Special attention was paid on gender balance. The invited lectures covered a wide range of topics on systems biology and molecular economy of microbial communities. This workshop provided a valuable opportunity for cross-fertilization across different fields, including statistical physics, microbial ecology, experimental microbiology, and bioinformatics. Participants of this workshop had been selected among all applicants based on rigorous evaluation, and the resulting participants were highly motivated.

Each speaker was given enough time to present his/her work, followed by sufficient time for questions and comments from the audience. We observed that speakers and audience were enjoying stimulating discussions and were exploring for possible collaborations, during seminars, break, lunch time, etc. Overall, the workshop was successful in terms of inspiring the participants as well as of overviewing the current state of microbial community research. Based on our observation, we believe that this workshop has provided great learning and collaborative opportunities for speakers and participants. Therefore, we expect it will have a long-lasting effect in the scientific community.

One downside of the workshop was that the participants from the Asia-Pacific region were rather less than expected, and proportionally less than those from other regions in the world.

(6) Comments

This workshop was very timely, in view of the availability of experimental data and theoretical/computational tools in the field of microbial community research, as also pointed out by several speakers. The joint support for the workshop by three international institutes, including APCTP, was very much appreciated and it was a key to the success of the workshop. This type of workshops would certainly help to develop statistical mechanics of collective phenomena in biological systems, and to establish quantitative life sciences as a solid scientific discipline. We hope that workshops on similar topics, in such discussion-encouraging forms, will continue.

11th APCTP-BLTP JINR-PINP NRC KI-SPbSU Joint Workshop "Modern problems in nuclear and elementary particle physics"

(1) Period

July 24 ~ 28, 2017

(2) Venue

New Petergof Hotel, Peterhof, Saint-Petersburg, Russia

(3) Organizers

Victor Voronov (BLTP JINR) (Chairman)
Yongseok Oh (Kyungpook National University and APCTP) (Co-chairman)
Victor Kim (PNPI NRC KI, Gatchina & SPbPU) (Co-chairman)
Nikolai Kochelev (BLTP JINR) (Scientific Secretary)
Elena Rusakovich (JINR) (Secretary)
Sergey Afonin (SPbU)
Vladimir Andrianov (SPbU)
Yaroslav Berdnikov (SPbPU)
Sergey Bondarenko (BLTP JINR)
Alexey Gladyshev (BLTP JINR)
Atsushi Hosaka (Osaka University, RCNP)
Maxim Matveev (PNPI NRC KI)
Pengming Zhang (IMP, CAS)

(4) Total Participants

59 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 Asia Pacific Center for Theoretical Physics (APCTP) and the Bogoliubov Laboratory of Theoretical Physics (BLTP) of the Joint Institute for Nuclear Research (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, on 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, 3 physicists from Japan joined. In the 8th Joint Workshop, which was held at Jeju Island from June 29 to July 4, 2014, 10 physicists 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 physicists 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 were 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, through the support by the branch office of JINR at Almaty and the 10th workshop at RIKEN in Japan under the title "The 10th APCTP-BLTP/JINR-RCNP-RIKEN Joint Workshop on Nuclear and Hadronic Physics" between Korea (APCTP) and Japan (RCNP, RIKEN). Following the effort in the previous workshops, we had the 11th workshop at St. Petersburg in Russia from July 24 to 28, 2017 through the support by Petersburg Nuclear Physics Institute of National Research Centre "Kurchatov Institute" (PNPI NRC KI) and Saint Petersburg University (SPbU). As shown in the list of participants and in the scientific program in the previous part of this report, the number of the participants from Korea, Russia, China, Japan, Kazakhstan, Slovakia, and Spain were 60, the number of the talks was 48. During the workshop, the intensive talks on modern nuclear and elementary particle physics were given and many discussions in the participants were done. Therefore, it is expected that this joint activity could initiate another international collaboration among the participants. 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 conclude that this joint activity is beneficial to the both sides of APCTP and BLTP JINR and this workshop was very successful.

(6) Comments

11th APCTP-BLTP JINR-PNPI NRC KI-SPbU Joint Workshop "Modern problems in nuclear and elementary particle physics" was held at St. Petersburg, Russia, from July 24 to July 28, 2017, in order to enlarge the scope of the workshop wider continuously. There were intensive 48 talks on modern nuclear and elementary particle physics. The number of participants was 60, including 12 invited speakers from Korea, 25 invited speakers from Russia, 7 invited speakers from China, 2 invited speakers from Japan, 1 invited speaker from Kazakhstan, 1 invited speaker from Slovakia, and 1 invited speaker from Spain. During the workshop, very active discussions and exchange of ideas were made. Korea and Russia sides agreed to enlarge the scope of the Joint Workshop by having the next Joint Workshop at Busan in Korea. Since Busan is the second biggest city and the one of the most famous city in Korea, this will be another big step to make this Joint Workshop to be more internationally recognized meeting. Therefore, this workshop was very successful in physics discussions as well as in enlarging the scope of the Workshop.

9th IACS APCTP Joint Activity on Novel Quantum Phases in Oxide Materials and Low Dimensional Systems

(1) Period

November 27 ~ 29, 2017

(2) Venue

Vedic Village, Kolkata, India

(3) Organizers

Y. Bang (Chonnam National University)
A Barman (S.N. Bose National Centre for Basic Sciences)
I. Dasgupta (Chair) (Indian Association for the Cultivation of Science)
S Majumdar (Indian Association for the Cultivation of Science)
D.D. Sarma (Indian Institute of Science)
K Sengupta (Indian Association for the Cultivation of Science)
S. Ray (Indian Association for the Cultivation of Science)
Jaejun Yu (Co-Chair) (Seuol National University)

(4) Total Participants

54 persons

(5) Activity Evaluation

In the three day meeting there were 25 invited talks, 4 short presentations by young post-doctoral researchers, poster presentations by graduate students and ample time for discussion. The talks covered variety of subjects including novel superconductivity in 2H-NbSe2, 2H-PdxTaSe2 and 1T MoS2, Graphene, Topological Insulators, Spin Liquids, Iridates, and multifunctional oxides(both bulk and interfaces). In addition to theoretical talks there were experimental talks. The theme of the conference namely Novel Quantum Phases in Oxide Materials and Low Dimensional Systems represented an area of research that is thriving in the Asia Pacific region and the conference therefore provided a very efficient platform for the active researchers in this region to meet, discuss and exchange ideas. The conference was also instrumental in attracting young researchers as can be seen from the list of participants and enthuse the young mind to carry out research in this direction.

(6) Comments

In view of the strong interest shown by the speakers and the participants it was felt that such an activity should be continued like past years. The next conference, the 10-th IACS-APCTP conference is suggested to take place in Korea in 2018 as a continuation of this activity

2017 Asian-Pacific School and Workshop on Gravitational and Cosmology

(1) Period

August 14 ~ 20, 2017

(2) Venue

The Chinese University of Hong Kong, Hong Kong

(3) Organizers

Tjonnie Guang Feng Li (The Chinese University of Hong Kong)
Ming Chung Chu (The Chinese University of Hong Kong)
Gungwon Kang (Korea Institute of Science and Technology Information)
Sang Pyo Kim (Kunsan National University)
Kei-ichi Maeda (Waseda University)
Misao Sasaki (Kyoto University)
Takahiro Tanaka (Kyoto University)
Rong-Gen Cai (Chinese Academy of Sciences)
Sadakazu Haino (Academia Sinica)
Hoi-lai Yu (Academia Sinica)
Hyung Mok Lee (Seoul National University)
David Blair (University of Western Australia)
Bala Iyer (International Centre for Theoretical Sciences, Bengaluru)

(4) Total Participants

38 persons

(5) Activity Evaluation

The Asian-Pacific School and Workshop on Gravitation and Cosmology series aim at the frontier issues in Gravitation and Cosmology, to put forth new ideas, to discuss current issues and finally to propose challenging problems for young physicists. This year, the focus was on gravitational-wave astrophysics, including the basics of gravitational waves theory and the (astro)physics we can learn from their detection.

In the school, experts had delivered series of lectures from introductory to research level to help students and junior fellows to grasp the essences of the cutting edge developments in gravitational waves in an effective way. Topics included: general relativity, compact binaries, supernovae, numerical relativity, post-Newtonian theory. Moreover, two days were reserved for attendees to present their current research. The workshop portion allowed participants to present their own work in the field of

gravitation and cosmology, and was followed by intense discussion on a broad spectrum of topics within gravitation and cosmology.

The school successfully brought people from the Asian-Pacific community together to improve their network and collaboration. Participants and speakers mingled during the programme and forged connections and increased their network. Moreover, several research projects have originated from this programme, including ones between China, Taiwan, South Korea and Australia.

(6) Comments

With two gravitational-wave detectors planned in the Asian-Pacific region, this programme was a good opportunity to forge stronger connection amongst researchers in this field, and to train the next generation scientists that will carry the field forward.

The programme could not have been possible without the generous help of the APCTP, and other institutions or collectives that supported the programme. This year marked the 11th iteration of this school, and I look forward to many more successful occasions

IV. Research Programs Report

1. Summary of Research Programs

2. Scientific Reports of Junior Research Groups

1. Summary of Research Programs

Junior Research Groups (JRG)

(1) Group List

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	Classical and Quantum Theory of Gravity	Dong-han Yeom
6	Electronic Structure and Magnetism	Igor Di Marco
7	Design Principles of Cellular Networks *	Junghyo Jo
8	Particle Physics and the Early Universe *	Chang Sub Shin
9	Generation and Evolution of Cosmic Structure *	Jin-Ouk Gong
10	Gauge/gravity Duality and String Theory **	Chanyong Park

* Research period ended in 2017

** Research period ended in February 2018

(2) Number of Members

10 professors, 19 Postdoctoral Fellows, 8 Ph.D. Students (total 37 persons)

(3) Scientific Activities

44 Visitors, 8 Workshops (235 participants), 28 Seminars (244 participants)

Young Scientist Training Program (YST)

No.	Name	Nationality	Field
1	Sangho Kim	Korea	Nuclear Physics

No.	Name	Nationality	Field
2	Parada Hutauruk	Indonesia	Nuclear Physics
3	Yun-Long Zhang	China	String Theory
4	Kiesang Jeong	Korea	High Energy Nuclear Physics
5	Heetae Kim	Korea	Statistical Physics
6	Ilya Bakhmatov	Russia	String Theory
7	Taegeun Song	Korea	Biological Physics

Visitor Programs

Total	Member Country		Non Member Country
	Korea	Others	
47	36	6	5

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
  - Geradus 't Hooft: Utrecht University
  - Viacheslav Mukhanov: Arnold Sommerfeld Center for Theoretical Physics
- Period: October 25 ~ October 28
- Research Activities
  - APCTP-KPS Keynote Speech (Oct. 25): Geradus 't Hooft
  - APCTP Keynote Speech (Oct. 26): Viatcheslav Mukhanov
  - APCTP Benjamin Lee Sepcial Session (Oct. 26): Geradus 't Hooft
  - JRG Internal Seminar (Oct. 27): Geradus 't Hooft and Viatcheslav Mukhanov
  - POSTECH-APCTP Public Lecture (Oct. 27): Geradus 't Hooft
  - Pohang-APCTP Public Lecture (Oct. 28): Viatcheslav Mukhanov

Publications of Research

57 Publications published by JRG/YST (SCI: 57 Publications, IF: 4.632)

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 Classical and Quantum Theory of Gravity
06 Electronic Structure and Magnetism

Final Report

01 Design Principles of Cellular Networks
02 Particle Physics and the Early Universe
03 Generation and Evolution of Cosmic Structure
04 Gauge/gravity Duality and String Theory

Main Pictures

JRG Workshops

JRG Group Meetings

Many-body Theory and Correlated Systems

Group Information

- Leader : Prof. Alireza Akbari (PhD., IASBC, Iran (2007))
- Homepage : http://apctp.org/jrg/blogindex.php?JrgId=16
- Period : Dec. 1, 2014~Nov. 30, 2019
- Members

Name	Position	Nationality	Period
Alireza Akbari	Leader	Iran	2014.12.01~2019.11.30
Utkarsh Mishra*	Postdoc	India	2016.03.04~2018.10.31
Fabrizio Cossu	Postdoc	Italy	2016.05.27~2018.05.26
Nimisha Raghuvanshi	Postdoc	India	2017.07.01~2018.06.30
Mehdi Biderang	PhD student	Iran	2016.06.02~2018.12.31

* Joint Researcher with Prof. Jaeyoon Cho's group

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

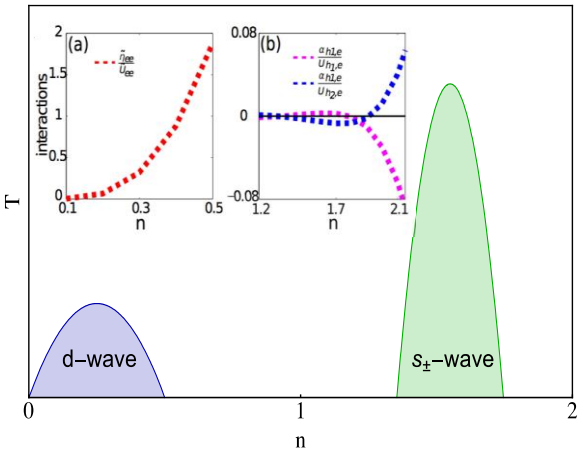


Figure 1. Putative superconducting phase diagram arising from the repulsive interactions. Onset:
(a) Evolution of the cos 4φk cos 4φk′ angular dependence of the pair-scattering between electron pockets with increasing doping. (b) Evolution of the cos 2φk angular dependence between electron and hole pockets with increasing doping.

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 s±-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 behaviour 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. 1,2). The result of this research is going to be published in New J. Phys 2018.

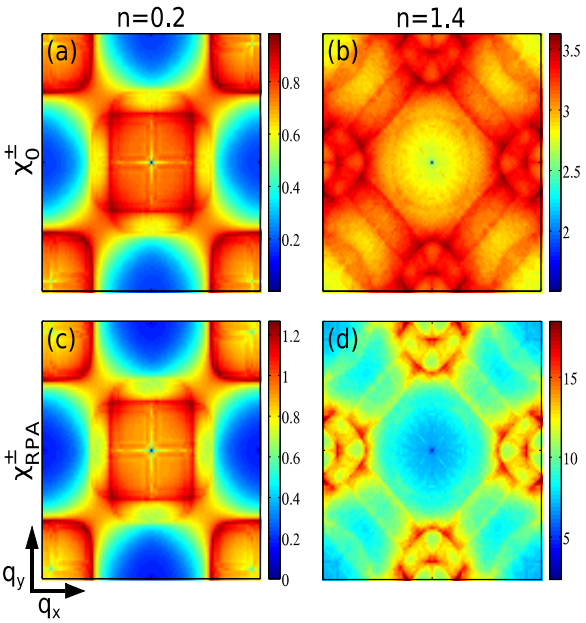


Figure 2. (a, b) Bare transversal susceptibilities in states/eV for doping levels n=0.2 and n=1.4, respectively. (c,d) Corresponding RPA transversal susceptibilities for the same doping levels. The peaks in the bare susceptibility are enhanced within the RPA only for the larger value of n. If the incommensurate peak at (π/3,π/3) and the one close to (π,π) for n = 0.2 are only slightly enhanced, the peaks close to the antiferromagnetic wave-vector Q=(π,0) for n=1.4 are enhanced significantly due to the fact the pockets have a different character. While the pockets near the Γ and M pockets are hole like, the pockets near X and Y -pints are electron like. Momentum ranges are given by (−π ≤qx/y≤ π).

