April 2017–March 2018

Kavli IPMU

ANNUAL REPORT 2017

THE UNIVERSITY OF TOKYO

KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

UTIAS 東京大学国際高等研究所 THE UNIVERSITY OF TOKYO INSTITUTES FOR ADVANCED STUDY

wpi World Premier International Research Center Initiative

KAVLI IPMU

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On the cover:
Group photo at the ceremony for the Kavli IPMU 10th anniversary.

FOREWORD

Hitoshi Murayama
Director

Milestone

It is hard to believe. This is our 10th Annual Report!

When IPMU was launched back on October 1, 2007, I was very worried that IPMU wouldn't exist after March 31, 2017, when the WPI funding was slated to finish. My sentiment has been that of an owner of a small company. I hired 100 excellent employees. The company has been off to a great start: good products, high reputation, exciting developments. Yet no cash reserve (government funding cannot be carried over to the next fiscal year), and the venture capital (WPI) is scheduled to withdraw in ten years. What am I gonna do??? Fortunately, at the very end of the period covered by this annual report, a bulk of government funding was rolled into the regular University operating funds, and it is meant to be there permanently. We are not going to disappear from the map; we are here to stay.

We had a great celebration of first ten years of IPMU (including last five years as Kavli IPMU) on Oct 16, 2017. You can see the group photo from the event on the front cover. In addition to current members of the institute, we invited many alums who have been very successful, many distinguished guests including two Nobel Laureates and two Fields medalists, representative from the government, the mayor of the city of Kashiwa, and Director Takigawa of ISSP representing the Kashiwa campus. In addition, we had President Gonokami of the University and President Conn of the Kavli Foundation affirming their support. We are fortunate to receive support from three major sources: MEXT, University, and Kavli Foundation, all on permanent basis. And the local support and other donors are very important. The ceremony finished with Beethoven's Symphony No. 9 played by our members and volunteers including myself. It was a fantastic event, announcing that we would be here to stay.

The celebration also included a three-day symposium. It truly showcased the science we do, people we trained, and amazing history that made the day possible. Many scientists and some journalists attended the symposium, truly enjoying what we accomplished. They all got the message: we are here to stay.

In this 10th Annual Report, you will find dizzying array of exciting research that is going on, statistics on our research products and activities, numerous awards to our scientists and our staff. Yes, staff. Without their dedicated support, we cannot do anything. We all appreciate their work, which made it all possible. Thanks to them, we can say, we are here to stay.

Ten years have been a long time. But in view of 13.8 billion years of the history of the Universe, and of even four centuries of modern science since Galileo whom we commemorate on the obelisk in the interaction area with his quote "L'universo è scritto in lingua matematica", ten years is only a blip of a moment. Rather than dwelling on our success and sitting on our laurels, we'd like to keep our eyes wide open looking forward to our future. Science changes as major discoveries are made. But our goals will remain the same: we would like to understand our Universe! We must keep a long-term view. And to make it happen, yes, we are here to stay, for another ten years, another hundred years. I'm looking forward to our 100th anniversary event in October 2107!

1 INTRODUCTION

Kavli IPMU celebrated 10 years since the establishment and hosted a 10th Anniversary Ceremony inside the Kavli IPMU building on Kashiwa Campus on 16 October 2017. Around 230 people, including distinguished guests, researchers, and many of those who have been or currently are involved with the Kavli IPMU watched over the ceremony. Congratulatory speeches were given by several distinguished guests, including University of Tokyo President Makoto Gonokami, Institute for Solid State Physics Director, and Representative of Kashiwa Campus Masashi Takigawa, Nobel laureate David Gross, Fields medalist Shing-Tung Yau, Ministry of Education, Culture, Sports, Science and Technology Research Promotion Bureau Director-General Seki Yasunao, Kashiwa City Mayor Hiroyasu Akiyama, WPI Program Director Akira Ukawa, Kavli IPMU External Advisory Committee Chair Steven Kahn, and Kavli Foundation President Robert W. Conn. In addition to the anniversary ceremony, the institute also hosted a three-day 10th Anniversary Symposium at the Kashiwanoha Conference Center, which overall was attended by more than 500 researchers and students.

We enter the 5-year extension period of the WPI funding for which we have added the following 9 new challenges. Below are brief summaries of our work against each challenge.

1. Creating new areas and tools of statistics, integrating mathematics with observation and experiments
The JST CREST project "Statistical Computational Cosmology" led by N. Yoshida is aimed at developing fast imaging data analysis applications for the Subaru Hyper-Suprime Cam (HSC) survey. In 2017, the project members developed a deep convolutional neural-network that performs multi-label classification of supernovae. The classifier has been successfully installed and a number of distant Type Ia supernovae with redshifts greater than 1 were identified. They developed a machine-learning strong lensing estimator and examined its performance of the lens mass and ellipticity estimations. They will test the machine using real strong lensing images in the HSC survey.

2. Creating new synergies among fields not imagined at the launch
The Kavli IPMU and the Japan Aerospace Exploration Agency's (JAXA) Institute of Space and Astronautical Science (ISAS) started a new collaboration to apply their work in artificial satellites, particularly in developing hard X-ray and gamma ray detectors, to biomedical research. Both X-ray and gamma rays are valuable to researchers studying astronomy, but they are also useful in everyday life because they allow humans to see inside objects or people. Researchers at the Kavli IPMU and ISAS/JAXA will work together with the Keio University School of Medicine to transfer their technology to nuclear medicine soon. They aim to see the location of cancer stem cells with a 100μm accuracy, and to push forward research in cancer treatment. We succeeded in attracting T. Takahashi, a former professor in JAXA and a leader of this project, as a new professor at the Kavli IPMU. This work demonstrates the application of fundamental science to medical research.

3. Discovering new major framework for geometric thinking in mathematics and physics with the derived and non-commutative geometry, such as to unify various types of dualities
Several recent results from Kavli IPMU mathematicians fit into the general framework of derived and non-commutative geometry. The approach of derived geometry provides a way to speak about virtual fundamental classes of various moduli spaces in algebraic geometry. The work of Y. Toda has developed and studied, by using appropriate virtual fundamental classes, new Gopakumar-Vafa type invariants for 3- and 4-dimensional Calabi-Yau manifolds. Non-commutative methods have been developed by Y. Toda and W. Donovan to analyze the role of derived categories in birational geometry and to construct the moduli spaces of semistable sheaves. The unifying role here is played by the concept of perverse sheaves and by their categorical generalizations, perverse schobers. Thus, perverse sheaves of vanishing cycles are at the basis of the approach to Gopakumar-Vafa invariant by Y. Toda, while the relation of perverse schobers to birational geometry was studied by W. Donovan and by A. Bondal and M. Kapranov, jointly with V. Schechtman.

4. Executing projects successfully to produce world-competitive results on dark energy, dark matter, and inflation

- The Hyper Suprime-Cam (HSC) members published 40 papers for their research achievements in the HSC special issue of the peer reviewed journal Publications of the Astronomical Society of Japan in January 2018. The science team of the collaboration was led by M. Takada. The HSC Weak Lensing Working Group built the catalog of galaxy shapes from the high-quality, high-resolution HSC images for 10 millions galaxies. Kavli Associate Scientist M. Oguri used the weak lensing measurement to reconstruct two- and three-dimensional maps of dark matter over an unprecedented area and spatial resolution. PFS, the multi-fiber spectrograph for Subaru to follow up HSC imaging survey, fully completed the mass production of 2550 fiber positioners. The metrology camera will be installed soon. The science observation is expected to start in 2021.
- XMASS updated the annual modulation search for low mass WIMPs using 2.7 years data. XMASS also improved the upper limits at about one order of magnitude by searching for two-neutrino double electron capture on 124Xe and 126Xe. XMASS presented the first experimental result for Kaluza-Klein axions and set an upper bound for the axion coupling constant.
- T2K furthered the world leading search for CP violation in neutrino and antineutrino oscillations. Kavli IPMU member M. Hartz was chosen among the 500+ member international collaboration to make the first presentation of T2K results at a KEK colloquium and press conference, showing that the T2K data disfavor absence of CP violation at a 95% confidence level.
- LiteBIRD, our leading satellite mission searching for primordial gravitational waves produced during the cosmic inflation era, has now progressed to the JAXA/ISAS Phase A1 and has been selected as a top-priority large-scale project "Master Plan 2017" by the Science Council of Japan. The LiteBIRD team extends the collaboration in different fields and also in master and doctor students.

5. Attracting and retaining the best and broadly minded scientists from around the world
We retained the best and broadly minded scientists from around the world. The total number of Principal Investigators (PIs) increased from 19 to 26 and the average age of PI became 7 years younger than FY 2016. Among them, the number of on-site PIs increased from 5 to 9. All of our 26 Principal Investigators (7 non-Japanese: 27%) are world-leading scientists. Among PIs, M. Kapranov is a distinguished mathematician and conducts research as a leader in higher category theory. H. Murayama received a Research Award from the Alexander von Humboldt Foundation in recognition of giving a significant impact on relevant academic fields. In addition, he was named as one of the 100 influencers in the world listed in the book Genius: 100 Visions of the Future. E. Komatsu and D. Spergel were awarded the 2018 Breakthrough Prize in Fundamental Physics for their prominent research in developing detailed maps of the early Universe. Y. Nomura, a professor of UC Berkeley, is well known in the field of particle physics and cosmology, was named a new American Physical Society Fellow on his excellent work pioneering contributions to a variety of areas of particle theory. M. Vagins has lead the EGADS project and the concept will be realized in the on-going SK-Gd project. M. Takada is the leader of the HSC project, and the fruitful scientific results have just come out in the latest issue of the Publications of the Astronomical Society of Japan including

40 new studies related to HSC observation. Other faculty members also play leading roles in each field and include PIs of big international projects such as Belle II, KamLAND-Zen, SuMIRe, and LiteBIRD.

6. Bringing successful system reforms to the rest of the University and other research institutions to help boost the overall competitiveness of Japan on a global scale

2008's achievement for "web site to accept the foreign researchers in Kashiwa Campus" has already been requested to be adopted by administrative sections of many other faculties. 2013's "thoroughgoing safety education by network distribution of education video and final quiz" has been requested to be adopted by the U Tokyo environmental and safety research center in Kashiwa, Graduate school of Engineering U Tokyo, Graduate school of Mathematical Science U Tokyo and ICRR. 2015's "language website to explain U Tokyo's employee procedures for international researchers" has been used freely through the U Tokyo website. 2016's "Win-Win project towards University Globalization" has been requested by the U Tokyo hospital medical administrative section and ICRR.

7. Making a serious attempt to create a new international graduate program with vigorous student exchanges

Oxford doctoral students studying for D.Phil. research degrees in Astrophysics or Particle Physics at U Oxford are being supervised by faculty members of the Kavli IPMU and are being provided the opportunity to conduct research in collaboration with Kavli IPMU researchers. Also, the Kavli IPMU is working very well together with another international graduate program in physics (GSGC), which we hope will be extended to astronomy. Young students are becoming attracted to the Kavli IPMU.

8. Enlarging the force for outreach to young students, by organizing workshops for scientists and high school teachers

- Two new female faculty professors were recruited successfully. Prof. H. Yokoyama is specialized in Science Communication and Policy. She can provide advice for outreach to high school teachers. Prof. Y. Ito, currently a cross-appointment with the Nagoya University, is a mathematician in Algebraic Geometry working on McKay correspondence using inspiration from physics.
- Our PI, Y.-K. Kim was elected to the American Academy of Arts and Science as a member of its 237th class. She is the fourth researcher from the Kavli IPMU to become a member. Also she gave a talk at the Kavli IPMU Science Café titled 'What Can A Particle Accelerator Discover?'.
- H. Ooguri was elected to the Japan Writers' Association. He was nominated to the Association by the Vice Chair Masahiro Mita and the Board member Masahiko Murakami. He published a new book titled as 'Quest to the Truth – Dialogue between Buddhism and Astrophysics'.
- Hamamatsu Photonics K.K. was awarded the U Tokyo, Shokumon Award in recognition of establishing the first endowed professorship for fundamental science and their support for Kavli IPMU research into the Dark side of the universe.
- The Kavli IPMU, the Institute for Solid State Physics, and the Institute for Cosmic Ray Research jointly hosted an event called "Actually I Really Love Physics! - Career Paths of Female Physics Graduates" at the Kavli IPMU for the second time, and there were 19 participants. This event was held to support female students in physics to plan their careers.
- The Kavli IPMU and Tamarokuto Science Center co-hosted a series of Science Cafes. A Kavli IPMU project researcher, W. Donovan, presented his works on mathematics by linking between soap bubbles and spacetime. Another Kavli IPMU project researcher, D. Stark, presented his works on the birth, growth, and death of galaxies.
- H. Murayama and H. Yokoyama started the proposed activity to enlarge the force for outreach to young students, by organizing workshops for scientists and high school teachers along with the Consortium for Renovating Education of the Future, U Tokyo (CoREF).

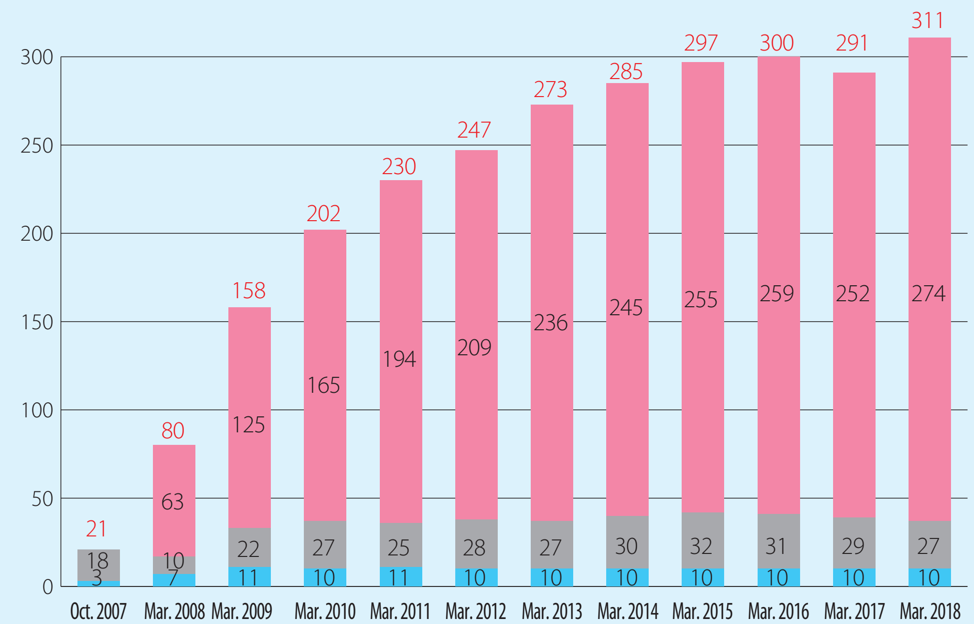
(9) Attaining sufficient stability of the organization so that we can bring our research objectives beyond the WPI funding

The positioning of the Kavli IPMU within U Tokyo is quite clear. President Gonokami's 'Vision 2020' emphasizes the importance of "Expansion and Establishment of Internationally-renowned Bases for Research". An action to realize this vision 'Action 2020' has been set up saying "Establish and expand upon internationally-renowned bases for research at U Tokyo by carrying out such initiatives as advancing the development of both the University's strongest fields in which it is leading the world and unique areas of original research which should unwaveringly continue to be studied, promoting joint research and international collaboration that goes beyond the framework of U Tokyo, and creating new, interdisciplinary knowledge that is the first of its kind in the world." As already been declared by the President at the WPI Program Committee meeting in recent years, the President recognizes that the Kavli IPMU perfectly matches his vision as a role model for the rest of the University. The Kavli IPMU enhances the value of the University, which enables the University to attract new revenues. It is reasonable for U Tokyo to support the Kavli IPMU with top priority. We made the effort to strengthen the University's financial base. Based on this stance, U Tokyo put together a plan for the extension period and beyond. U Tokyo has already provided 10 tenured positions, and permanent assignment of nine administrative staff members. Thanks to MEXT, from FY 2018, the 'university functionality boost' budget from MEXT for 13 positions and for operation has been approved to be a permanent budget. The University will maintain and hopefully expand the Kavli IPMU even after WPI support finishes. A new budget request in the period from FY 2018 to FY 2021 was ranked as No.1 in U Tokyo, while it was not approved by the government. This budget request is crucial to sustain the Kavli IPMU permanently, and we will keep making the request continuously.

