APCTP

Status Report 2009

April, 2010

Asia Pacific Center for Theoretical Physics

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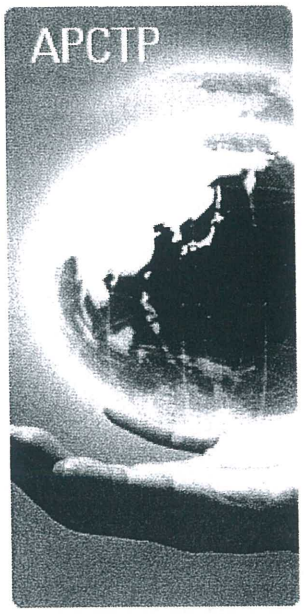
1. Overview of the APCTP

1.1 Vision

☐ 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. The Center was established in June 1996 in Korea, with Professor C. N. Yang as its founding president. As an international Non-Governmental Organization (NGO), its current member countries/regions are Australia, Beijing, India, Japan, Korea, Lao PDR, Malaysia, Mongolia, Philippines, Singapore, Taipei, Thailand and Vietnam. More countries in the Asia Pacific region are expected to join the APCTP in the near future.

The Center aims to

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

To achieve its purposes, 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
- publish a web journal and create high-quality literary contents
- carry out distinguished lectures and activities accessible to the public

☐ Milestones

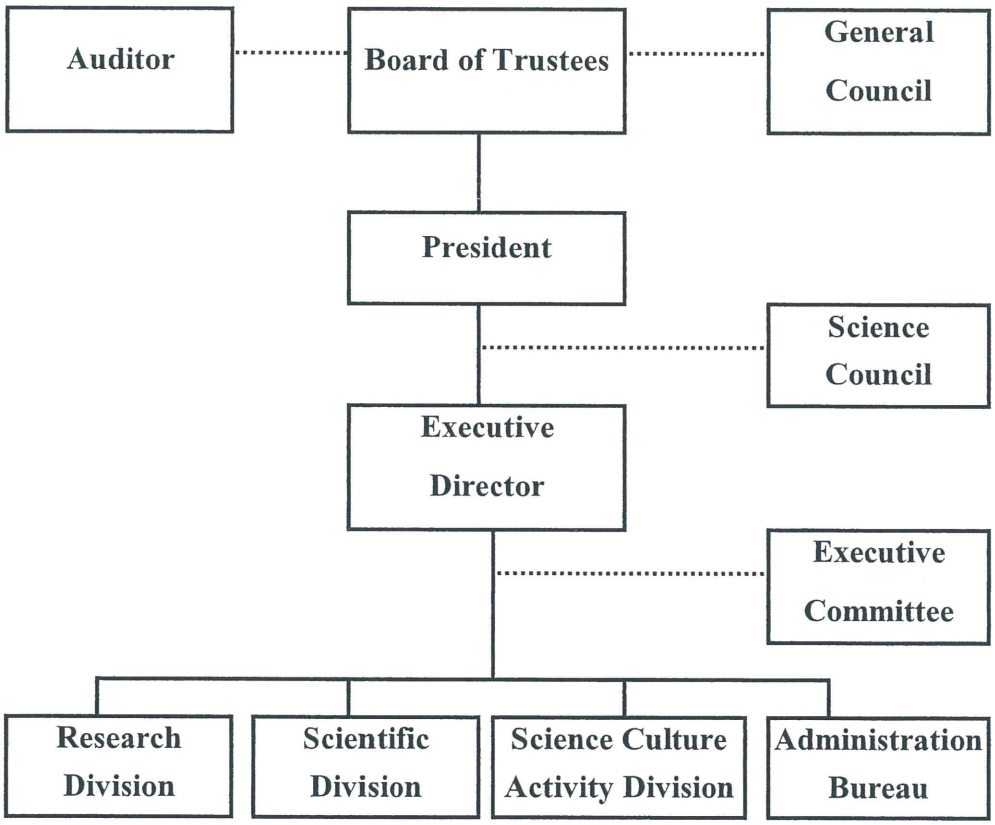
1993. 02	Formation of the International Planning Committee (IPC)
1994. 05	IPC recommends Korea as the host of the APCTP headquarters
1994. 11	Association for Science Cooperation in Asia (ASCA) endorses the proposal to host the APCTP in Korea
1995. 09	UNESCO PAC, IUPAP, and AAPPS endorses proposal for APCTP
1996. 06	Inauguration conference and establishment of APCTP
1996. 06	Exchange of Memorandum of Cooperation between APCTP and ICTP
1996. 11	President of Korea announces the supports for APCTP at APEC Science Ministers Meeting in Seoul
1997. 01	The Board appoints Prof. C. N. Yang (1957 Nobel Laureate for Physics) as the1st President and Chairman
1997. 04	APCTP Foundation is registered at the Korean Ministry of Science & Technology
1998. 05	Launch of the biannual APCTP Bulletin
1998. 10	Exchange of Agreement of Collaboration between APCTP and CRM
1999. 12	Exchange of Agreement of Collaboration between APCTP and NCTS
1999. 12	Opening of annex building in Kangnam-gu, Seoul for KFAS
2001. 01	Activity-Financing Contract between UNESCO and APCTP
2001. 04	Prof. A. Arima (Former Minister of Education of Japan) elected as the 2nd Chairman of the Board of Trustees
2001. 07	Exchange of Agreement of Collaboration between APCTP and PIMS
2001. 08	APCTP Headquarters moves to its new host, POSTECH; Seoul Branch Office located in annex building
2003. 03	Exchange of Agreement of Collaboration between APCTP and ECT*
2003. 07	Exchange of Agreement of Collaboration between APCTP and TPI
2004. 04	The Board appoints Prof. R. B. Laughlin(1998 Novel Laureate for Physics) as the 2nd President
2004. 11	Start of Young Scientist Training Program
2005. 02	Science Communication program launched
2005. 03	Relocation of APCTP headquarters to the Hogil Kim / Memorial Building 5th Floor of POSTECH
2005. 07	Exchange of Agreement of Collaboration between APCTP and ITP
2005. 10	APCTP Web journal (Crossroads) launched

2005. 12	Prof. N. V. Hieu elected as the 3rd Chairman of the Board
2006. 04	Exchange of Agreement of Collaboration between APCTP and MPI-PKS
2006. 07	Exchange of Agreement of Collaboration between APCTP and JINR
2006. 11	APCTP 10th Anniversary
2006. 11	Exchange of Agreement of Collaboration between APCTP and RIKEN Nishina Center
2006. 11	Admission of Lao PDR and Mongolia as new members of the APCTP
2007. 01	Exchange of MOU between APCTP and IPNS/KEK
2007. 03	The Board appoints Prof. P. Fulde as the 3rd President
2007. 03	Exchange of Agreement of Collaboration between APCTP and YITP
2007. 08	Renew of Agreement of Collaboration between APCTP and ICTP
2007. 10	Exchange of Agreement of Collaboration between APCTP and MPG, POSTECH
2007. 10	Exchange of Agreement of Collaboration between APCTP and IOP, ISSP
2008. 03	Admission of India as a new member of APCTP
2008. 06	Start of the Junior Research Groups (JRG)
2008. 10	Opening of a new wing on JRG
2008. 10	Renew of Agreement of Collaboration between APCTP and TPI
2008. 11	Exchange of Letter of Agreement between ASEAN and APCTP
2009. 01	Exchange of Agreement of Collaboration between APCTP – AAPPS
2009. 04	Exchange of Agreement of Collaboration between APCTP - IOP, VAST
2009. 04	Exchange of Agreement on the Consortium of Asian Physics Institutions (KITPC/ITP, ICTS, IPNS/KEK, CQUeST, KIAS, APCTP)
2009. 06	Exchange of Agreement of Collaboration between APCTP - PI

1.2 Organization and Management of the Center

☐ Organization Chart

- Board of Trustees : 15 members including the Chairman (N.V.Hieu, Vietnam), President (Peter Fulde, Germany), Standing Trustee (Won Namkung, USA), Executive Director (Seunghwan Kim, Korea)
- General Council: 20 representatives from 13 member countries
- Science Council: 6 world-renowned scholars



☐ Incumbent Board of Trustees Members

Position	Name	Nationality	Affiliation	Term
Chairman	Nguyen Van Hieu	Vietnam	Vietnamese Academy of Science & Technology	Apr. 4, 2007 ~Apr. 3, 2010
President	Peter Fulde	Germany	APCTP/MPI-PKS	Apr. 4, 2007 ~Apr. 3, 2010
Standing Trustee	Won Namkung	USA	POSTECH	Nov.18, 2006 ~Nov.17, 2009
Trustee	Seunghwan Kim	Korea	President, APCTP POSTECH	Ex-Officio Apr. 4, 2007 ~Apr. 3, 2010
〃	Young Pak Lee	Korea	President, Korean Physical Society	Ex-Officio
〃	Chan-Mo Park	USA	President, NRF of Korea	Ex-Officio
〃	Kazuo Fujikawa	Japan	Nihon University	Apr. 5, 2009 ~Apr. 4, 2012
〃	Duk In Choi	Korea	KAIST	Apr. 4, 2007 ~Apr. 3, 2010
〃	Byung-taik Kim	Korea	Sungkyunkwan University	Apr. 4, 2007 ~Apr. 3, 2010
〃	Sooyoung Chang	Korea	POSTECH	Apr. 4, 2007 ~Apr. 3, 2010
〃	Yuan T. Lee	Taipei	Academia Sinica	Apr. 4, 2007 ~Apr. 3, 2010
〃	Paul A.Pearce	Australia	University of Melbourne	Jan. 23, 2007 ~Jan. 22, 2010
〃	Yue-Liang Wu	Beijing	Institute of Theoretical Physics, CAS	Apr. 5, 2009 ~Apr. 3, 2010
〃	Hee Sung Song	Korea	Seoul National University	Apr. 4, 2007 ~Apr. 3, 2010
〃	Chung Nam Whang	Korea	Yonsei University	Apr. 4, 2007 ~Apr. 3, 2010
Auditor	Doochul Kim	Korea	Seoul National University	Apr. 5, 2009 ~Apr. 4, 2011
〃	Hiroshi Miyamoto	Japan	Accelerator Research Promotion Office, RIKEN	Apr. 5, 2009 ~Apr. 4, 2011

☐ Incumbent General Council Members

Nationality	Name	Affiliation	Term
Australia	Robert Dewar	The Australian National Univ.	Jan. 1, 2008 ~Dec. 31, 2010
Beijing	Zhong-can Ou-Yang <Chairman>	Chinese Academy of Sciences	Jan. 1, 2008 ~Dec. 31, 2010
	Gui Lu Long	Tsinghua Univ.	Jan. 1, 2008 ~Dec. 31, 2010
	Yue-Liang Wu	Chinese Academy of Sciences	Apr. 5, 2009 ~Dec. 31, 2010
Japan	Hikaru Kawai	RIKEN	Jan. 1, 2008 ~Dec. 31, 2010
	Noboru Kawamoto	Hokkaido Univ.	Jan. 1, 2008 ~Dec. 31, 2010
	Naoto Nagaosa	Univ. of Tokyo	Jan. 1, 2008 ~Dec. 31, 2010
Korea	Yunkyu Bang	Chonnam National Univ.	Jan. 1, 2008 ~Dec. 31, 2010
	Doochul Kim	Seoul National Univ.	Jan. 1, 2008 ~Dec. 31, 2010
	Bum Hoon Lee	Sogang Univ.	Jan. 1, 2008 ~Dec. 31, 2010
Lao PDR	Sourioudong Sundara	Science Technology and Environment Agency (STEA)	Jan. 1, 2007 ~Dec. 31, 2009
Malaysia	Swee Ping Chia	Univ. of Malaya	Jan. 1, 2008 ~Dec. 31, 2010
Mongolia	Tuvdendorj Gabaartar	Mongolian Academy of Sciences	Jan. 1, 2010 ~Dec. 31, 2012
The Philippines	Jose Perico Henson Esguerra	Univ. of the Philippines-Diliman	Jan. 1, 2008 ~Dec. 31, 2010
Singapore	Kok Khoo Phua	World Scientific Publishing Co.	Jan. 1, 2008 ~Dec. 31, 2010
Thailand	Sukit Limpijumnong	Suranaree Univ. of Technology	Jan. 1, 2008 ~Dec. 31, 2010
Taipei	Hsiang-nan Li	Academia Sinica	Jan. 1, 2008 ~Dec. 31, 2010
	Chung-Yu Mou	National Tsing Hua Univ.	Jan. 1, 2008 ~Dec. 31, 2010
India	Dipankar Das Sarma	Indian Institute of Science	Mar. 29, 2008 ~Mar. 28, 2011
Vietnam	Nguyen Hong Quang	Vietnamese Academy of Science and Technology	Jan. 1, 2008 ~Dec. 31, 2010

☐ Incumbent Science Council Members

Name	Nationality	Affiliation	Term
Peter Fulde	Germany	APCTP/MPI-PKS	Ex-Officio
Ganapathy Baskaran	India	Institute of Mathematical Sciences	Mar. 1, 2008 ~Feb. 28, 2013
Yu Lu	Beijing	Institute of Theoretical Physics, Chinese Academy of Sciences	Mar. 1, 2008 ~Feb. 28, 2013
Kazuo Ueda	Japan	The Institute for Solid State Physics of the University of Tokyo	Mar. 1, 2008 ~Feb. 28, 2013
Fuchun Zhang	Hong Kong	University of Hong Kong	Mar. 1, 2008 ~Feb. 28, 2013
Steven G. Louie	USA	University of California at Berkeley	Jul. 1, 2009 ~Jun. 30, 2014