(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 theseedge states and determination of the superconducting gap symmetry arediscussed based on the quasi-particle interference (QPI) technique (See Fig3). The results of this research have been published in PRB: M.H. Zare, M. Biderang, A. Akbari, Phys. Rev. B 96, 205156 (2017).

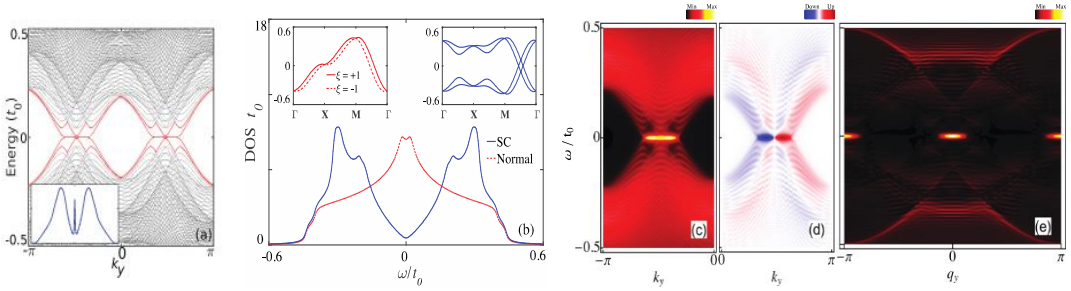


Figure 3. (a) The Bogoliubov electronic dispersion of hole doped Sr2IrO4 on a ribbon for the topological phase; the red bands indicate the topological in-gap edge states with two-fold degenerate zero-energy Majorana-type with flat bands. Inset represents the edge LDOS of the su- perconducting state, where the zero energy pick is originated from the zero-energy flat bands; the range of the plot is the same as (b). (b) Bulk LDOS in normal (red-dashed) and su- perconducting (blue-solid) phases. Insets: left shows the band structure of quasi-spin-orbit split bands: $\xi = \pm 1$, in normal phase, and right presents the quasi-particle bands in super- conducting phase. (c,d) The intensity plots of the momentum- and spin-resolved LDOS along the Γ-Y momentum direction, respectively. The up and down helical states in (d) correspond to the states with the winding numbers +1 and −1, respectively. (e) Intensity of the QPI dispersion (absolute value) at the edge (slab: n = 1) for the Y′-Γ-Y momentum direction.

(iii) Surfac 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 (F. Lambert, A. Akbari, P. Thalmeier, and I. Eremin, 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)

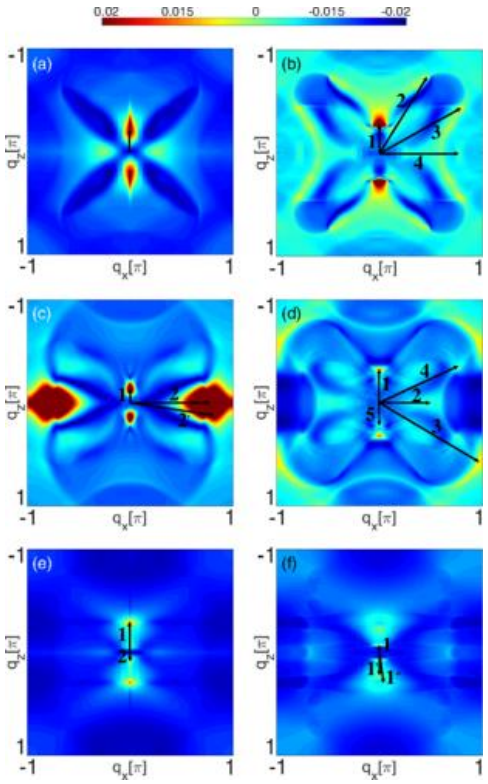


Figure 4. Comparison of QPI spectrum for E1g (top), E2u (center), and E1u (bottom) at zero bias (ω=0, left-hand column) and positive bias (ω=0.2, right-hand column). The left-hand column gives the QPI image of topological Weyl arcs, and the right-hand column corresponds to continuum surface states QPI contribution (Phys. Rev. Lett. 118, 087004, 2017).

Quantum Information and Many-Body Theory

Group Information

- Leader : Jaeyoon Cho (PhD., KAIST, Korea (2005))
- Home Page : www.apctp.org/jrg/blogindex.php?JrgId=19
- Period : Nov. 1, 2015 ~ Oct. 31, 2018
- Members

Name	Position	Nationality	Period
Jaeyoon Cho	Leader	Korea	2015.11.01 ~ 2018.10.31
Utkarsh Mishra*	Postdoc	India	2016.03.04 ~ 2018.10.31
Chae-Yeun Park	Postdoc	Korea	2017.05.01 ~ 2018.04.30

* Joint Researcher with Prof. Alireza Akbari's group

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

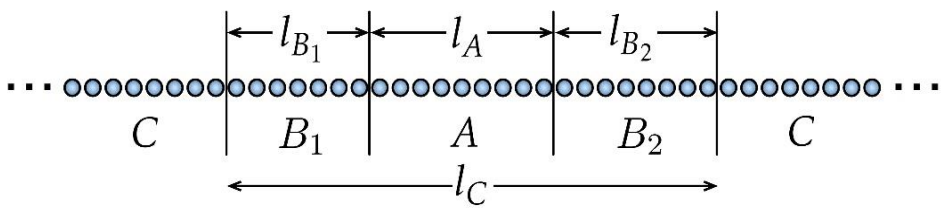
Understanding the universal nature of strongly-correlated many-body systems is one of the central topics in theoretical physics. Even though strongly-correlated systems are generally intractable, it is possible to unfold the universal relationship between their characteristic attributes, providing a 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 $\sim \xi^{(const)\xi}$. 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 $\sim \xi(\log \xi)2^{(const)\xi}$, 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) Realistic area-law bound on entanglement from exponentially decaying correlations

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

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

where $\rho_A = \mathrm{Tr}_B \rho_{AB}$ and $\rho_B = \mathrm{Tr}_A \rho_{AB}$. Letting $P_A(i) = \mathrm{Tr}[(M_i \otimes I_B)\rho_{AB}]$, $P_B(j) = \mathrm{Tr}\big[(I_A \otimes N_j)\rho_{AB}\big]$, and $P_{AB}(i,j) = \mathrm{Tr}\big[(M_i \otimes N_j)\rho_{AB}\big]$, 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

Supergravity & String Theory

Group Information

- Leader : Eoin O Colgain (PhD., Imperial College London, UK (2007))
- Period : Dec. 1, 2015 ~ Nov. 30, 2018
- Members

Name	Position	Nationality	Period
Eoin O Colgain	Leader	Ireland	2015.12.01~2018.11.30
Ilya Bakhmatov*	Postdoc	Russia	2016.09.01~2018.09.20
Thiago Araujo	Postdoc	Brazil	2016.09.21~2018.08.31

* YST Member

Scientific Scope

Our group is interested in subjects at the interface of conformal field theory, sigma-models and gravity. In particular, in 2017 we devoted considerable effort to understanding Yang-Baxter sigma-models and how integrable deformations at the level of the sigma-model can be mapped into transformations of gravity solutions. Separately, we authored papers on holographic entanglement entropy, gravity theories that make dualities manifest and Chern-Simons matter theories.

Overview

String theory is a framework to study physics problems that is best described by either conformal field theory or supergravity. Our work is on the relation between these two topics.

Research Highlights

(i) Yang-Baxter sigma-models

In 2013 Delduc, Magro & Vicedo applied a prescription for integrable deformations of sigma-models due to Klimcik to sigma-models in the context of string theory. In string theory integrability techniques allow one to study the AdS/CFT correspondence at all orders in the coupling constant so that one can interpolate from the weakly coupled field theory description to the strongly coupled string theory description. This technique works well for highly symmetric settings, such as the duality between N = 4 super Yang-Mills and string theory on AdS5 x S5. The example of Delduc et al. breaks symmetries, but yet preserves integrability, so it opens up the prospect of studying AdS/CFT in less contrived, more physical settings.

Later it was understood that the Delduc technique, called Yang-Baxter sigma-models, could be applied to generate a much larger class of integrable deformations. In the geometry, it was noted that these

transformations were described by non-Abelian T-duality transformations and that there was a class of deformations that were not supergravity solutions, but satisfied equations of motion of a "generalized" supergravity theory.

Our contribution to this story is realising that Yang-Baxter sigma-model is nothing but an open-closed string map in the sigma-model target space. This map is a matrix inversion, which reduces the algebra to a high-school level matrix inversion. This had been missed by numerous experts in Europe and offers new perspective. Building on this observation, we provided an alternative formulation of the Yang-Baxter sigma-model that may be applied to all geometries not just cosets to find new solutions.

One interesting feature of our prescription is that the Classical Yang-Baxter Equation (CYBE), which is an input in the Yang-Baxter sigma-model, is actually an outcome of the open-closed string map. This implies that gravity knows about the CYBE and that gravity may be exploited to classify solutions to the CYBE. We have checked that this works out for explicit solutions and now we are working on the proof. Our work provides a radically new perspective on Yang-Baxter sigma-models, which we can start to understand as some special case of a more general transformation.

Our findings were published in Phys.Rev. D95 (2017) no.10, 105006; Eur.Phys.J. C77 (2017) no.11, 739. There are also two preprints arXiv:1705.02063, arXiv:1710.06784. Our results essentially trivialise large parts of the literature, so our results are slow to be accepted by the community.

(ii) Calibrated Entanglement Entropy

Entanglement can be determined holographically using a prescription due to Ryu and Takayanagi. While the method is simple, one has to determine minimal surfaces in a bulk geometry and it is tricky to identify minimal surfaces that are not spherically symmetric, since one has to solve second-order differential equations. In mathematics, minimal surfaces are usually determined using closed differential forms called calibrations, which lead to first-order equations, so we decided to introduce the technique for holographic entanglement entropy. We succeeded in recovering the known minimal surfaces for locally AdS3 black holes and for AdS geometries in higher dimensions. One interesting feature of calibrations is that in the presence of a background flux or field strength, the form is no longer closed and closes into the field strength. We showed that this technique worked for warped geometries supported by flux.

Our findings were published in JHEP 1707 (2017) 117; EPJ Web Conf. 168 (2018) 03003

(iii) Penrose limits and spin chains in Chern-Simons matter theories

(iv) Publications

1. "Observables in Guarino-Jafferis-Varela/CS-SYM duality", T. Araujo, H. Nastase, JHEP 1707 (2017) 020
2. "Yang-Baxter sigma-models, conformal twists and noncommutative Yang-Mills", T. Araujo, I. Bakhmatov, E. O Colgain, J. Sakamoto, M. Sheikh-Jabbari, K. Yoshida, Phys.Rev. D95 (2017) no.10, 105006
3. "Conformal twists, Yang-Baxter sigma-models and holographic noncommutativity", T. Araujo, I. Bakhmatov, E. O Colgain, J. Sakamoto, M. Sheikh-Jabbari, K. Yoshida, arXiv:1705.02063, under review at Journal of Physics A

4. “Calibrated Entanglement Entropy”, I. Bakhmatov, S. Deger, J. Gutowski, E. O Colgain, H. Yavartanoo, JHEP 1707 (2017) 117
5. “Penrose limits and spin chains in the GJV/CS-SYM duality”, T. Araujo, G. Itsios, H. Nastase, E. O Colgain, JHEP 1712 (2017) 137
6. “I in generalized supergravity”, T. Araujo, E. O Colgain, J. Sakamoto, M. Sheikh-Jabbari, K. Yoshida, Eur. Phys. J. C77 (2017) no. 11, 739
7. “Classical Yang-Baxter Equation from Supergravity” I. Bakhmatov, O. Kelekci, E. O Colgain, M. M. Sheikh-Jabbari, under review at PRL
8. “Exotic Branes in Exceptional Field Theory: the SL(5) duality group”, I. Bakhmatov, D. Berman, A. Kleinschmidt, E. Musaev, R. Otsuki, arXiv:1710.09740

(v) Scientific Activities

Collaborations: As our publication list shows we collaborated with scientists at Albert Einstein Institute Potsdam, Bogazici University Istanbul, Kyoto University, IFT Sao Paulo, University of Su Collaborations: As our publication list shows we collaborated with scientists at Albert Einstein Institute Potsdam, Bogazici University Istanbul, Kyoto University, IFT Sao Paulo, University of Surrey and IPM Tehran

I was invited to give talks in Zagreb, Croatia and Kyoto, Japan at conferences.

We hosted a number of visitors to present seminars at various stages throughout the year: M. van Putten (Sejong), Sang-Jin Sin (Hanyang), F. Schaposnik Massolo (IBS), Yermek Aldabergenov (Tokyo Metropolitan), Hossein Yavartanoo (KITPC Beijing), Mike Kosterlitz (Brown & KIAS)

In December our group organised a workshop titled “New Perspectives on gravitation and cosmology”, which provided a platform for 20 scientists from Korea to present talks across the subjects of astrophysics, cosmology, classical & quantum gravity and gravitational waves.
(https://www.apctp.org/plan.php/npgs2017rrey and IPM Tehran)

Statistical Physics of Complex Dynamics

Group Information

- Leader : Hang-Hyun Jo (PhD., KAIST, Korea (2006))
- Homepage : https://sites.google.com/site/codylab23/
- Period : May. 1, 2017 ~ Apr. 30, 2020
- Members

Name	Position	Nationality	Period
Hang-Hyun Jo	Leader	Korea	2017.05.01~2020.04.30
Takayuki Hiraoka	Postdoc	Japan	2017.07.01~2018.06.30
Juyong Song	PhD student	Korea	2013.03.01~2018.12.31
Jin Xu	PhD student	China	2013.09.01~2018.12.31
Byoung-Hwa Lee	PhD student	Korea	2017.06.01~2018.05.31
Min-Young Lee	PhD student	Korea	2017.10.01~2018.01.31
Taekho You	PhD student	Korea	2017.10.01~2018.09.30

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. These interacting behaviors generically show inhomogeneous temporal patterns, which have been characterized by non-Poissonian processes. Our group focuses on the development of the quantitative analysis framework for such non-Poissonian processes and on its applications to the real world problems such as epidemic spreading in a population.