In the following pages, various statistics are show in plots: The lists of Seminar & Conferences, Publications, and Conference Talks can be found in Kavli IPMU web page, https://www.ipmu.jp/en/research-activities on "Research Activities".

STAFF

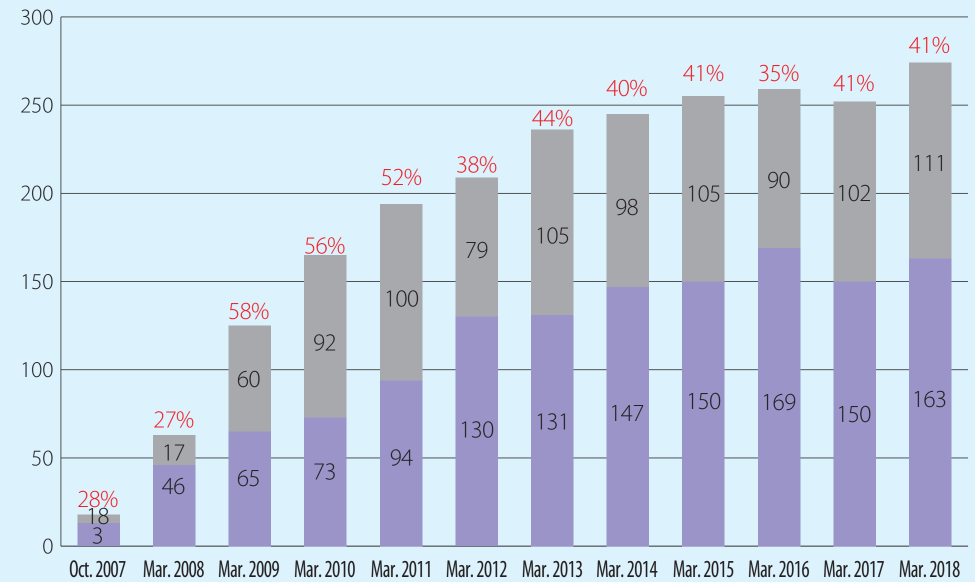
Total Number of Staff



	Oct. 2007	Mar. 2008	Mar. 2009	Mar. 2010	Mar. 2011	Mar. 2012	Mar. 2013	Mar. 2014	Mar. 2015	Mar. 2016	Mar. 2017	Mar. 2018
Researchers	18	63	125	165	194	209	236	245	255	259	252	274
Research Support Staffs	0	10	22	27	25	28	27	30	32	31	29	27
Administrative staff	3	7	11	10	11	10	10	10	10	10	10	10
Total	21	80	158	202	230	247	273	285	297	300	291	311

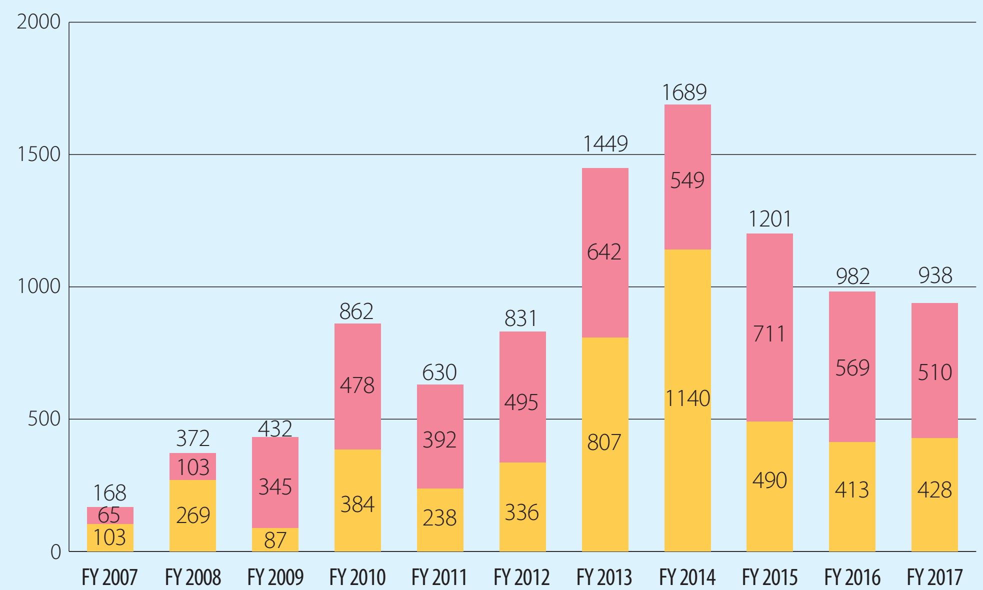
RESEARCHERS

Percentage of Overseas



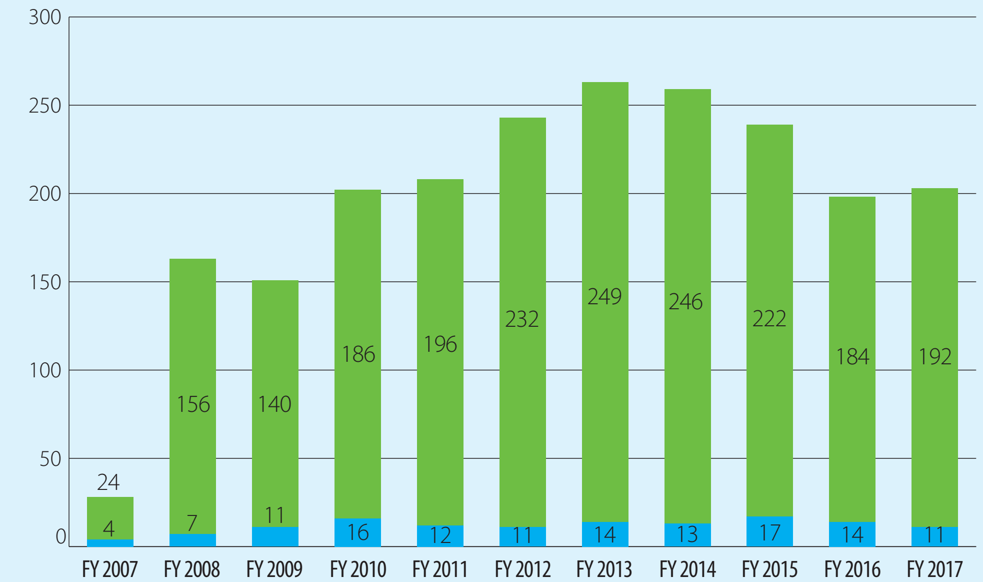
	Oct. 2007	Mar. 2008	Mar. 2009	Mar. 2010	Mar. 2011	Mar. 2012	Mar. 2013	Mar. 2014	Mar. 2015	Mar. 2016	Mar. 2017	Mar. 2018
Overseas	5	17	60	92	100	79	105	98	105	90	102	111
Domestic	13	46	65	73	94	130	131	147	150	169	150	163
% of Overseas	28%	28%	48%	56%	52%	38%	44%	40%	41%	35%	41%	41%
% of Female	0%	2%	5%	6%	5%	2%	5%	5%	6%	4%	6%	8%

RESEARCH ACTIVITIES



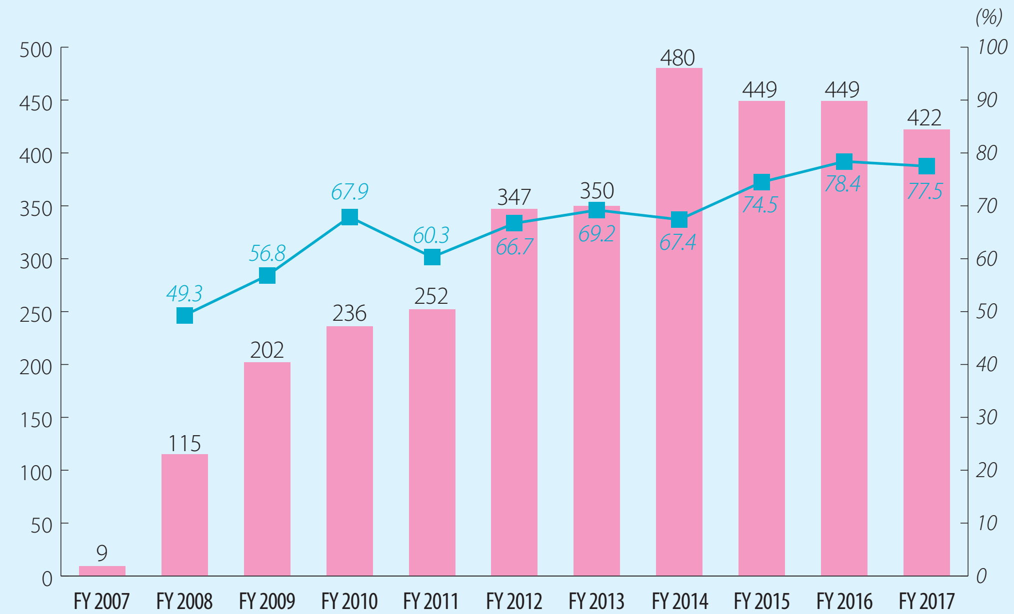
	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Visitors (Overseas)	65	103	345	478	392	495	642	549	711	569	510
Visitors (Domestic)	103	269	87	384	238	336	807	1140	490	413	428
Visitors (Total)	168	372	432	862	630	831	1449	1689	1201	982	938

SEMINER & CONFERENCES



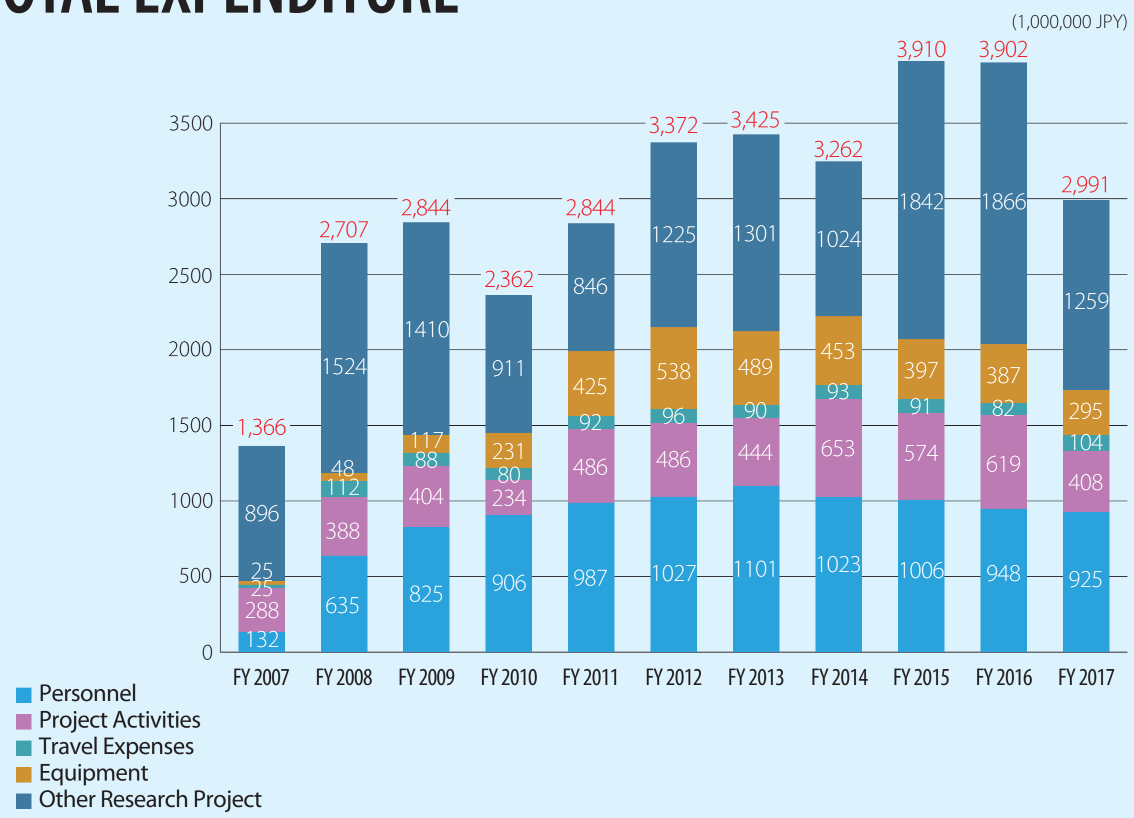
	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Seminars	24	156	140	186	196	232	249	246	222	184	192
Conferences	4	7	11	16	12	11	14	13	17	14	11

PUBLICATIONS

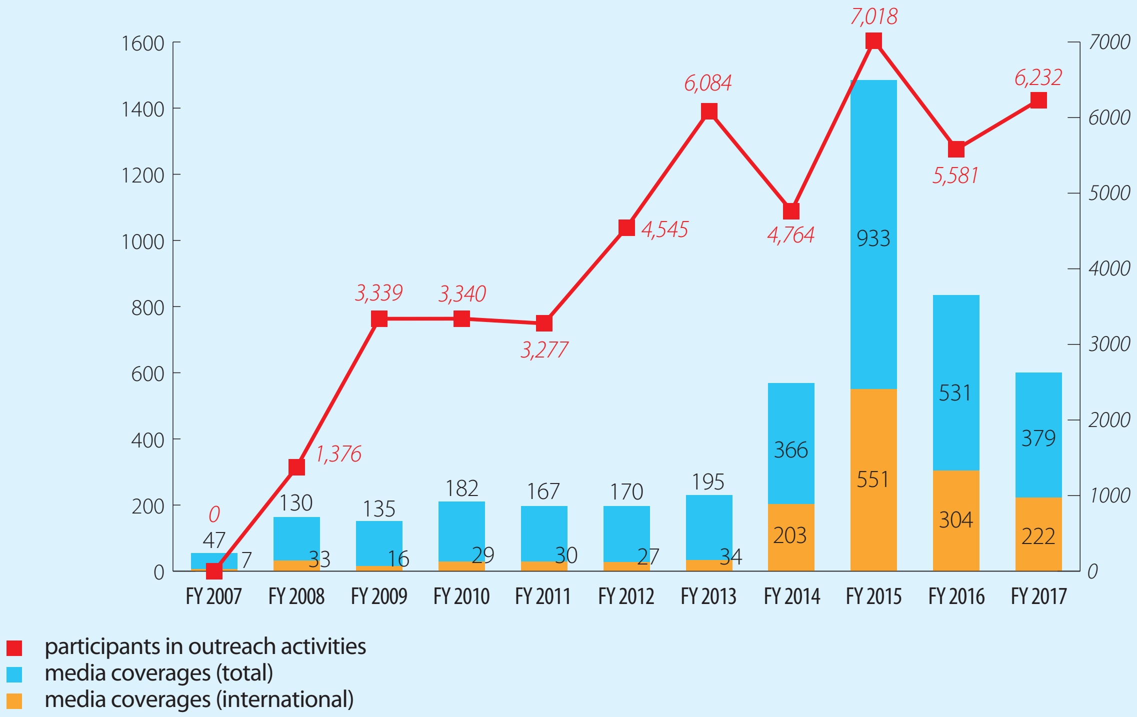


	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Publications	9	115	202	236	252	347	350	480	449	449	422
% of international collaboration		49.3%	56.8%	67.9%	60.3%	66.7%	69.2%	67.4%	74.5%	78.4%	77.5%