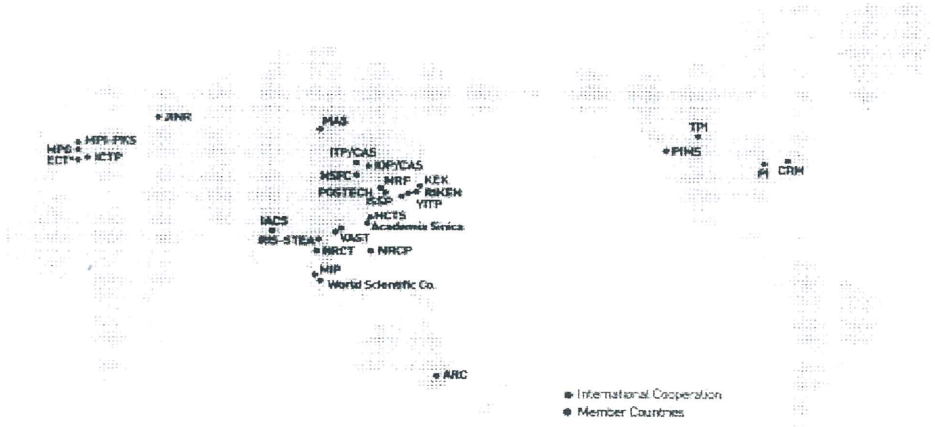
☐ Incumbent Program Coordinators

Name	Nationality	Affiliation	Term
Sang Pyo Kim	Korea	Kunsan Nat'l Univ.	Jul. 1, 2008 ~ Jun. 30, 2010
Hyungtae Kook	Korea	Kyungwon Univ.	Aug. 1, 2008 ~ Jul. 31, 2010
Mahn-Soo Choi	Korea	Korea Univ.	Jan. 1, 2010 ~ Dec. 31, 2011
Jaemo Park	Korea	POSTECH	Jan. 1, 2010 ~ Dec. 31, 2011

☐ Incumbent Editorial Board

Name	Nationality	Affiliation	Term
Hyungtae Kook	Korea	Kyungwon Univ.	Mar. 1, 2009 ~ Feb. 28, 2011
Sangjoon Park	Korea	POSTECH	Mar. 1, 2009 ~ Feb. 28, 2011
Myung-Hyun Rhee	Korea	Yonsei Univ.	Jan. 1, 2010 ~ Dec. 31, 2011

1.3 Member Entities and Agreement Institutes



<Member Countries & Entities: 13 members>

- Australia : Australia Research Council (ARC)
- Beijing: National Natural Science Foundation of China (NSFC)
- India : India Association for the Cultivation of Science (IACS)
- Japan : RIKEN
- Korea : Korea Science and Engineering Foundation (KOSEF)
- Lao PDR : The Research Institute of Science, Science Technology and Environment Agency (RIS-STEA)
- Malaysia : Malaysian Institute of Physics (MIP)
- Mongolia : The Mongolian Academy of Sciences (MAS)
- Philippines : National Research Council of the Philippines (NRCP)
- Singapore : World Scientific Co.
- Taipei : Academia Sinica
- Thailand : National Research Council of Thailand (NRCT)
- Vietnam : Vietnamese Academy of Science and Technology (VAST)

<Int'l Cooperation: Agreement Institutes>

- ICTP (The International Center for Theoretical Physics): 1996. 7, 2007.8
- CRM (Le Center De Recherches Mathematiques): 1998. 10
- NCTS (National Center for Theoretical Science): 1999. 12
- PIMS (The Pacific Institute for the Mathematical Sciences): 2001. 7
- ECT* (The European Centre for Theoretical Studies in Nuclear Physics and.Related Areas): 2003. 3
- TPI (The Theoretical Physics Institute of the University of Alberta): 2003. 7, 2008. 10
- ITP (Institute of Theoretical Physics Chinese Academy of Sciences): 2005. 7
- MPI-PKS (Max Planck Institute for Physics of Complex Systems) 2006.4
- JINR (The Joint Institute for Nuclear Research): 2006. 7
- RIKEN Nishina Center (RIKEN Nishina Center for Accelerator Based Sciences): 2006. 11
- IPNS/KEK (The Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization, KEK):2007. 1
- YITP (Yukawa Institute for Theoretical Physics, Kyoto University): 2007. 3
- MPG (Max Planck Society) / POSTECH (Pohang University of Science and Technology): 2007. 10
- IOP (The Institute of Physics, the Chinese Academy of Sciences)
  ISSP (The Institute for Solid State Physics of the University of Tokyo) : 2007. 10
- AAPPS (The Association of Asia Pacific Physical Societies): 2009. 1
- IOP, VAST (The Institute of Physics, Vietnam Academy of Science and Technology): 2009. 4
- Consortium of Asian Physics Institutions (KITPC/ITP, ICTS, IPNS/KEK, CQUeST, KIAS, APCTP): 2009. 4
- PI (Perimeter Institute for Theoretical Physics): 2009. 6

2. Details and Data in 2009 Activities

2.1 Reports of Academic Activities

2.1.1 Summary of Academic Activities

☐ Programs and Visitors of Academic Activities

	Visitors											
	2007				2008				2009			
	P*	K*	M/C*	Non M/C*	P*	K*	M/C*	Non M/C*	P*	K*	M/C*	Non M/C*
Topical Research Programs	13	679	37	28	11	534	25	39	11	900	139	59
Schools	5	322	64	22	5	269	32	16	9	471	61	24
Conference & Workshops	10	298	35	10	13	480	153	118	8	351	54	72
Focus Programs	4	88	38	16	4	46	6	27	4	63	24	27
Visitors Program		21	6	11		18	18	5		3	6	9
Total	**32**	**1,408**	**180**	**87**	**33**	**1,347**	**234**	**205**	**32**	**1,788**	**284**	**191**

* P: Number of Programs
* K: Korean Visitors
* M/C: Visitors from Member Countries excluding Korea
* Non M/C: Visitors from Non Member Countries

☐ Reprints of Academic Activities

- 12 Reprints (SCI: 11 reprints, IF: 3.976)

2.1.2 Details of Academic Activities

☐ Topical Research Programs

Topical Research Programs provide researchers and students with joint research opportunities through a broad range of academic activities from one month to a year, including seminars, lectures, and (mini) workshops on specialized research topics. These programs are designed to encourage local scientific groups and communities to develop internationally and to integrate into the Asia-Pacific community.

No	Topic	Contents of Program		Number of Visitors
		Lectures & Seminars	Mini-Workshop	
I	**Particle Physics**			
	①String Theory and Cosmology	-	4	100
II	**Condensed Matter Physics**			
	②Frontiers in electronic quantum matter	4	2	214
	③Quantum Coherence and Correlations in Mesoscopic and Nano-Structure Systems	-	1	75
	④Theory of Emergent Materials	17	-	17
	⑤Emergent Material Research	-	2	140
III	**Statistical Physics/Complex Systems**			
	⑥Statistical Physics of Disordered, Non-equilibrium and Complex Systems	17	1	135
	⑦Molecular Dynamics Simulation in nano/bio systems	5	2	29
	⑧Quantum Dynamics and Chaos	-	1	60
IV	**Astrophysics/ Nuclear Physics**			
	⑨Relativistic Heavy-Ion Collisions: Transition from RHIC to LHC	-	6	217
	⑩ Computational Approaches in Gravitation and Astrophysics	25	3	72
	⑪APCTP Theory of Spintronics Miniworkhsop	-	1	39
	Total	**68**	**23**	**1,098**

☐ Schools

Schools provide graduate students and young postdoctoral researchers by international training-programs including intensive lectures and seminars on the current research topics in physics. These are held at the Center or other approved locations during the winter/summer vacation.

No	Title	Period	Venue	Organizers
1	6th APCTP-KIAS Winter School on Statistical Physics	Feb. 4-6, 2009	PIC, POSTECH, Pohang, Korea	Jae Woo Lee (Inha Univ.)
2	2009 APCTP Winter Workshop on Frontiers in Electronic Quantum Matter	Feb. 8-12, 2009	Hilton Namhae Resort, Korea	Han-Yong Choi (Sungkyunkwan Univ.)
3	APCTP/IEU Field Theory Winter School 2009	Feb.16-20, 2009	APCTP, Pohang, Korea	Chanju Kim (Ewha Univ.)
4	2009 1st Laboratory, space, and astrophysical plasma workshop	Feb. 20-23, 2009	PIC, POSTECH, Pohang, Korea	Chang-Mo Ryu (POSTECH)
5	YongPyong Astro-Particle and Conformal Topical Physics 2009	Feb. 23-27, 2009	YongPyong, Gangwon-do, Korea	C. S. Kim (Yonsei Univ.)
6	7th Nuclear Physics School 2009	Jun. 29-Jul. 3, 2009	APCTP, Pohang, Korea	Hyun-Chul Kim (Inha Univ.)
7	2009 Int'l School on Numerical Relativity and Gravitation	Dec. 7-11, 2009	APCTP Seoul Branch Office, Korea	Gungwon Kang (KISTI)
8	The 9th Summer Institute for Theoretical Physic	Aug. 4-14, 2009	APCTP, Pohang, Korea	Jaemo Park (POSTECH)
9	APCTP School on Econophysics	Aug. 24-27, 2009	APCTP, Pohang, Korea	Hawoong Jeong (KAIST)

☐ Conference & Workshop

Conferences & Workshops are to promote scientific cooperation among diverse international physics groups and communities on the cutting –edge research topics.

No	Title	Period	Venue	Organizers
1	2nd Woskhop for Emergent Material Research	Jul. 15-16, 2009	PIC, POSTECH, Pohang, Korea	Jae-Hoon Park (POSTECH)
2	XQCD 2009	Aug. 3-5, 2009	Sejong Univ.,Seoul, Korea	Seyong Kim (Sejong Univ.)
3	APCTP 2009 LHC Physics Workshop at Korea	Aug. 25-27, 2009	Konkuk Univ., Seoul, Korea	Sun Kun Oh (Konkuk Univ.)
4	11th Italian-Korean Symposium on Relativistic Astrophysics	Nov. 2-4, 2009	Sogang Univ., Seoul, Korea	Sang Pyo Kim (Kunsan Nat'l Univ.) Bum Hoon Lee (Sogang Univ.)
5	5th Korean Astrophysics Workshop on "Shock Waves, Turbulence, and Particle Acceleration	Nov. 18-21, 2009	PIC, POSTECH, Pohang, Korea	Dongsu Ryu (Chungnam Nat'l Univ.)
6	The 4th APCTP-KAIST School for Brain Dynamics	Dec. 11-12, 2009	KAIST, Daejeon, Korea	Jaeseung Jeong (KAIST)
7	ICAMD 2009	Dec. 9-11, 2009	Ramada Plaza Jeju Hotel, Jeju, Korea	Kungwon Rhie (Korea Univ.)
8	APCTP-KPS Joint Workshop on Networking of Woman in Physics	Dec. 15, 2009	APCTP Seoul Branch Office, Korea	Young Soon Kim (Myongji Univ.)

☐ Focus Program

Focus Programs attract small groups of active international researchers to the Center in a sharply focused field of the utmost interest in physics and related areas. The core organizers and participations are encouraged to have intensive collaborations and discussions at the Center for two week up to one month.

No	Title	Period	Venue	Organizers
1	APCTP Focus Program on Liouville, Integrability and Branes(5)	May 17-30, 2009	APCTP, Pohang, Korea	Changrim Ahn (Ewha Univ.)
2	APCTP Focus Program on Aspects of Holography and Gauge/string duality	Jul 20-31, 2009	APCTP, Pohang, Korea	Deog Ki Hong (Pusan Nat'l Univ.)
3	APCTP Focus Program on Recent Developments in Neutrino Physics and Astroparticle Physics	Jun 15-25, 2009	APCTP, Pohang, Korea	Yong-Yeon Keum (IEU/Ewha Univ.)
4	Current Trends in String Field Theory	Dec. 7-18, 2009	APCTP, Pohang, Korea	Yoonbai Kim (Sungkyunkwan Univ.)

☐ Visitors Program

The Center strongly encourages short and long-term visits by researchers or small research groups from the Asia-Pacific region, as well as world-class scholars.

Total	Member Country		Non Member Country	Seminars	P/M*
	Korea	Others			
18	3	6	9	14	16

(1 Person Month (P/M): 28 days)

2.2 Reports of International Cooperation

2.2.1 Joint/External Activities

☐ Joint Activities

No	Institute	Title	Period	Venue
1	ITP (Beijing)	The 3rd Asian Winter School on String Theory	Jan.7~17, 2009	ITP, Beijing
2	NCTS (Taipei)	APCTP-NCTS International School/Workshop on Gravitation and Cosmology	Jan.16~20, 2009	APCTP Headquarters, Korea
3	ICTP (Italy)	Spring school on Superstring Theory and Related Topics	Mar.23~31, 2009	ICTP, Italy
4	BLTP JINR (Russia)	APCTP - BLTP JINR Joint Workshop on Frontiers in Black Hole Physics at Dubna	May 25~30, 2009	BLTP JINR, Russia
5		APCTP-BLTP JINR Joint Workshop on Frontiers in Nuclear Physics at Dubna	May 28~30, 2009	
6	PI (Canada)	Summer School on Particles, Fields and Strings	Jun.24~Jul.1, 2009	PI, Canada
7	MPI-PKS (Germany)	Topological Order: From Quantum Hall Systems to Magnetic Materials Seminar and Workshop	Jun.29~Jul.24, 2009	MPI-PKS, Germany
8	YITP (Japan)	What is Evolution? "Bicentennial of Charles Darwin's Birth"	Oct.15~18, 2009	Co-op Inn, Kyoto, Japan
9	ICTP (Italy)	ICTP Regional School on Physics at the Nanoscale: Theoretical and Computational Aspects	Dec.14~25, 2009	IOP/VAST, Hanoi, Vietnam