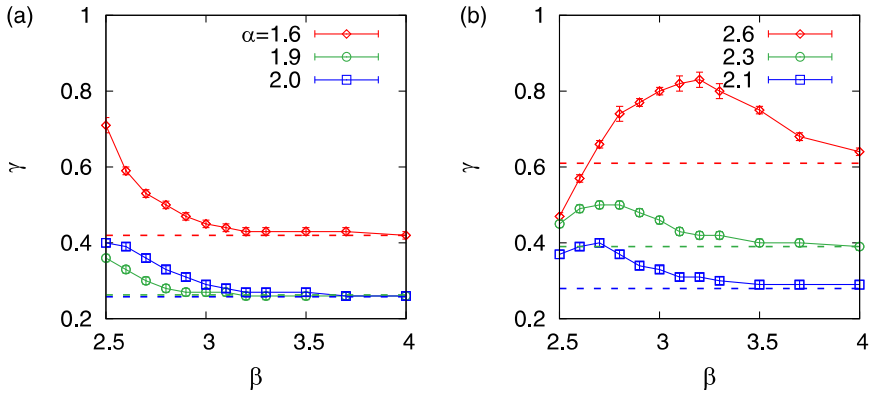
Overview

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) Modeling correlated bursts by the bursty-get-burstier mechanism

The long-range memory effect in time series or event sequences has been characterized by measuring the autocorrelation functions with power-law decaying exponent, denoted by γ. This exponent is determined by the power-law exponent α of the inter-event time distribution if inter-event times are totally uncorrelated with each other: $\alpha + \gamma = 2$ if $1 < \alpha < 2$ and $\alpha - \gamma = 2$ if $2 < \alpha < 3$. We studied the effects of correlations between inter-event times on the scaling relation between α and γ. Particularly, when the burst size distributions have the power-law tails with exponent β. Here the burst size is the number of events in a bursty train in which consecutive inter-event times within the burst are less than a given time window, while inter-event times between events in the burst and other events in other bursts are larger than the time window. The power-law burst size distributions for a wide range of time windows were observed in various datasets and they imply "the bursty-get-burstier" effect by which it means that large bursts tend to follow large bursts, while small bursts tend to follow small bursts. In order to investigate the effects of β on the scaling relation between α and γ, we devise a recipe to generate event sequences from the given inter-event time distribution with exponent α and the burst size distributions with exponent β. Such generated event sequences are analyzed by measuring autocorrelation functions to find the functional form of γ as a function of α and β.



The numerical results in the above figure enable us to conclude that the correlations between inter-event times have a strong influence on the scaling relation between inter-event time distribution and autocorrelation function. The next step is to understand such dependence more rigorously.
Reference: H.-H. Jo, Physical Review E 96, 062131 (2017)

(ii) Limits of memory coefficient in measuring correlated bursts

The memory coefficient is a Pearson correlation coefficient between one inter-event time and the next inter-event time. This measure has been widely used due to its simplicity. In the literature, we observe that the larger value of memory coefficient tends to be associated with the heavier tails of burst size distributions. In addition, in human activities, we find almost zero memory coefficients but power-law burst size distributions with exponent around 4, which seems contradictory. In order to tackle this issue, we derived an analytic solution of the memory coefficient as a function of parameters describing inter-event time distribution and burst size distribution. Then we find the general tendency of the smaller memory coefficient for the burst size distribution with heavier tail. In addition, we indeed find very small values of memory coefficient for the burst size distribution with exponent 4, implying that the seemingly inconsistent observations in human activities are indeed consistent. But it also implies that the memory

coefficient might have limits to properly measure the correlated bursts especially when the power-law exponent of burst size distribution is relatively large.
Reference: H.-H. Jo and T. Hiraoka, arXiv:1801.01118

(iii) Issues related to the machine learning

Juyong Song has participated in a project, "emergence and relevance of criticality in deep learning (arXiv:1710.11324)." He found interesting features of neural networks machine learning, emergence of criticality, especially in deep belief networks (DBN). DBN is an unsupervised clustering and the clustering size distributions in a DBN follows a power law. The power-law clustering is known as the most asymmetric clustering given the resolution of the clustering, where the resolution is defined as the state entropy, H[s]. Asymmetries between the cluster sizes mean the importance of the features extracted by the clustering from the data. We can measure this asymmetricity by the frequency entropy, H[k], called relevance, maximized by power-law size distributions. Moreover, it was suggested that the power-law activities in nature is related to the criticality of the 2nd order phase transition in physics, and they showed that nature prefers the power-law exponent 1, called Zipf's law. We found that power law exponent is important for the generative ability in a DBN and it can generate the learned data with evenly distributed label patterns at Zipf's law.

In order to understand immune response further by perceptron models, Jin Xu has studied some basic knowledge of machine learning. During the past several months, what she has studied include but not limited to the knowledge of artificial neural networks, supervised learning, back-propagation algorithm from some classical papers and by attending a winter school "the 15th KIAS-APCTP Winter School on Statistical Physics" (January 8- January 12, 2018). Technically, she becomes familiar with coding in python and TensorFlow. What she has done so far is a necessary preparation to complete this project in the following and likely the final six months staying in APCTP no later than August 2018.

Classical and Quantum Theory of Gravity

Group Information

- Leader : Dong-han Yeom (PhD., KAIST, Korea (2011))
- Home page : https://www.apctp.org/jrg/blogindex.php?JrgId=23
- Period : Sep. 1, 2017 ~ Aug. 31, 2020
- Members

Name	Position	Nationality	Period
Dong-han Yeom	Leader	Korea	2017.09.01~2020.08.31
Brahma Suddhasattwa	Postdoc	India	2017.10.12~2018.09.30
Alexey Golovnev	Postdoc	Russia	2018.01.01~2018.12.31

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.

During 2017, our group was started and settled down. We continued not only previous projects but also several new projects. The main results will come out 2018 and later, but we shortly review about results as well as on-going works.

Research Highlights

(i) Published papers

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

In this work, I and my colleagues investigated tunneling decay of false vortices. In fact, this is a continuation of a series of papers since 2013 with coworkers in Sogang University and Monteal University (arXiv:1308.3501, arXiv:1310.3005). The new aspect of the present work is to include effects of gravitation, while we did not consider the effect for the previous two works.

(ii) Preprints

Why concave rather than convex? (arXiv:1706.07784)

In this work, we would like to explain the reason why the inflaton potential should have such a shape rather than the other shape. More specifically, it is known that the recent CMB data prefers a concave shape

of the inflaton potential rather than a convex shape. Perhaps, the Euclidean quantum cosmology can give a hint. In this paper, we assumed the Euclidean wormholes as an approximation of the Hartle-Hawking wave function. Then, in order to give the classicality, the inflaton potential should have a concave shape rather than a convex shape. If it is the truth, then following observational consequences, e.g., comparison to CMB data, will be a very interesting future projects.

Suppression of long-wavelength CMB spectrum from the no-boundary initial condition (arXiv:1707.01471)

In this paper, we investigated the CMB spectrum that is created by the Hartle-Hawking instantons. Interestingly, if we assume a specific mass scale of the inflaton field, one can obtain a power suppression for long-wavelength CMB modes. Based on this paper, it will be interesting to extend the other instantons, e.g., Euclidean wormholes.

Pre-Hawking radiation cannot prevent the formation of apparent horizon (arXiv:1710.01533)

There have been several radical suggestions such that Hawking radiation can prevent the formation of the apparent horizon, the event horizon, and even the singularity. However, in this paper, within very conservative assumptions, we have shown that it is indeed impossible, unless the collapsing matter behaves exotic way, e.g., moves a space-like direction, which is a causal and unphysical. Therefore, our paper clarifies and shows that many papers in the literature are indeed wrong and we should not follow these directions.

Tunneling from the past horizon (arXiv:1712.00207)

In this paper, we considered a tunneling process from the past horizon to outside the black hole. This is unusual, since many people are interested in tunneling from the future horizon to outside the black hole. Because of this, we can see many unusual features and we can find interesting applications to holography, e.g., in the context of the ER=EPR conjecture.

How can we erase states inside the black hole? (arXiv:1712.00347)

In this work, we investigated the Page curve, that shows the relation between the entropy and information contents between inside and outside a black hole, of the black hole remnant picture. In order to obtain the correct result, we relied on numerical investigations of entanglements of quantum states. In conclusion, if the remnant picture works, then the internal number of states of a black hole should monotonely increase at least after the Page time. The future works based on quantum gravity will judge whether this assumption is physical or not.

(iii) Work in progress

After I joined APCTP, I could make several interesting projects. These are the topics that are on-going by our group and should be completed within several months.

1. Internal structure of a black hole based on loop quantum gravity

Based on the effective field approach of loop quantum gravity, one can see the internal structure of a black hole. We can ask whether one can resolve the singularity or not. Also, one can ask whether such a

solution consistent (within the Hamiltonian formalism) or not. If it is not consistent, then one can search a new consistent solution within the frame work.

2. Bridge between Euclidean and loop quantum cosmology

One can also apply the similar approach to quantum cosmology. In the loop quantum cosmology community, it was traditionally believed that our universe experienced a big bounce. However, if we apply the Euclidean quantum cosmology, which is a quite reasonable approach, then we can also regard that our universe was created from nothing, where it can be either a single universe or two entangled universes. This will shed some new lights in the context of loop quantum gravity.

3. Singularity free black holes in modified gravity

There have been several papers which argued that there is no singularity in such a modified gravity model, especially in the context of the mimetic gravity. We are still investigating and we can explicitly confirm or falsify their models. We believe that (either confirm or falsify) our explicit calculations will contribute a very important role in the modified gravity community.

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	Position	Nationality	Period
Igor Di Marco	Leader	Italy	2017.12.04~2020.12.03

Scientific Scope

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 Fe3O4 (magnetite), and lanthanides-based permanent magnets, such as SmCo5. In addition, we focus on more novel systems, including magnetically doped topological insulators and two-dimensional materials.

Overview

The present research group was established in December 2017 and is currently in the process of hiring suitable members. In this initial phase, the group has been working on the properties of the dilute magnetic semiconductor Mn-doped GaAs, which has a key importance in the development of spin-based electronics (spintronics). We have also been investigating the ultrafast magnetic response exhibited by a ferromagnetic material after an intense laser pulse. In particular, we addressed whether a linear proportionality between magnetic asymmetry and magnetization exists or not.

Research Highlights

(i) Strong electronic correlations in Ga1-xMnxAs

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 [see e.g. T. Dietl et al., Rev. Mod. Phys. 86, 1877 (2014)]. Among the materials under scrutiny, the present JRG has been particularly interested in Ga1-xMnxAs. 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 Fig. 1. 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 Fig. 1 clearly illustrates that theory and experiment are in good agreement with each other, and they both locate the Mn-3d 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. This situation is not easy to model quantitatively using models that are routinely available. Therefore, we are currently working 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.

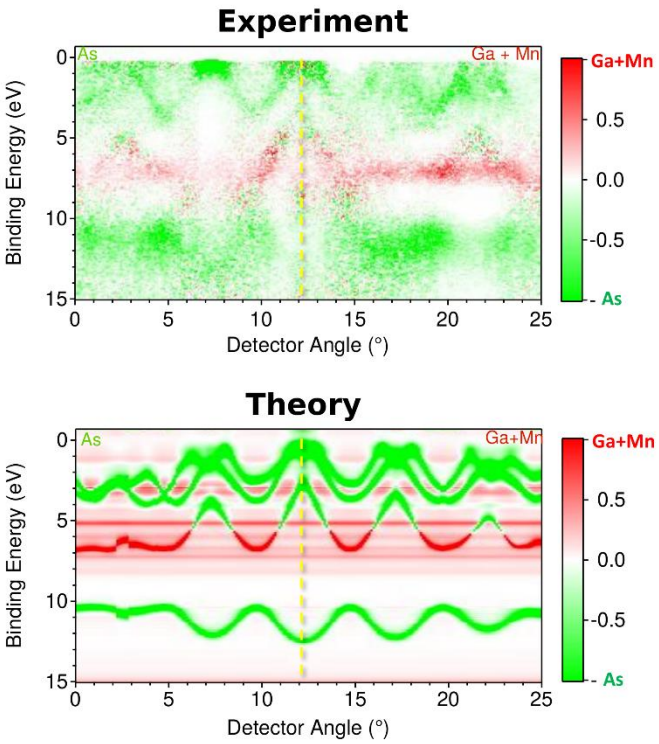
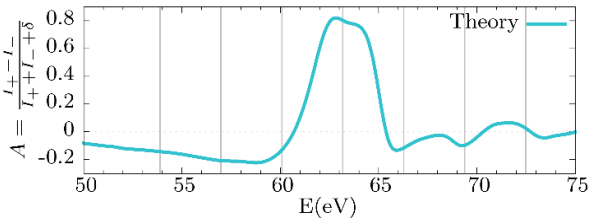


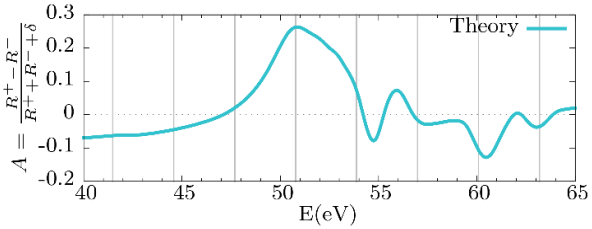
Figure 1: experimental and theoretical SW-HARPES spectra for $Mn_{1-x}Ga_xAs$, where x=0.05.

(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



(a)Theoretical magnetic asymmetry Ni (100 nm)



(b)Theoretical magnetic asymmetry Fe (100nm)

Figure 2: Theoretical magnetic asymmetry for thin films of Ni and Fe, obtained for a T-MOKE geometry and in equilibrium conditions.

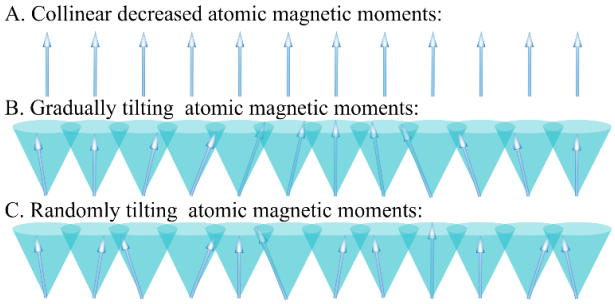


Figure 3: magnetic configurations considered in our theory

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 [I. Locht et al., Phys. Rev. B 92, 064403 (2015)]. The JRG has been recently working on extending results obtained with 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 I±(E), measured for opposite magnetization directions ± 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. Our results for the equilibrium state (without laser excitation) of Fe and Ni are shown in Fig. 2, and compare well to experimental data available in literature. In collaboration with an experimental group at Uppsala University, 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 Fig. 3.

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. As Fig. 4 illustrates, this proportionality does not universally hold even for the simplest scenario, which is the presence of gradually tilting moments (see middle panel of Fig. 3). As expected, more complicated scenarios (see bottom and top panels of Fig. 3) 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.

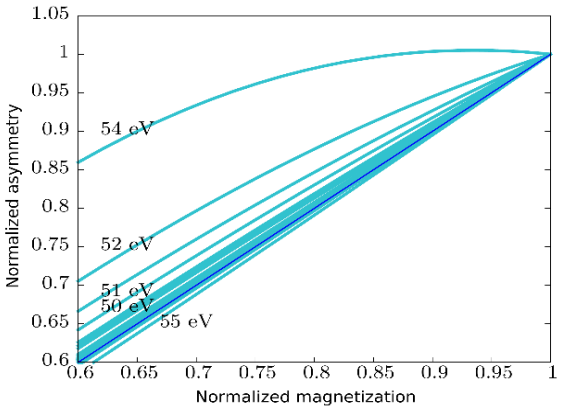


Figure 4: Magnetic asymmetry normalized with respect to its value at equilibrium as a function of the magnetization. The reduction of the magnetization is obtained solely with a tilting of the equilibrium magnetic moments, as illustrated in the middle panel of Fig. 3.