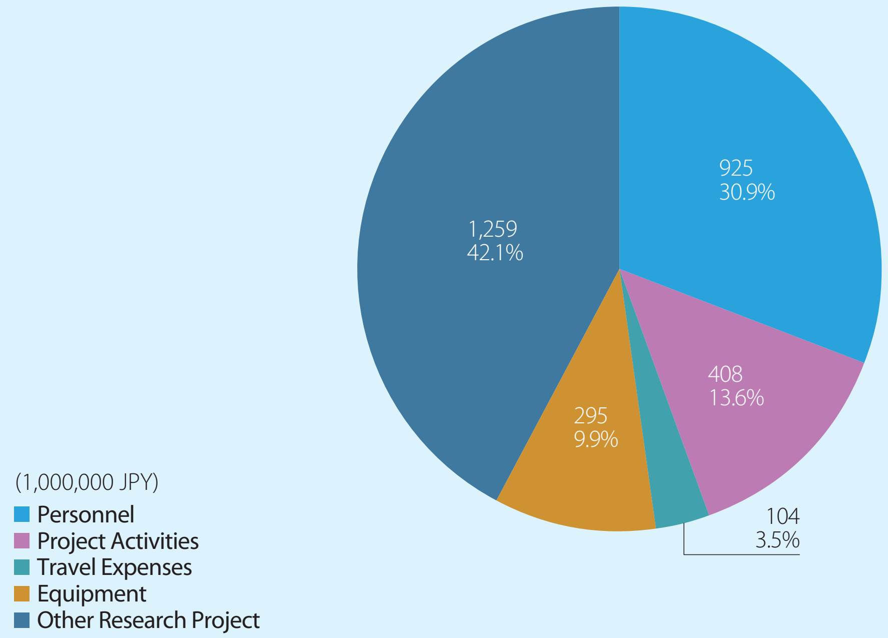
TOTAL EXPENDITURE



MEDIA COVERAGES AND OUTREACH ACTIVITIES



BREAKDOWN OF FY 2017 TOTAL EXPENDITURE



2 News & Events April 2017-March 2018

APRIL
- >> VLA, ALMA team up to give first look at birthplaces of most current stars
- >> Young-Kee Kim elected to American Academy of Arts and Sciences
- >> Kavli IPMU and ICRR host 16th joint public lecture

MAY
- >> Developments of mathematics at IPMU: in honor of Kyoji Saito
- >> Hitoshi Murayama named one of the 100 influencers in the world

JUNE
- >> Neutrino discovery: a step closer to finding CP violation
- >> First Lecture at Science Café Universe 2017
- >> Workshop "Deep learning and physics"
- >> Hirosi Ooguri elected to the Japan Writers' Association

JULY
- >> 2017 WPI Site Visit to Kavli IPMU
- >> Second Lecture at "Science Café Universe 2017"
- >> Kavli IPMU Science Café "What Can a Particle Accelerator Discover?"
- >> Director of the Office for the Promotion of Basic Research General Seki visits Kali IPMU

AUGUST
- >> T2K presents hint of CP violation by neutrinos
- >> Booth at the 2017 Super Science High School Student Fair
- >> Learning and Creating Physics – From High School to the Forefront Research of the Universe

SEPTEMBER
- >> The E61 (NuPRISM) meeting
- >> 5th Hyper-Kamiokande Proto-Collaboration Meeting
- >> Science communication meeting for crowd funding science
- >> Workshop "Stellar Evolution, Supernova Nucleosynthesis Across Cosmic Time"
- >> Ultraviolet light from superluminous supernova key to revealing explosion mechanism
- >> MEXT Vice Minister Kazuo Todani visits Kavli IPMU
- >> Supersonic gas streams left over from the Big Bang drive massive black hole formation

OCTOBER
- >> Kavli IPMU celebrates the 10th anniversary of its foundation
- >> Kavli IPMU 10th anniversary symposium
- >> Violent helium reaction on white dwarf surface triggers supernova explosion
- >> "Kavli IPMU-JAXA Joint Research Program on Hard X-Ray and Gamma-Ray Imaging" launched
- >> Open Campus Kashiwa 2017

NOVEMBER
- >> Kavli IPMU joins new organization to lead future neutrino experiments: the Next-Generation Neutrino Science Organization (NNSO)
- >> Takaaki Kajita awarded the 4th Berkeley Japan Prize
- >> 17th Kavli IPMU/ICRR Joint Public Lecture
- >> Researchers find way to improve simulations of neutrinos and astrophysical plasma dynamics
- >> Focus week on primordial black holes
- >> 9th PFS general collaboration meeting
- >> Event : "Actually I Really Love Physics! – Career Paths of Female Physics Graduates"

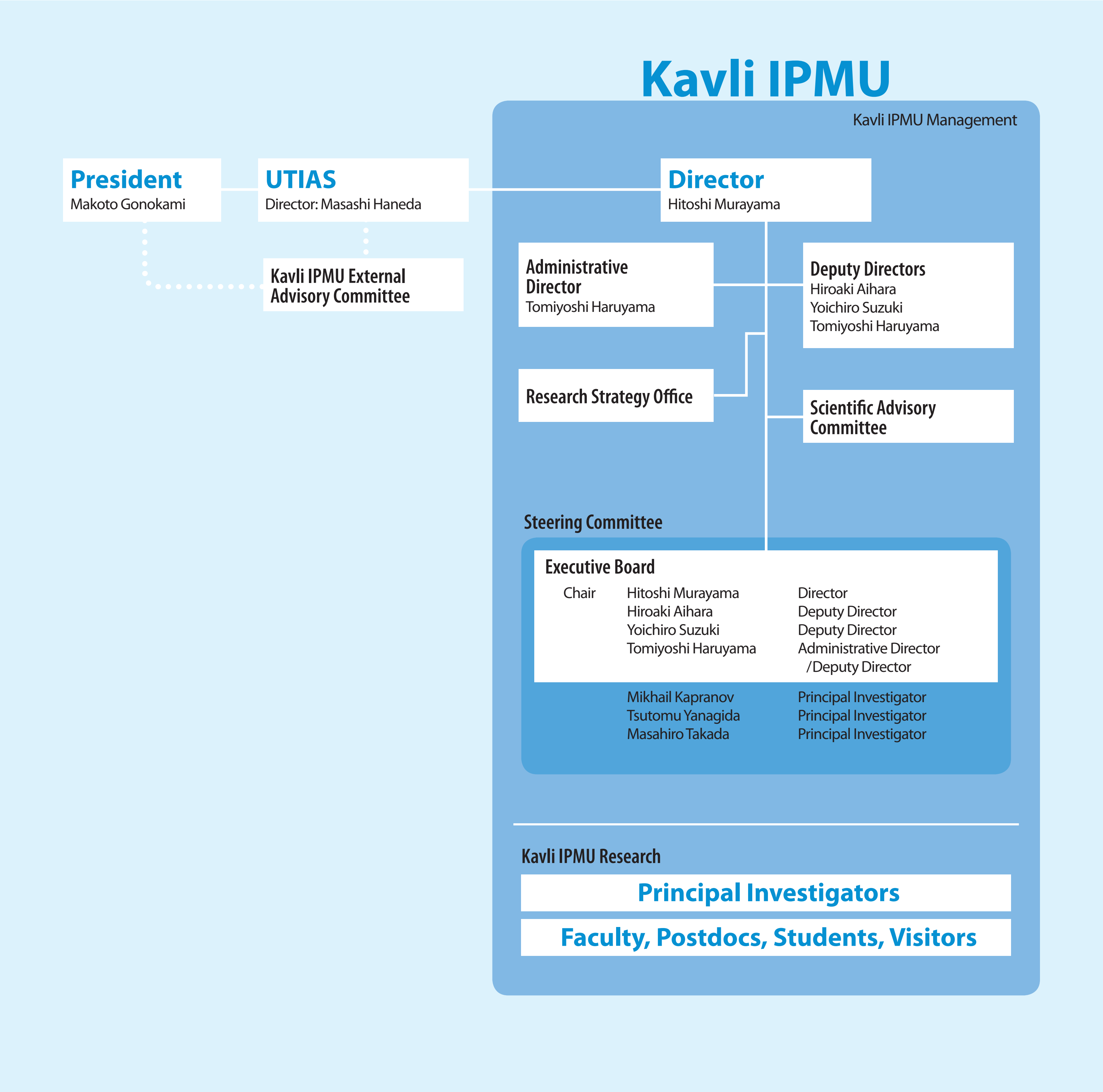
DECEMBER
- >> David Spergel and Eiichiro Komatsu awarded the 2018 Breakthrough Prize in Fundamental Physics
- >> Long time Kavli IPMU supporter Hamamatsu Photonics honored by the University of Tokyo
- >> Daisuke Kaneko receives Young Scientist Award from the Physical Society of Japan
- >> Yasunori Nomura named new American Physical Society Fellow
- >> Hitoshi Murayama receives Research Award from Alexander von Humboldt Foundation
- >> Kavli IPMU staff receive 2017 President's Award for Business Transformation

JANUARY
- >> Sculptor Kentaro Haruyama joins Kavli IPMU 2017
- >> String Theory in Greater Tokyo 6A
- >> Kavli IPMU-Berkeley Symposium – Statistics, Physics and Astronomy –
- >> The 3rd Kavli IPMU / ELSI Joint Public Lecture "A Question of Origins"
- >> Berkeley Week@IPMU

FEBRUARY
- >> Rare first moment of stellar explosion captured by amateur astronomer
- >> 6th Annual WPI Science Symposium "Unfolding Future"
- >> AAAS 2018 Annual Meeting in Austin, Texas
- >> MEXT Director General Keisuke Isogai Visits Kavli IPMU

MARCH
- >> Forty new studies published from first data of world's biggest map of the Universe
- >> SuperKEKB accelerator kicks into a new gear
- >> Lectures on higher structures and quantisation
- >> 1st Kavli IPMU Artist-In-Residence Program Artist Exhibition

3 ORGANIZATION



The Kavli IPMU has a rather unique organization. While research is conducted in a flatstructure manner with loosely defined grouping, the decision making is done in a top-down scheme under the Director's strong leadership. This scheme minimizes the administrative load for the researchers. It is also intended to maximally extract young researcher's creative and challenging minds as well as to encourage daily cross-disciplinary interactions.

The Director is appointed by the President of the University of Tokyo and reports directly to his office. The Director proposes to hire the Principal Investigators to the President. For other hiring of research staff and administrative staff, he has a complete authority. He is also solely responsible for making all other decisions. He is assisted by the two Deputy Directors, the Associate Director, and the Administrative Director. They constitute the Executive Board (EB) and regularly meet to ensure smooth operation of the Institute. The EB has direct access to the Office of the President for consultations on both scientific and administrative matters.

The Director is obliged to report the appointments of new Principal Investigators and faculty members to the Director of the University of Tokyo Institutes for Advanced Study (UTIAS). Also, to clear the university formality in faculty hiring, the decisions of the Institute have to be endorsed by the Steering Committee of the Kavli IPMU.

The Principal Investigators are world's leading scientists in their fields. They have a large autonomy in the research they conduct. They can make proposals to the Director to hire research staff at the Institute.

The Scientific Advisory Committee (SAC) gives advice to the Director on hiring scientific staff and planning scientific strategies. The members are appointed by the Director.

The External Advisory Committee (EAC), appointed by the President of the University of Tokyo, reviews annually the scientific achievement and activities of the Institute and advises the President on scientific priorities and the research activities to keep the Institute stay on the course of its objectives.

The Scientific Advisory Committee Members (March 2018)

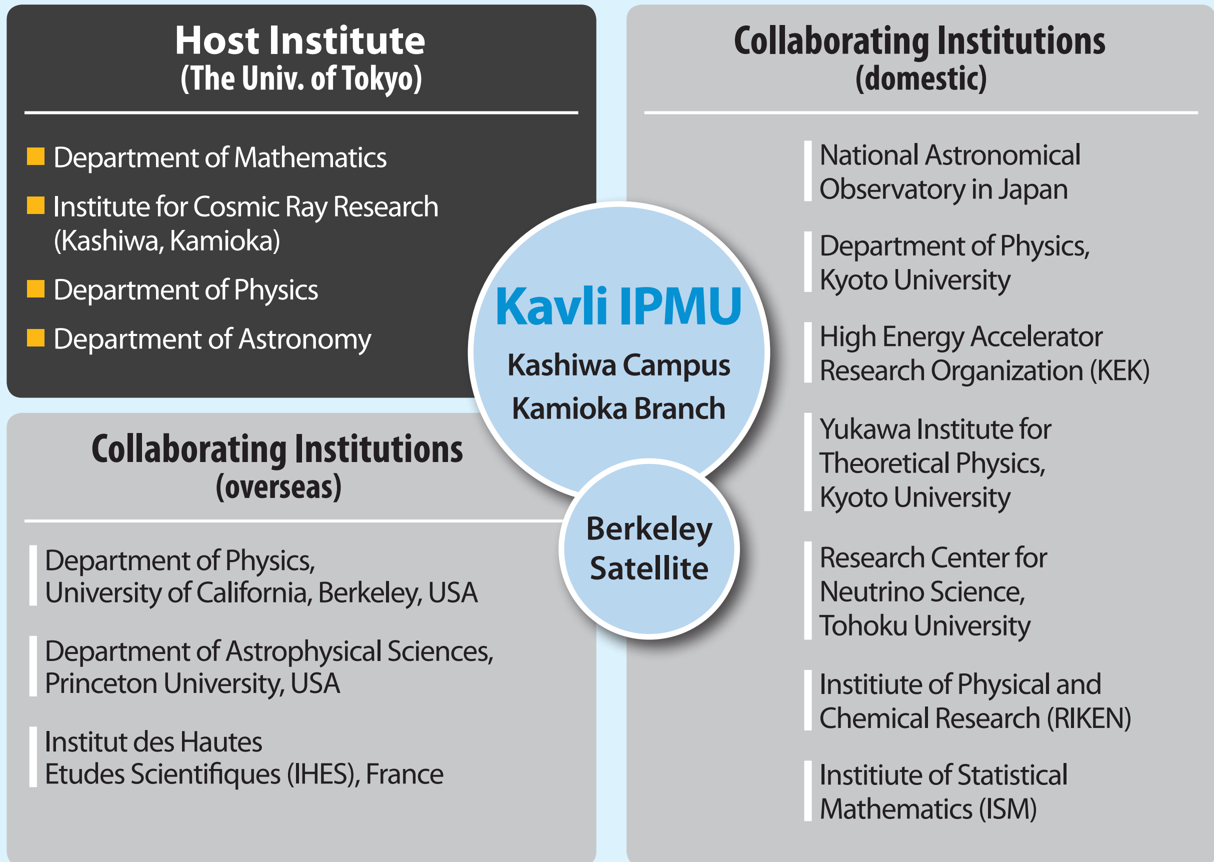
Hiroaki Aihara	U Tokyo, Physics Dept	High Energy Physics
Yoichiro Suzuki	U Tokyo, ICRR	Astroparticle Physics
Nobuhiko Katayama	Kavli IPMU	High Energy Physics
Toshitake Kohno	U Tokyo, Mathematics Dept	Mathematics
Hirosi Ooguri	Caltech	Particle Theory
Kyoji Saito	Kavli IPMU	Mathematics
David Spergel	Princeton U	Astrophysics
Tsutomu Yanagida	Kavli IPMU	Particle Theory

The External Advisory Committee Members (March 2018)

John Ellis	King's College London	Particle Theory
Steven Kahn	SLAC/Stanford U; Chair	Astrophysics
Young-Kee Kim	U Chicago	High Energy Physics
Sadayoshi Kojima	Tokyo Tech	Mathematics
David Morrison	UC Santa Barbara	Mathematics and Physics
Sadanori Okamura	Hosei U	Astronomy
Nigel Smith	SNOLAB	Astroparticle Physics

The Research Strategy Office pursues external funds in order to strengthen the research activities. A university research administrator (URA) was hired to start the office activities.