☐ External Activities

No	Country	Title	Period	Venue
1	Australia	Symposium on Cosmology and Particle Astrophysics (CosPA 2009)	Nov.18~20, 2009	Univ. of Melbourne, Melbourne
2	Beijing	COMPLEX' 2009	Feb.23~25, 2009	Shanghai
3		The Ninth Asia-Pacific International Conference on Gravitation and Astrophysics (ICGA9)	Jun.22~26, 2009	Huazhong Univ. of Science & Tecnology, WuHan
4		The 12th Asian Workshop on First-Principles Electronic Structure Calculations (ASIAN12)	Oct.26~28, 2009	IOP, CAS, Beijing
5	India	Recent trends in Strongly Correlated Systems	Feb.2~4, 2009	IACS, Kolkata
6	Malaysia	Third International Meeting on Frontiers of Physics (IMFP 2009)	Jan.12~16, 2009	Awana Genting
7	Taipei	22nd Spring school on Particles & Fields	Mar.31~Apr.03, 2009	Tung-Hai Univ., Taichung
8		4th International Symposium on Symmetries in Subatomic Physics (ISS2009)	Jun.2~5, 2009	Nat'l Taiwan Univ., Taipei
9	Vietnam	15th Vietnam School of Physics (15^{th} VSOP)	Jul.20~31, 2009	Quang Binh Univ., Donghoi
10		The 5th International Conference of the Asian Consortium on Computational Materials Science (ACCMS5)	Sep.7~11, 2009	Melia Hotel, Hanoi
11		The 2nd International Workshop on Nanotechnology and Application	Nov.12~14, 2009	Palace Hotel, Vung Tau

2.2.2 APCTP Faculties & Researchers

☐ Programs: JRG & YST

- Junior Research Groups (JRG): 4 JRGs & 1 Research Professor
  - Leaders & Members: 17 persons
  - 1 NRF researcher
  - Visitors (59), Workshops (4), Seminars (23), Discussion meetings (33) and Invited talks (36)
- Young Scientist Training Program (YST): 14 persons
  - Visitors (2)
- 42 Reprints and 18 Preprints

JRG	**[Group 1]** Condensed Matter & Field Theory	Leader / Prof. Xin Wan	JRG Members	**Scientific Activities & Joint Research**
	[Group 2] Multi-scale Modeling	Leader / Prof. Xin Zhou	JRG Members	
	[Group 3] String Theory for Strongly Interacting Systems	Leader / Prof. Youngman Kim	JRG Members	
	[Group 4] Cooperative Phenomena in Correlated Electron Systems	Leader / Prof. Tetsuya Takimoto	JRG Members	
	Quantum Phase Transitions in Strongly Correlated Electron Systems	Research Prof. Ki-Seok Kim	Members	
YST				

□ Junior Research Groups (JRG)

• [Group 1] Condensed Matter & Field Theory (Leader- Prof. Xin Wan (Since June 1, 2008))

- Overview

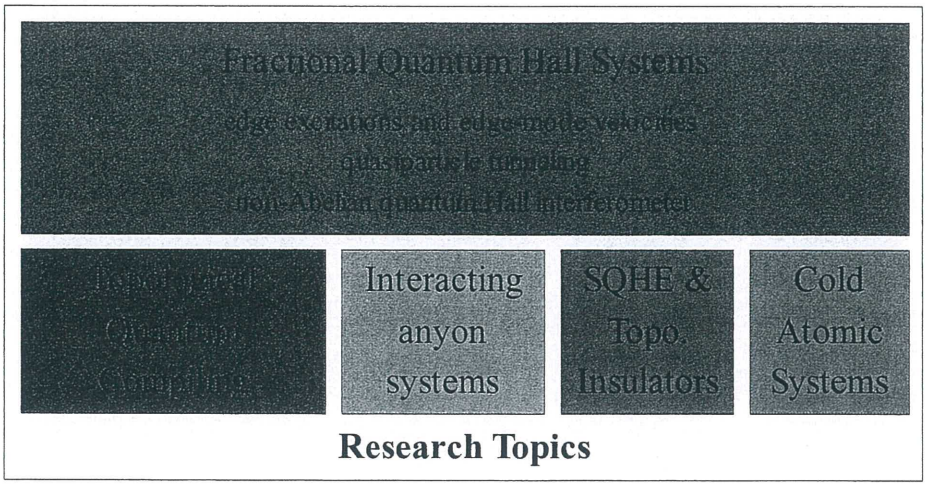
Established at the Asia Pacific Center for Theoretical Physics (APCTP) in June 2008, the Independent Junior Research Group led by Dr. Xin Wan focuses on condensed matter theory a nd its connection to topology and quantum information. Currently, there are two postdocs, Dr. Hyun-Jung Lee and Dr. Zi-Xiang Hu, and a PhD student, Mr. Ki Hoon Lee.

The group has been working on fractional quantum Hall effect, topological quantum computation, impurity quantum phase transitions, graphene and other interesting condensed matter systems. Combining effective field theories and numerical techniques, the group attempts to approach the fractional quantum Hall systems with more quantitative analysis, bridging the gap between theory and experiment. The group is interested in the broader aspects of topological states of matter and topological quantum computation. For example, the group also works on efficient schemes to construct topological quantum gates and simulate quantum circuit model in the framework of topological quantum computation.

The Junior Research Group at APCTP is supported by the Max Planck Society and the Korea Ministry of Education, Science and Technology.

http://sites.google.com/site/xinwan90/

- Research



Research Topics

The fractional quantum Hall (FQH) effect, among other development around 1980s, ushered an era in condensed matter physics beyond Landau's paradigm. People have studied the FQH effect from the angles of variational wavefunction, Chern-Simon theory, chiral Luttinger liquid theory, etc. We now understand the FQH liquids as an example of the topological states of matter, whose low-energy effective theories are topological quantum field theories. A profound property of such systems in (2+1) dimensions is that they support quasiparticle excitations with Abelian fractional statistics or even non-Abelian statistics.

Topological quantum computation (TQC) is a paradigm to build quantum computers based on encoding and braiding non-Abelian anyons. The inspiration comes from A. Kitaev's idea of fault-tolerant quantum computation by anyons and M. Freedman's program to understand the computational power of topological quantum field theories. Both theories are modular tensor categories. TQC has been shown to be equivalent to the quantum circuit model in efficiency; but the novel proposal is robust against local noises. A few years ago, Microsoft established Station Q, dedicated to TQC research led by M. Freedman, at the University of California at Santa Barbara.

The research group is working actively on the understanding of (1) whether there are non-Abelian anyons in FQH systems, (2) how to efficiently encode and braid anyons to realize interesting gates in TQC, (3) emergence of new phases (or conformal field theories) in interacting anyon systems, and (4) new materials and systems that may support non-Abelian anyons, such as topological insulators and cold atomic systems.

Understanding the Non-Abelian Quantum Hall Interferometry

The leading candidate that may support non-Abelian anyons is the fractional quantum Hall (FQH) system at filling factor 5/2, whose ground state is believed to be the Moore-Read state (or its particle-hole conjugate), a reincarnation of a chiral p-wave superconductor in the FQH context. In 2008, experimental groups published data in tunneling conductance and noise measurement across a single quantum point contact in this system. The best fits of the data are most consistent with the existence of charge-e/4 quasiparticles predicted by theory. Interestingly, theory also predicts that the quasiparticles carry, apart from charge (a bosonic component), a neutral Majorana fermion, whose existence in Nature has never been confirmed for more than 70 years since E. Majorana first proposed it. The neutral Majorana fermion is believed to be responsible for the non-Abelian statistics of the

quasiparticles, which may be probed in a Fabry-Perot type FQH interferometer consisting of two adjacent quantum point contacts that define an interference loop for quasiparticles propagating along the edge.

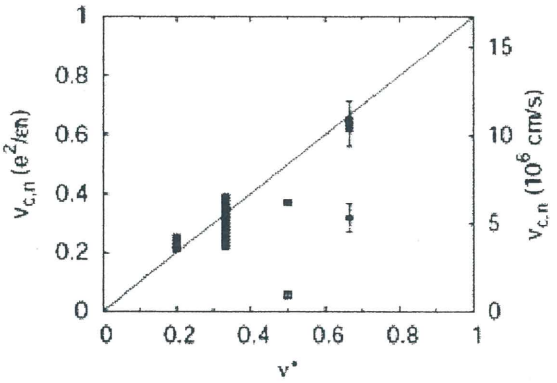


FIG. 1. Calculated ranges of edge-mode velocities at various valence filling n*

In 2008, the first experiment on the interference of quasiparticles in the 5/2 FQH state by R. Willett [Proc. Natl. Acad. Sci. USA **106**, 8853 (2009)] showed that resistance oscillations from charge-e/4 and charge-e/2 quasiparticles alternate to appear in the interference pattern at low temperatures. As temperature increases, e/2 oscillations start to dominate before the disappearance of coherence oscillations. These observations were predicted by Dr. Xin Wan and Dr. Zi-Xiang Hu, together with their collaborators [Phys. Rev. B **77**, 165316 (2008)]. The research team found in realistic 5/2 model study that the neutral Majorana fermion propagates about one order of magnitude slower than the charged boson and, thus, argued that the thermal decoherence of the non-Abelian e/4 quasiparticles severely suppresses the corresponding interference pattern; instead, Abelian charge e/2 quasiparticles, less relevant in inter-edge tunneling, can dominate the interference pattern, especially at higher temperatures.

This year, the research team strengthened their arguments by demonstrating (1) the stark difference in the bosonic and fermionic velocities is robust under the change of interaction and confining potential [Fig. 1, arXiv:0908.3563], and (2) the inter-edge tunneling amplitude for the e/4 quasiparticles is quantitative larger than the e/2 quasiparticles, although both are relevant in the renormalization group sense [Fig. 2, arXiv:0905.3607, to appear in Phys. Rev. B]. In fact, R. Willett posted a second manuscript [arXiv:0911.0345] arguing the alternating e/4 and e/2 interference oscillations are consistent with the non-Abelian nature of the 5/2 FQH state. The experimental paper cites two papers from the research group, together with two papers from C. Nayak at Station Q and his collaborators, for providing a consistent theory for the observation of both e/4 and e/2 interference oscillations.

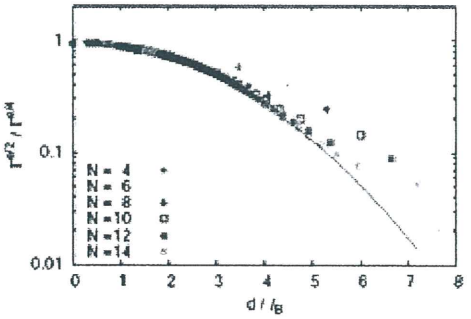


FIG. 2. Ratio of the tunneling amplitudes for e/2 and e/4 quasiholes across a Moore-Read FQH stripe with edge-to-edge distance d.

It is likely that the Willett experiments are, in fact, performing interferometry on the $\nu = 5/2$ state and are detecting non-Abelian quasiparticles.

Topological Quantum Compiling

While topological quantum computation (TQC) is fault-tolerant on the hardware level and equivalent to the quantum circuit model, its implementation needs more subtle considerations. For example, tensor decomposition is unnecessary and inconvenient for TQC – a leakage error occurs when a tensor decomposition is forced. This calls for the study of topological quantum compiling, which deals with the implementations of interesting gates in the quantum circuit model and the algorithms for solving interesting number theoretical questions in TQC.

Plainly speaking, in a topological quantum computer, quantum information is encoded in the intrinsic Hilbert space of non-Abelian anyons with fixed locations. Braids of non-Abelian anyons in the (2+1) dimensional space-time form quantum gates, whose fault tolerance relies on the topological, rather than geometric, properties of the braids. When a two-qubit gate is implemented in the tensor space of two single qubits, an leakage error is bound to occur – the qubits evolve into the non-encoding space. In a previous work, Dr. Xin Wan and his former Master's student H. Xu discovered that if a phase error (which can be canceled later) is allowed to be carried into two-qubit gate construction, the leakage error can be reduced algebraically. They extended the idea now to the single-qubit gate construction by noting that the phase error corresponds to a U(1) symmetry of the two-qubit gate construction; in the single-qubit gate construction, there is a larger SU(2) symmetry [Phys. Rev. A 80, 012306 (2009)]. Therefore one can construct much more efficient single-qubit gates with very little additional cost. This essentially rules out the practical necessity of the error correction due to imperfect gate construction (using, e.g., the Solovay-Kitaev algorithm).

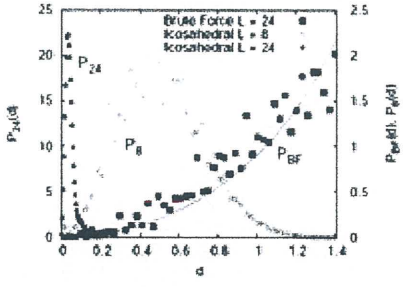


FIG. 3. Distribution of errors for various searching algorithms. The pseudo icosahedral group approaches render Wigner-Dyson distributions.

A second development originated from noticing the similarity between the distribution of braid representations in the space of unitary matrices and that of the impurities in doped semiconductors that Dr. Xin Wan has studied. Such a distribution is known to be broad on the logarithmic energy scale, so the mean value of the distribution is drastically different from the most probable value. This prompted the research group to develop a renormalization group (RG) like scheme to search for

a desired gate. With G. Mussardo and his student M. Burrello, the research group developed an algorithm similar to the hashing algorithm in computer science by constructing a pseudo icosahedral group [which approximates an SU(2) group] with different levels of accuracy in its braid representation. Interestingly, in the RG like iteration, the accuracy (or inaccuracy) follows the Wigner-Dyson distribution of the eigenvalue spacing in the unitary ensemble in random matrix theory [Fig. 3, arXiv:0903.1497]. This leads to an explicit RG flow equation for the universal random-matrix distribution. As a byproduct, open-source object-oriented implementations and library for topological quantum compiling was released at *http://sites.google.com/site/braidanyons/.*

The recent work will appear in Phys. Rev. Lett.