Final Report 01

Design Principles of Cellular Networks

Personal Data

- Name: Junghyo Jo
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- Period: Sep. 1, 2012 – Aug. 31, 2017

Main Research Fields

- Computational Biology
- Machine Learning
- Statistical Mechanics

Topics of Research

Multicellular organisms function with symbiotically interacting cells. Cellular differentiation may reduce complexity of individual cells and provide robustness in the organism as a whole. Our group computationally studies dynamic interactions and spatial organizations of live components, cells, in biological systems. Two specific examples are the cellular network in the pancreatic islet for controlling energy homeostasis; and neural networks for stable and flexible learning. We are also interested in algorithms for generating optimal cellular networks that are adaptable for given challenges. Three main topics are listed as follows:

- Design principles of pancreatic islets
- Machine learning of neural networks
- Molecular recognition of immunological receptors

Summary of Research

Our group aimed to understand design principles of cellular/molecular networks. We have investigated (i) how the network of endocrine cells regulate metabolism; (ii) how the network topology of neuronal cells contributes to flexible and stable learning; and (iii) how the molecular network of immunological receptors effectively recognizes pathogen peptides. Furthermore, we are also interested in fundamental problems in statistical physics such as fluctuation theorems and nonequilibrium/stochastic processes in life.

(1) Design principles of pancreatic islets

The islets of Langerhans, embedded within the pancreas, play a crucial role in maintaining blood glucose levels constant by secreting the counter-regulatory hormones, insulin and glucagon. Glucose homeostasis is important for brain function. Persistent elevation of glucose levels is by definition diabetes, an

increasingly common metabolic disease. The islet micro-organ consists mainly of endocrine α, β, and δ cells. Although these components are differentiated from the same progenitor, α and β cells play opposite roles: at low glucose levels, α cells secrete glucagon to increase glucose levels, while at high glucose levels, β cells secrete insulin to decrease glucose levels. It seems that two counter-regulatory components are sufficient to control (increase/decrease) glucose levels. The role of somatostatin-secreting δ cells for glucose homeostasis is still a mystery.

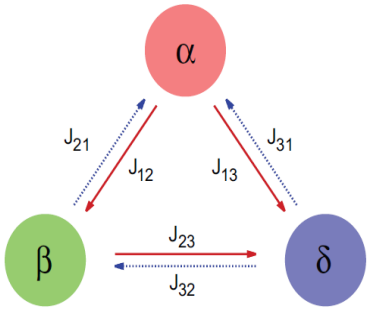

Figure 1. Cellular interactions between α, β, and δ cells. Red (blue) arrows represent positive (negative) interactions.

These endocrine cells secrete their hormones in pulsatile manners, and the hormone pulses have special coordination. At a very high glucose condition, glucagon and insulin pulses are out of phase, while insulin and somatostatin pulses are in phase. This suggests that α, β, and δ cells communicate to each other. Pieces of the interactions have been observed in experiment (Fig. 1). We developed a mathematical model to describe the hormone pulses and their coupling by using a generalized Kuramoto model (Hong, Jo, and Sin, 2013). The model generated the out-of-phase coordination of glucagon and insulin pulses at high glucose conditions, which was consistent with previous observations. However, the model predicted an in-phase coordination of the two pulses at low glucose conditions. Furthermore, the model predicted that the special interaction symmetry of α, β, and δ cells allowed multiple coordination of hormone pulses at normal glucose conditions. This was distinct from the single coordination of the out-of-phase or the in-phase state at high or low glucose conditions. The change of possible coordination number, depending of glucose conditions, is a special feature of the interaction symmetry (Fig. 1). We will discuss on the physical meaning of the coordination-number change later.

Considering cellular interactions within a single islet, the spatial organization of α, β, and δ cells may have functional implications. Interestingly, different species have different architectures (cellular composition and arrangement) of islets for the glucose control. However, the islet size range (clusters of a few cells to several thousand cells) is similar across species having very different body sizes, suggesting the existence of an optimal islet size. In mice, β cells are located in the islet core, while non-β cells are located on the periphery. In contrast, human islets have more α cells (20-30% vs. 10-15% in mouse islets), and non-β cells are distributed throughout islets (Fig. 2).

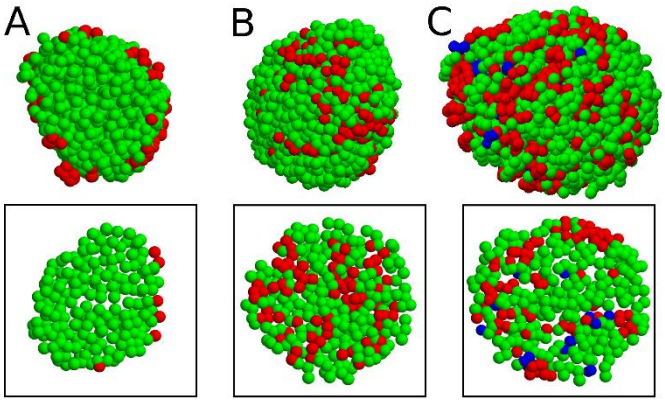

Figure 2. Cellular organizations of α (red), β (green), and δ (blue) cells in (A) mouse, and (B) human islets in the ignorance of δ cells. (C) A human islet with δ cells. Bottom pictures represent cross-sections of the top 3-dimensional islets to show their inner structures.

We developed a physical model to describe the cellular organization by adapting the differential adhesion hypothesis (Hoang, …, Jo, 2014). Based on the three-dimensional positions of individual cells in islets, we computationally inferred the relative attractions between cell types, and found a conserved rule that the attractions between homotypic cells were slightly, but significantly, stronger than the attractions between heterotypic cells

commonly in mouse, pig, and human islets. We thus concluded that the origin of the different islet structures is the cellular composition rather than their organization mechanism.

Based on these previous research on cellular interactions and islet architectures, we put the oscillator model of α, β, and δ cells on the observed islet structures, and examined structure-function relations in the system design for controlling homeostasis (Fig. 3). We found that the shell-core and the partial mixing structures are good for both synchronization and desynchronization of cells inside an islet (Hoang, Hara, and Jo, 2016). At emergency conditions such as low/high glucose conditions, the endocrine cells showed synchronized hormone pulses, while at normal glucose conditions, they showed desynchronized hormone pulses that could hide unnecessary hormone actions.

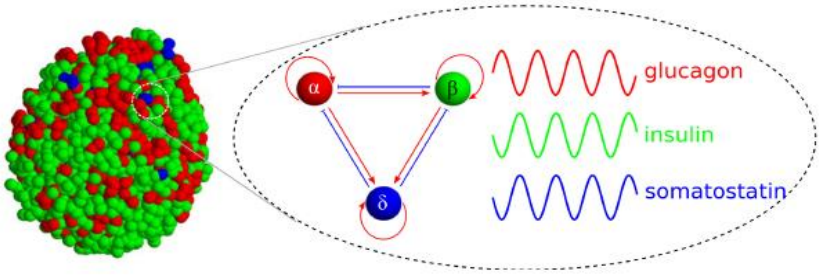

Figure 3. Cellular organization and interaction in pancreatic islets. Endocrine α, β, and δ cells generate pulses of glucagon, insulin, and somatostatin, respectively. They positively (red arrow) or negatively (blue bar-headed arrows) affect hormone pulses of neighboring cells.

In addition to the synchronization between cells inside an islet (intra-islet synchronization), the synchronization between islets in the pancreas (inter-islet synchronization) is another important issue in the islet-biology field. One potential hypothesis for the inter-islet synchronization is that the oscillatory glucose level entrains islets to be synchronized. We have found that the possible coordination between glucagon and insulin pulses changes with glucose levels (Hong, Jo, and Sin, 2013). This result lead us an intriguing hypothesis: The multiple coordination at normal glucose conditions may make islets harder to be entrained by the glucose oscillation. On the other hand, the unique coordination between glucagon and insulin pulses at low/high glucose conditions makes islets to be easily entrained by the glucose oscillation. We have confirmed this hypothesis with a whole feedback model of hormone secretion and glucose regulation (Fig. 4). Finally, we have found a functional meaning of the asymmetric interactions between islet cells (Fig. 1). The special network motif allows pancreatic islets to consume less hormones to stably regulate glucose levels, and it makes the synchronization of hormone secretions controllable depending on glucose conditions (Park, Song, Hoang, Xu, and Jo, 2017). We have further examined the controllable synchronizability of the coupled nonlinear oscillators theoretically (Xu, Park, and Jo, 2017).

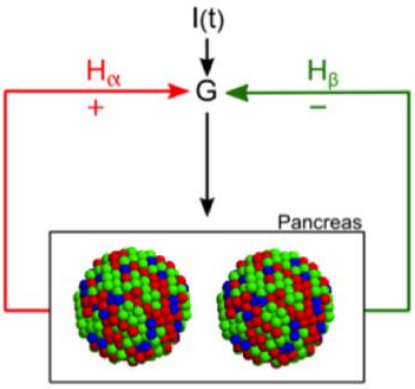

Figure 4. Glucose regulation with multiple islets. Pancreatic islets secrete glucagon (red) and insulin (green) to increase and decrease glucose levels, respectively, given external glucose infusion.

Regarding the pulsatility of insulin secretion, we have collaborated with the Ryu group at the department of life sciences, POSTECH. Through the tight collaboration for five years, we have found that the phase of insulin pulses is modulated by glucose and insulin, which have been recently published (Lee, …, Ryu, and Jo, 2017a; 2017b).

(2) Machine Learning of Neural Networks

We explore the robustness and adaptability of neural networks. The nervous system relies on cellular communications to a much larger extent than other physiological systems. Motivated by the study of neuronal connections, neural networks have been proposed to learn certain tasks. Recent studies have reported that neural networks in the brain are scale-free or small-world networks, as widely observed in biological and social networks. We plan to investigate how the network structures affect learning and memory through the machine learning of artificial neural networks. First, we examined optimal network size for memorizing patterns with various complexity. It is a rule of thumb that more complex tasks require larger networks. However, the design of optimal network architectures for specific tasks is still an unsolved fundamental problem. We considered three-layered neural networks for memorizing binary patterns (Fig. 5). We developed a new complexity measure of binary patterns, and estimated the minimal network size for memorizing them as a function of their complexity. We formulated the minimal network size (hidden layer size) for regular, random, and complex patterns (Pastor, Song, Hoang, and Jo, 2016).

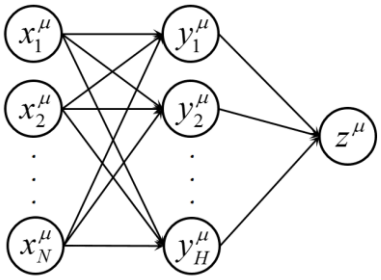

Figure 5. Feedforward neural network with input (x), hidden (y), and output (z) layers.

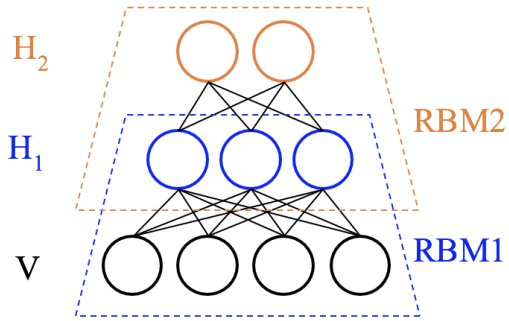

Figure 6. Deep belief network (DBN). Stacks of restricted Boltzmann machines (RBM) construct a DBN. Input data in visible (V) layer is processed into deep hidden (H) layers.

Discrimination and generation are two categorizations of machine learning. The above study was a discrimination problem of binary patterns using the back-propagation algorithm. Second, we have investigated a generation problem using the Boltzmann machine algorithm. We considered a deep belief network (Fig. 6), and the generation of hand-written digit images using the MNIST database. The neural network has multiple layers of which node numbers decrease as layers become deeper from the input layer. We counted the configuration of node activities at different layers, and calculated the entropy of the frequencies. Then, we found that the entropy measure was correlated with the generation performance of hand-written digits (Song, Marsili, and Jo, submitted). This new measure can suggest an optimal number and size of hidden layers for certain tasks.

(3) Molecular recognition of immunological receptors

Finally, we study the mechanism how the immune system can distinctively recognize self and nonself molecules. The immune system recognizes pathogens such as viruses, bacteria, fungi, and parasites through membrane receptors that take part in communication between the cell and the outside world. Then, the system is expected to equip with an almost infinite range of specificities for the countless pathogens. If one gene encodes one receptor, the immune receptor diversity is implausible because human genome contains only ~20,500 genes which cover whole proteins, not just immune receptors, in the body. This puzzle has been resolved by the gene recombination mechanism. Human genome has

multiple gene segments of V1, V2, ..., D1, D2, …, J1, J2, … regions for generating immune receptors. A specific receptor is then generated from the stochastic recombination (e.g., V2D2J1) of the segments, called VDJ recombination. In addition to the segment selection variability, nucleotide deletion and insertion happens during the recombination process. This stochastic recombination thus has huge capacity for generating diverse receptors to recognize numerous pathogens. Then, one following question is how the randomly-generated receptors recognize specific molecules. The success or failure of molecular recognition is determined by the binding energy between immune receptors and pathogen peptides. To model the recognition process, we considered the one-dimensional sequences of amino acids for receptors and peptides, and their pair-wise interaction energies by using the Miyazawa-Jernigan potential. Then, we have realized cross-reactivity in the molecular recognition: different receptors can recognize similar peptides, while similar receptors can recognize different peptides. Immunologists have already pointed out the importance of the cross-reactivity, because this concept can serve as a mechanism for explaining how finite receptor repertoire can cover infinitely many pathogens. However, we have recognized that the degree of cross-reactivity is heterogeneous between receptors. In other words, the distribution of cross-reactivity is broad. We reasoned that T-cell receptors have diverse amino acid compositions, leading to a broad spectrum of cross-reactivity in peptide binding. High/low cross-reactive T-cell receptors have more/less strongly interacting amino acids. Then, we investigated the target searching time of the natural T-cell repertoire and compared the target searching time between the high and low cross-reactive T-cell repertoires. According to our computational results, the natural T-cell repertoire is specific and sufficiently rapid in searching for certain targets. High cross-reactive and non-specific T cells require more time to unbind from incorrect targets, while low cross-reactive T cell receptors require more time to search for the correct targets. Our computational platform, which is based on molecular sequences and their pairwise binding energy, could be useful in further explorations of immunological recognition (Xu and Jo, submitted).

Interim Statement

When the Design Principles of Cellular Networks group was launched in 2012, I have aimed (i) to complete the mathematical modeling of pancreatic islets, and (ii) to expand new research subjects (machine learning and immunology). After five years, our group has successfully achieved the two goals.

Interim Plan

Two graduate students are now preparing their PhD defense with the above accomplishments. Mr. Juyong Song, who studied machine learning, plans to have his defense on December, 2017, and Ms. Jin Xu, who studied computational immunology, plans to have her defense in the spring semester, 2018.