The main laboratory building on the Kashiwa Campus provides a basis for our researchers. Even most of experimentalists who are involved in Kamioka experiments and astronomical observations spend a good fraction of their time in Kashiwa for analyzing data, sharing seminars and discussing with theorists. The Kamioka Branch is a basis for the Kavli IPMU staff members who are engaging in the underground experiments conducted at the Kamioka underground laboratory. The Berkeley Satellite, besides being a place for research, serves as a contact place to the US scientific community. We also have close collaborative relations with several institutions both in Japan and overseas as well as with other departments within the University of Tokyo.



The Kavli IPMU holds close relations with similar research institutions in the world for encouraging exchanges in research and training of young research staff. We have signed either an agreement or a memorandum of understanding with those institutions.

Foreign institutions/consortia/programs having MOU with the Kavli IPMU

The University of California, Berkeley, Department of Physics
National Taiwan University, Leung Center for Cosmology and Particle Astrophysics (LeCosPA)
The Astrophysics Research Consortium [on the Sloan Digital Sky Survey III]
The Astrophysics Research Consortium [on the Sloan Digital Sky Survey AS3 ("After SDSS III")]
The Astrophysics Research Consortium [on the Sloan Digital Sky Survey IV]
Garching/Munich Cluster of Excellence on "The Origin and Structure of the Universe"
UNIFY (Unification of Fundamental Forces and Applications) [under the EU's Seventh Framework Program]
The Scuola Internationale Superiore di Studi Avanzati (SISSA)
The Academia Sinica Institute of Astronomy and Astrophysics of Taiwan (ASIAA) [on the SuMIRe Project]
The Intermediate Palomar Transient Factory (iPTF)
Steklov Mathematical Institute, Russian Academy of Sciences
Center for Mathematical Sciences, Tsinghua University
The Tata Institute of Fundamental Research
TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics)
Deutsches Elektronen Synchrotron (DESY)
Princeton University
The University of Oxford, Department of Physics
The Kavli Institute for Astronomy and Astrophysics at Peking University (KIAA)
Le Centre National de la Recherche Scientifique (CNRS)
The Mainz Institute for Theoretical Physics (MITP)

4 STAFF

Director
Hitoshi Murayama, Particle Theory

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5 Research Highlights

5.1 EGADS Evolves

Mark Vagins

About fifteen years ago Kavli IPMU Professor and PI Mark Vagins first proposed introducing 100 tons of a water-soluble gadolinium (Gd) compound, gadolinium chloride, $GdCl_3$, or the less reactive though also less soluble gadolinium sulfate, $Gd_2(SO_4)_3$, into the Super–Kamiokande (Super-K, SK) detector. Called GADZOOKS! (Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!), the basis of this load-SK-with-Gd idea is that neutrons, currently nearly invisible in SK, will be captured on the dissolved Gd ions and emit detectable light. This will allow a large reduction in backgrounds and greatly enhance the detector's response to both supernova neutrinos (galactic and diffuse) and reactor antineutrinos. It will also improve the detector's sensitivity to proton decays by cutting backgrounds; genuine nucleon decay events should usually not have free neutrons in the final state. In addition, solar neutrino studies will benefit from reduced spallation backgrounds.

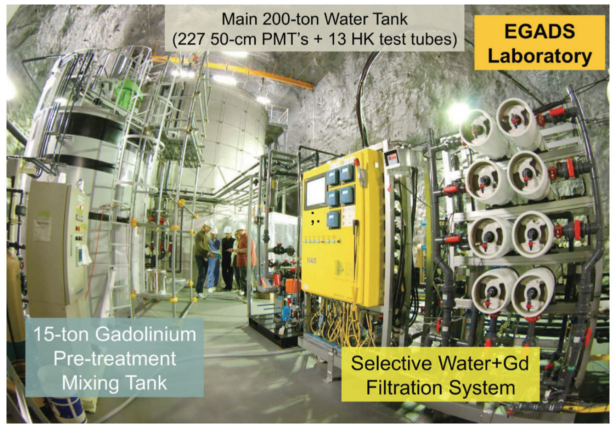


Figure 1 : EGADS, the large-scale gadolinium test facility in the Kamioka mine

While the physics potential of the GADZOOKS! concept was apparent, there were technical issues to address if it were to become a reality. Naturally, the compatibility of gadolinium with detector materials needed to be demonstrated, but the primary challenge was that in detectors such as Super–Kamiokande the long mean free path of light (~100 meters) is maintained by constant recirculation of the water through a water purification system. The existing SK purification system would rapidly eliminate any added gadolinium along with all of the unwanted contaminants that are removed to maintain optical clarity.

To solve this problem, Vagins developed a fundamentally new type of filtration system: his "Molecular Band-pass Filter" was designed to selectively extract $Gd_2(SO_4)_3$ from the water and return it to the tank, while simultaneously allowing all other impurities to be removed. Starting in September of 2009 a new experimental chamber was excavated in the Kamioka mine, close to Super–Kamiokande. There, a dedicated, large-scale gadolinium test facility and water Cherenkov detector (a 200 ton scale model of Super–K), was built as depicted in Figure 1. Known as EGADS (Evaluating Gadolinium's Action on Detector Systems), it was designed to make absolutely sure that the introduction of Gd would not interact adversely with detector materials and to certify the viability of the Gd-loading technique. After close to a decade of work, in FY2017 these studies were completed. The key EGADS findings:

- The band-pass produced and maintained Gd-loaded water in EGADS with a transparency comparable to that of SK's ultrapure water.
- During 650 passes of the entire water volume through the Gd-capable water filtration systems there were no detectable losses of gadolinium sulfate whatsoever.

With these results in hand it was time to open the tank and look inside. Figure 2 is a view through the top hatch in the EGADS tank at the Gd-loaded water inside, and Figure 3 is an image taken in the bottom wall region looking up the side of the drained tank. Everything was shiny and beautiful: no changes following years of exposure to the 0.2% $Gd_2(SO_4)_3$.

These EGADS findings resulted in official approval from both the Super-Kamiokande and T2K Collaborations to move forward with our IPMU-led plans to load gadolinium into Super-K. After 2018's in-tank refurbishment, the first Gd could be in SK as early as 2019.

Figure 2 : Looking down into the full EGADS tank following two years of exposure to Gd

Figure 3 : Looking up the side wall of the empty EGADS tank after 2.5 years of soaking in Gd

Meanwhile, with its R&D role finished, EGADS has had its data acquisition hardware and online computing power significantly upgraded and now lives on as the world's most advanced water-based supernova neutrino detector. Refilled and building upon the confidence provided by Gd neutron tagging, its ambitious goal is to make a fully automated, standalone announcement of a galactic supernova explosion within one second of the first neutrino's arrival in the detector. This reborn EGADS is now associated with a Japanese network of optical, X-ray, gamma-ray, infrared, and gravitational wave observatories, for true multimessenger astronomy. Even the EGADS acronym has been repurposed: Employing Gadolinium to Autonomously Detect Supernovas.

5.2 The Farthest Star Ever Seen

Masamune Oguri

We study the structure of evolution of the Universe by observing galaxies. These galaxies consist of typically 10 billions of stars, but unless galaxies are located very close (about less than 100 million light-years) to Earth, we cannot observe individual stars that constitute these galaxies simply because they are too faint. One possible way to overcome this is to make use of gravitational lensing magnification to magnify only one of the stars in a galaxy, yet such an event had not been known.

Our team discovered such a gravitational lensing event for the first time by chance, when we were observing the galaxy cluster MACS J1149+2223 with Hubble Space Telescope. In 2016, we found fast transients near the critical curve (high magnification region) of the cluster (Fig. 1). This transient event, which was dubbed "Icarus", turned out to be an individual star that belongs to a galaxy located behind the cluster, about 9 billion light-year from Earth [Kelly et al., Nature Astronomy, 2, 334-342 (2018)]. Due to gravitational lensing magnifications by both dark matter in the cluster and a star floating in the cluster, we estimate that the background star was magnified by more than 2,000 times its true brightness at the time of its peak brightness. The magnified star was found to be a blue supergiant with its radius about 200 times that of Sun. This discovery sets a new distance record for the farthest individual star ever seen by observing a single star way beyond 100 million light-years.

Our extensive analysis of the light curve of Icarus and gravitational lensing calculations have revealed that observations of such ultra high magnification microlensing events offer a unique opportunity to test the nature of dark matter. As a specific example, when dark matter is made up mostly of a large number of primordial black holes (PBHs) with masses tens of times larger than the Sun, which correspond to black holes discovered by recent gravitational wave observations, we find that magnifications are saturated due to gravitational lensing by a too large number of PBHs. We find that we can use this phenomenon to rule out PBH dark matter scenario for a wide range of PBH masses [Oguri et al. Phys. Rev. D, 97, 023518 (2018)]. Therefore, the discovery of Icarus has opened up a new window to study dark matter in the Universe. We expect that, by using the future James Webb Space Telescope, we can discover many more such ultra high magnification events in cores of massive clusters, which will tightly constrain the nature of dark matter.

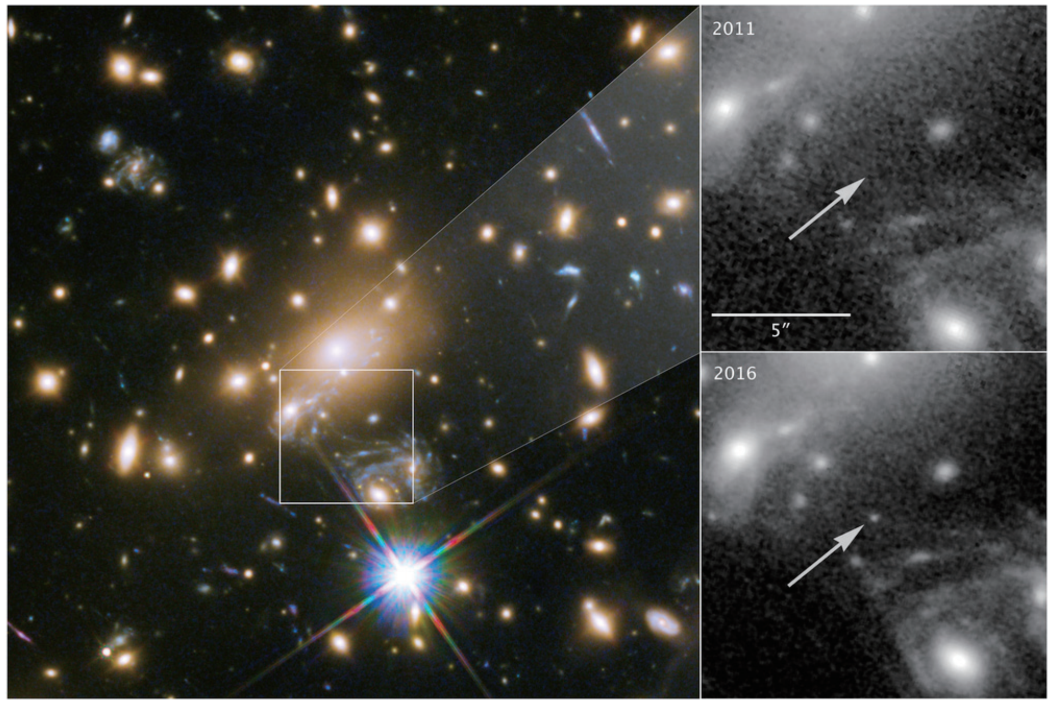
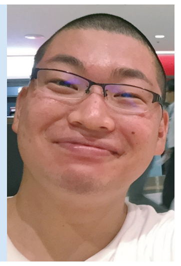


Fig. 1: The Hubble Space Telescope image of Icarus. The left panel shows the location of Icarus that appeared behind the galaxy cluster MACS J1149+2223. The right panels show enlarged images around Icarus, which was not seen in 2011 (upper) but was detected in 2016 (lower). (credit: NASA/ESA/P. Kelly)

5.3 Universal Spatial Distribution of Entanglement Entropy

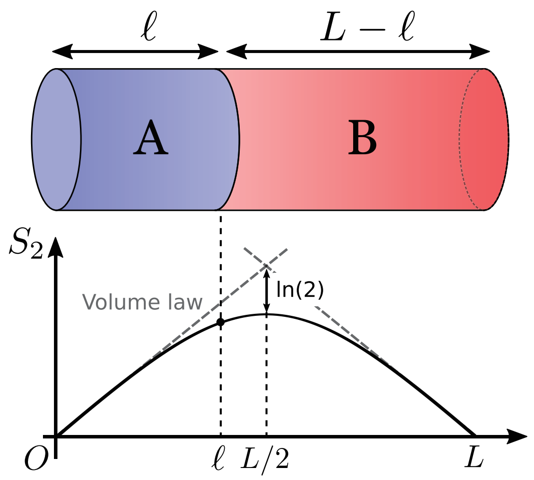


Masataka Watanabe

Where does the information go when Black Holes evaporate, although you should have unitary evolution of states in the quantised version of gravity (whatever that is)? This is called the Black Hole information paradox, and this question is worth asking because of AdS/CFT – quantum gravity must be really unitary.
There will be various stages in which you could say you have solved this paradox, but the least ambitious stage to say that is to compute the entanglement entropy between a Black Hole and its Hawking radiation. This computation even is not easy to accomplish in realistic models, but we could set up a toy model for the sake of the argument.
The toy model we considered was a finite-length spin chain Σ with length L, in which we split the whole system into two parts (A and B) and computed the (second Renyi) entanglement entropy $S_2(\ell)$ in terms of the size ℓ of A. In this toy model, the expectation is that A serves as the Hawking radiation. The result of what we computed (using the method of TPQ states) is the following;

$$S_2(\ell) = -\log K(\beta) + \ell \log a(\beta) - \log\left(1 + a(\beta)^{-L+2\ell}\right), \qquad (1)$$

which is striking because it only depends on two unknown coefficient (dependent only on temperature $T \equiv \beta^{-1}$) for any (fast-scrambled) lattice models.
Although I introduced this work in terms of Black Holes, this result contains much more fruitful and definite implications towards statistical physics and condensed matter physics. This is closely related to how closed systems like cold-atom systems reach thermal equilibrium without a heat bath, which is substituted by its own subsystem itself. The entanglement entropy takes the role of the thermal entropy, and it was already known to have the linear scaling in terms of $\ell \ll L$ (just like the thermal entropy).
What we have proposed, adding to this, is that this universality persists for any values of ℓ/L for any fast-scrambled models. This universality, first of all, lets us understand the thermalization of closed systems more. Not only that, we were able to use this formula as a fit function to diagnose if one system is fast-scrambled or not. Likewise, it was able to detect MBL-ETH trnasitions with better precision. We therefore strongly believe this study will not only be a conceptual toy model for Black Hole information paradox, but will also be of practical use in analysing scrambling in condensed mater systems.