- Members

Name	Title	Nationality	Period
Xin Wan	Leader/ Prof.	Beijing	Jun.1, 2008~May31, 2013
Hyun Jung Lee	Dr.	Korea	Sep.1, 2008~Aug.31, 2010
Ki Hoon Lee	Mr.	Korea	Sep.1, 2008~Aug.31, 2010
Zixiang Hu	Dr.	Beijing	Feb.6, 2009~Feb.5, 2011
Hua Chen*	Mr.	Beijing	Feb.6, 2009~May31, 2009
Mahn-Soo Choi**	Prof.	Korea	Sep.5, 2009~Jan.15, 2010

* Short term visiting exchange student
** Adjunct professor

• [Group 2] Multi-scale Modeling (Leader- Prof. Xin Zhou (Since June 1, 2008))

- Overview

The Independent Junior Research Group (JRG) on Multiscale modeling and simulations was established on June 1st, 2008, financially supported by Max-Planck Society, Germany and Korean Government. The JRG focuses on developing and applying multi-scale computation and simulation methods to study equilibrium and dynamical properties of biological macromolecules in different spatial and temporal scales. Up to November of 2009, there are five members in the JRG, including one professor, one postdoctoral researcher and three Ph.D candidates. The JRG has built a 22-nodes (176 processors) PC cluster computer for our normal simulations. The JRG is communicating and collaborating with some research groups in the world, and publishing some interesting results on multiscale methods and their applications in soft materials.

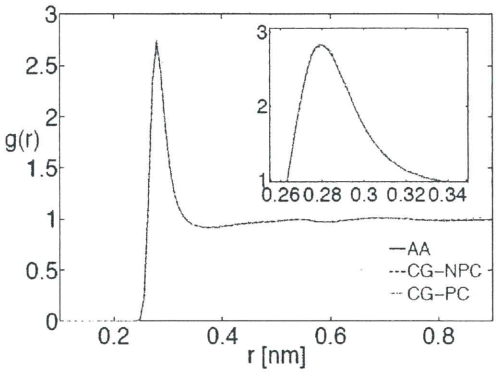
- Research

The phenomena and processes of biologic macromolecules (such as proteins, DNA/RNA) and another complex system, such as glass transitions, often happen in very wide time and space scales. The current single-scale molecular simulations, involving first-principle, all-atomic, and different-level coarse-grained simulations, usually only focus on a single scale, so that it is hard to detect the intrinsic interplays among the different scales.

We are working on developing a systematic multiscale strategy by combining these different-scale simulations and techniques to extend the time and space scales of computer simulations in complex systems. We developed methods in coarse-graining models, enhanced sampling for equilibrium conformations, constructing hierarchic kinetic transition networks for understanding and simplifying systems, and accelerating slow dynamics for reaching experimentally interesting time scale.

In the year, we already achieved interesting progresses in these different parts of establishing multiscale simulation methods:

Construction of Coarse-grained Models



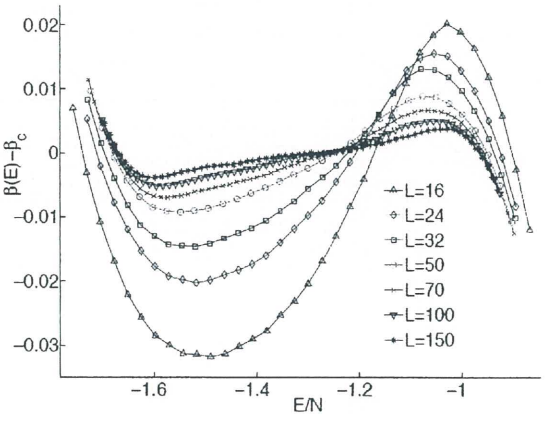
Due to too many degrees of freedom in complex systems, it is very hard to apply standard Monte Carlo and molecular dynamics simulations to detect interesting equilibrium and dynamical properties. By averaging some less important degrees of freedom, it is possible to construct coarse-grained models to simplify the complex systems. The main question is how to get the effective force field in the coarse-grained models to best reproduce properties of the original systems. Traditional coarse-graining techniques fit parameters of effective force fields of coarse-grained models by requiring reproducing some preselected interesting thermodynamic variables of the fine-grained models, thus it is unknown how well the obtained coarse-grained model reproduces the other properties. By developing our previous works where coarse-grained models are required to match free energy surface of the fine-grained models, we presented a new coarse-graining scheme to optimize the effective force fields by matching the probability density in a high-dimensional space. The method has advantages of both the traditional coarse-graining techniques (needing less computing time) and the free-energy-matching methods (taking into account the overall characteristics of free energy surface). The new coarse-graining method can be applied to bridge any two different level models or theories, such as building a connection between the microscopic particle-based molecular simulations and the macroscopic field-based continuous theories of fluids.

We test the new coarse-graining method in liquid water, from all-atomic TIP3P water model to a single-site pair additive water model. The obtained single-site coarse-grained water model reproduces very well the structure [radial distribution function g(r)] of the all-atomic water model. We are also extending the method to chain molecules and to get more transferable coarse-graining models.

Enhanced Sampling

Standard Monte Carlo and molecular dynamics simulation techniques can effectively sample high-dimensional conformational space to get equilibrium and dynamical properties of simpler systems. However, in complex systems, such as biological macromolecules and glasses, due to the rugged energy (or free energy) surface, it is difficult to get complete sample based on these standard techniques in our affordable computing resource. Lots of advanced techniques

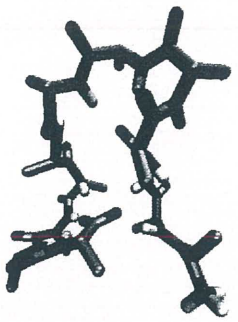
have been developed to overcome the difficulties. Despite the success already achieved, it is still difficult to thoroughly investigate a practically interesting system even based on these advanced techniques.



We presented a generalized canonical ensemble method to overcome the free energy barriers. The 1st order phase transition region in large-size Potts model is a good workhorse for testing the new general enhanced sampling method. Furthermore, we combined the generalized canonical ensemble method with the parallel tempering techniques to improve efficiencies of sampling. In the right figure, we show the relation between the reverse statistical temperature and potential energy in the paramagnetic/ferromagnetic coexisted region of the 1st order phase transition in two-dimension 10-state Potts models with different sizes. The thermodynamic instable coexisted phases in the normal canonical ensemble are stabilized in the generalized canonical ensemble, the critical point, the coexisted temperature, the free energy barriers between the paramagnetic phase and ferromagnetic phase, and phase separation are achieved. We are applying the new method in another system to improve the sampling efficiencies.

Construction of Kinetic Transition Network

Both the simplification of complex systems and the improvement of simulation efficiencies require understanding high-dimensional conformational space of the complex systems. Traditional methods usually intuitively presume one (or a few) reaction coordinates and project simulation-generated conformations to the low-dimensional space to achieve equilibrium and dynamical properties of the systems. The methods often oversimplify the systems since the reaction coordinates are usually complex and unknown. Recently, ones try to construct kinetic transition network based on Markov models. We presented a more flexible method to analyze simulation data to form the hierarchic meta-stable state structures and transition network among the states in the complex systems, such as biological



macromolecules. We independently generate multiple short trajectories from dispersed initial conformations instead of a single very long trajectory. Not matter where the initial conformations are obtained, such as from high-temperature or coarse-graining simulations, these multiple short trajectories can be applied to get equilibrium and dynamical properties of the systems based on a trajectory-reweighting process, and the weight of trajectories simply satisfies a homogeneous linear equation. The result not only provides a simple but efficient method for improving sampling efficiencies of simulations by using the current cheap distributed computers, but also divide the high-dimensional conformational space into some meta-stable states according to the real dynamics. Furthermore, we enable to map each short trajectory (or each segment of a long trajectory) to a vector and calculate the inner product of the trajectory-mapped vectors to form the hierarchic kinetic transition network. The method provides a natural (approximated) picture of dynamics in complex systems in any time scale. We analyze the dynamics in polypeptide (with 12 amid acid residuals) and get the hierarchic transition network.

Combining these progresses and the current related works in other groups together, we are attempting to form a complete multiscale simulation scheme to detect the interesting slow dynamics problem in complex systems, such as protein folding/unfolding dynamics.

- Members

Name	Title	Nationality	Period
Xin Zhou	Leader/ Prof.	Beijing	Jun.1, 2008~May31, 2013
Shun Xu	Mr.	Beijing	Nov.18, 2008~May17.2010
Linchen Gong	Mr.	Beijing	Dec.11, 2008~May10, 2010
Shijing Lu	Mr.	Beijing	Jan.19,2009~Jan.18, 2010
Pakpoom Reunchan	Dr.	Thailand	Nov.1,2009~Oct.31, 2010

• [Group 3] String Theory for Strongly Interacting Systems (Leader- Prof. Youngman Kim (Since March 1, 2009))

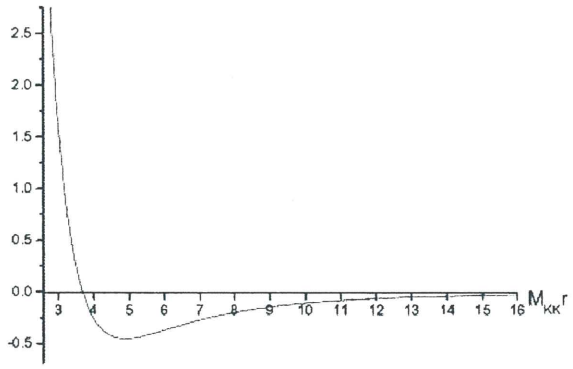
- Overview

The goal of my JRG (SSIS) is about applications of string theory technique in strongly interacting systems. SSIS stands for string theory for strongly interacting systems. Typical examples are strongly interacting quark gluon plasma, dense QCD matter, low energy hadron physics, and condensed matter systems. SSIS had launched in March of this year 2009, and in this October it was more or less shaped with two research fellows and one Ph. D student. Since there were no members except myself till end of August, visitors mostly from Seoul has been a main driving force for SSIS activities. The series of (mini)-workshop, SSIS2009-xx, is sort of a research meeting with a few speakers from outside of my collaboration who pump new developments and ideas into SSIS. So far focus was on applications of AdS/CFT on QCD in extreme conditions and hadron physics with small touch on holographic superconductors.

- Research

Holographic Deuteron and Nucleon-Nucleon Potential

We compute the potential between a pair of nucleons in the D4-D8 holographic QCD. In the large 't Hooft coupling limit, $\lambda >> 1$, the hadronic size of the baryon is small ~ 1/λ1/2MKK, and their interaction with mesons are well approximated by a set of dimension four and five operators. The nucleon-nucleon potential emerges from one-boson exchange picture involving massless pseudo-scalars and an infinite tower of spin one mesons. We find in particular that ρ meson exchanges are dominated by a dimension five derivative coupling of tensor type, whereas for ω mesons and axial mesons, such tensor couplings are completely absent. The potential is universally repulsive ~ 1/r2 at short distance, and has the usual long-distance attractive behavior ~ along a isosinglet and spin triplet channel. Both the large Nc form and the finite Nc form are given. In the former, a shallow classical minimum of depth ~ 0.1MKKNc/λ forms at around rMKK 5.5. Below is the nucleon-nucleon potential.



Here the horizontal axis is rMKK, while the vertical potential energy is in unit of MKK/4 Pi. The main difference from conventional approach is that in our holographic study all the coupling constants in the potential are fixed by the 5D wave function, while in the conventional case those are fitted to experiments.

Ref.: ***Youngman Kim****, Sangmin Lee, and Piljin Yi, Holographic Deuteron and Nucleon-Nucleon Potential,* ***JHEP 0904:086, 2009****.*

The Effect of gluon condensate on holographic heavy quark potential

The gluon condensate is very sensitive to the QCD deconfinement transition since its value changes drastically with the deconfinement transition. We calculate the gluon condensate dependence of the heavy quark potential in AdS/CFT to study how the property of the heavy quarkonium is affected by a relic of the deconfinement transition. We observe that the heavy quark potential becomes deeper as the value of the gluon condensate decreases. We interpret this as a dropping of the heavy quarkonium mass just above the deconfinement transition, which is similar to the results obtained from QCD sum rule and from a bottom-up AdS/QCD model. As an example, we calculate the gluon condensate dependent mass of bound state of two bottom quarks out of the heavy quark potential. The numbers shown in the table below.

c (GeV^4)	r_0 (GeV^{-1})	Binding energy (GeV)	Meson mass (GeV)
0.02	0.285	−0.624	8.357
0.2	0.291	−0.465	8.675
0.9	0.304	−0.121	9.364

One thing that should be improved in our study is that the deformed AdS black hole background has a singularity, though our potential does not see the singularity.

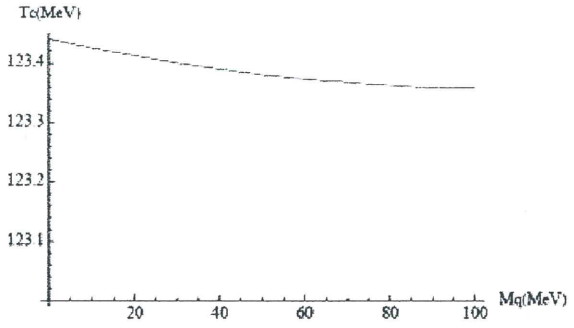
So in future we need to find out a regular but deformed AdS black hole.

Ref.: ***Youngman Kim****, Bum-Hoon Lee, Chanyong Park, and Sang-Jin Sin, The Effect of gluon condensate on holographic heavy quark potential,* ***Phys. Rev. D 80, 105016 (2009)****.*

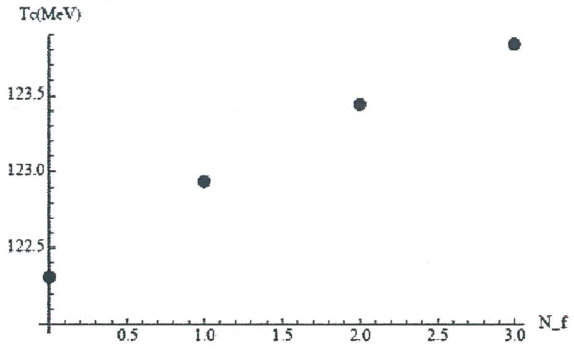
Holographic phase transition of QCD with back-reaction of flavors

We revisit confinement/deconfinement transition in holographic QCD to consider the back-reaction of a bulk scalar field. The bulk scalar field is dual to a quark bi-linear operator, and it encodes explicit and spontaneous chiral symmetry breaking of QCD. To perform the Hawking-Page transition analysis with the back-reaction, we first obtain a deformed AdS black hole solution due to a finite quark mass. Through the Hawking-Page analysis with the back-reacted geometry, we study the flavor number Nf and finite quark mass dependence of the critical temperature of the confinement/deconfinement transition of QCD. In addition, we confirm that unphysical QCD phase haunting around in a previous study disappears with the back-reaction. The quark mass and flavor number dependence of the QCD deconfinement temperature are given in the figures below.