List of attending Conferences, Seminars, School etc.

(1) Conferences

1. 2017 NIMS Joint Workshop on Interdisciplinary Research Connecting Mathematics and Biology, Daejeon
2. 2017 The 10th National Conference on Soft Matter and Biophysics Xiamen, China
3. 2016 Workshop on stochasticity and uctuations in small systems, Pohang
4. 2016 APCTP-ICTP joint workshop: Quantitative Life Sciences, Pohang
5. 2016 Machine learning and its application to speech recognition, Incheon

6. 2016 NetSci satellite symposium, Seoul
7. 2015 Korean Biophysical Society Meeting, KAIST, Daejeon
8. 2013 The Statphys25 satellite meeting: computational methods for bio and complex systems, Seoul
9. 2013 Quantitative Approach to Biological Complexity (QABC), Pohang

(2) Seminars

1. 2016 The 23rd Innovative Workshop on Soft/Bio Materials, Yeosu
2. 2015 Department of Medical Cell Biology, Uppsala University, Uppsala, Sweden
3. 2015 Diabetes and Nutritional Sciences Division, King's College London, London, UK
4. 2015 Colloquium, Department of Physics, POSTECH, Pohang
5. 2014 The 13th Innovative Workshop on Soft/Bio Materials, KAIST, Daejeon
6. 2014 Colloquium, Department of Physics, SKKU, Suwon
7. 2014 Graduate School of Medical Science and Engineering, KAIST, Daejeon
8. 2014 Department of Physics and Astronomy, Seoul National University, Seoul
9. 2014 APCTP Communication of Science, Culture and Art, Sobaeksan
10. 2013 National Institute for Mathematical Sciences (NIMS), Daejeon
11. 2013 Department of Physics and Astronomy, Seoul National University, Seoul
12. 2013 The 3rd Innovative Workshop on Soft/Bio Materials, Changwon National University, Changwon
13. 2013 Colloquium, Department of Physics, Chonbuk National University, Jeonju
14. 2013 Colloquium, Department of Biomedical Engineering, UNIST, Ulsan
15. 2012 The 72nd Statphys Monthly Meeting, KIAS, Seoul
16. 2012 Department of Physics, Korea University, Seoul
17. 2012 Department of Life Sciences, POSTECH, Pohang
18. 2012 Department of New Biology, DGIST, Daegu

(3) Schools

1. 2017 Biophysics Summer School, What does physics do for understanding life, Pohang
2. 2016 Biophysics Summer School, Information and Energy in Life, Pohang
3. 2015 Biophysics Summer School, Information Processing in Life, Pohang
4. 2014 Biophysics Summer School, Information of Life, Pohang

List of Publications

1. Lee B, Song T, Lee K, Kim J, Berggren PO, Ryu SH, and Jo J. Insulin modulates the frequency of Ca2+ oscillations in mouse pancreatic islets, PLoS ONE, 12:e0183569 (2017b)

2. Xu J, Park DH, and Jo J. Local complexity predicts global synchronization of hierarchically networked oscillators, Chaos, 27:073116 (2017)

3. Park DH, Song T, Hoang DT, Xu J, and Jo J. A local counter-regulatory motif modulates the global phase of hormonal oscillations, Scientific Reports, 7:1602 (2017)

4. Lee B, Song T, Lee K, Kim J, Han S. Berggren PO, Ryu SH, and Jo J. Phase modulation of insulin pulses enhances glucose regulation and enables inter-islet synchronization, PLoS ONE, 12:e0172901 (2017a)

5. Hoang DT, Hara M, and Jo J. Design principles of pancreatic islets: glucose-dependent coordination of hormone pulses, PLoS ONE, 11:e0152446 (2016)

6. Pastor M, Song J, Hoang DT, and Jo J. Minimal perceptrons for memorizing complex patterns, Physica A, 462:31-37 (2016)

7. Hoang DT, Venkatech BP, Han S, Jo J, Watanabe G, and Choi MS. Scaling law for irreversible entropy production in critical systems, Scientific Reports, 6:27603 (2016)

8. Hoang DT, Jo J, and Hong H. Traveling wave in a three-dimensional array of conformist and contrarian oscillators, Phys Rev E, 91:032135 (2015)

9. Grapov D, Fahrmann J, Hwang J, Poudel A, Jo J, Periwal V, Fiehn O, and Hara M. Diabetes associated metabolic perturbations in NOD mice, Metabolomics, 11:425-437 (2015)

10. Hoang DT, Matsunari H, Nagaya M, Nagashima M, Millis JM, Witkowski P, Periwal P, Hara M, and Jo J. A conserved rule for pancreatic islet organization, PLoS ONE, 9:e110384 (2014)

11. Song J, Jo J_, Hoang DT, and Kim J. Population balancing with species switching. J Korean Phys Soc, 61:111-116 (2014)

12. Kim J and Jo J. An exactly solvable correlated stochastic process in _nite time. Physica A, 406:230-235 (2014)

13. Hoang DT, Song J, and Jo J. Partial mixing phase of binary cells in _nite systems. Phys Rev E, 88:062725 (2013)

14. Hong H, Jo J, and Sin SJ. Stable and exible system for glucose homeostasis. Phys Rev E, 88:032711 (2013)

15. Koh DS, Moody M, and Jo J. Collection of islets of Langerhans using an equilibrium method. Biotechniques, 55:34-37 (2013)

16. Wang X, Misawa R, Zielinski MC, Cowen P, Jo J, Periwal V, Ricordi C, Khan A, Szust J, Shen J, Millis JM, Witkowski P, and Hara M. Regional di_erences in islet distribution in the human pancreas - preferential beta-cell loss in the head region in patients with type 2 diabetes. PLoS ONE, 8:e67454 (2013)

17. Jo J, Hornblad A, Kilimnik G, Hara M, Ahlgren U, and Periwal V. The fractal spatial distribution of pancreatic islets in three dimensions: a self-avoiding growth model. Phys Biol, 10:036009 (2013)

Manuscripts under review

1. Song J, Marsili M, and Jo J_. Emergence and relevance of criticality in deep learning. arXiv:1710.11324 (submitted)

2. Hoang DT, Song J, Periwal V_, and Jo J_. Maximizing weighted Shannon entropy for network inference with little data. arXiv:1705.06384 (submitted)

3. Xu J and Jo J_. Broad cross-reactivity of the T-cell repertoire achieves specific and sufficiently rapid target searching. arXiv:1712.04633 (submitted)

Book Chapters

1. Jo J and Ghim CM. "Design" principles of intracellular biological circuits. Physics and High Technology, 25:7-12 (2016)

2. Jo J, Striegel DA, Hara A, and Periwal V. Mathematical modeling of islet generation, degeneration and regeneration (Pancreatic islet biology edited by Hardikar AA), Springer (2016)

3. Jo J, Shreif Z, Gaillard JR, Arroyo M, Cushman SW, and Periwal V. Mathematical models of adipose tissue dynamics (Studies in mechanobiology, tissue engineering and biomaterials edited by Amit Gefen), Springer (2013)

Comments

(1) In what ways could APCTP be improved?

The Junior Research Group (JRG) program provides an excellent opportunity for young researchers to maximize their research potentials as independent groups. I have really enjoyed the opportunity and obtained some achievements. Nevertheless, I frequently observed that JRG leaders including me had hard time to attract good students and postdocs to APCTP. I think APCTP needs to demonstrate that the institute is a really prestigious place for doing good science in Korea. To do this, as discussed many times, Senior Research Groups (SRGs) with established scientists are necessary to synergize with JRGs. APCTP runs many good workshop/school programs, which are the unique opportunity for the in-house researchers to interact with many people. If APCTP strengthens the in-house research program with JRGs and SRGs, APCTP may become the research hub in Korea, beyond just the meeting hub. To attract more good researchers, providing competitive salary and pleasant research space are also important issues. I know that APCTP has put enormous efforts to establish the SRG program and its own physical space. As a former APCTP member, I have fully realized the necessity. I hope these dreams are realized in the near future.

(2) Please add comments on living and study environments at APCTP.

APCTP has provided an excellent housing and office for JRG leaders. I liked it, but I have been felt sorry to our students and postdocs who are working hard in windowless offices. As proposed before, it may help to move them to visitor offices (having windows). Temporal visitors may accept the windowless offices for a few days. However, again, I hope APCTP has its own building with enough spaces soon.

Date: Dec. 15, 2017
Name: Junghyo Jo

Signature: 

Final Report 02

Particle Physics and the Early Universe

Personal Data

- Name: Chang Sub Shin
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- Period: Sep. 1, 2016 – Oct. 31, 2017

Main Research Fields

The group was performing systematic studies to answer the following questions.

1) What is the nature of dark matter and its cosmological implication?

2) What is the origin of matter-antimatter asymmetry and how can we identify it by experiments?

3) What is the correct solution to the fine-tuning problems in the Standard Model (SM) of particle physics, and its unavoidable consequences?

It is still unclear the form of new sector beyond the SM, because of no clear hint on that. The null results of the several experiments are stimulating to extend our understanding of new physics, and various possibilities are actively studied compared to several years ago. Their observable consequences are very interesting. One of the great hopes is that on-going and planned cosmological observations of CMB, gravitational waves, large and small scale structure can provide the information about the details of new sector and early history of the Universe. The systematic study on such possibilities is most important goal of the group, "particle physics and the early Universe".

Topics of Research

During my period of research in APCTP, the following topics were specially studied.

- Thermal evolution of WIMP dark matters
- Observable baryogenesis scenarios
- Phenomenological understanding of new solutions to the hierarchy problems

Summary of Research

In this section, I will state summary of research by explaining the motivations and achievement of our published papers for each topics in section III

(1) Thermal evolution of WIMP dark matters

The WIMP (Weakly Interacting Massive Particle) dark matter is one of best candidates of dark matter. However, the experimental evidence for the particle nature of dark matter is still absent. We studied more observable WIMP dark matter scenario by considering non-trivial evolution of dark matter at the early

Universe. In this case, the detailed study on the distribution function of dark matter is crucial to determine its prediction at present Universe. In the work [Phys.Lett. B768 (2017) 292-298], we found that decoupling of elastic scattering could become very important to determine the relic density of dark matter unlike the conventional wisdom for the WIMP dark matter in which only chemical decoupling is important. Such a nontrivial dependence on elastic scattering rate gives more information on dark matter evolution at early Universe if we can detect it in the future.

(2) Observable baryogenesis

Baryogenesis based on new physics is necessary because the SM cannot predict a correct abundance of present baryon asymmetry. Usually, the baryon number is generated at high temperatures, so that it is really difficult to confirm or detect the prediction in low energy experiments. In the work [JHEP 1710 (2017) 177], we proposed a very simple effective model of baryogenesis in which the baryon asymmetry is generated at low temperature so that the possible connection between baryogenesis and observable effect on neutron-antineutron oscillation is made. In order to realize such scenarios, we found that the supersymmetric axion model is very natural to provide a good candidate of mother particle that decays at late time to generate an asymmetry. This is very natural set-up to relate the baryogenesis and observables.

(3) Phenomenological understanding of new solutions to the hierarchy problems

Recently the new solutions to the hierarchy problems are suggested, such as clockwork mechanism, and relaxion mechanism. There are lots of works to understand their nature and to make them more viable. We studied their effects on particle phenomenology such as effects on muon g-2, neutrino masses and strong CP problem in the SM. We found several interesting facts about the setup in series of papers [PRD accepted, Phys.Lett. B776 (2018) 222-226, JHEP 1801 (2018) 121], which were not explicitly captured by previous works.

List of attending Conferences, Seminars, School etc.

1. "Twin mechanism for baryon and dark matter asymmetries" Invited NAPP seminar (Seoul National University, Korea, Sep. 22, 2016)
2. "A map of the non-thermal WIMP" Invited talk at Dark Matter from aeV to ZeV: 3rd IBS-MultiDark-IPPP Workshop (Lumley Castle, UK, Nov. 21, 2016)
3. "A map of the non-thermal WIMP" Invited talk at Focus Workshop on Particle Physics and Cosmology (Daejeon IBS-CTPU, Korea, Dec. 6, 2016)
4. "Twin mechanism for baryon and dark matter asymmetries" Invited talk at High1-2017, IBS-KIAS Joint workshop on particle physics, and cosmology (High1 resort, Korea, Feb. 7, 2017)
5. "A map of the non-thermal WIMP" Invited CAU THEP LAB seminar (Chung-Ang University, Korea, Apr. 6, 2017)
6. "Theoretical overview of DM searches" Invited talk at 2nd KR-LHC TH-EXP Cross seminar (Seoul National University, Korea, May 26, 2017)
7. "General continuum clockwork" Invited talk at the 2017 CERN-CKC workshop: What's going on at the weak scale? (Jeju Island, Korea, Jun. 2, 2017)
8. "Beyond Standard Model and dark matter" Invited colloquium at Chonnam National University (CNU, Korea, Jun. 8, 2017)

9. "A map of the non-thermal WIMP" Invited seminar at LeCosPA (National Taiwan University, Taiwan, Jun. 19, 2017)

10. "Clockwork theories" Invited lecture in the 1st snail lecture in 2017 (Yonsei University Korea, Jun. 24, 2017)

11. "General Continuum Clockwork" Invited talk at The 13th International Workshop on the Dark Side of the Universe (CTPU-IBS, Korea, Jul. 14, 2017)

12. "General Continuum Clockwork" Invited talk at Dark Matter and the LHC (NCTS Lecture Room, Taiwan, Aug. 30, 2017)

13. "Clockwork axion and its continuum limit" Invited talk at Light Dark World 2017 (University of Pittsburgh, USA, Oct. 20, 2017)

List of Publications

1. Hyungjin Kim, Jeong-Pyong Hong, Chang Sub Shin, "A map of the non-thermal WIMP", Published in Phys.Lett. B768 (2017) 292-298

2. Deog Ki Hong, Du Hwan Kim, Chang Sub Shin, "Clockwork graviton contributions to muon g-2", Accepted by Phys.Rev. D

3. Seong Chan Park, Chang Sub Shin, "Clockwork seesaw mechanisms", Published in Phys.Lett. B776 (2018) 222-226

4. Lorenzo Calibbi, Eung Jin Chun, Chang Sub Shin, "LSP baryogenesis and neutron-antineutron oscillations from R-parity violation", Published in JHEP 1710 (2017) 177

5. Kwang Sik Jeong, Chang Sub Shin, "Peccei-Quinn Relaxion", Published in JHEP 1801 (2018) 121

Comments

(1) In what ways could APCTP be improved?

In the research-wise, the APCTP provides very good environment. Operating JRG is very unique in Korea and I enjoyed many things, and recommend for others to apply this positions. However, it seems still necessary to make APCTP as an independent research institute with in-house members and permanent research positions.

(2) Please add comments on living and study environments at APCTP.

I especially thank all devoted supports from administrative staffs.