5.4 Formation of Massive Black Holes Driven by Supersonic Gas Streams Left Over from the Big Bang

Naoki Yoshida

The physical mechanisms that drive the formation of super-massive black holes and their growth are poorly understood. Our research group has used supercomputer simulations of early structure formation to identify a promising process that gives rise to massive black holes in the early universe. The key is supersonic "wind" in the cosmic primordial gas left over from the Big Bang.

The simulations are begun with the initial conditions that are determined from observations of the early universe. During the first 100 million years after the Big Bang, the gas is streaming faster than the sound-speed, preventing condensation to trigger star formation. The high-speed gas streams are eventually caught by a heavy dark matter halo, and yield a dense, turbulent gas cloud. A star is formed at the cloud center, and then rapidly grows by accreting the inflowing gas. The star gains a mass of 34,000 times larger than the Sun, and then its own enormous weight causes a complete gravitational collapse, leaving behind an equally massive black hole.

While there are other theories about early black hole formation, we are encouraged by the fact that the abundance of massive black holes produced by the proposed mechanism is remarkably close to the number density of supermassive black holes recently discovered at the distant universe.

We continue working on whether or not and how the "seed" massive black holes grow to be super-massive ones at an epoch when the first generation of galaxies are assembled.

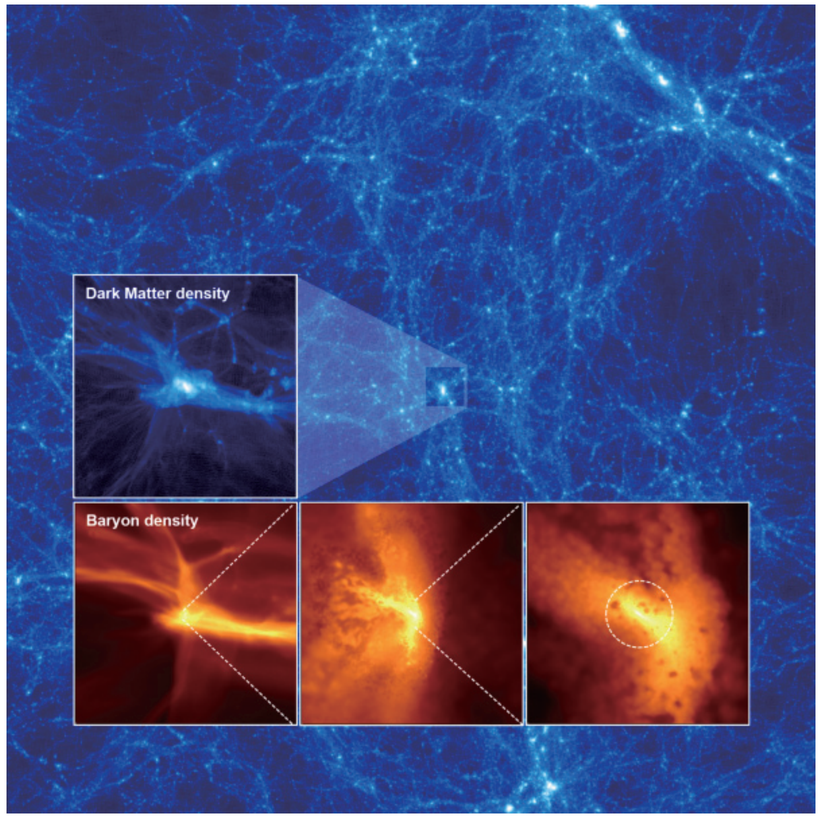


Figure 1. Projected density distributions of dark matter (background and top panel) and gas (bottom three panels) components when the first star forms. The high-speed gas is initially moving from left to right in the figure, but is trapped by the strong gravity of a massive clump of dark matter. A massive black hole is formed at the centre of the turbulent gas cloud. (Credit: Shingo Hirano [Kyushu University])

Reference

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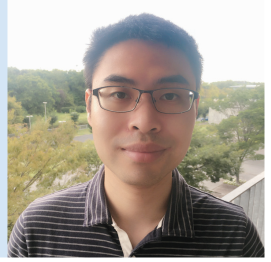
5.5 Muon *g* – 2 and Rare Top Decays in Up-Type Specific Variant Axion Model



Po-Yen Tseng

The up-type specific Variant Axion Model (VAM) can solved the strong CP problem in QCD (Quantum Chromodynamics) theory, which is a fine-tuning issue, at the same time avoid the Domain Wall problem in Cosmology, if we assume only one flavor quark is assigned with none-zero Peccei-Quinn (PQ) charge. On the other hand, the muon $g-2$ anomaly, 3σ deviation of the muonic magnetic dipole moment between the E821 experimental measurement and the Standard Model theoretical prediction, is a long standing issue over decades. We found in the preferred parameter region of up-type specific VAM with light mass pseudoscalar boson A about 15 GeV and large $\tan\beta \sim 40$ can explain the above two issues, meanwhile consistent with other constraints. Moreover, we find that there are no conflict against any flavor observables as long as the mixing angle ρ_u among up-type quark is small enough but non-zero, and a small mixing angle $\rho_u \sim \pi/100$ is slightly favored mainly due to the $B_s \to \mu\mu$ observation. The up-specific VAM predicts the flavor violating top rare decay $t \to uA$ followed by $A \to \tau\tau$, which would provide a smoking gun signature at the LHC (Large Hadron Collider). We show current searches of A already impose some constraints on the parameter space but not sensitive to the most interesting light m_A region.

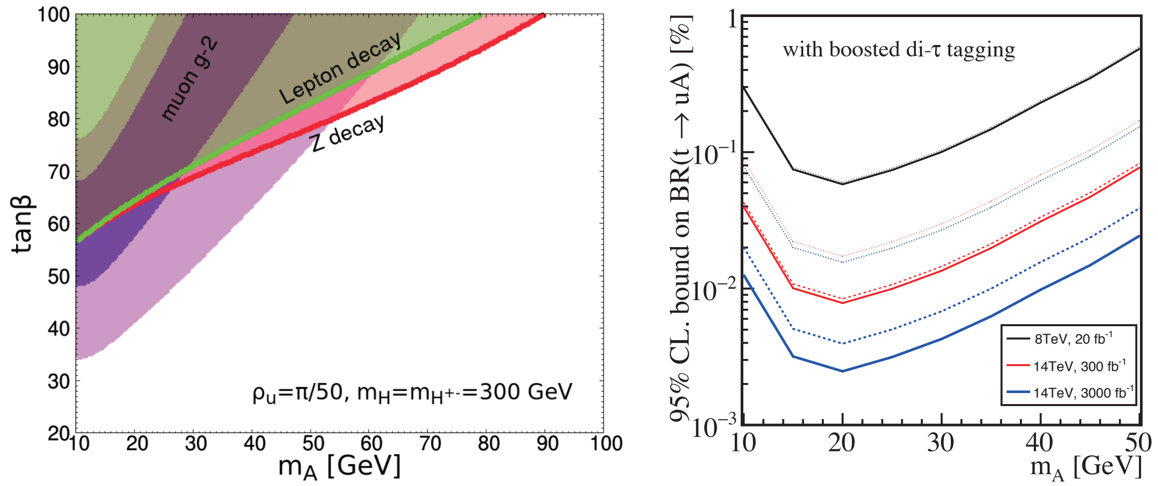


FIG. 1 : Left-panel: preferred region for muon $g-2$ anomaly. Right-panel: the present and future sensitivities for the top-quark flavor violating decay at LHC.

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5.6 Hunting Dark Matter at Collider

Satoshi Shirai

The dark matter is a well-established and most mysterious object in the Universe. It is reasonable to expect that the dark matter is composed of unknown particles. To reveal the fundamental properties of the dark matter is the most important target for particle physics.

Collider experiments are powerful tools to study the particle nature. The discovery and measurement of a dark matter are primary goals of the Large Hadron Collider (LHC). However, finding the dark matter at the LHC is hard work, even if so many dark matter particles can be produced. There is no way to directly detect the dark matter, as the dark matter is (almost) invisible. Usually we may find the dark matter as missing energy signals, since the dark matter particles "steal" the momentum and energy of the collision event. Unfortunately, neutrinos in the Standard Model (SM) also provide similar missing energy signatures, which leads so huge backgrounds. In some cases, even if millions of dark matter particles are produced, it is still hard to tell apart the dark matter signatures from the SM backgrounds.

So far, the LHC has not found any evidence of the dark matter signal, but set the lower-bound on the dark matter mass. For instance, for the Higgsino dark matter, which is a supersymmetric partner of the Higgs boson, the mass constraint from the latest LHC result is around 100 GeV. Actually, this constraint is not improved so much for more than a decade from the LEP experiment, because of the large background. To utilize the LHC experiment as much as possible for the dark matter search, we need new observable signals and/or efficient ways to reduce the backgrounds.

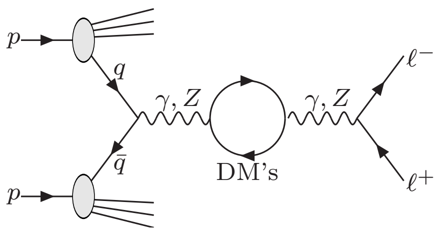

Figure 1 : Quantum correction from dark matter.

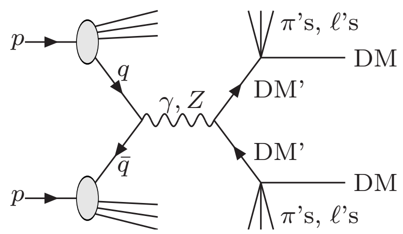

Figure 2 : Exotic tracks from dark matter partner DM'.

We propose new strategies for the dark matter search at the LHC. One is indirect detection of the dark matter [1]. Even without real production of the dark matter, there should be the virtual quantum effect from the dark matter, as the dark matter should obey quantum mechanics. This correction affects the Standard Model process. Fig. 1 shows an example of such corrections to the lepton production. Typically, this quantum correction changes the SM cross section by $O(1)$%. We can indirectly detect the dark matter, by measuring the SM process very precisely.

Another idea is detection of the exotic tracks from the dark matter partner [2]. In many new physics models, the dark matter is not a lonely particle, but has some partners. For instance, the Higgsino dark matter has two partners, one is electrically neutral and another is charged. In this case, dark matter can be produced from the decay of the partner particles as in Fig. 2. It is often the case, the partners can be long-lived. The decay length depends on the details of the dark matter model and typically is 1 mm - 10 cm. If the charge particle is metastable, it will provide disappearing charged track, which is a very useful probe of the dark matter. However, the existing search is not so efficient for the decay length much shorter than $O(10)$cm. We proposed an idea of experimental strategy to catch a shorter charge track, which enable the LHC to test a wider class of dark matter models.

Both strategies can increase the LHC capability to discover the dark matter. For the Higgsino dark matter, up to 400-500 GeV mass region can be tested in theory. For more realistic prospect, we need study the theoretical and especially experimental systematic uncertainties in detail. I am now investigating these issues in collaboration with both theoretical and experimental physicists.

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5.7 Localization Meets Holography

Seyed Morteza Hosseini

One can assign a macroscopic entropy to a black hole equal to one quarter of its horizon area measured in Planck units:

$$S_{\mathrm{BH}} = \frac{\text{Area}}{4G_{\mathrm{N}}} \,,$$

where G_{N} is the Newton's constant. The number of black hole microstates d_{micro} should then read

$$d_{\mathrm{micro}} = e^{S_{\mathrm{BH}}} \,.$$

But where are the microstates accounting for the black hole entropy? A consistent theory of quantum gravity seems to be required in order to answer this question. String theory, the prime candidate for such a theory, provides a microscopic explanation of the Bekenstein-Hawking entropy for a class of asymptotically flat BPS black holes in type IIB string theory on $K3 \times S^1$ by counting the degeneracy of BPS soliton bound states [1]. The situation for asymptotically anti de Sitter (AdS) black holes in $D \geq 4$ is rather different since we do not know the D-branes description of this class of black holes. The most natural setting in order to study the subject in asymptotically AdS spacetimes is the gauge/gravity duality. The holographic picture then suggests that the microstates of the black hole correspond to states in the dual conformal field theory (CFT). In particular, the microscopic entropy of certain four-dimensional static, dyonic, BPS black holes, which can be embedded in $AdS_4 \times S^7$, has been derived in this manner [2, 3], by showing that the ABJM *topologically twisted index* [4], at large N, agrees with the area law for the black hole entropy.

A key ingredient of this computation is the technique of *supersymmetric localization* [5]. The localization principle allows one to reduce the path integral of the theory into a finite-dimensional integral, *i.e. matrix integral*, and compute some *exact* results for supersymmetric observables in strongly coupled quantum field theories. It thus gives very precise predictions for the gauge/gravity duality.

Given the state of the art, my research aims to develop this realm of theoretical physics further. In [6–8], I evaluated the twisted index of a large class of three-dimensional $N = 2$ gauge theories with an M-theory or a massive type IIA dual and four-dimensional $N = 1$ gauge theories with a type IIB dual. Building on the previous results, I showed that the Bekenstein-Hawking entropy of class of black holes in massive type IIA backgrounds $AdS_4 \times S^6$ [9] and black strings in type IIB backgrounds $AdS_5 \times S^5$ [8] can be obtained with a microscopic computation in the dual CFT. Another interesting result is the relation between anomaly polynomial of $N = 4$ super Yang-Mills (6D $N = (2, 0)$ theory) and rotating, electrically charged, AdS black holes in five (seven) dimensions [10, 11].

Finally, I generalized the above results to higher dimensions by computing the partition function of $N = 1$ gauge theories on $M_4 \times S^1$, where M_4 is a toric Kähler manifold and S^1 a circle [12]. The partition function for $N = 2$ super Yang-Mills on $\mathbb{P}^1 \times \mathbb{P}^1 \times S^1$ scales as N^3 and is in perfect agreement with the holographic results for black strings in $AdS_7 \times S^4$. For 5D Seiberg theories, it scales as $N^{5/2}$ and gives a prediction for the entropy of a class of magnetically charged black holes in massive type IIA supergravity background $AdS_6 \times S^4$.

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5.8 Mirror Symmetry for Orbifold Quotients of Fermat Calabi–Yau Hypersurfaces

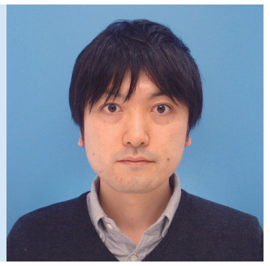
Todor Milanov

Mirror symmetry is a very interesting phenomenon in Mathematics that was first observed by physicists. It is a correspondence between symplectic and complex geometry which can be stated in various ways. The most attractive feature of mirror symmetry is that usually difficult problems for symplectic manifolds correspond to easy problems for complex manifolds and vice versa.