Ref.: ***Youngman Kim****, Tatsuhiro Misumi, and* ***Ik Jae Shin****, Holographic phase transition of QCD with back-reaction of flavors, e-print:* ***arXiv:0911.3205*** *[hep-ph].*



The mass dependence of the critical temperature for $N_f = 2, N_3 = 3$ is depicted. T_c decreases with the quark mass m_q getting large.



The N_f dependence of the critical temperature for $m_q = 0, N_c = 3$ is depicted. T_c increases with N_f getting large.

Our findings with some large N corrections are that the critical temperature of QCD decreases with the quark mass, while it becomes bigger as the number of quark flavor increase.

- Members

Name	Title	Nationality	Period
Youngman Kim	Leader/ Prof.	Korea	Mar.1, 2009~Feb.28, 2012
Takuya Tsukioka	Dr.	Japan	Sep.1, 2009~Aug.31, 2010
Deokhyun Yi	Mr.	Korea	Sep.1, 2009~Aug.31, 2010
IkJae Shin	Dr.	Korea	Oct.1, 2009~Sep.30, 2010

- **[Group 4] Cooperative Phenomena in Correlated Electron Systems (Leader- Prof. Tetsuya Takimoto (Since July 1, 2009))**

- Overview

On April 2009, I have joined to APCTP. After a selection, I became a JRG leader of APCTP since July 2009. In order to develop the research, I would like to have one or two postdocs in my group. Actually, I offered a postdoc position to Japanese. Unfortunately, he chose other postdoc position in Japan. I put an advertisement for the postdoc position into a Japanese mailing list and a homepage of job list for physicists. Recently, I offer Mr. Mukherjee APCTP Research Fellow at JRG, who will get Ph.D in November 2010. Still, I seek the candidate of postdoc position in my group. In addition, I had visitors, Prof. Kontani from Nagoya University to collaborate on the transport phenomena like spin Hall conductivity in noncentrosymmetric systems and Prof. Kkeda from Kyoto University to collaborate on hidden ordered phase of URu_2Si_2.

Now, my research field is magnetism and superconductivity in strongly correlated electron systems, since the PhD student day. After I joined to APCTP, I am researching on following topics mainly.

(1) The mode-mode coupling theory of spin fluctuations in noncentrosymmetric compounds.

The new and important point of this theory is to incorporate the mode-mode coupling between usual spin fluctuation and anomalous spin fluctuation, where the anomalous spin fluctuation remains only in noncentrosymmetric systems. Due to the consideration of the mode-mode coupling, I expect some characteristic critical behavior intrinsic to the noncentrosymmetric system. I hope that the theory gives an explanation from the spin fluctuation viewpoint for the non-Fermi liquid behavior in MnSi.

(2) Spin fluctuation theory developed for a checkerboard Hubbard model.

When the second neighbor hopping is equal to the nearest neighbor hopping in the checkerboard Hubbard model, the upper band reduces to a dispersion-less band touching the upper limit of the lower band. Then, the frustration nature appears around the half-filled case. Unfortunately, the traditional spin fluctuation theory is unsuitable to treat the frustration, where the system is assumed to be close to an magnetic ordered phase. The goal of this research is to extend the spin fluctuation theory to frustrated systems from one of simplest models. This study is directed by Prof. Ueda.

(3) Kondo effect in the multipole ordered phase.

In the Kondo state, a spin of localized electron and a spin of conduction electrons form a spinsinglet state under the time reversal invariance. On the other hand, no magnetic moment is induced in the multipole ordered phase,

whose representation differs from representation of spin operator, and some multipole like octupole has odd parity for the time reversal. From these things, it is expected that the Kondo effect will be affected differently by the representation of the multipole ordered phase. I hope that this research gives a key to clarify the order parameter of hidden ordered phase in URu_2Si_2. On this topic, I now collaborate with Dr. Ki-Seok Kim and Dr. Tran Minh-Tien in APCTP.
In order to develop these researches and future studies, I would like to find one or two postdocs as early as possible. Furthermore, I would like to contribute to an international workshop as an organizer. Through the workshop and collaborations with inhouse and outside researchers, I would like to develop the research activity.

- Research

Characteristic property in noncentrosymmetric compounds.

A noncentrosymmetric compound MnSi of a cubic symmetry shows a helical magnetic order at T_M = 30 K in the ambient pressure. Increasing the pressure, T_M decreases monotonously, and vanishes at p_c =14.6 kbar. From the standard spin fluctuation theory, a quantum critical behavior is expected only around p_c. However, a non-Fermi liquid behavior of the resistivity proportional to $T^{3/2}$ is observed at least up to 30 kbar. It is desired to explain the origin of the non-Fermi liquid behavior.
Recently, it has been pointed out that in addition to the usual spin fluctuation of $<\mathbf{S}^2>$ type, anomalous spin fluctuations, for example, $<S^{\alpha}S^{\beta}>$ type ($\alpha \neq \beta$), do not vanish in noncentrosymmetric systems. In the spirit of spin fluctuation theory, not only the mode-mode coupling between usual spin fluctuations but also the mode-mode couplings between usual and anomalous spin fluctuations and the mode-mode coupling between anomalous spin fluctuations are crucial to the unusual temperature dependence of the physical quantity. At present, we construct the appropriate form of the mode-mode coupling term in the GL free energy.
In addition, in the collaboration with Prof. Kontani of Nagoya University, we study the effect of electron correlation on the transport phenomena like the spin Hall effect in a noncentrosymmetric system.

Spin fluctuation theory developed for a checkerboard Hubbard model.

Some compounds like $YbRh_2Si_2$ show a frustration nature. In this case, the usual spin fluctuation theory is insufficient, because the theory is only reliable for the system close to the second-order magnetic transition, where relevant spin fluctuation is considerably enhanced. In the frustrated system, several spin

fluctuation modes should be enhanced. Then, it is required to incorporate coupling between these different spin fluctuation modes for an explanation of the frustration nature.
We regard that the checkerboard Hubbard model is a simplest one modeling the frustration nature. When the second neighbor hopping is equal to the nearest neighbor hopping in the checkerboard Hubbard model, the upper band reduces to a dispersion-less band touching the top of the lower band. Then, the frustration nature is expected around the half-filled case. Before we proceed to construct the reasonable spin fluctuation theory, we carry out the weak coupling theory to calculate the density of state and spin fluctuation structure for various hopping parameter sets. The goal of this research is to extend the spin fluctuation theory to frustrated systems. This study is directed by Prof. Ueda.

Kondo effect in the multipole ordered phase.
It is known that URu_2Si_2 shows a second-order transition at $T = T_o = 17.5$ K in the ambient pressure, where the order is called as "hidden order", because the order parameter is not clarified yet. Increasing the pressure, T_o increases monotonously, and the compound shows a transition from the hidden order phase to the antiferromagnetic phase. The type of this transition is regarded as a first-order one under the observation of staggered magnetic moment in the high pressure phase, even though the phase transition line from the high temperature phase does not show any anomaly. Decreasing the temperature at ambient pressure, the specific heat decreases from $C/T \sim 180$ mJ/K^{2}mol at $T = T_o$ to ~ 60 mJ/K^{2}mol at T = 2 K due to a partial gap opening. From the specific heat below T_o, it is considered that a heavy fermion state is formed even in the hidden ordered phase.
As the candidate of the order parameter of the hidden ordered phase, multipole moments like quadrupole or octupole are suggested by many theoretical groups. However, it is difficult to identify the multipole type experimentally. One of the reasons is the fact that the system is metallic even in the hidden ordered phase. Recently, we have started collaboration with Dr. Ki-Seok Kim and Dr. Tran Minh-Tien in APCTP, on the Kondo effects in multipole ordered phases applying the slave boson technique to an impurity Anderson model. Through this research, we would like to find a key to distinguish the multipole type.

- Member

Name	Title	Nationality	Period
Tetsuya Takimoto	Leader/Prof.	Japan	Jul.1, 2009~Jun.30, 2012

• Quantum phase transitions in Strongly Correlated Electron Systems (Research Prof. Ki-Seok Kim (Since October 1, 2008))

- Overview

(1) Purpose

Quantum phase transitions in strongly correlated electrons give rise to crisis in two cornerstones of modern theory of metals, Landau Fermi liquid theory and Landau-Ginzburg-Wilson framework. In particular, the origin of non-Fermi liquid near quantum critical points of heavy fermions and doped Mott insulators has been debated for several decades, and mechanism of superconductivity out of non-Fermi liquids has been one of the outstanding problems in condensed matter physics. We try to understand such non-Fermi liquid physics and mechanism of superconductivity based on newly developed non-perturbative frameworks such as gauge theory formulation, supersymmetric bosonization, and AdS/CFT correspondence.

(2) Contents

We develop the gauge theory approach, supersymmetric bosonization methodology, and AdS/CFT technique for strongly correlated electrons. We first reveal the origin of non-Fermi liquid near the quantum critical point in the heavy-fermion transition, and propose new mechanism of superconductivity based on the slave-fermion gauge theory, where electron fractionalization is expected to allow new universality class for magnetic transitions beyond the conventional approach. Next, we propose new mechanism of superconductivity in the Mott insulator based on the SU(2) slave-rotor gauge theory, where two kinds of energy scales would appear to be consistent with experiments. In this gauge theory approach we develop how to calculate transport coefficients, not fully understood until now because its theoretical structure differs from the standard framework. The most notorious issue so called confinement will be addressed, and critically investigated in association with experiments. We develop the supersymmetric bosonization method for non-perturbative understanding of strongly correlated electrons. Particularly, we solve gauge theories based on this methodology, and compare this physics with the gauge theory approach, focusing on confinement. Finally, we apply the so called AdS/CFT correspondence, developed in the string theory context, to strongly correlated electrons, particularly quantum critical points, where conformal symmetry appears naturally. We evaluate transport coefficients based on this method, and compare these results with those of field theoretic techniques.

(3) Expected Contribution

Our gauge-theory approach based on the slave-boson, slave-fermion, and slave-rotor representations will give a stable framework for studying strongly

correlated electrons because confinement of such fractionalized excitations is introduced beyond the previous gauge theory approach. In particular, our methodology for transport coefficients in the Luttinger-Ward functional approach can be used in other studies for not only strongly correlated electrons and but also various nano structures. The confinement issue will open a new era in condensed matter physics, discussed with newly developed techniques such as the supersymmetric bosonization and AdS/CFT correspondence. Such analytic tools are expected to enlighten new quantum states of strongly correlated electrons.

(4) Keywords

Quantum phase transition / Heavy fermion and Mott insulator / Non-Fermi liquid and superconductivity / Gauge theory and confinement / Supersymmetric bosonization / AdS/CFT correspondence

Ki-Seok Kim is supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 2009-0074542). The total grant is 43,000,000 in the first year and 40,000,000 in the second and third years. Based on this support, Ki-Seok Kim invites one research fellow, Dr. Tran Minh-Tien.

- Research

(1) Ki-Seok Kim, "Superconductivity from a non-Fermi liquid metal: Kondo fluctuation mechanism in the slave-fermion theory," Phys. Rev. B. 81, 094507 (2010).

We propose Kondo fluctuation mechanism of superconductivity, differentiated from the spin fluctuation theory as the standard model for unconventional superconductivity in the weak coupling approach. Based on the U(1) slave-fermion representation of an effective Anderson lattice model, where localized spins are described by the Schwinger boson theory and hybridization or Kondo fluctuations weaken antiferromagnetic correlations of localized spins, we found an antiferromagnetic quantum critical point from an antiferromagnetic metal to a heavy fermion metal in our recent study. The Kondo induced antiferromagnetic quantum critical point was shown to be described by both conduction electrons and fermionic holons interacting with critical spin fluctuations given by deconfined bosonic spinons with a spin quantum number 1/2. Surprisingly, such critical modes turned out to be described by the dynamical exponent $z = 3$, giving rise to the well known non-Fermi liquid physics such as the divergent Gr¨uneisen ratio with an exponent 2/3 and temperature-linear resistivity in three dimensions. We find that the $z = 3$ antiferromagnetic quantum critical point becomes unstable against

superconductivity, where critical spinon excitations give rise to pairing correlations between conduction electrons and between fermionic holons, respectively, via hybridization fluctuations. Such two kinds of pairing correlations result in multi-gap unconventional superconductivity around the antiferromagnetic quantum critical point of the slave-fermion theory, where s-wave pairing is not favored generically due to strong correlations. We show that the ratio between each superconducting gap for conduction electrons c and holons f and the transition temperature Tc is 2Dc/Tc ~ 9 and 2Df /Tc ~ O(0.1), remarkably consistent with CeCoIn5. A fingerprint of the Kondo mechanism is emergence of two kinds of resonance modes in not only spin but also charge fluctuations, where the charge resonance mode at an antiferromagnetic wave vector originates from d−wave pairing of spinless holons. We discuss how the Kondo fluctuation theory differs from the spin fluctuation approach.

(2) Ki-Seok Kim and Mun Dae Kim, "Superconductivity from purely repulsive interactions in the strong coupling approach: Application of the SU(2) slave-rotor theory to the Hubbard model," Phys. Rev. B 81, 075121 (2010).

We propose a mechanism of superconductivity from purely repulsive interactions in the strong coupling regime, where the BCS (Bardeen-Cooper-Schrieffer) mechanism such as the spin-fluctuation approach is difficult to apply. Based on the SU(2) slave-rotor representation of the Hubbard model, we find that the single energy scale for the amplitude formation of Cooper pairs and their phase coherence is separated into two energy scales, allowing the so called pseudogap state where such Cooper pairs are coherent locally but not globally, interpreted as realization of the density-phase
uncertainty principle. This superconducting state shows the temperature-linear decreasing ratio of superfluid weight, resulting from strong phase fluctuations.