Date: Feb. 20, 2018
Name: Chang Sub Shin

Signature: 

Final Report 03

Generation and Evolution of Cosmic Structure

Personal Data

- Name: Jinn-Ouk Gong
- Date of birth: 9 September 1976
- Nationality: Korea
- Email: jinn.ouk.gong@gmail.com

- Period: Nov. 1, 2012 – Oct. 31, 2017

Main Research Fields

My main research theme is to understand the generation and evolution of the cosmological perturbations. They are believed to be generated in the very early universe, presumably during primordial cosmic inflation, and later become the seed of the observable structure such as the temperature fluctuations in the cosmic microwave background (CMB) and the large-scale distribution of galaxies (large-scale structure, LSS). With precise upcoming cosmological observations ahead, my foci are to study non-linear processes quantitatively and to provide a coherent picture on the evolution of the universe.

Topics of Research

My research topics include, but not limited to, the following:

- Cosmic inflation (model building, quantum field theory of inflation…)
- Primordial perturbations (inflationary / non-inflationary…)
- Structure formation (relativistic theory, Boltzmann equation…)
- Particle cosmology (dark matter, Higgs stability, effective field theory…)

Summary of Research

The summary of my past researches, categorized in terms of broad perspectives, is as follows:

(1) Formalism of non-linear perturbations

As current observational data indicates, cosmological perturbations may include initial non-linearities large enough to be detected in future experiments. To study non-linear perturbations systematically, I have employ various approaches: a geometric identity called the delta-N formalism, non-linear Einstein equation that can be solved order by order, and the action formulation of the primordial perturbation fields. Each method has its own pros and cons. Thus we need to employ all these approaches to fully understand the physics of non-linear perturbations, since one complements the others.

I have tried to clarify and understand close relations between these formalisms coherently beyond individual applications. I am particularly interested in linking directly the primordial perturbation produced during inflation using the action formulation and the matter inhomogeneity which leads to galaxy formation using the Einstein equation at non-linear level.

(2) Cosmological implications for particle physics

The standard model of particle physics, experimentally well established with great precision, is regarded as a low-energy effective theory. With the null detection of any signatures for new physics beyond the standard model of particle physics from terrestrial accelerator experiments, we are led to make use of the universe as a huge particle accelerator that probed an extremely high energy in the distant past. Thus cosmology can provide complementary and critical information for particle physics.

I am particularly interested in the roles played by additional degrees of freedom ubiquitous in theories beyond the standard model. Inflation is a representative phenomenon they can give rise to, but they can also change thermal history of the universe after inflation. I will study the possible observational signatures they can leave, like isocurvature perturbation, which will be a powerful probe to the properties of new physics. Meanwhile, it is also extremely interesting to study the constraints on the early universe placed by the current particle experiments. I am interested in the role of the Higgs boson, whose stability can place a bound on the energy scale of inflation compatible to or even stronger than the current one from cosmological observations.

(3) Application of methods in theoretical physics to cosmology

Many theoretical tools in modern physics have been proved extremely powerful in both predicting observational signatures and providing deep insights into physical phenomena. They can be applied to cosmology as well to provide alternative viewpoints to the conventional approaches and can serve as useful tools for predicting new observational signatures. A good example is the effective field theory for inflation.

I have applied various methods in theoretical physics to cosmology. One interesting issue is to study the consistency relations in multi-field inflation in the context of space-time symmetries. The space-time symmetries, which lead to a cosmological Ward-Takahashi identity, cannot absorb all the matter degrees of freedom during multi-field inflation. Thus the new consistency relations, coming from the improved Ward-Takahashi identity, are sensitive to the structure of multi-field inflation.

(4) Accurate theoretical modeling of non-linear clustering

LSS observations can provide the measurements of geometrical distances, growth of structure and the shapes of the primordial correlation functions. They can also break the degeneracies among cosmological parameters. Furthermore, the full 3-dimensional information with a huge redshift coverage available for the LSS observations naturally yields measurements of the properties of dark energy, neutrino and the physics of the early universe. Understanding non-linearities accurately for LSS is essential to make full and proper use of future data from ongoing and planned galaxy surveys.

I am very interested in using galaxies to study the properties of the primordial perturbations. This is because the density perturbation field that develops galaxies is sensitive to the non-linear primordial perturbations. Combined with the gauge-invariant geodesic approach for the photons from galaxies, this will turn out to be a truly innovative way of studying the early universe by LSS observations. These studies also provide crucial information on the pure general relativistic non-linear effects.

List of attending Conferences, Seminars, School etc.

I have participated in a number of domestic and international conferences during my tenure at APCTP. To list only a few selected meetings:

1. COSMO-17, Paris, France, 28 Aug – 1 Sep 2017
2. Understanding cosmological observations, Centro de Ciencias de Benasque, Benasque, Spain, 31 Jul – 4 Oct 2017
3. International Symposium on Gravitational Waves, Beijing, China, 25 – 29 May 2017
4. New Perspectives on Cosmology, APCTP, Korea, 13 – 17 Feb 2017
5. COSMO 2016, Ann Arbor, Michigan, USA, 8 – 12 Aug 2016
6. Dark Side of the Universe 2016, Bergen, Norway, 25 – 29 Jul 2016
7. New Perspectives on Cosmology, APCTP, Korea, 4 – 8 Jan 2016
8. CosPA 2015, IBS, Daejeon, Korea, 12 – 16 Oct 2015
9. Workshop on High Energy Physics Phenomenology, Indian Institute of Technology, Kanpur, India, 6 – 12 Dec 2015
10. 2nd APCTP-TUS workshop on Dark Energy, Tokyo University of Science, Tokyo, Japan, 3 – 5 Aug 2015
11. CosPA 2014, Auckland, New Zealand, 8 – 12 Dec 2014
12. Cosmology after Planck, MPA, Munich, Germany, 1 – 19 Sep 2014
13. 1st APCTP-TUS workshop on Dark Energy, APCTP, Pohang, Korea, 2 – 5 Jun 2014
14. New Perspectives on Cosmology, Hong Kong University of Science and Technology, Hong Kong, 19 – 23 May 2014
15. Effective field theory in inflation, Lorentz Center, Leiden, the Netherlands, 5 – 9 Aug 2013
16. Gravity and Cosmology 2012, Yukawa Institute for Theoretical Physics, Kyoto, Japan, 18 Nov – 22 Dec 2012

List of Publications

1. Jinn-Ouk Gong and Misao Sasaki, "Squeezed primordial bispectrum from general vacuum state", published in Classical and Quantum Gravity 30, 095005 (Apr 2013)
2. Ana Achucarro, Jinn-Ouk Gong, Gonzalo Palma and Subodh P. Patil, "Correlating features in the primordial spectra", published in Physical Review D 87, 121301(R) (Jun 2013)
3. Vincent Desjacques, Jinn-Ouk Gong and Antonio Riotto, "Non-Gaussian bias: insights from discrete density peaks", published in Journal of Cosmology and Astroparticle Physics 09, 006 (Sep 2013)
4. Jinn-Ouk Gong, Shi Pi and Misao Sasaki, "Equilateral non-Gaussianity from heavy fields", published in Journal of Cosmology and Astroparticle Physics 11, 043 (Nov 2013)

5. Jinn-Ouk Gong and Tomo Takahashi, "Higher order non-linear parameters with PLANCK" published in Physical Review D 89, 023516 (Jan 2014)

6. Jinn-Ouk Gong, Koenraad Schalm and Gary Shiu, "Correlating correlation functions of primordial perturbations", published in Physical Review D 89, 063540 (Mar 2014)

7. Sang Gyu Biern, Jinn-Ouk Gong and Donghui Jeong, "Non-linear matter bispectrum in general relativity", published in Physical Review D 89, 103523 (May 2014)

8. Jinn-Ouk Gong, "Blue running of the primordial tensor spectrum", published in Journal of Cosmology and Astroparticle Physics 07, 022 (Jul 2014)

9. Yi-Fu Cai, Jinn-Ouk Gong and Shi Pi, "Inflation beyond T-models and primordial B-modes", published in Physics Letters B 738, 20-24 (Sep 2014)

10. Hassan Firouzjahi, Jinn-Ouk Gong and Mohammad Hossein Namjoo, "Scale-dependent hemispherical asymmetry from general initial state during inflation", published in Journal of Cosmology and Astroparticle Physics 11, 037 (Nov 2014)

11. Jinn-Ouk Gong, Min-Seok Seo and Spyros Sypsas, "Higher derivatives and power spectrum in effective single field inflation", published in Journal of Cosmology and Astroparticle Physics 03, 009 (Mar 2015)

12. Kenji Kadota, Jinn-Ouk Gong, Kiyotomo Ichiki and Takahiko Matsubara, "CMB probes on the correlated axion isocurvature perturbation", published in Journal of Cosmology and Astroparticle Physics 03, 026 (Mar 2015)

13. Jinn-Ouk Gong, Godfrey Leung and Shi Pi, "Probing reheating with primordial spectrum", published in Journal of Cosmology and Astroparticle Physics 05, 027 (May 2015)

14. Jinn-Ouk Gong, "Running of scalar spectral index in multi-field inflation", published in Journal of Cosmology and Astroparticle Physics 05, 041 (May 2015)

15. Jai-chan Hwang, Hyerim Noh, Donghui Jeong, Jinn-Ouk Gong and Sang Gyu Biern, "Non-linear power spectra in the synchronous gauge", published in Journal of Cosmology and Astroparticle Physics 05, 055 (May 2015)

16. Jinn-Ouk Gong and Misao Sasaki, "A new parameter in attractor single-field inflation", published in Physics Letters B 747, 390-394 (Jun 2015)

17. Dario Cannone, Jinn-Ouk Gong and Gianmassimo Tasinato, "Breaking discrete symmetries in the effective field theory of inflation" published in Journal of Cosmology and Astroparticle Physics 08, 003 (Aug 2015)

18. Xian Gao and Jinn-Ouk Gong, "Towards general patterns of features in multi-field inflation", published in Journal of High Energy Physics 08, 115 (Aug 2015)

19. Inyong Cho and Jinn-Ouk Gong, "Spectral indices in Eddington-inspired Born-Infeld inflation", published in Physical Review D 92, 064046 (Sep 2015)

20. Yi-Fu Cai, Jinn-Ouk Gong, Shi Pi, Emmanuel N. Saridakis and Shang-Yu Wu, "On the possibility of blue tensor spectrum within single field inflation", published in Nuclear Physics B 900, 517-532 (Oct 2015)

21. Ki-Young Choi, Jinn-Ouk Gong and Chang Sub Shin, "WIMP isocurvature perturbation and small scale structure", published in Physical Review Letters 115, 211302 (Nov 2015)

22. Jinn-Ouk Gong and Godfrey Leung, "Correlation of isocurvature perturbation and non-Gaussianity", published in Journal of Cosmology and Astroparticle Physics 12, 042 (Dec 2015)

23. Jaiyul Yoo and Jinn-Ouk Gong, "Relativistic effects and primordial non-Gaussianity in the matter density fluctuation", published in Physics Letters B 754, 94-98 (Mar 2016)

24. Jaiyul Yoo and Jinn-Ouk Gong, "Exact analytic solution for non-linear density fluctuation in a ΛCDM universe", published in Journal of Cosmology and Astroparticle Physics 07, 017 (Jul 2016)

25. Jinn-Ouk Gong, Min-Seok Seo and Gary Shiu, "Path integral for multi-field inflation", published in Journal of High Energy Physics 07, 099 (Jul 2016)

26. Stephen Appleby, Jinn-Ouk Gong, Dhiraj Kumar Hazra, Arman Shafieloo and Spyros Sypsas, "Direct search for features in the primordial bispectrum", published in Physics Letters B 760, 297-301 (Sep 2016)

27. Yi-Fu Cai, Jinn-Ouk Gong, Dong-Gang Wang and Ziwei Wang, "Features from the non-attractor beginning of inflation", published in Journal of Cosmology and Astroparticle Physics 10, 017 (Oct 2016)

28. Jinn-Ouk Gong, "Multi-field inflation and cosmological perturbations", invited review published in International Journal of Modern Physics D 26, 1740003 (Jan 2017)

29. Jinn-Ouk Gong, Naoya Kitajima and Takahiro Terada, "Curvaton as dark matter with secondary inflation", published in Journal of Cosmology and Astroparticle Physics 03, 053 (Mar 2017)

30. Guillem Domenech, Jinn-Ouk Gong and Misao Sasaki, "Consistency relation and inflaton field redefinition in the delta-N formalism", published in Physics Letters B 769, 413-417 (Apr 2017)

31. Jinn-Ouk Gong and Masahide Yamaguchi, "Correlated primordial spectra in effective theory of inflation", published in Physical Review D 95, 083510 (Apr 2017)

32. Jinn-Ouk Gong, Gonzalo A. Palma and Spyros Sypsas, "Shapes and features of the primordial bispectrum", published in Journal of Cosmology and Astroparticle Physics 05, 016 (May 2017)

33. Jinn-Ouk Gong and Naoya Kitajima, "Small-scale structure and 21cm fluctuations by primordial black holes", published in Journal of Cosmology and Astroparticle Physics 08, 017 (Aug 2017)

34. Jinn-Ouk Gong and Naoya Kitajima, "Cosmological stochastic Higgs field stabilization", published in Physical Review D 96, 063521 (Sep 2017)

35. Jinn-Ouk Gong, Jai-chan Hwang, Hyerim Noh, David Chan Ron Wu and Jaiyul Yoo, "Exact non-linear equations for cosmological perturbations", published in Journal of Cosmology and Astroparticle Physics 10, 027 (Oct 2017)

36. Jinn-Ouk Gong and Min-Seok Seo, "Consistency relations in multi-field inflation", published in Journal of Cosmology and Astroparticle Physics 02, 008 (Feb 2018)

Comments

(1) In what ways could APCTP be improved?

I think eventually APCTP should decide which direction it would eventually develop into: either an established research institute, or a research-support organization. The latter, such as the Aspen Center for Physics, has been an important function of APCTP and the current organization structure of APCTP is

optimized for that purpose: there is no decision made by APCTP in-house members, many external board and committee, and so on. I should emphasize that in such a form, no serious researcher regards APCTP as a research institute where original cutting-edge researches are conducted. If, however, APCTP is to develop into a research institute, permanent research members should be hired at any cost, even if the number of JRGs are significantly reduced for years. The decision should be made by the APCTP in-house members, and the role of external board and committee should be limited to advice and evaluation.

Date: 12 Feb, 2018
Name: Jihn-Ouk Gong

Signature: 

Final Report 04

Gauge/gravity Duality and String Theory

Personal Data

- Name: Chanyong Park
- Date of birth: 1971.11.06
- Nationality: Korea
- Email: chanyong.park@apctp.org
- Period: Oct. 19, 2015. – Feb. 28, 2018

Main Research Fields

- String theory
- Gauge/gravity duality and its applications
- Holographic renormalization group flow

Topics of Research

- Holographic entanglement entropy and its renormalization group flow
- Holographic hadrons in the nuclear medium
- Emergent geometries of real condensed matter systems
- Entanglement entropy of strongly interacting systems and its RG flow
- Holographic transport coefficients with a momentum relaxation

Summary of Research

In order to understand non-perturbative aspects of strongly interacting systems, the AdS/CFT correspondence was conjectured as a very useful tool in string theory. Interests of our group were to understand the underlying structure of the AdS/CFT correspondence in depth and to generalize it to the gauge/gravity duality defined on the non-AdS geometry. Those researches are very helpful to investigate the physical properties of a strongly interacting system like quantum chromodynamics (QCD) and condensed matter theory (CMT). Furthermore, by using the concepts and technologies obtained in our research we tried to understand the renormalization group (RG) flow of an interacting quantum field theory (QFT), which might provide some hints to figure out the occurrence of new macroscopic laws from a fundamental microscopic theory.