The mirror symmetry established in my work "Gromov-Witten Theory of Quotient of Fermat Calabi-Yau varieties", joint with Hiroshi Iritani, Yongbin Ruan, and Yefeng Shen, was proposed originally by Givental. His proposal is that the quantum differential equations defined via the genus-0 Gromov–Witten invariants of a smooth projective variety X can be solved in terms of oscillatory integrals $\int e^{f/z}\,\omega$ where f is a holomorphic function on the total space of some family of varieties $Y \to B$ and ω is a relative holomorphic volume form on Y. The mirror of X is defined as the tripple (Y, f, ω). It is usually called *Landau–Ginzburg model* or *Givental's mirror model* of X depending whether we want to emphasize the connection to physics or to acknowledge the contribution of Givental. Let us point out that Givental's proposal is still far away from being completed. The best understood case is when X has semi-simple quantum cohomology. Then we expect that the mirror (Y, f, ω) exists and it satisfies the axioms of a *primitive form* introduced by Kyoji Saito in the early 80's. Even in this case there are many difficulties. The construction of Givental's mirror for an arbitrary smooth projective variety X with semi-simple quantum cohomology is still a very difficult problem.

We proved that every Fermat polynomial $f = x_1^{d_1} + \cdots + x_n^{d_n}$ satisfying the condition $\frac{1}{d_1} + \cdots + \frac{1}{d_n} = 1$ is a Givental's mirror for the orbifold $X = \tilde{X}/G$, where $\tilde{X}$ is the Calabi-Yau hypersurface defined by the polynomial f in an appropriate weighted projective space and G is the maximal group of diagonal symmetries of $\tilde{X}$. There are two interesting applications of our result. First, using some standard fixed point localization computations in Gromov-Witten theory we can compute explicitly all primitive forms in terms of generalized hypergeometric functions. The second application is the other way around. We can express the Gromov-Witten invariants of X in terms of period integrals, which allows us to prove that Gromov-Witten invariants can be extended analytically with respect to the Novikov's variables. Moreover, we can describe explicitly the dependance of the analytic continuation on the choice of a path. Both problems of finding explicit formulas for the primitive form and the Gromov-Witten invariants are very difficult, so the mirror symmetry philosophy here is demonstrated in full strength.

5.9 Non-Commutative Crepant Resolutions for Some Toric Singularities



Yusuke Nakajima

A resolution of singularities is one of effective methods for understanding singularities. In particular, a crepant resolution of singularities has typical properties, thus we often consider this nice resolution (if it exists). Even if a crepant resolution exists for a given singularity, it is not unique in general, and crepant resolutions often give non-trivial derived equivalences. Namely, even if crepant resolutions *X* and *Y* are not isomorphic, their bounded derived categories of coherent sheaves would be equivalent, and this kind of phenomenon is important in birational geometry, mirror symmetry and their related areas. Under these backgrounds, it was conjectured by Bondal and Orlov that the bounded derived categories of coherent sheaves are equivalent for all crepant resolutions. This conjecture was proved by Bridgeland for the three dimensional case, and Van den Bergh gave another approach to this conjecture. Precisely, Van den Bergh considered a non-commutative algebra that is derived equivalent to *X* and *Y*. Since then, such an algebra was formulated, and nowadays it is called a non-commutative crepant resolution (or NCCR for short). A typical example of an NCCR is found in the derived McKay correspondence, which was established by Bridgeland-King-Reid. In their paper, it was shown that any three dimensional Gorenstein quotient singularity admits a crepant resolution, and its bounded derived category of coherent sheaves is equivalent to the bounded derived category of finitely generated modules over a certain skew group algebra, in which case this skew group algebra is an NCCR of a quotient singularity.

On the other hand, when we have a derived equivalence between an NCCR and a geometric crepant resolution, we can observe such a resolution from the viewpoint of representation theory of algebras. Thus, the representation theoretic properties on NCCRs are also important. In particular, it had been discovered that NCCRs are related to Auslander-Reiten theory, cluster theory etc, which are important subjects in representation theory of algebras.

In such a way, NCCRs are related to many branches of mathematics and physics, thus the importance of NCCRs has been increased. However, any singularity does not necessarily admit an NCCR. Thus, we should understand whether a given singularity admits an NCCR or not. For example, any three dimensional Gorenstein toric singularity admits an NCCR and it is obtained by using a dimer model which is a bipartite graph described on the real two-torus. However, we do not know the existence of NCCRs for higher dimensional toric singularities except few cases.

In my papers arXiv:1702.07058 and arXiv:1801.05139 (the former one is a joint work with Akihiro Higashitani), I considered a special class of toric singularities called Hibi rings, which are arisen from partially ordered sets. In particular, I showed the existence of NCCRs and gave their precise description for some Hibi rings by using the combinatorial structure of the associated partially ordered sets. I hope that the method used in these papers would be valid for other toric singularities.

5.10 Stability Conditions and Periods

Akishi Ikeda

In mathematics, D-branes in string theory can be described in terms of category theory.
In particular, A-type D-branes form the derived Fukaya category in symplectic geometry (A-model side) and B-type D-branes form the derived category of coherent sheaves in algebraic geometry (B-model side). The Kontsevich's homological mirror symmetry conjecture implies that there is an equivalence of categories between the derived Fukaya category of a Calabi-Yau manifold X and the derived category of coherent sheaves of a Calabi-Yau manifold Y, where Y is mirror partner of X. So surprisingly, the mirror symmetry exchanges the symplectic geometry and the algebraic geometry.

M. Douglas introduced the Π-stability of D-branes and considered BPS D-branes.
Following this work, T. Bridgeland introduced the notion of a stability condition on a derived category in mathematical terminology. Again from mirror symmetry, it is expected that if one considers stability conditions on the derived category of coherent sheaves of a Calabi-Yau manifold Y, then it describes the (extended) moduli space of complex structures on the mirror partner X. And central charges of A-type D-branes are described as the periods of Lagrangian submanifolds (A-type D-branes) in X by integrating the holomorphic volume form of the Calabi-Yau manifold X.

Following this idea, in the work (arXiv:1807.00469) with Yu Qiu, we described the space of stability conditions on Calabi-Yau categories associated with ADE-quivers. In particular for type A case, we clarify that the space of stability conditions on these categories can be identified with the moduli spaces of deformations of type A-singularities. The interesting geometric structures, called Frobenius structure or flat structures, on these spaces were introduced by Kyoji Saito in 1980s and he studied them for a long time. In our paper, we showed that the central charges of objects (D-branes) in the Calabi-Yau categories can be described as the periods of primitive forms in Kyoji Saito's theory. So our work gives the new interpretation of his theory of periods as central charges of stability conditions on derived categories. In addition, also in this work, we introduce the q-deformation of stability conditions along with the dimension of Calabi-Yau categories. This theory unifies the spaces of stability conditions on Calabi-Yau categories with different dimensions and give a new insight into the geometric structures of spaces of stability conditions.

5.11 Why are Women Underrepresented in Physics Departments?

Hiromi M. Yokoyama

In Japan, only 4% of bachelor's degrees in physics are awarded to women, which is a serious problem for the Kavli IPMU. The parents of women who hope to join physics departments worry about their daughters' marriage prospects. There appears to be a strong conservative social norm regarding women. In order to address this problem, the modern science theory group in the humanities and sociology group of the Kavli IPMU began a 3-year research policy project called Ristex (Research Institute of Science and Technology for Society). The research question is "What are the social barriers to women joining physics departments?"

Much of the research in this area is in the field of educational psychology. There is a negative stereotype that girls are not good at mathematics (Spencer 1999, Betz 2005, Morinaga 2017). Girls' self-efficacy in mathematics is lower than that in boys (Meece 1990). Studies have demonstrated gender stereotypes regarding occupation (Adachi 2014); in particular, "physicist" is a representative male occupation in Japan.

In 2017, the project's first year, we found that certain academic fields are viewed by the general public as being suitable or unsuitable for women; for instance, nursing sciences are appropriate for women, while mechanical engineering is not. Less than 10% of the general public thinks that learning physics is suitable for women. However, more than 60% of parents would approve if their daughter wished to join a physics department.

We decided to use a tool, SESRA-S, that assesses viewpoints on gender stereotypes. Parents who scored strongly on gender equality and who had a daughter in college agreed that women were well-suited not only for joining physics departments but also other departments. We will make policy-related recommendations in three years.

Besides this theme, based on the old question in science and technology theory, "Who decides science?", we pointed out the difference between ordinary science and crowdfunding, the latter of which is a process that generally lacks peer review. We proposed two new concepts, "budget community" and "crowd-created science" [1].

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5.12 Upcoming Start of the Belle II Experiment

Takeo Higuchi

As part of our efforts to realize new physics beyond the Standard Model (SM) of particle physics, the high-energy physics experiment Belle II will begin in early 2019 at KEK. The experiment will search for new physics containing B, τ, and other particles produced from collisions of 7.0 GeV e^- and 4.0 GeV e^+ accelerated with the SuperKEKB accelerator (Fig. 1). The particle behaviors in the produced events will be examined from many aspects. The compatibility of the behaviors with SM predictions will be tested because a significant incompatibility indicates the existence of new physics. We plan to collate a list of incompatibilities to describe the structure of new physics.

New physics effects are expected to be miniscule compared to the SM. Consequently, numerous particle events are needed before incompatibility can be claimed. The designed luminosity of SuperKEKB is 8×10^{35} cm^{-2} s^{-1}, which is 40 times the achieved luminosity by its ancestor accelerator KEKB upon increasing the storage beam current and squeezing the bunch size in the e^+-e^- interaction region.

The particle detector Belle II (Fig. 2) is located at the interaction region. It is an upgraded version of the previous detector Belle. The detector has a cylindrical structure so as to surround the SuperKEKB beam pipe. The approximate length along the beam pipe and detector diameter are 7 m and 7.5 m, respectively. The pixel detector (PXD) and silicon vertex detector (SVD) are the innermost and next innermost sub-detectors in Belle II, which consist of two and four cylindrical layers, respectively. They can locate a charged-particle position with ~35 μm precision. The central drift chamber (CDC), which is comprised of 14,336 strung sense-wires and low-Z gas, is installed next to the SVD. The CDC detects a charged-particle track by sensing electrons induced along the track trail.

The time-of-propagation (TOP) counter and aerogel ring image Cherenkov (ARICH) counter are the main devices for charged-particle identification together with the CDC; both measure Cherenkov light from a charged particle. The TOP counter is installed in the barrel region next to the CDC. It has 16 identical modules, each of which is comprised of a quartz bar and 32 photodetectors. A particle is identified by measuring the propagation time of Cherenkov light to the bar ends because its emission angle depends on the particle velocity, and consequently, yields a difference in path length. The ARICH counter is installed to the forward end-cap region. It has 124 pairs of aerogel tiles as a Cherenkov-light radiator and 420 photodetectors. A particle is identified by measuring the ring diameter made on the photodetection plane because the emission angle dependence on the particle velocity gives the difference in the ring diameter.

The energies of electrons and photons are measured by the electromagnetic calorimeter (ECL), which is comprised of 8,736 crystal bars of CsI(Tl). Although the ECL design is the same as Belle, the online calculation of hit timing and energy deposit with the waveform sampling method is newly introduced to accommodate the higher event rate. The K_L^0 and μ detector (KLM) is the outermost sub-detector in Belle II. It is made of a stack of iron plates and resistive plate counters. A particle that is not detected by the inner sub-detectors and leaves a hadronic-shower signal on the KLM is identified as K_L^0; a charged particle that is detected by the CDC but leaves small signals on the ELC and a trajectory in KLM is identified as μ. The Belle II data acquisition (DAQ) system is newly developed to accommodate a large event size of 1 MB (PXD) plus 100 kB (others) and a high level-1 trigger rate of 30 kHz. Newly implemented deeper pipelines and CPUs on readout electronics and a new computing farm for high-level event filtering allow handling of the larger and faster data. The system for rigger and clock signal distribution is replaced with a more scalable one than Belle. The huge amount of collected data is analyzed by the

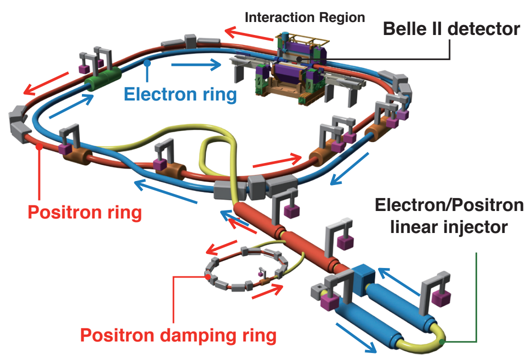


Figure 1 : The SuperKEKB accelerator (Credit: KEK).

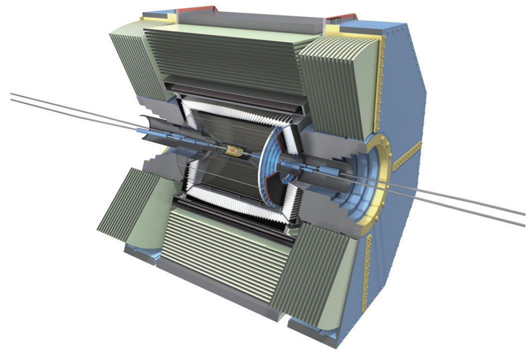


Figure 2 : The Belle II detector (Credit: Belle II collaboration, Rey.Hori).

computing systems distributed around the world using the GRID technology.
SuperKEKB was initially commissioned in 2016. The second commissioning occurred in March 2018 for further SuperKEKB tuning, assessment of the beam background effect on the inner sub-detectors, and detector commissioning. We attempted the e^+-e^- collision beginning on the evening of April 25, 2018 and confirmed the first collision $e^+e^- \rightarrow q\bar{q}$ by the Belle II detector at 00:38 in the next morning. Figure 3 shows a display of the very early collision event. The second commissioning successfully ended in July 2018 with a total integrated luminosity ~500 pb^{-1}. We have already re-discovered B meson decays in the data (Fig. 4).
The PXD and SVD will be commissioned separately from the other sub-detectors. The SVD has a characteristic lantern shape with a forward diameter smaller than the backward one to keep a larger detector coverage with fewer sensors. The innermost, second, third, and outermost SVD layers are composed of 14, 30, 48, and 80 rectangular or trapezoidal silicon sensors, respectively. All sensors are arrayed in a ladder-like structure. The outermost SVD ladder has five sensors and the layer is comprised of 16 ladders.
The Belle II team at Kavli IPMU tackled production of the outermost SVD ladders. Research and development of the ladder assembly began in 2012 in the clean room at Kavli IPMU. By the summer of 2014, we established ladder-assembly procedures to reproducibly glue ladder components, bond wire with a strong-enough pull force, and qualify the electrical ladder quality. In the summer of 2014, we assembled a single-sensor module. Testing of the module confirmed all the procedures work well in principle. In parallel, we developed ladder-assembly tools that allow precise sensor alignment because if a sensor touches something, it can crack easily.
The procedures and tools were concluded in January 2016 by confirming a sufficient mechanical quality of a mockup ladder assembly. Then we prepared an assembly of a prototype ladder with the full electrical functionality. The prototype ladder was tested on the DESY beamline in March 2016. The prototype ladder successfully detected the electrons. We kicked off ladder mass production on May 18, 2016.
The mass-production mode focuses on maintaining ladder quality while minimizing human errors. For instance, we edited a detailed 100-page manual, which is referred to during the assembly process. We also inspect the quality of all incoming parts to protect the line and installed a license system so that only qualified operators are allowed to work on the assembly. After two years of mass production on May 24, 2018, we had assembled 16 good ladders plus three spare ladders. All the good ladders are mounted on the SVD structure (Fig. 5, left) and are being tested with cosmic rays. Finally, we confirmed the SVD nicely detects a cosmic ray (Fig. 5 right).
The Belle II detector is planned to be activated to collect data in early 2019 with the combined PXD and SVD being installed in 2018 fall.