(3) Minh-Tien Tran and Ki-Seok Kim, "To probe quantum criticality with scanning tunneling spectroscopy," Phys. Rev. B 81, 035121 (2010).

We investigate the role of quantum coherence in tunneling conductance, where quantum criticality turns out to suppress Fano resonance. Based on the nonequilibrium noncrossing approximation, we show that the linear tunneling conductance exhibits weak Fano line-shape with sharp cusp at zero energy in the multichannel Kondo effect, resulting from incoherence associated with quantum criticality of impurity dynamics. In particular, shift of the peak position in the Fano resonance is predicted not to occur for the multichannel Kondo effect, distinguished from the Fermi liquid theory in the single channel Kondo effect.

(4) K.-S. Kim and C. Pepin, "Quantum Boltzman equation study for the Kondo breakdown quantum critical point,"J. Phys.: Condens. Matter 22, 025601 (2010).

We develop the quantum Boltzman equation approach for the Kondo breakdown quantum critical point, involved with two bands for conduction electrons and localized fermions. Particularly, the role of vertex corrections in transport is addressed, crucial for non-Fermi liquid transport of temperature linear dependence. Only one band of spinons may be considered for scattering with gauge fluctuations, and their associated vertex corrections are introduced in the usual way, where divergence of self-energy corrections is cancelled by that of vertex corrections, giving rise to the physically meaningful result in the gauge invariant expression for conductivity. On the other hand, two bands should be taken into account for scattering with hybridization excitations, giving rise to coupled quantum Boltzman equations. We find that vertex corrections associated with hybridization fluctuations turn out to be irrelevant due to heavy mass of spinons in the so called decoupling limit, consistent with the diagrammatic approach showing the non-Fermi liquid transport.

(5) Ki-Seok Kim and Chenglong Jia, "z = 3 antiferromagnetic quantum criticality driven by the Kondo effect," submitted to Phys. Rev. Lett.

A new universality class is proposed for an antiferromagnetic (AF) quantum critical point (QCP) in the heavy fermion quantum transition, driven by the Kondo effect and described by deconfined bosonic spinons with the dynamical exponent z = 3. Thermodynamics and transport of the z = 3 AF QCP are shown to be consistent with the well known non-Fermi liquid physics such as the divergent Gruneisen ratio with an exponent 2/3 and temperature-linear resistivity. The hallmark of the Kondo driven AF QCP is suggested to be the uniform spin susceptibility diverging with an exponent 2/3, remarkably consistent with an experiment for YbRh2Si2.

(6) Ki-Seok Kim and Hyun-Chul Kim, "Non-Fermi liquid from confinement in doped Mott insulators," submitted to Phys. Rev. Lett.

A phenomenological description for confinement of fractionalized excitations is proposed in the gauge theory approach for doped Mott insulators. Introducing the Polyakov-loop parameter into an SU(2) gauge theory for the t-J model, we show that electron excitations emerge below the socalled coherence temperature, resulting from confinement of spinons and holons via the formation of the Polyakov loop. Remarkably, such confined electrons turn out to exhibit non-Fermi liquid physics without quantum criticality, yielding the electric resistivity in quantitative agreement with experimental data. The Higgs phase is not allowed due to confinement, suggesting a possible novel mechanism of superconductivity in the strong coupling approach.

(7) Ki-Seok Kim and C. Pepin, "The thermopower as a signature of quantum criticality in heavy fermions," submitted to Phys. Rev. B.

We present a series of arguments showing that the Seebeck coefficient can be used as a decisive experiment to characterize the nature of the quantum critical

point (QCP) in heavy fermion compounds. Being reactive almost exclusively to the presence of delocalized entropic carriers, the Seebeck coefficient shows a drastic collapse at the Kondo breakdown QCP, as the reconstruction of the Fermi surface takes place. In contrast, around a Spin Density Wave (SDW) QCP, the Seebeck coefficient is broadly symmetric. We discuss the possibility of a change of sign at the QCP, the characteristic variation of |S/T | with temperature and external parameter, as well as the capacity of the Seebeck coefficient to distinguish between localized and itinerant anti-ferromagnetism (AF). Suggestions of experiments are given in the case of four non conventional compounds: YbRh2Si2, Ce(Mn)In5, CeCu6−xAux and URu2Si2.

- Members

Name	Title	Nationality	Period
Ki-Seok Kim	Research Prof.	Korea	Oct.1, 2008~Sep.30, 2013
Tran Minh-Tien*	Dr.	Vietnam	Aug.1, 2009~Feb.28, 2011

* Supported by the National Research Foundation of Korea (NRF)

□ Young Scientist Training Program (YST)

- The APCTP Young Scientist Training Program (YST) offered several postdoctoral positions in theoretical physics and related fields.
  - YST: 13 persons
- Junior YST Network Program (Junior YST) aimed for supporting graduate students in cooperation with membership countries.
  - Junior YST: 1 person

Name	Nationality	Field	Period
Dr. Tran Minh-Tien	Vietnam	Strongly correlated electron systems	Mar.5, 2009 ~Jul.31, 2009
Dr. Masayoshi Yamamoto	Japan	Supersymmetric field theories and string theory	May1, 2006 ~Feb.28, 2009
Dr. Sungyun Kim	Korea	Numberical simulation of physical systems	Sep.1, 2007 ~Feb.28, 2009
Dr. Yoshinori Matsuo	Japan	String theory; matrix models, AdS/CFT correspondence	Sep.3, 2007 ~Nov.31, 2009
Dr. Takuya Tsukioka	Japan	Topological field theory, String Theory	Sep.17, 2007 ~Aug.31, 2009
Dr. Mesfin Asfaw	Ethiopia	Biophysics, Soft matter physics and Statistical physics	Sep.1, 2008 ~Jul.27, 2009
Dr. Liming Cao	Beijing	AdS/CFT correspondence, Black hole theory	Sep.1, 2008 ~Aug.31, 2009
Dr. Vincent Sacksteder	USA	Path integrals applied to complex and disordered systems, mesoscopic physics, networks, and chaos, development of new linear scaling algorithms	Sep.1, 2008 ~Aug.31, 2010
Dr. Shingo Takeuchi	Japan	Precise confirmation of the gauge/gravity correspondence, Spontaneous symmetry breaking of SO(10) in the IIB matrix model	Sep.1, 2008 ~Aug.31, 2010
Dr. Chul-Moon Yoo	Korea	General Relativity, Cosmology	Sep.1, 2008 ~Mar.31, 2010
Dr. Shin Nakamura	Japan	Application of AdS/CFT to QCD, Baryon chemical potential in AdS/CFT and holographic description of time-dependent hydordynamic systems of YM theories	Dec.1, 2008 ~Feb.28, 2009
Dr. Chang-Woo Shin	Korea	Onlinear dynamics and complex systems / Computational neuroscience	Jul.1, 2009 ~Feb.28, 2010
Dr. Woojoo Sim	Korea	String Theory	Sep.1, 2009 ~Jan.31,2010
Galbadrakh Dagvadorj	Mongolia	Bose-Einstein condensation in cold atoms, ultracold atoms in optical lattice and its applications	Sep.9, 2008 ~Feb.28, 2009

2.2.3 AP Scholars for Joint Research

In order to attract science leaders for the next generation and perform joint research, established scholars in Asia-Pacific are invited for an extended period as an APCTP faculty or an adjunct faculty. This program is expected to strengthen the resident research groups at the Center.

Total	Member Country		Non Member Country	P/M*
	Korea	Others		
10	4	3	3	17.5

(1 Person Month (P/M): 28 days)

2.3 Reports of AP Scientist Network Activities

2.3.1 Aim

- Motivate and nurture young scientists in the Asia Pacific region to become global leaders in the future
- Foster the top brain network in Asia Pacific and promote science communication among the public
- Create and distribute the highest-quality scientific literary contents to bring a maximum impact through the AP scientist network

2.3.2 Publication

- Creation and distribution of high-quality scientific literary contents by the AP scientist network

☐ **On-line web-journal "Crossroads"**

Year	2005 (Oct.~Dec.)	2006 (Jan.~Dec.)	2007 (Jan.~Dec.)	2008 (Jan.~Oct.)	2009 (Jan.~Dec.)
Total Unique (Total Visits)	4,763 (16,299)	33,956 (91,554)	41,300 (84,312)	46,606 (255,531)	167,064 (232,254)

	Korea	USA	Japan	Canada	Beijing	UK	Germany	Etc.
2005	3,918	526	115	28	8	7	-	161
2006	16,871	13,431	122	249	430	93	425	2,335
2007	17,094	8,145	35	224	1,556	148	275	13,823
2008	28,316	6,537	275	135	2,947	73	112	8,211
2009	144,758	12,695	386	1,221	2,092	282	288	5,342

· Lead the Vision for Science, Future and Humanity
  - Build up a network for scientist in the Asia-Pacific region and set an example of web-journal in the science field
  - Expand the base of science and lead popularization of science through communication among scientist and the public and various journals

· Published monthly in English and Korean
  ; Volume 5 Issuel (January) ~ Volume 5 Issue 12 (December)

· Total number of 89 articles
  ; Editorial (12), Column (14), Feature (8), Essay (24), SF (11), Window to Asia (2), HOT APCTP (18)

☐ **Science Book publication: The 3rd SF series of Crossroads**

- Title: "Telling to the deceased" (Published in July 2009)
- Author: 10 persons

2.3.3 Lecture

☐ **APCTP-POSTECH Distinguished Lecture Series**

Lectures were held by Asia Pacific Scientists on the topics of physics and beyond. (Jointly organized with POSTECH)

No	Topic	Period	Place	Speaker	Affiliation	Participants
1	Critical Casimir effect	May. 11, 2009	APCTP Headquarters	Siegfried Dietrich	Max Planck Institute for Metals Research and Univ. of Stuttgart	23
2	The Ring of Brownian motion : the good, the bad and the simply silly	Jun. 8, 2009	APCTP Headquarters	Peter Hänggi	Univ. of Augsburg, Germany	27
3	Carbon Nanotube Superconductivity : An Update	Jul. 6, 2009	APCTP Headquarters	Ping Sheng	Hong Kong Univ. of Science and Technology	31
4	Spin Current in Superconductors / Spin Current, Charge Current and their Interaction in Magnetic Nanostructures	Nov. 9, 2009	APCTP Headquarters	Sadamichi Maekawa	Institute for Materials Research, Tohoku Univ.	36
5	Mott-Hall Insulator and Chiral Spin Liquid Phase in Neutral Graphene in a Magnetic Field	Dec. 2, 2009	APCTP Headquarters	Ganapathy Baskaran	Institute of Mathematical Sciences	29
Total						**146**

2.3.4 Outreach Programs

- Promote science communication through literary contents
- Lead the vision, future & humanity for young scientists in Asia Pacific
- Raise awareness in the field of science among public

☐ Science Communication School

The university students in science and engineering who had been selected on the applicants were trained as Science Communicators through science writing & debating programs at the Center.

No	Topic	Period	Place	Participants
1	Development of the Universe	Feb. 14~16, 2009	APCTP Headquarters	32
2	What did the Internet do? & Is Darwin's Evolution Theory still effective?	Aug. 13~15, 2009	APCTP Headquarters	16

☐ Science Communication Forum/Lecture

A small, intimate forum for communicating multi-disciplinary ideas between science and society at the Center

No	Topic	Period	Place	Speaker	Affiliation	Participants
1	Film-making of <The Old Partner>	May 27, 2009	POSTECH Info. Research Lab.	C. R. Lee	Film Director	93
2	Science-economics by a country doctor	Nov. 2, 2009	APCTP Headquarters	G. C. Park	Economist	116
3	Computational Search and Design of Hydrogen-Storage Nanomaterials	Nov. 24, 2009	APCTP Headquarters	J. S. Ihm	Seoul Nat'l Univ.	31
4	When Psychology meets Physics	Dec. 14, 2009	APCTP Headquarters	H. N. Kim	Nanoori Hospital	76
5	When Science meets leadership	Dec. 15, 2009	APCTP Headquarters	G. U. Kim	Seoul Nat'l Univ.	35
Total						**351**

☐ Physics in Library

Physicists, Scientists and Popular science writers were invited to communicate with readers.

No	Topic	Period	Place	Speaker	Affiliation	Participants
1	From Atom to Conan	Apr. 16, 2009	Gimje Library	Y. G. Gang	Pressian	44
2	Science in Harry Potter	Apr. 17, 2009	Hongseong Library	J. M. Lee	Yonsei Univ.	110
3	An exciting trip to our body with physics	Apr. 18, 2009	Yanggu Library	H. G. Kim	Seoul Nat'l Univ.	138
4	A date with Movie and Science	Apr. 27, 2009	Jeju Library	S. W. Kim	Pusan Nat'l Univ.	75
5	Substance, Universe, and Life	May. 20, 2009	Yangju Library	M. Y. Choi	Seoul Nat'l Univ.	78
6	The Telescope	Jul. 4, 2009	Sacheon Library	H. Y. Jang	Kyungpook Nat'l Univ.	60
7	Search for Extraterrestrial Intelligence	Jul. 31, 2009	Cheongju Library	M. H. Lee	Yonsei Univ.	112
8	The truth of the growth curve	Sep. 5, 2009	Andong Library	S. S. Hong	Seoul Nat'l Univ.	76
9	Korean traditional astrophysics tools	Sep. 26, 2009	Yangpyeong Library	S. H. Kim	Korea Astronomy and Space Science Institute	70
10	Time travel with 400 astronomical telescopes	Nov. 26, 2009	Yeosu Library	H. K. Moon	Korea Astronomy and Space Science Institute	143
Total						**906**

☐ **Best Science Book 10" selected by APCTP (December 2009)**

The best science books were selected and promoted by APCTP for wide readership.