Interim Statement

Our research activities were mainly focused on how we can understand an one-dimensional higher gravity theory from the dual quantum field theory point of view. This topic is important to understand

more realistic strongly interacting systems of nuclear and condensed matter physics at low energy scale. In the strong coupling regime, in general, the traditional and well-established perturbation technique of quantum field theory does not work, so that we need a new non-perturbative way to figure out such strongly interacting systems. In this situation, people hope that the gauge/gravity duality can shed light on explaining such strongly interacting systems. In spite of such hope, there are still many obstacles in applying the gauge/gravity duality to real nuclear and condensed matter systems. One of the most important issues is how to construct the dual gravity of real nuclear and condensed matter systems.

Interim Plan

Although we succeed in reconstructing the dual geometry of the transverse Ising and Kondo models, there still remains many interesting issues to clarify the gauge/gravity duality. One of them is how we can obtain the Einstein equation of the dual gravity consistent with the renormalization group flow of the dual quantum field theory. Based on our recent works, we will further investigate the underlying structure of the gauge/gravity duality and apply the concepts and techniques to real strongly interacting systems of nuclear and condensed matter.

List of attending Conferences, Seminars, School etc.

1. Workshop on Fields, Strings, and Gravity, KIAS (Korea), Feb. 2016
2. 100+1 General Relativity Meeting, Jeju Univ. (Korea), Apr. 2016
3. "Holographic entanglement entropy in a deformed CFT", NCTS (Taiwan), May, 2016
4. Lecture Series on Real-space renormalization group approach, APCTP (Korea), June, 2016
5. Quantum Matter, Spacetime and Information, YITP (Japan), June, 2016
6. Holography and Topology of Quantum Matter, APCTP (Korea), Aug. 2016
7. The 2nd Sogang-Jeju Joing Workshop on Quantum Spacetime, Jeju Univ. (Korea), Oct. 2016
8. 2016 KPS Fall Meeting, Kwangju (Korea), Oct. 2016
9. 1st IBS Brainstorm Workshop, SNU (Korea), Oct. 2016
10. 2nd IBS Brainstorm Workshop, Pohang (Korea), Dec. 2016
11. 3rd IBS Brainstorm Workshop, Pohang (Korea), Feb. 2017
12. 100+2 General Relativity & Beyond Meeting, Jeju Univ. (Korea), Mar. 2017
13. 2017 KPS Spring Meeting, Daejon (Korea), Apr. 2016
14. International Conference on Gravitation, Ewha Womans Univ. (Korea), July, 2017
15. "ANISOTROPIC DYONIC BLACK BRANE AND ITS EFFECTS ON HYDRODYNAMICS", Hanyang Univ. (Korea), July, 2017
16. Discrete Approaches to the Dynamics of Fields and Space-Time, APCTP (Korea), Sep. 2017
17. 2017 KPS Fall Meeting, Kyungju (Korea), Oct. 2017

18. NCTS Annual Theory Meeting 2017: Particles, Cosmology and Strings, NCTS (Taiwan), Dec, 2017

19. "ENTANGLEMENT ENTROPY IN A QUARK MEDIUM", NCTS (Taiwan), Dec, 2017

List of Publications

1. Chanyong Park, "Logarithmic corrections to the entanglement entropy", Physical Review D 92 (2015) 126013

2. Chanyong Park, "Thermodynamic law from the entanglement entropy bound", Physical Review D 93 (2016) 086003

3. Ki-Seok Kim and Chanyong Park, "Emergent geometry from field theory: Wilson's renormalization group revisited", Physical Review D 93 (2016) 121702

4. Chanyong Park, "Meson's Correlation Functions in a Nuclear Medium", Physics Letters B 760 (2016) 79

5. Sunly Khimphun, Bum-Hoon Lee, and Chanyong Park, "Conductivities in an anisotropic medium", Physical Review D 94 (2016) 086005

6. Chanyong Park, "On black hole thermodynamics with a momentum relaxation", Classical and Quantum Gravity 33 (2016) 245017

7. Bum-Hoon Lee, Siyoung Nam and Chanyong Park, "Holographic trace anomaly at finite temperature", Journal of the Korean Physical Society, Vol. 70, No. 1 (2017) 34

8. Ki-Seok Kim and Chanyong Park, "Renormalization group flow of entanglement entropy to thermal entropy", Physical Review D 95 (2017) 106007

9. Youngman Kim, Bum-Hoon Lee, D.G. Pak, Chanyong Park, and Takuya Tsukioka, "Quantum stability of nonlinear wave type solutions with intrinsic mass parameter in QCD", Physical Review D 96 (2017) 054025

10. Sunly Khimphun, Bum-Hoon Lee, Chanyong Park, and Yun-Long Zhang, "Anisotropic dyonic black brane and its effects on holographic conductivity", Journal of High Energy Physics 1710 (2017) 064

11. Ki-Seok Kim, Miok Park, Jaeyoon Cho, and Chanyong Park, "Emergent geometric description for a topological phase transition in the Kitaev superconductor model", Physical Review D 96 (2017) 086015

12. Yunseok Seo, Geunho Song, Chanyong Park, and Sang-Jin Sin, "Small Fermi Surfaces and Strong Correlation Effects in Dirac Materials with Holography", Journal of High Energy Physics 1710 (2017) 204

13. Bum-Hoon Lee, Chanyong Park and, Sunyoung Shin, "Vacua and Walls of mass-deformed K\"{a}hler nonlinear sigma models on SO(2N)/U(N)", Physical Review D 96 (2017) 105017

14. Sunly Khimphun, Bum-Hoon Lee, Chanyong Park, Yun-Long Zhang, "Rindler fluid with weak momentum relaxation", Journal of High Energy Physics 01 (2018) 058

15. Chanyong Park and Jung Hun Lee, "Nucleon form factors in the nuclear medium", International Journal of Modern Physics A Vol. 33, No. 2 (2018) 1850016

Comments

(1) In what ways could APCTP be improved?

I convince that Asia Pacific Center for Theoretical Physics (APCTP) made a significant contribution to the development of theoretical physics by providing excellent research environments to JRG leaders and researchers. The JRG leader, unfortunately, is limited to a maximum of five years, so there is a serious constraint for each group to continue in-depth research and lead in the latest research results in each area. If there will be more chances for JRG leaders to continue their researches at APCTP, I do not doubt that APCTP will be positioned as a leading institute for theoretical physics in the world beyond Asia.

(2) Please add comments on living and study environments at APCTP.

Research and residential environments provided by APCTP were excellent, and they were also helpful to concentrate on research. I believe that such supports from APCTP will be instrumental for new JRG leaders to carry out intensive and continuous researches.

Date: 2018.02.19
Name: Chanyong Park

Signature: 

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 13, Issue 1 ~ Issue 12
- number of articles by section (total 96 articles):
  APCTP People(6), APCTP Plaza(11), Cross Street(23), Book Review(12), SF Review(10), Science Fiction(12), Special Section(1), APCTP Everywhere(21)

(3) Number of visitors and page views

Item	2015	2016	2017
Visitors	248,464	354,513	551,616
Page Views	414,769	551,141	742,163

(4) Number of visitors worldwide

Year	2015	2016	2017
USA	123,679	175,747	216,785
Korea	74,222	113,591	197,248
Canada	18,016	28,958	50,738
Beijing	2,511	3,815	7,507
UK	186	3,067	5,773
Japan	658	990	3,659
Germany	633	982	773
Etc.	28,559	27,363	69,133
Total	**248,464**	**354,513**	**551,616**

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	Junggeun Oh (NIMS)	53
Science Books Lectures(II)	Mar.9	Sungook Hong (Seoul Nat'l Univ.)	61
Science Books Lectures(III)	Mar.16	Jeongmo Yi (Seoul Science Center)	52
Science Books Lectures(IV)	Mar.23	Sang Wook Kim (Pusan Nat'l Univ.)	65
Science Books Lectures(V)	Mar.30	Jihoon Jeong (Kyunghee Cyber Univ.)	57
Science Books Lectures(VI)	Jul.20	Jinho Cho (Korean Minjok Leadership Academy)	76
Science Books Lectures(VII)	Aug.10	Sin Yeong Yoon (Donga Science)	32
Science Books Lectures(VIII)	Aug.17	Myunghyun Rhee (Science Writer)	50
Science Books Lectures(IX)	Aug.24	Gang Yeong Lee (Gyeongsang Nat'l Univ.)	49
Science Books Lectures(X)	Aug.31	Seungwoo Son (Hanyang Univ.)	43
Communication of Science, Culture and Art (Venue: Sobaeksan Optical Astronomy Observatory)			
Communication of Science, Culture and Art(I)	Jul.6-Jul.8	Jeakweon Han (Hanyang Univ.) & Younseal Eum (Sookmyung Women's Univ.)	24
Communication of Science, Culture and Art(II)	Nov.2-Nov.4	Hang Bae Kim (Hanyang Univ.) & Hojun Song (Artist)	26

Science Fiction Symposium (Venue: Dongasia Books)			
Science Fiction Symposium	Nov.22	Sang-Joon Park(Seoul SF Archive) & Changgyu Kim(Writer)	6
Public Lecture (Venue: POSCO International Center)			
Public Lecture	Dec. 16	Taegeun Song (POSTECH)	143
Total			**737**

Science Books Lectures

Communication of Science, Culture and Art

Science Fiction Symposium

Public Lecture

“Best Science Book 10” selected by APCTP (December 2017)

The best science books are selected and promoted by APCTP for a wide readership. To announce the list and to express gratitude for supporting the APCTP, the ‘Asia Pacific Network Evening’ was held on December 8, 2017 at APCTP Headquarters, Pohang.

No	Title	The date of Issue	Author
1	Making Hope Out of Sorrow	Sep. 13, 2017	Seung-sup Kim
2	Lab Girl	Feb. 16, 2017	Hope Jahren
3	The Information	Jan. 18, 2017	James Gleick
4	Ultra Sociality	Jun. 19, 2017	Dae-Ik Jang
5	The Neuroscience Lab	Sep. 29, 2017	Minryung Song
6	Universe, Spacetime and Matter	Feb. 20, 2017	Hang Bae Kim
7	The Birth of Intelligence	Apr. 13, 2017	Dae Yeol Lee
8	The Echo of Big Bang	Oct. 15, 2017	Kang-hwan Lee
9	The Science of Curiosity	Dec. 20, 2016	Jae Jun Yu
10	The Gene : An Intimate History	Mar. 6, 2017	Siddhartha Mukherjee

Science Communication School

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

- Topic: Artificial Intelligence
- Period: February 1 ~ 3, 2017
- Venue: APCTP Headquarters, Pohang
- Participants: 24 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: The Quantum Universe
- Period: October 28, 2017
- Venue: POSCO International Center
- Speaker: Viatcheslav Mukhanov (Arnold Sommerfeld Center for Theoretical Physics)
- Participants: 250 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: Make Future, Play Science!
- Period: November 11 ~ 12, 2017
- Venue: Pohang Sports Complex
- Participants: around 40,000 persons

VI. List of Publications

1. Publications Summary

2. Publications of Scientific Activities

3. Publications of Research Programs

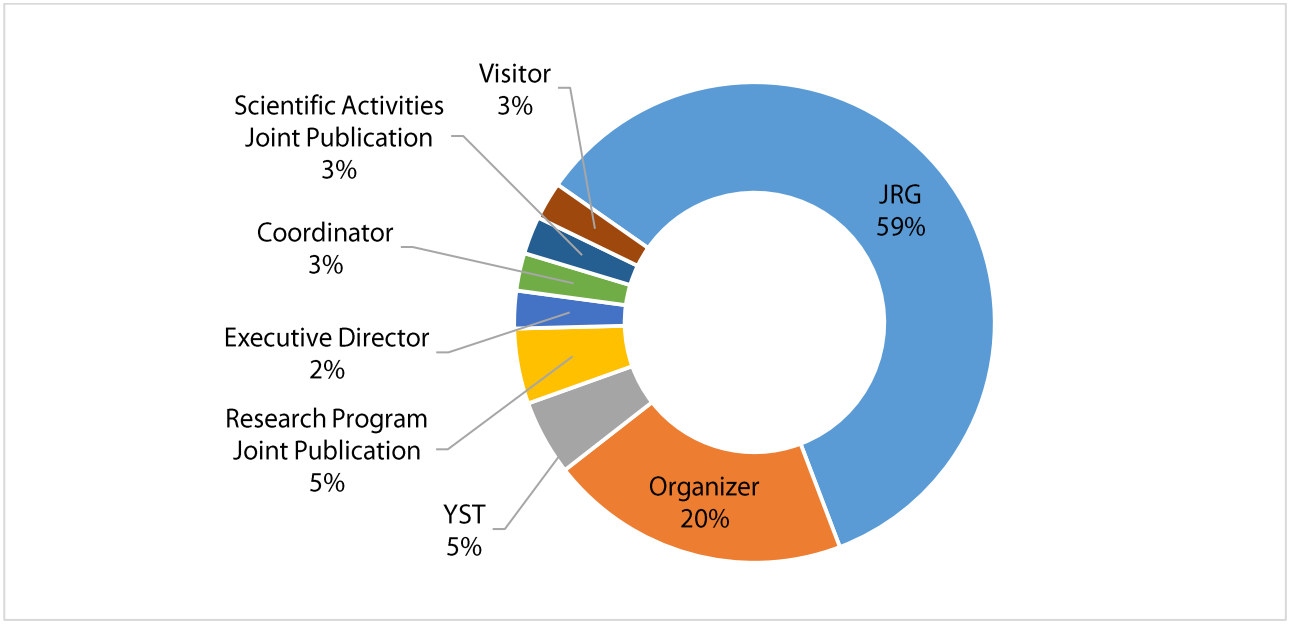
1. Publications Summary

Number of Publications

Program	No. of Publications			SCI	Impact Factor
	Total	Author Category	No.		
Scientific Activities	22	Executive Director	2	100 %	3.6085
		Coordinator	2		
		Organizer	16		
		Joint Publication*	2		
Research Program	57	JRG	47	100 %	4.6325
		YST	4		
		Visitor	2		
		Joint Publication*	4		
Total	79	-	79	100 %	4.347

*a publication belongs to multiple categories.