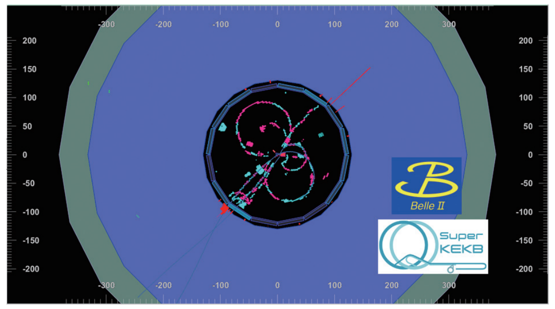


Figure 3 : The display of a very early collision event.

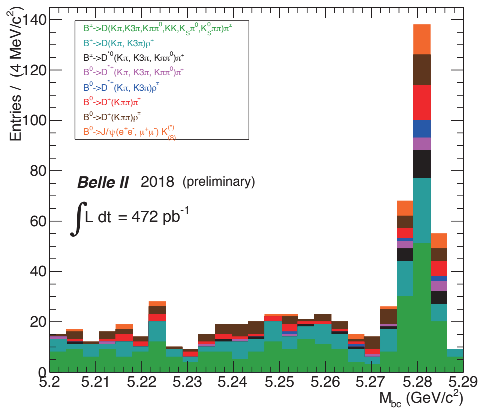
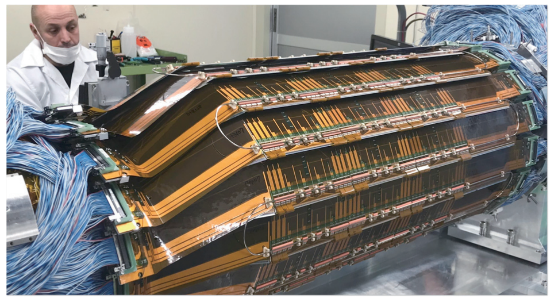


Figure 4 : The distribution of the beam-energy constrained mass of B-meson candidates in 472 pb^{-1} of collision data, in the mode $B \rightarrow D^{(*)}h$ and $J/\psi K^{(*)}$ where $h = \pi, \rho$.



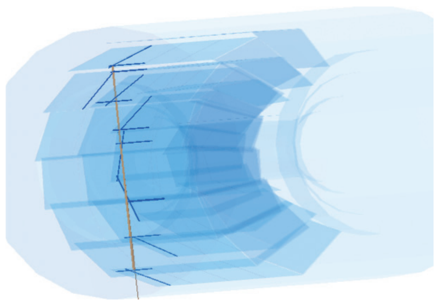


Figure 5 : The SVD ladders mounted on the SVD structure (left) and the display of a cosmic ray caught by the SVD (right).

5.13 Neural Networks and the Search for Strong Gravitational Lenses

Matthias Weissenbacher

The search for gravitational strong lenses in the image data set of the HSC-SPP survey is a challenging task. Gravitational lenses are the result of light of a distance galaxy "the source" being bend around a closer "lensing galaxy". Observing the often multiple images of the source galaxy is the precisest way to reconstruct the mass of the lensing galaxy. Thus one may infer the shape and dark matter content of the lensing galaxy.
Our task is to use current state of the art machine learning image recognition techniques to firstly identify strong lenses in the vast landscape of HSC image data. And secondly, when a strong lense is identified we use AI image analyzing techniques to model the mass density of the lensing galaxy. For conventional algorithms both above tasks are exceedingly time consuming and do not allow exhaustive scans of data. Preliminary results suggest that machine learning algorithms are up to 1000 times faster.

Artificial neural networks are computing systems vaguely inspired by the biological neural networks of the brain. This analogy is drawn due to the capability of such systems to be trained for totally different tasks. In particular we work with **Convolutional Neural Networks (CNN's)** which consist of multiple layers. The input layer takes the image, i.e. a 2d array of values for each color. Multiple intermediate layers perform data manipulations to conclude on the final output layer, which for the example of the classification lense vs. non-lense is simply the number 0 or 1.

Fig 1.: Action of the convolutional neural network on real HSC image data. Ideally it returns probability 1 on lenses and probability 0 for non lense images.

Convolutional layers perform a mathematical operation known as cross-correlation on the image. This establishes correlations of adjacent pixel regions. Pooling layers perform a down sampling of the image information of the 2d array of values to a smaller array, until one is left with one real number representing the image.
We use supervised learning for both the lense classification Fig 1 as well as the lense analyzing automatization. For task one we train our network with images of lenses and non-lenses Fig 2. the CNN parameters get fixed such that the chance of reproducing the correct answer is increased.

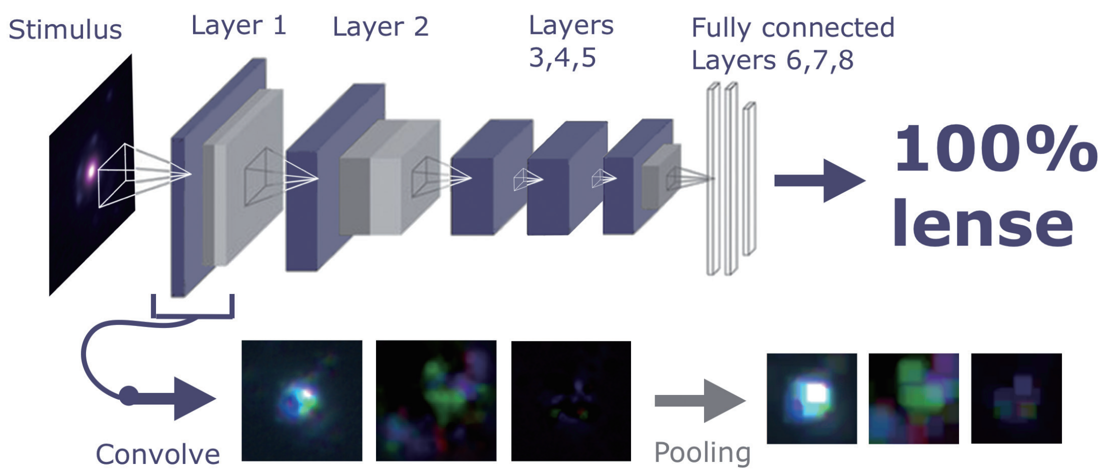


Fig 2.: Layer Structure of a CNN. Blue layers are convolution layers, dark grey ones are pooling layers, and bright gray ones are normalization layers. The stimulus on the left is a gravitational lense. The graphic depicts three possibilities of the action of the convolution layer on the stimulus. We then use the same Pooling function to reduce the image size.

The main challenge is the absence of realistic HSC training data. One distinguishes in between the negative sample, i.e. those images which are clearly not a lense and should be projected to zero probability by the network, see e.g. Fig.1. And the positive training sample, i.e. lenses where the distorted arc of the source galaxy is clearly visible in the image, and image which might be lenses but need a closer inspection by an human expert on the subject. Latter, images when acted on with the CNN should be projected to a high probability e.g. >70%, see Fig.1. At the time of this writing we have about 104 thousand negative images which we augment by rotations & inversion from 13 thousand hand selected unique negative HSC images. For the positive sample simply not enough real lenses are known thus we need to simulate them. We use arc simulations and add them on top of the 13 thousand negatives images to get our positive training sample. The simulations are added randomly, in mass, shape, eccentricity of the lensing galaxy. The main challenges are to reduce the statistical correlation in our simulations and to make the simulations as realistic as possible comparable to real HSC lense images see Fig. 3.

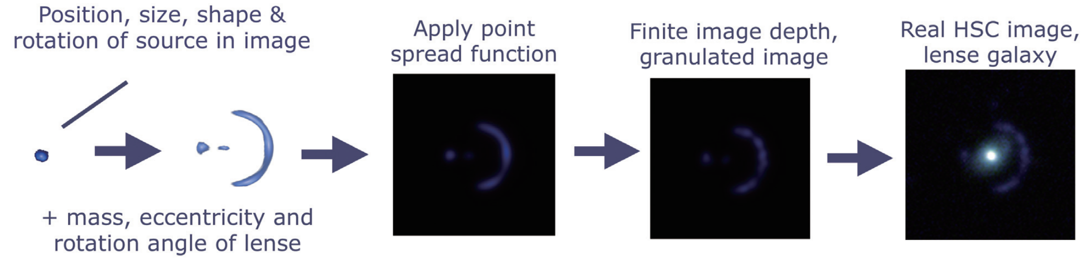


Fig 3.: Depicts the steps to generate simulated lenses. Starting from the image of the realistic source galaxy on the left. To the final semi-realistic lense image on the right. The step of accounting for finite image depth is currently not incorporated in the entire training sample.

The second project aims to analyze lenses automatically when the CNN network has identified them. The goal is to read of the mass, eccentricity and rotation of the lensing galaxy automatically. To accomplish this task we are currently utilizing GAN's.

Generative Adversarial Networks (GAN's) are an example of unsupervised learning. Consisting of two networks which "train each other". Usually one which generates examples and the other one which discriminates them. Recent advances have shown its power to solve inverse problems.

To analyze lenses we face an inverse problem, namely reconstructing the the source galaxy from given arc images, i.e. in Fig.3 inverting the direction of arrows starting from the right side. Such networks should allow to directly "invert" arcs and infer the parameters of the lensing galaxy.

5.14 A Stellar Explosion Caught at Birth

Melina Bersten

Understanding the explosive end of massive stars is a key aspect of astrophysics. The first electromagnetic signal of the explosion, a flash of photons known as the shock breakout (SBO), conveys unique information about the final evolution and structure of the exploding star. However, the unpredictable nature of supernova events hinders the detection of this brief initial phase despite the large observational efforts of the recent years.

Luckily, on September 20, 2016, amateur astronomer Víctor Buso from Rosario, Argentina, was testing his new camera on his rooftop observatory in hope of photographing his first supernova. After an hour of taking images Buso noticed a new tiny object had appeared, and it became more obvious with time (Figure 1). The discovery images obtained encompass 1.5 hours during which the supernova is seen to appear and quickly rise. The initial 20 minutes show no sign of the supernova, but 45 minutes later the supernova is detected and subsequently doubles its flux during the final 25 minutes (that is, at a rate of ≈ 40 mag/day).

After the supernova was announced and dubbed SN 2016gkg a team of researchers lead by Melina Bersten, researcher at the Instituto de Astrofísica de La Plata, CONICET - UNLP, Argentina, and Visiting Associate Scientist at the Kavli Institute for the Physics and Mathematics of the Universe, carefully analyzed the images. The rapid brightening rate combined with a very low luminosity had no analogue among known supernovae, and the team concluded Buso had discovered SN 2016gkg during the elusive SBO phase. Thier conclusions were based on comparing the photometry of the images with their computer simulations. The explosion models showed that initial sharp brightening in supernova light could only be explained by shock emergence (Figure 2). Moreover, the models naturally account for the complete supernova evolution over distinct phases that are regulated by different physical processes.

The physical properties derived for SN 2016gkg indicate that this is a rather ordinary event, which would imply that the observed initial phase is common to all supernovae, as models predict. The team's results were published in *Nature* on February 22.

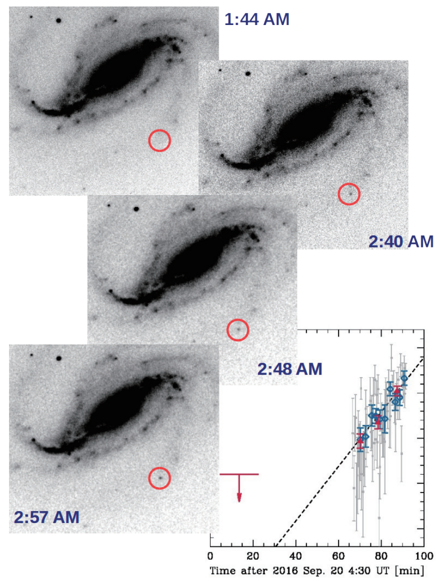


Figure 1: Sequence of combined images obtained by Víctor Buso as SN 2016gkg arises in the outskirts of galaxy NGC 613. Labels indicate the time each image was taken. The supernova location is indicated by the red circles. Notably the supernova appears and stabrightens and steadily brightens within one hour, as shown in the lower-right panel.

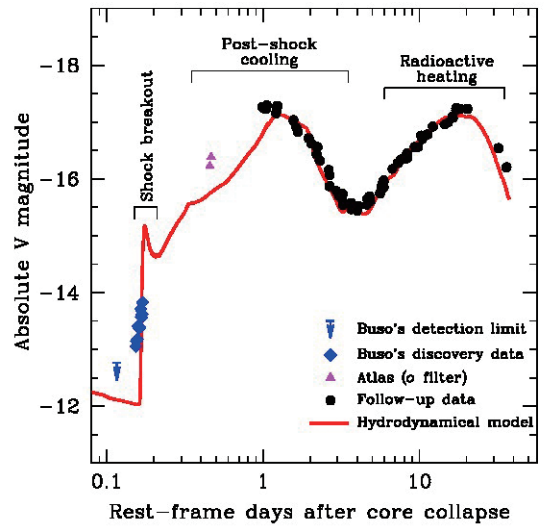
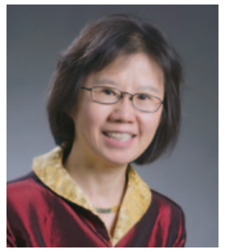


Figure 2: Observed light curve of SN 2016gkg (dots) and explosion model (red line). The model reproduces three distinct phases in the supernova evolution that occur on different time scales. First, the shock breakout (with a time scale of hours), then the post-shock cooling emission (days), and finally the emission due to radioactive heating (weeks). Buso's discovery observations, shown in blue, indicate such a rapid rise that can only be attributed to the shock breakout.

6 AWARDS

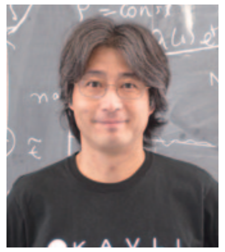


Young-Kee Kim Elected to the American Academy of Arts and Sciences

On April 12, 2017, it was announced that Chicago University Professor and Kavli IPMU Principal Investigator (PI) Young-Kee Kim was named a new member of the American Academy of Arts and Sciences. Established in 1780, it is one of the oldest learned societies in the United States. Its members have made significant accomplishments in academia, arts, business, and politics, and selection by the Academy has been one of the highest honors in the United States. So far, three Kavli IPMU members have been selected by the Academy as its members: PI David Spergel in 2012, Director Hitoshi Murayama in 2013, and PI Hirosi Ooguri in 2016.

Professor Young-Kee Kim has long been a leading physicist in the field of high-energy physics experiments using particle accelerators. Her research activities include participation in the CDF experiment at Fermilab in the US and the ATLAS experiment at the CERN LHC. She also served as Deputy Director of Fermilab from 2006 to 2013.

The 228 new members announced this year will be inducted at a ceremony at the Academy's head-quarters in Cambridge, Massachusetts on October 7.



Hitoshi Murayama Named One of the 100 Influencers in the World

It has been 100 years since Albert Einstein established the General Theory of Relativity in 1915 and published it in 1916. To commemorate this historic milestone, the Albert Einstein Foundation is promoting the Einstein Legacy Projects. "Genius: 100 Visions of the Future" is one of these projects. It aims at collecting and publishing the visions of 100 significant influencers in the world including scientists, artists, thinkers, and innovators. Kavli IPMU Director Hitoshi Murayama has been named by the Foundation as one of the contributors for this project. Those already on the list include Kyoto University Professor and Nobel Laureate Shinya Yamanaka. The 100 visions will be compiled into the world's first 3D-printed book featuring Einstein's face, designed by the world-famous designer, Israel-born Ron Arad.