No	Title	The date of Issue	Speaker	Affiliation
1	Physics Lecture by Prof. Moo Young Choi	Dec. 20, 2008	M. Y. Choi	Seoul Nat'l Univ.
2	Disturbing The Universe	Feb, 10, 2009	Freeman Dyson	Space Studies Institute
3	Big Bang Theory for All	Sep. 30, 2009	S. Y. Lee	Yonsei Univ.
4	A Religious War	Jun. 12, 2009	D. I. Jang J. S. Shin Y. S. Kim	Dongduk Women's Univ. /Honam Theological Univ. and Seminary/Seoul Nat'l Univ.
5	Darwin : The Life of a Tormented Evolutionist	Nov. 23, 2009	Adrian Desmond James Moore	Univ. College London /Open Univ.
6	Power, Sex, Suicide : Mitochondria and the Meaning of Life	Jan. 23, 2009	Nick Lane	Univ. College London
7	The Science of Janus	Nov. 28, 2008	M. J. Kim	Seoul Nat'l Univ.
8	Making Genes, Making Waves	Oct. 10, 2009	John Beckwith	Harvard Univ.
9	Not By Genes Alone : How Culture Transformed Human Evolution	Aug. 10, 2009	Robert Boyd Peter J.Richerson	Univ. of California Univ. of California
10	In Search of Memory : The Emergence of a New Science of Mind	Mar. 19, 2009	Eric R. Kandel	Columbia Univ.

☐ Science in City Hall

High Quality Science Contents combined with Science, Education, Art, and Experience

No	Topic	Period	Place	Speaker	Affiliation	Participants
1	The Amazing Science Journey for the Dmitri Donskoi ship near Ulleung Island(East Sea of Korea) & Science Musical Performance "A Treasure Island"	Jun. 17 , 2009	Pohang City Hall	H. S. Yoo	Korea Ocean Research & Development Institute	650

☐ The 6th Pohang Family Science Festival held with Pohang City

No	Topic	Period	Place	Participants
1	Amazing Science Trip to Universe	Nov. 6~8, 2009	POSTECH Tennis stadium, Pohang	14,394

☐ Invited Talk for International Year of Astronomy (June 2009)

No	Topic	Period	Place	Speaker	Affiliation	Participants
1	Culture and Astrophysics In Korean Currency	Jun. 27 , 2009	Pohang Library	Y. B. Lee	Seoul Nat'l Univ. of Education	80

2.4 Brief Summary of Financial Statements

(May 1996 - December 2009)

(Unit: million Korean Won)

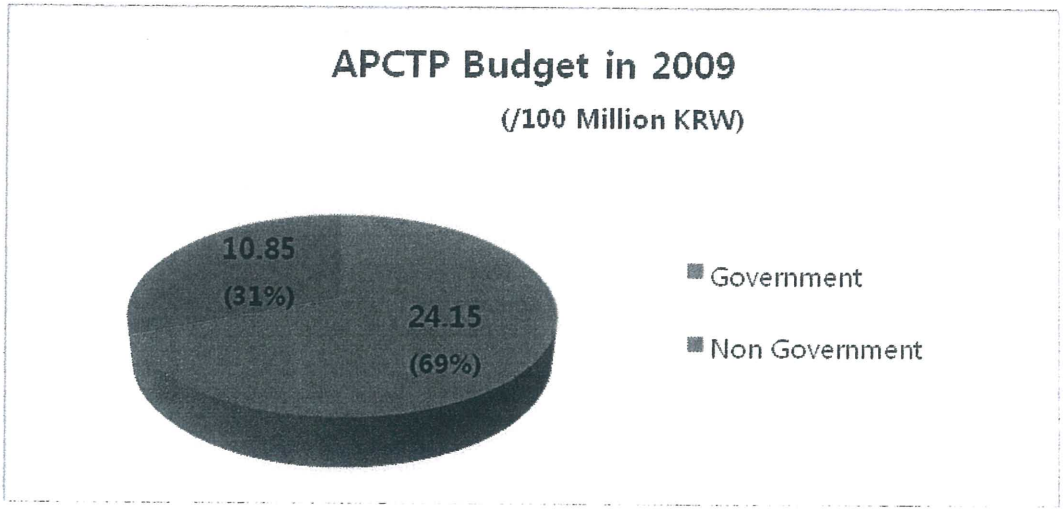
Fiscal year	May 1996 ~ Aug 1997	…	Mar 2000 ~ Feb 2001	Mar 2001 ~ Feb 2002	Mar 2002 ~ Dec 2002	Jan 2003 ~ Dec 2003	Jan 2004 ~ Dec 2004	Jan 2005 ~ Dec 2005	Jan 2006 ~ Dec 2006	Jan 2007 ~ Dec 2007	Jan 2008 ~ Dec 2008	Jan 2009 ~ Dec 2009
Activities	444 /172	…	125 /148	0 /300	0 /158	540 /0	540 /0	600 /0	600 /0	700 /0	700 /0	700 /0
Joint researches	364 /59	…	78 /43	0 /104	0 /121	160 /0	160 /0	200 /0	200 /0	400 /0	1,000 /0	1,300 /0
Operation & management expenses	142 /0	…	297 /129	200 /296	200 /121	0 /400	0 /400	0 /400	0 /350	0 /500	0 /1,000	0 /1,085
Science Communication		…						700 /200	400 /150	400 /0	400 /0	415 /0
Total	950 /231	…	500 /320	200 /700	200 /400	700 /400	700 /400	1,500 /600	1,200 /500	1,500 /500	2,100 /1,000	2,415 /1,085

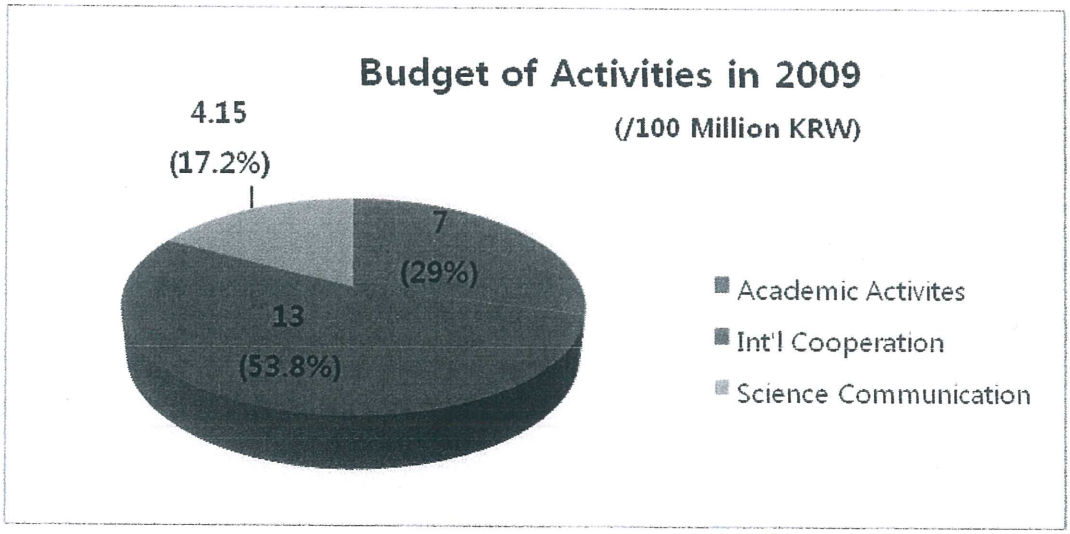
*(Korean Government Fund / Non Government Fund)

3. Statistics of APCTP Activities in 2009

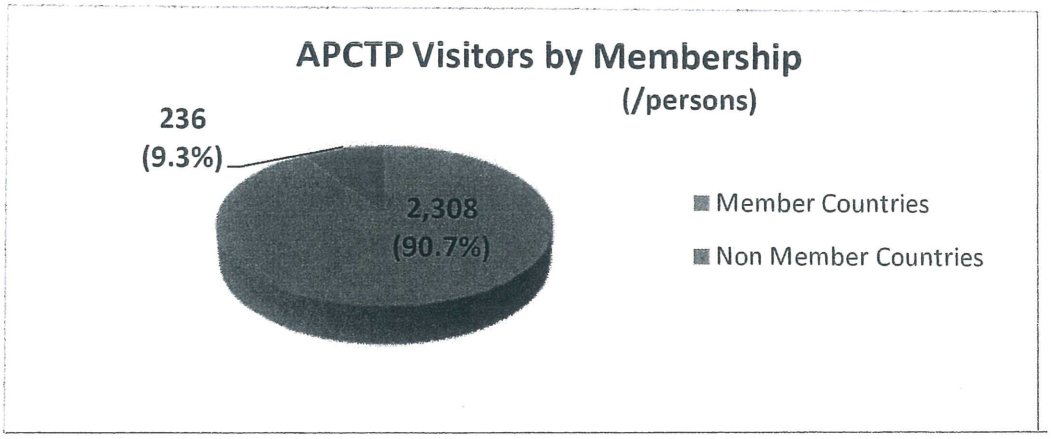
3. Statistics of APCTP Activities in 2009

☐ **Total Budget in 2009: 3.5 billion KRW**





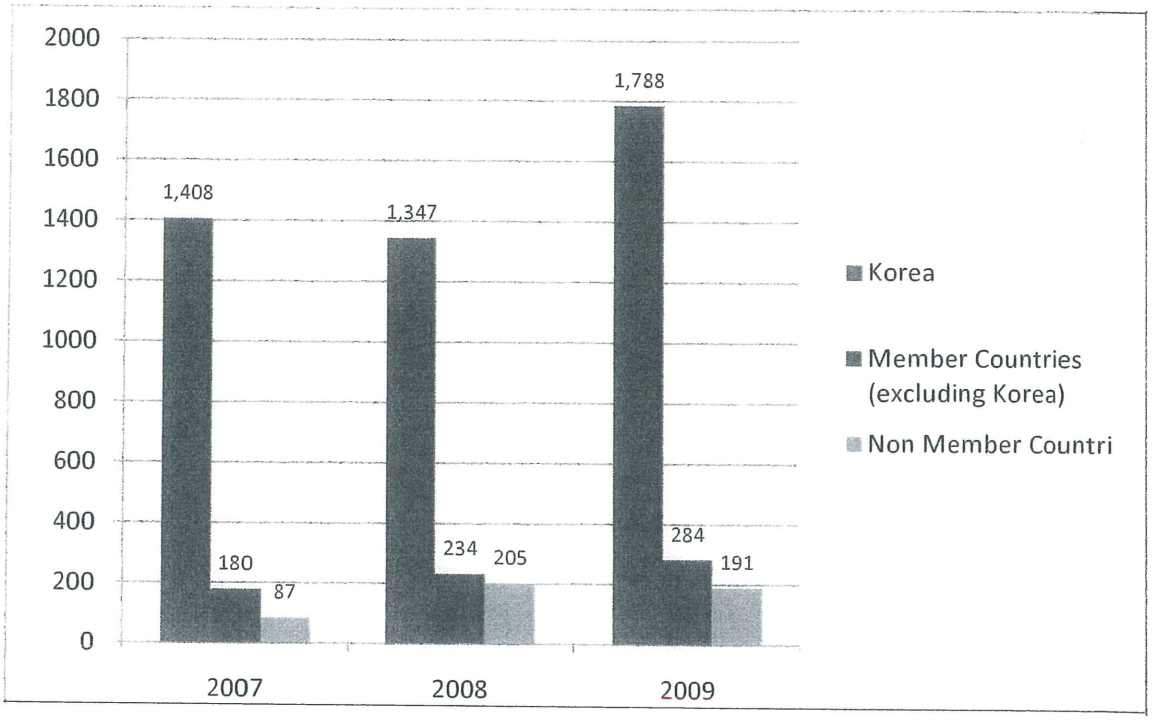
☐ Total Visitors in 2009: 2,544 persons



☐ APCTP Visitors in 2009 by region

Region	Countries	Visitors (persons)	Ratio (%)
Far East	Beijing, Japan, Korea, Taipei, Mongolia	2,268	89.15
South East Asia and the Pacific	Vietnam, Thailand, , Indonesia, Lao PDR, Malaysia, Australia	29	1.13
Middle and South Asia	India, Uzbekistan, Israel	20	0.78
Eastern Europe	Russia, Czech, Hungary, Bulgaria, Romania, Slovenia	13	0.53
Western Europe	Italy, France, Germany, UK, Netherlands, Switzerland, Ireland, Denmark, etc.	140	5.52
North America	Canada, USA	68	2.67
Latin America	Argentina, Brazil, CostaRica	3	0.11
Africa	Algeria, Ethiopia	3	0.11
Total		**2,544**	**100**

☐ Visitors of Academic Activities (2007 to 2009)



(* Academic Activities: Topical Research Programs, Schools, Conferences & Workshops, Focus Programs and Visitors Program)

☐ Statistics of APCTP Faculties & Researchers

- Number of APCTP Faculties & Researchers

Program	Number of Faculties & Researchers				Person Month*
	Prof.	Dr.	PhD. Stud.	Total	
JRG & NRF Researcher	6	6	6	18	163.50
YST	-	13	1	14	103.50
Total	**6**	**19**	**7**	**32**	**267.00**

* Person Month (PM): 1 PM = 28 days

Korea	Beijing	Japan	Vietnam	Ethiopia, Mongolia, Thailand, USA	Total
11	8	7	2	Each 1	32