Ratios by Author Category



2. Publications of Scientific Activities

Number of Publications: 22

No.	Category	Journal	Authors	Article
1	Executive Director	Human Brain Mapping	Heonsoo Lee, **Woo-Sung Jung** and 7 others	Diversity of Functional Connectivity Patterns is Reduced in Propofol-Induced Unconsciousness
2	Executive Director	Neuroscience Letters	Jisung Wang, **Woo-Sung Jung** and 6 others	Suppressed neural complexity during ketamine- and propofol-induced unconsciousness
3	President, Visitor	International Journal of Modern Physics A	**Bum-Hoon Lee**, Youngman Kim, **D. G. Pak**, Takuya Tsukioka, P. M. Zhang	Gauge invariant gluon spin operator for spinless nonlinear wave solutions
4	Coordinator	Physical Review C	Yeunhwan Lim, **Yongseok Oh**	Nuclear energy density functional and the nuclear α decay
5	Coordinator	Physical Review D	Byung-Geel Yu, **Yongseok Oh**, Kook-Jin Kong	Regge approach to the reaction of γn →k∗ Λ
6	Organizer	Modern Physics Letters A	**Seung-il Nam**	Quasi-distribution amplitudes for pion and kaon via the nonlocal chiral-quark model
7	Organizer	Physical Review D	**Seung-il Nam**	Photo- and electroproduction of Λ(1405)via γ(*)p→K+π+Σ−
8	Organizer	Journal of the Korean Physical Society	**Seung-il Nam**, Chung-Wen Kao	QCD topological susceptibility from the nonlocal chiral quark model
9	Organizer	Journal of the Physical Society of Japan	Chung Wen Kao, Dong Jing Yang, Wen Chen Chang, Fu Jun Jiang, **Seung-il Nam**	Consistency check of charged hadron multiplicities and fragmentation functions in SIDIS
10	Organizer	Journal of the Physical Society of Japan	Chung Wen Kao, Dong Jing Yang, Wen Chen Chang, Fu Jun Jiang, **Seung-il Nam**	Consistency Check of Charged Hadron Multiplicities and Fragmentation Functions in SIDIS
11	Organizer, President, Visitor	Physical Review D	**Seoktae Koh, Bum-Hoon Lee, Gansukh Tumurtushaa**	Reconstruction of the Scalar Field Potential in Inflationary Models with a Gauss-Bonnet term
12	Organizer	Applied Physics Letters	Su Jin Lim, **Myung Chul Choi**, Byung Mook Weon, Bopil Gim	Lattice Boltzmann simulations for water coalescence

No.	Category	Journal	Authors	Article
13	Organizer	Methods in Cell Biology	Peter J.Chung, **Myung Chul Choi** and 6 others	Chapter 8 - Synchrotron small-angle X-ray scattering and electron microscopy characterization of structures and forces in microtubule/Tau mixtures
14	Organizer	Current Applied Physics	Suho Lee, Dae-Woong Jeong, **Myung Chul Choi**	Vertical order of DPPC multilayer enhanced by cholesterol-induced ripple-to-liquid ordered (LO) phase transition: Synchrotron X-ray reflectivity study
15	Organizer	Physical Review D	**Ki-Young Choi**, Tomo Takahashi	New bound on low reheating temperature for dark matter in models with early matter domination
16	Organizer	Physical Review D	**Hyeong-Chan Kim**	Heat capacity of a self-gravitating spherical shell of radiations
17	Organizer	Physical Review D	Yeong-Bok Bae**, Hyung Mok Lee, Gungwon Kang**, Jakob Hansen	Gravitational radiation driven capture in unequal mass black hole encounters
18	Organizer	Physical Review Letters	**Yunseok Seo**, Geunho Song, Philip Kim, Subir Sachdev, Sang-Jin Sin	Holography of the Dirac Fluid in Graphene with Two Currents
19	Organizer	Plasma Sources Science and Technology	Min Uk Lee, Jimo Lee, Jae Koo Lee, **Gunsu S Yun**	Extended scaling and Paschen law for micro-sized radiofrequency plasma breakdown
20	Organizer	Journal of High Energy Physics	Kang-Sin Choi, **Soo-Jong Rey**	E(lementary)-strings in six-dimensional heterotic F-theory
21	Organizer	Journal of High Energy Physics	Kanghoon Lee, **Soo-Jong Rey**, Yuho Sakatani	Effective action for non-geometric fluxes duality covariant actions
22	Organizer	Physics Letters B	**Ki-Young Choi**, Kenji Kadota, Inwoo Park	Constraining dark photon model with dark matter from CMB spectral distortions

3. Publications of Research Programs

Number of Publications: 57

No.	Category	Journal	Authors	Article
1	JRG	Scientific Reports	**Jaeyoon Cho**, Kun Woo Kim	Quantum phase transition and entanglement in topological quantum wires
2	JRG	Scientific Reports	**Dong-Ho Park, Taegeun Song, Danh-Tai Hoang, Jin Xu, Junghyo Jo**	A Local Counter-Regulatory Motif Modulates the Global Phase of Hormonal Oscillations
3	JRG	Journal of High Energy Physics	Yan Gobeil, BumHoon Lee, Wonwoo Lee, Richard MacKenzie, Manu B. Paranjape, Urjit A. Yajnik, **Donghan Yeom**	Tunneling decay of false vortices with gravitation
4	JRG	Journal of High Energy Physics	Yunseok Seo, Geunho Song, **Chanyong Park**, Sang-Jin Sin	Small Fermi surfaces and strong correlation effects in Dirac materials with holography
5	JRG	Journal of High Energy Physics	Lorenzo Calibbi, Eung Jin Chun, **Chang Sub Shin**	LSP baryogenesis and neutron-antineutron oscillations from R-parity violation
6	JRG	Physical Review Letters	Seokhwan Choi, **Alireza Akbari** and 11 others	Correlation of Fe-Based Superconductivity and Electron-Phonon Coupling in an FeAs/ Oxide Heterostructure
7	JRG	Physical Review Letters	**Sukjin Yoon, Watanabe Gentaro**	Pairing Dynamics of Polar States in a Quenched p -Wave Superfluid Fermi Gas
8	JRG	Journal of High Energy Physics	Jaemo Park, **Hyeonjoon Shin**	Notes on worldvolume supersymmetries for D-branes on AdS5×S5 background
9	JRG	Physical Review E	Jaeyoung Kwak, **Hang-Hyun Jo**, Tapio Luttinen, Iisakki Kosonen	Jamming transitions induced by an attraction in pedestrian flow
10	JRG	The European Physical Journal C	Bogeun Gwak, **Daeho Ro**	Dilaton Field Released under Collision of Dilatonic Black Holes with Gauss-Bonnet Term
11	JRG	ACS Nano	Sangsik Kim, **Yongjin Lee** and 9 others	Salt Triggers the Simple Coacervation of an Underwater Adhesive When Cations Meet Aromatic π Electrons in Seawater

No.	Category	Journal	Authors	Article
12	JRG, YST	Journal of High Energy Physics	**Bakhmatov Ilya**, N.S. Deger, J. Gutowski, **E. Ó Colgáin**, H. Yavartanoo	Calibrated entanglement entropy
13	JRG	Journal of High Energy Physics	**Thiago R. Araujo**, Horatiu Nastase	Observables in the Guarino-Jafferis-Varela/CS-SYM duality
14	JRG	Chaos	**Jin Xu, Dong-Ho Park, Junghyo Jo**	Local complexity predicts global synchronization of hierarchically networked oscillators
15	JRG	Physics Letters B	Guillem Domènech, **Jinn-Ouk Gong**, Misao Sasakia	Consistency relation and inflaton field redefinition in the δN formalism
16	JRG	Nature Communic-ations	**Jaeyun Sung, Seunghyeon Kim, Josephine Jill T. Cabatbat**, Sungho Jang, Yong-Su Jin, Gyoo Yeol Jung, Nicholas Chia, **Pan-Jun Kim**	Global metabolic interaction network of the human gut microbiota for context-specific community-scale analysis
17	JRG	Physics Letters B	Hyungjin Kim, Jeong-PyongHong, **Chang SubShin**	A map of the non-thermal WIMP
18	JRG	Physical Review Letters	Fabian Lambert, **Alireza Akbari**, Peter Thalmeier, Ilya Eremin	Surface State Tunneling Signatures in the Two-Component Superconductor UPt3
19	JRG	Journal of High Energy Physics	**Bum-Hoon Lee, Daeho Ro**, Hyun Seok Yang	Matrix models from localization of five-dimensional supersymmetric noncommutative U(1) gauge theory
20	JRG	Astrophysical Journal	**Amir Aghamousa**, Arman Shafieloo	TIME DELAY ANALYSIS of the LENSED QUASAR SDSS J1001+5027
21	Executive Director, JRG	Physical Review E	Taekho You, Minji Kwon, **Hang-Hyun Jo, Woo-Sung Jung**, Seung Ki Baek	Chaos and unpredictability in evolution of cooperation in continuous time
22	JRG	Physical Review E	**Hang-Hyun Jo**	Modeling correlated bursts by the bursty-get-burstier mechanism
23	JRG	Journal of High Energy Physics	Sunly Khimphun, **Bum-Hoon Lee, Chanyong Park, Yun-Long Zhang**	Anisotropic dyonic black brane and its effects on holographic conductivity
24	JRG	The European Physical Journal C	**T. Araujo, E. Ó Colgáin**, J. Sakamoto, M. M. Sheikh-Jabbari, K. Yoshida	I in generalized supergravity

No.	Category	Journal	Authors	Article
25	JRG	Physics Letters B	Seong Chan Park, **Chang Sub Shin**	Clockwork seesaw mechanisms
26	JRG	Entropy	Bogeun Gwak, **Daeho Ro**	Spin interaction under the collision of two Kerr-(anti-)de Sitter black holes
27	JRG	Journal of Cosmology and Astropar-ticle Physics	**Jinn-Ouk Gong**, Naoya Kitajima	Small-scale structure and 21cm fluctuations by primordial black holes
28	JRG	PLoS One	Boah Lee, **Taegeun Song**, Kayoung Lee, Jaeyoon Kim, Per-Olof Berggren, Sung Ho Ryu, Junghyo Jo	Insulin modulates the frequency of Ca2+ oscillations in mouse pancreatic islets
29	JRG	Physical Review D	**Md. Wali Hossain**	First and second order cosmological perturbations in light mass Galileon models
30	YST, Organizer	Physical Review D	**Sangho Kim, Seung-il Nam**, Daisuke Jido, Hyun-Chul Kim	Photoproduction of Λ∗ (1405) with the N∗ and the t -channel Regge contributions
31	JRG	Physical Review B	**Y. Zhao**, S. Ahmed, J. Sirke	Localization of fermions in coupled chains with identical disorder
32	YST	Physical Review D	Rong-Gen Cai, Yong-Hui Qi, Yue-Liang Wu, **Yun-Long Zhang**	Topological non-Fermi liquid
33	JRG	EPL	**F. Cossu**, H. A. Tahini, N. Singh, U. Schwingenschlogl	Charge driven metal-insulator transitions in LaMnO3|SrTiO3 (111) superlattices
34	JRG	Physical Review C	**Sang-Ho Kim**, **Yongseok Oh**, Alexander I. Titov	Decay angular distributions of K∗ and D∗ vector mesons in pion-nucleon scattering
35	JRG	Journal of Cosmology and Astropar-ticle Physics	**Jinn-Ouk Gong**, Gonzalo A. Palma, Spyros Sypsas	Shapes and features of the primordial bispectrum
36	JRG	Journal of Cosmolo-gy and Astropar-ticle Physics	**Sang Gyu Biern**, Jaiyul Yoo	Gauge-invariance and infrared divergences in the luminosity distance
37	JRG	Physical Review D	**Jinn-Ouk Gong**, Masahide Yamaguchi	Correlated primordial spectra in effective theory of inflation
38	JRG	Journal of Cosmology and Astropar-ticle Physics	**Jinn-Ouk Gong**, Naoya Kitajimaa, Takahiro Terada	Curvaton as dark matter with secondary inflation

No.	Category	Journal	Authors	Article
39	JRG	PLoS One	Boah Lee, **Taegeun Song**, Kayoung Lee, Jaeyoon Kim, Seungmin Han, Per-Olof Berggren, Sung Ho Ryu, **Junghyo Jo**	Phase modulation of insulin pulses enhances glucose regulation and enables inter-islet synchronization
40	JRG	Journal of the Korean Physical Society	Bum-Hoon Lee, Siyoung Nam, **Chanyong Park**	Holographic trace anomaly at finite temperature
41	JRG	Physical Review D	**T. Araujo, I. Bakhmatov, E. Ó. Colgáin**, 3 J. Sakamoto, M. M. Sheikh-Jabbari, K. Yoshida	Yang-Baxter σ -models, conformal twists, and noncommutative Yang-Mills theory
42	JRG	Physical Review D	Bum-Hoon Lee, **Chanyong Park, Sunyoung Shin**	Vacua and walls of mass-deformed Kähler nonlinear sigma models on so (2N) /U (N)
43	JRG	International Journal of Modern Physics D	**Jinn-Ouk Gong**	Multi-field inflation and cosmological perturbations
44	JRG, YST	Journal of the Physical Society of Japan	**R. Jafari**, A. Langari, **Alireza Akbari**, Ki-Seok Kim	Real space renormalization of Majorana fermions in quantum nano-wire superconductors
45	JRG	Physical Review D	Ki-Seok Kim, **Chanyong Park**	Renormalization group flow of entanglement entropy to thermal entropy
46	YST	Physical Review D	**Mew-Bing Wan**	Effects of magnetic field topology in black hole-neutron star mergers: Long-term simulations
47	JRG	PHYSICAL REVIEW B	Mohammad-Hossein Zare, **Mehdi Biderang, Alireza Akbari**	Mixed-pairing superconductivity in 5d Mott insulators with antisymmetric exchange: Application to Sr2IrO4
48	JRG	Journal of Cosmology and Astroparticle Physics	**Jinn-Ouk Gong**, Jai-chan Hwang, Hyerim Noh,David Chan Lon Wu, Jaiyul Yoo	Exact non-linear equations for cosmological perturbations
49	JRG	Journal of Cosmology and Astroparticle Physics	**Naoya Kitajima**, David Langlois, Tomo Takahashi, Shuichiro Yokoyama	Refined study of isocurvature fluctuations in the curvaton scenario
50	YST	Journal of the Physical Society of Japan	Atsushi Hosaka, **SangHo Kim** and 8 others	Charmed baryons and their interactions

No.	Category	Journal	Authors	Article
51	YST	International Journal of Modern Physics A	**Chengcheng Han**	Probing light bino and higgsinos at the LHC
52	JRG	Physical Review D	Ki-Seok Kim, **Miok Park, Jaeyoon Cho, Chanyong Park**	Emergent geometric description for a topological phase transition in the Kitaev superconductor model
53	JRG	Physical Review D	**Jinn-Ouk Gong**, Naoya Kitajima	Cosmological stochastic Higgs field stabilization
54	JRG	Journal of Cosmology and Astroparticle Physics	**Sang Gyu Biern**, Jaiyul Yooa	Correlation function of the luminosity distances
55	JRG	Physical Review D	Youngman Kim, Bum-Hoon Lee, D. G. Pak, **Chanyong Park**, and Takuya Tsukioka	Quantum stability of nonlinear wave type solutions with intrinsic mass parameter in QCD
56	Visitor	Journal of Statistical Mechanics: Theory and Experiment	Alexi Morin-Duchesne, Andreas Klümper, **Paul A Pearce**	Conformal partition functions of critical percolation from D 3 thermodynamic Bethe Ansatz equations
57	Visitor	Journal of Physics A-Mathematical and Theoretical	**Paul A Pearce**, Alessandra Vittorini-Orgeas	Yang–Baxter solution of dimers as a free-fermion six-vertex model