● Scientific Activities of APCTP Faculties & Researchers

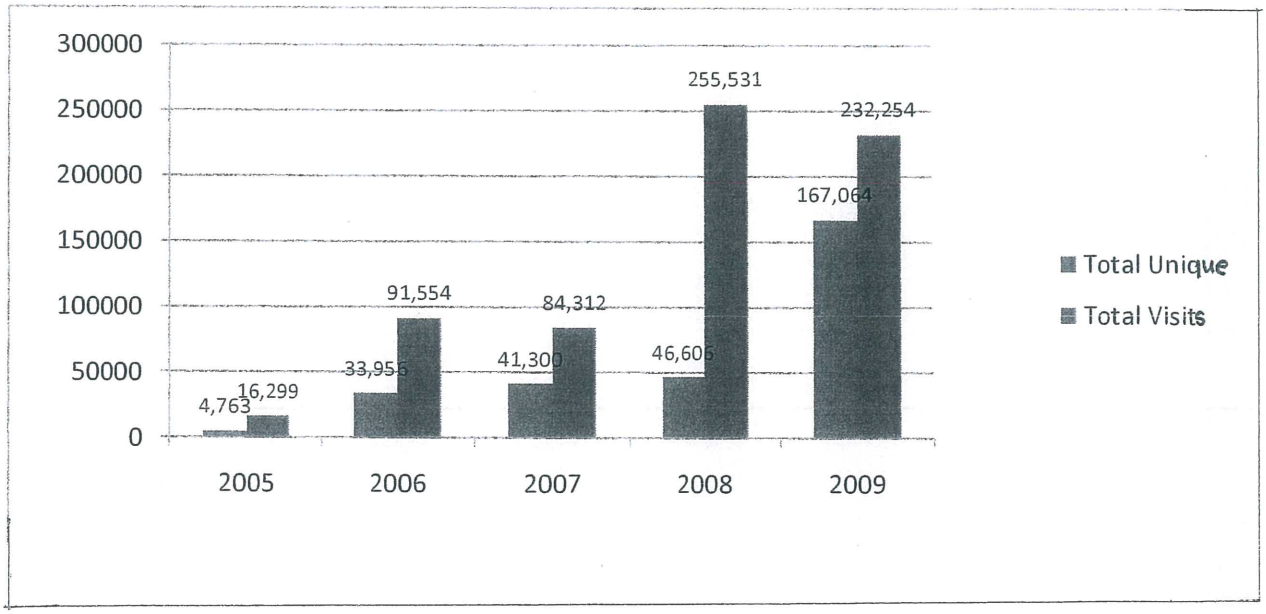
Activities	Visitors	Workshops	Seminars	Discussions
Number	61visitors	4 times	23 times	33 times
Remarks	12 PM	61 participants	274 participants	151 participants

☐ Reprint of APCTP

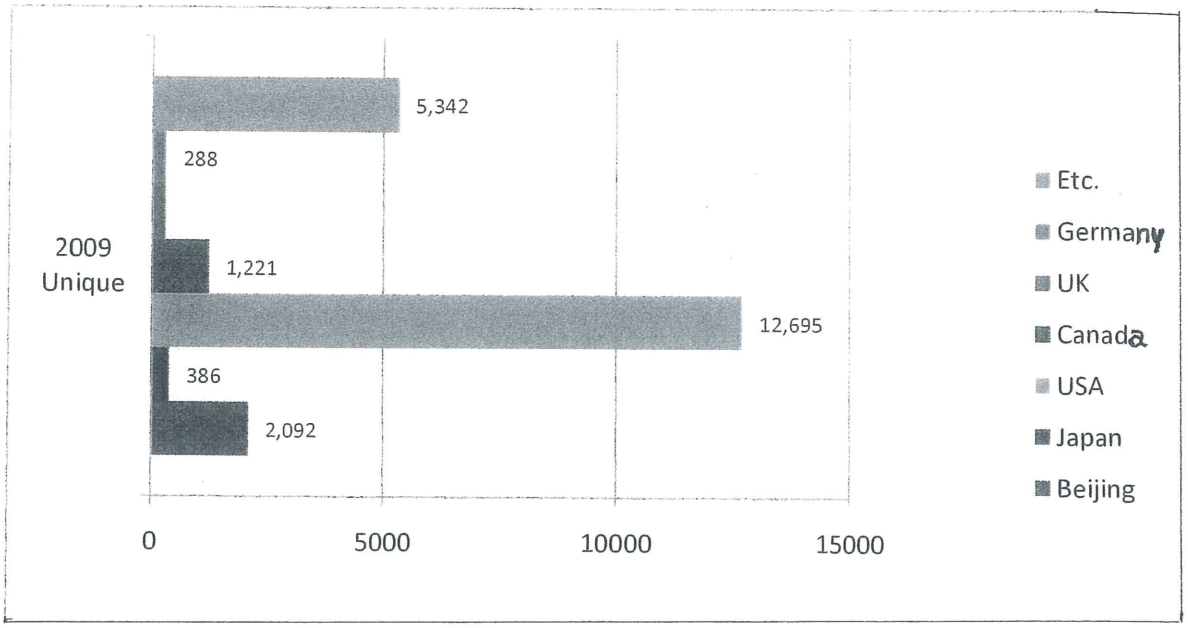
	Reprint	Preprint	SCI	Impact Factor
Faculties & Researchers	42	18	41	3.920
Academic Activities	12	-	11	3.976
Total	**54**	**18**	**52**	**3.974**

☐ On-line web-journal "Crossroads"

● Total Unique and Visits from 2005 to 2009



● 2009 Unique by region



4. Publications List in 2009

4.1. 2009 Reprints

4.1.1. Reprints list by APCT faculties & researchers

1. Haitan Xu, **Xin Wan,** *Exploiting geometric degrees of freedom in topological quantum computing,* Phys. Rev. A 80, 012306 (2009)

2. **Linchen Gong, Xin Zhou**, *Structuring and sampling complex conformation space: Weighted ensemble dynamics simulations*Phys. Rev. E 80, 026707 (2009)

3. **Ki-Seok Kim**, C. Pépin, *Violation of the Wiedemann-Franz Law at the Kondo Breakdown Quantum Critical Point*, Phys. Rev. Lett. 102, 156404 (2009)

4. **Youngman Kim**, Sangmin Lee, Piljin Yi, *Holographic Deuteron and Nucleon-Nucleon Potential*, JHEP04 (2009) 086

5. Hyun-Chul Kim, **Youngman Kim**, Ulugbek Yakhshiev, *Mesons and nucleons from holographic QCD in a unified approach*, JHEP11 (2009) 034

6. Kyung-Il Kim, **Youngman Kim**, Su Houng Lee, *Holographic deconfinement temperature with isospin and strangeness chemical potentials*, J. Korean Phys.Soc. 55,1381

7. **Youngman Kim**, T. Sato, F. Myhrer, K. Kubodera, *Two-pion-exchange and other higher-order contributions to the pp ---> pp pi0 reaction*, Phys. Rev. C80: 015206 (2009)

8. **Youngman Kim**, Bum-Hoon Lee, Chanyong Park, **Sang-Jin Sin**, *Effect of gluon condensate on holographic heavy quark potential*, Phys. Rev. D 80, 105016 (2009)

9. **Tetsuya Takimoto**, Peter Thalmeier, *Tripet Cooper Pair Formation by Anomalous Spin Fluctuations in Non-centrosymmetric Superconductors*, JPSJ 78, 10, 103703 (2009)

10. **Hua Chen, Zi-Xiang Hu**, Kun Yang, E. H. Rezayi, **Xin Wan**, *Quasiparticle tunneling in the Moore-Read fractional quantum Hall state*, Phys. Rev. B 80, 235305 (2009)

11. **Zi-Xiang Hu**, E. H. Rezayi, **Xin Wan**, Kun Yang, *Edge-mode velocities and thermal coherence of quantum Hall interferometers*, Phys. Rev. B 80, 235330 (2009)

12. **Youngman Kim**, Yumi Ko, **Sang-Jin Sin**, *Density driven symmetry breaking in holographic superconductors*, , Phys. Rev. D 80, 126017 (2009)

13. **Yoshinori Matsuo, Sang-Jin Sin, Shingo Takeuchi, Takuya Tsukioka, Chul-Moon Yoo**, *Sound Modes in Holographic Hydrodynamics for Charged AdS Black Hole*, Nuclear Physics B 820 (3)
14. **Li-Ming Cao, Yoshinori Matsuo, Takuya Tsukioka, Chul-Moon Yoo**, *Conformal Symmetry for Rotating D-branes*, Physics Letters B679 (4)

15. Hironobu Kihara, Muneto Nitta, Misao Sasaki, **Chul-Moon Yoo**, Ignacio Zaballa, *Dynamical Compactification and Inflation in Einstein-Yang-Mills Theory with Higher Derivative Coupling*, Phys.Rev.D80, 066004 (2009)

16. Masashi Kimura, Hideki Ishihara, Shinya Tomizawa, **Chul-Moon Yoo**, *Topology Changing Process of Coalescing Black Holes on Eguchi-Hanson Space,* Phys.Rev.D80:064030(2009)

17. Keitaro Takahashi, Atsushi Naruko, Yuuiti Sendouda, Daisuke Yamauchi, **Chul-Moon Yoo**, *Non-Gaussianity in Cosmic Microwave Background Temperature Fluctuations from Cosmic (Super-)Strings*, JCAP10(2009)003

18. Masanori Hanada, Yoshifumi Hyakutake, Jun Nishimura, **Shingo Takeuchi**, *Higher Derivative Corrections to Black Hole Thermodynamics from Supersymmetric Matrix Quantum Mechanics*, Phys. Rev. Lett. 102, 191602 (2009)

19. Masanori Hanada, Akitsugu Miwa, Jun Nishimura, **Shingo Takeuchi**, *Schwarzschild Radius from Monte Carlo Calculation of the Wilson Loop in Supersymmetric Matrix Quantum Mechanics*, Phys. Rev. Lett. 102, 181602 (2009)

20. **Mesfin Asfaw**, Hsuan-Yi Chen, *Adhesion-induced lateral phase separation of multicomponent membranes: The effect of repellers and confinement*, Phys. Rev. E 79(4), 041917 (2009)

21. Thomas R. Weikl, **Mesfin Asfaw**, Heinrich Krobath, Bartosz Róycki, Reinhard Lipowsky, *Adhesion of membranes via receptor–ligand complexes: Domain formation, binding cooperativity, and active processes,* Soft Matter, 2009, 5, 3213 - 3224

22. Tatsuo Azeyanagi, Masanori Hanada , Hikaru Kawai, **Yoshinori Matsuo**, *Worldsheet analysis of gauge/gravity dualities,* Nuclear Physics B 816 (2009) 278–292

23. Masanori Hanada, Lorenzo Mannelli, **Yoshinori Matsuo**, *Large-N reduced models of supersymmetric quiver, Chern-Simons gauge theories and ABJM*, JHEP11 (2009) 087

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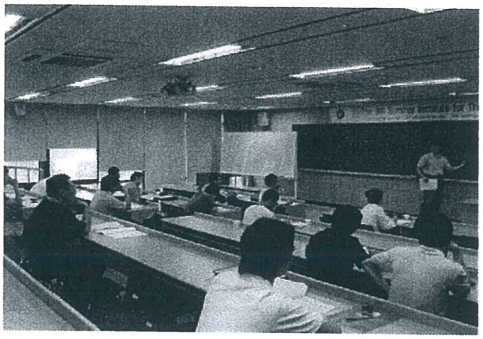
4.3 APCTP Bulletin

☐ 23rd ~ 24th APCTP Bulletin

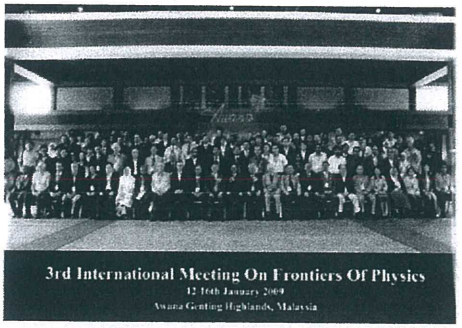
- Date of Publication: December 2009
- Contributors: Seunghwan Kim
- Circulation: 2,000

5. Photos

5.1 Academic Activities



5.2 Joint & External Activities



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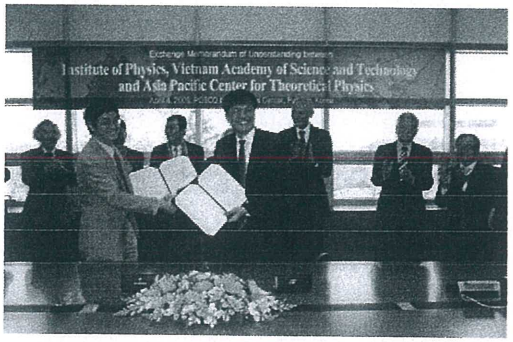
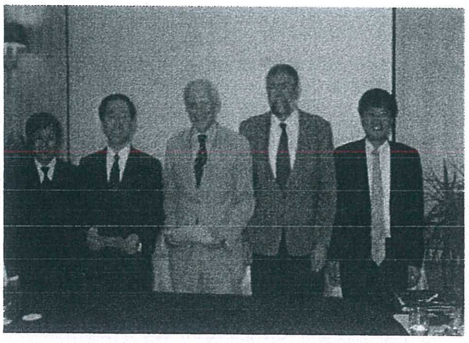
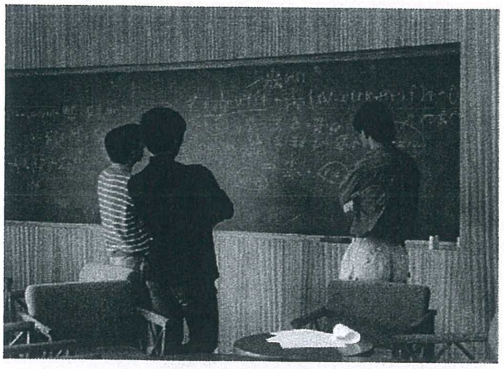
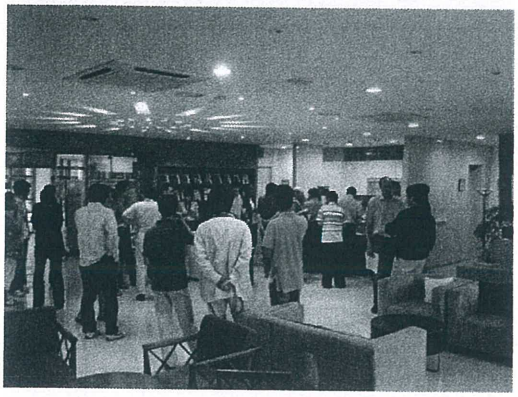




5.4 APCTP Faculties & Researchers


5.5 AP Scientist Network Activities