Receives Research Award from Alexander von Humboldt Foundation

Kavli IPMU Director Hitoshi Murayama receives a Research Award from the Alexander von Humboldt Foundation (AvH) in Germany; it was announced in October. The award is one of up to 100 the AvH grants every year to internationally renowned academics from abroad in recognition of their achievements to date; particularly academics whose fundamental discoveries, new theories, or insights have had a significant impact on their own discipline and who are expected to continue producing cutting-edge achievements in the future.*

The award ceremony will be held in June 2018 at the Annual Meeting of AvH.

*https://www.humboldt-foundation.de/web/ humboldt-award.html

Hirosi Ooguri Elected to the Japan Writers' Association

Hirosi Ooguri, Kavli IPMU Principal Investigator and Fred Kavli Professor at Caltech, has been elected to the Japan Writers' Association on June 23, 2017. He has written several popular science books, including "Introduction to Superstring Theory," which received the 2014 Kodansha Prize for Science Books, the most prestigious prize for science books in Japan (see *Kavli IPMU News* No. 27, p. 23).

The Japan Writers' Association was established in 1926. The Founding Chair was Kan Kikuchi, a well-known writer and founder of the major publishing company Bungeishunju Ltd. Though the association was disbanded during World War II, it was re-established in 1946 as a professional organization to promote literature, protect freedom of expression, and support writers. Its membership consists of writers, playwrights, critics, essayists, translators, and poets.

Takaaki Kajita Awarded the 4th Berkeley Japan Prize

ICRR Director and Kavli IPMU Principal Investigator Takaaki Kajita was awarded the 2017-2018 Berkeley Japan Prize. This Prize is a lifetime achievement award from the Center for Japanese Studies to an individual who has made significant contributions in furthering the understanding of Japan on the global stage.*

The past recipients of this prize are: Haruki Murakami (inaugural, 2008-2009), Hayao Miyazaki (2nd, 2009-2010), and Ryuichi Sakamoto (3rd, 2013-2014).

*http://ieas.berkeley.edu/cjs/berkeley_japan_prize.html


David Spergel and Eiichiro Komatsu Awarded the 2018 Breakthrough Prize in Fundamental Physics

On December 3, 2017, the Breakthrough Foundation announced the 2018 Breakthrough Prize in Fundamental Physics to be awarded to Charles L. Bennett, Gary Hinshaw, Norman Jarosik, Lyman Page Jr., David N. Spergel, and the Wilkinson Microwave Anisotropy Probe (WMAP) Science Team for detailed maps of the early universe that greatly improved our knowledge of the evolution of the cosmos and the fluctuations that seeded the formation of galaxies.

One of the five leading WMAP scientists, David Spergel is Professor of Astronomy at Princeton University and Kavli IPMU Principal Investigator. Also, Max Planck Institute for Astrophysics Director and Kavli IPMU Principal Investigator Eiichiro Komatsu is among the remaining 22 members of the WMAP science team.

Long Time Kavli IPMU Supporter Hamamatsu Photonics Honored by the University of Tokyo

In recognition of establishing the first endowed professorship for fundamental science and their support for Kavli IPMU research into dark matter and dark energy, Hamamatsu Photonics was awarded the "University Of Tokyo Shokumon Award" on October 10, 2017.

This is the second time an organization associated with the Kavli IPMU has received a Shokumon Award. Fred Kavli, representing the Kavli Foundation, received this Award in 2012 (see *Kavli IPMU News* No. 20, p. 25, where the story of "Shokumon" from Chinee history is also briefly explained).

Daisuke Kaneko Receives Young Scientist Award from the Physical Society of Japan

Kavli IPMU postdoctoral fellow Daisuke Kaneko is one of several researchers who have received the 2018 Physical Society of Japan Young Scientist Award. He has been recognized for his Ph.D. thesis on the search for $\mu^+ \rightarrow e^+\gamma$ decay in the MEG experiment at the Paul Scherrer Institute in Switzerland. In this experiment, the world's most stringent limit was obtained. A positive observation of this decay would be evidence of physics beyond the Standard Model, and currently, the MEG experiment is being upgraded to the MEG II experiment.

Yasunori Nomura Named New American Physical Society Fellow

Director of the Berkeley Center for Theoretical Physics at UC Berkeley and Kavli IPMU Principal Investigator Yasunori Nomura has been named a new fellow of the American Physical Society (APS). He was recognized for his pioneering contributions to a variety of areas of particle theory, including gauge unification in extra dimensions, electroweak symmetry breaking, supersymmetric models, dark matter, the multiverse, foundations of quantum mechanics, and black holes.*

*https://www.aps.org/programs/honors/fellowships/archive-all.cfm

Kavli IPMU Staff Receive 2017 President's Award for Business Transformation

For their risk management work in normalizing harassment prevention education, a group of Kavli IPMU staff, represented by Project Specialist Rieko Tamura, has been awarded the 2017 University of Tokyo President's Award for Business Transformation.

The Kavli IPMU team was commended for developing a harassment education video and online quiz in English. The team and their families (and one cat) developed the education video's storyboard, script, props, and starred in the video.

The video was made for researchers within the institute, half of whom are from overseas, and was also uploaded to the university's E-learning system to allow researchers on overseas trips to take part in university activities. Moreover, the video and quiz also became accessible to all University of Tokyo researchers with access to the university portal site.

Awards

7 CONFERENCES

Conference title Date, Place	Attendees (from abroad)
Developments of mathematics at IPMU: in honor of Kyoji Saito 25-28 April 2017, Lecture hall	94 (15)
The E61 (NuPRISM) Meeting 3-5 September 2017, Lecture hall	18 (13)
5th Hyper-Kamiokande Proto-Collaboration Meeting 6-9 September 2017, Lecture hall etc.	97 (42)
Science communication meeting for crowd funding science 16 September 2017, Lecture hall	35 (1)
Stellar Evolution, Supernova Nucleosynthesis Across Cosmic Time 18-29 September 2017, Lecture hall etc.	81 (46)
Kavli IPMU 10th anniversary symposium 16-18 October 2017, Kashiwa-no-ha Conference Center / Kavli IPMU	118 (12)
Focus week on primordial black holes 13-17 November 2017, Lecture hall	41 (8)
9th PFS general collaboration meeting 27 November - 1 December 2017, Lecture hall etc.	136 (79)
Berkeley Week@IPMU 10-12 January 2018, Seminar room B	23 (9)
Kavli IPMU-Berkeley Symposium - Statistics, Physics and Astronomy - 11-12 January 2018, Lecture hall	19 (8)
String Theory in Greater Tokyo 6A 16 January 2018, Lecture hall	10 (3)

8 CONFERENCE PRESENTATIONS AND SEMINAR TALKS

Invited talks given by the Kavli IPMU researchers.

Quantum Gravity, String Theory and Holography
(2017.4.3-7, Kyoto, Japan)
Hirosi Ooguri
Symmetry in Quantum Gravity

KITP program "The Mysteries and Inner Workings of Massive Stars"
(2017.4.6, KITP/UCSB in Santa Barbara,USA)
Ken'ichi Nomoto
Presupernova evolution of super-AGB stars

Hodge Theory, Stokes Phenomenon and Applications
(2017.4.10-14, CIRM - Luminy, France)
Todor Milanov
Primitive forms and Frobenius structures on the Hurwitz spaces

Princeton workshop on "A definitive Investigation of the Core-collapse Supernova Cassiopeia A"
(2017.4.19, Princeton Univ., USA)
Ken'ichi Nomoto
Binary star models for the Cas A progenitor

2017 STScI Spring Symposium on "Lifecycle of Metals Throughout the Universe: Celebrating 50 Years of UV Astronomy"
(2017.4.24, STScI in Baltimore, USA)
Ken'ichi Nomoto
Nucleosynthesis in First Stars and Chemical Enrichment in the Early Universe

Developments of mathematics at IPMU: in honor of Kyoji Saito
(2017.4.25-28, Kavli IPMU, Japan)
Kentaro Hori
Grade Restriction Rule from Hemisphere

Simons Symposium
(2017.5.1-5, Elmau, Germany)
Hirosi Ooguri
Symmetry in Quantum Gravity

MIAPP Scientific program 2017 "Superluminous supernovae in the next decade"
(2017.5.16, Tech. Univ. of Munich in Garching, Germany)
Ken'ichi Nomoto
Pulsational pair-instability models for UV bright superluminous supernovae

KITP Conference: Quantifying and Understanding the Galaxy—Halo Connection
(2017.5.15-19, KITP, UCSB, USA)
Surhud More
Assembly Bias and Splashback Radius on Cluster Scales: Observational Status

LHCP2017
(2017.5.15-20, Shanghai Jiao Tong Univ., China)
Satoshi Shirai
Compressed SUSY

LHCP2017
(2017.5.15-20, Shanghai Jiao Tong Univ., China)
Hitoshi Murayama
Closing Plenary "Theory vision"

PLANCK 2017
(2017.5.22-27, University of Warsaw, Poland)
Shigeki Matsumoto
Estimating J-factors of dSphs for indirect dark matter detection

Representation Theory at the Crossroads of Modern Mathematics: in honor of Alexandre Kirillov's 81st Birthday
(2017.5.29-6.2, Université de Reims, France)
Toshiyuki Kobayashi
Analysis of minimal representations-an approach to quantize nilpotent orbits

Algebraic Analysis in honor of Masaki Kashiwara's 70th birthday
(2017.6.6-9, IHÉS,Bures-sur-Yvette, France)
Mikhail Kapranov
Perverse schobers on surfaces via Ran categories

Arrangements and beyond: Combinatorics, geometry, topology and applications
(2017.6.6-9, Centro de Ricerca Matematica Ennio De Giorgi, Pisa, Italy)
Toshitake Kohno
Higher category extensions of holonomy maps for hyperplane arrangements

Matrix Factorizations in Mathematics and Physics
(2017. 6.12-16, Simons Center for Geometry and Physics, Stony Brook, USA)
Kentaro Hori
An introduction to the hemisphere partition function

Galaxy Evolution Across Time
(2017.6.12-16, École Normale Supérieure, Paris, France)
Surhud More
The edges of dark matter halos: theory and observations

Self-distributive system and quandle (co)homology theory in algebra and low-dimensional topology
(2017.6.12-16, KIAS Research Station Busan, Korea)
Toshitake Kohno
Representations of the category of braid cobordisms

Neutron Stars: Linking Nuclear Physics to Gravitational Radiation
(2017.7.6, Aspen Center for Physics, USA)
Ken'ichi Nomoto
Neutron star formation in Electron Capture Supernovae

X. International Symposium: Quantum Theory and Symmetries
(2017.6.19-25, Varna, Bulgaria)
Toshiyuki Kobayashi
Symmetry Breaking Operators in Conformal Geometry

PASCOS 2017
(2017.6.19-23, Madrid, Spain)
Hirosi Ooguri
Swampland Constraints

Algebraic Analysis and Representation Theory - In honor of Professor Masaki Kashiwara's 70th Birthday
(2017.6.26-30, RIMS, Kyoto U, Japan)
Mikhail Kapranov
Higher Kac-Moody algebras

Strings 2017
(2017, 6.26-30, Tel Aviv, Israel)
Hirosi Ooguri
Remarks on the occasion of the 20th anniversary of AdS/CFT correspondence

String-Pheno 2017
(2017.7. 3-7, Virginia Tech, USA)
Hirosi Ooguri
Swampland Constraints

String-Pheno 2017
(2017.7. 3-7, Virginia Tech, USA)
Taizan Watari
Gravitino mass, fluxes and arithmetic geometry

Astrophysics of Gravitational Radiation Sources and Multimessenger Astronomy in the Era of LIGO Detections
(2017.7.9-8.6, Aspen Center for Physics, USA)
Ken'ichi Nomoto
Black hole forming supernovae and First stars

The Nonlinear Universe
(2017.7.17-21, Smartno, Slovenia)
Masahiro Takada
Halo Emulator: Application to SDSS clusters

Simons Summer Workshop
(2017.7.17, Simons Center for Geometry and Physics, USA)
Hirosi Ooguri
Swampland Constraints

17th International Workshop on Low Temperature Detectors
(2017.7.17-21, Kurume City Plaza, Japan)
Hitoshi Murayama
CMB B-mode polarization-Probe the era before the Big Bang

Flat Connections in Physics and Geometry
(2017.7.20-22, University of Heidelberg, Germany)
Kentaro Hori
2d Seiberg duality, with boundary

String Math 2017
(2017.7.24-28, Univ. of Hamburg, Germany)
Kentaro Hori
Boundary conditions in 2d (2,2) gauge theories

GOPIRA symposium
(2017/7/24, NAOJ, Japan)
Naoyuki Tamura
Current status of PFS: From the viewpoint of international collaboration

The Progenitor-Supernova-Remnants Connection
(2017.7.24-28, Ringberg Castle, Germany)
Ken'ichi Nomoto
Electron capture supernovae from super AGB stars

Progress in particle physics: 2017
(2017.7.31-8.4, Yukawa Institute for Theoretical Physics, Kyoto U, Japan)
Masahiro Takada
Exploring fundamental physics with Subaru wide-area galaxy surveys

Workshop on Self-interacting dark matter
(2017.7.31-8.4, Niels Bohr Institute, Denmark)
Surhud More
Splashback radius of galaxy clusters: theory & observations

Tsinghua Summer Workshop in Geometry and Physics 2017
(2017.8.7-11, Tsinghua University, China)
Taizan Watari
Revisiting Heterotic - Type IIA Duality

TeVPA 2017
(2017.8.7-11, Center for Cosmology and AstroParticle Physics, The Ohio State Univ., USA)
Hitoshi Murayama
TeV frontier in particle astrophysics

Quantum Information in Quantum Gravity
(2017.8.14-18, UCB Vancouver)
Hirosi Ooguri
Symmetry in Quantum Gravity

2017 U Chicago Math Conference-Interactions between Representation Theory and Algebraic Geometry
(2017.8.21-25, University of Chicago, USA)
Mikhail Kapranov
Fourier transform on hyperplane arrangements

Recent Developments in Neutrino Physics and Astrophysics
(2017.9.4-7, L'Aquila, Italy)
Yoichiro Suzuki
From the Solar Neutrino Problem to the Oscillation Discovery and beyond

Stellar Evolution, Supernova, and Nucleosynthesis Across Cosmic Time
(2017.9.18-29, Kavli IPMU, Japan)
Ken'ichi Nomoto
Hypernovae and Extremely Metal-Poor Stars

Stellar Evolution, Supernova, and Nucleosynthesis Across Cosmic Time
(2017.9.18-29, Kavli IPMU, Japan)
Alexey Tolstov
Ultraviolet emissions from superluminous supernovae: CSM vs. PISN vs. Magnetar

Stellar Evolution, Supernova, and Nucleosynthesis Across Cosmic Time
(2017.9.18-29, Kavli IPMU, Japan)
Ken'ichi Nomoto
Electron capture supernovae

UCB Fundraising Symposium
(2017.10.3, Nomura Securities Worldwide Plaza,USA)
Hitoshi Murayama
the Quantum Universe

Post-Planck cosmology: Enigma, Challenges and Visions
(2017.10.9-12, IUCAA, Pune, India)
Surhud More
Cosmological constraints from joint analyses of galaxy clustering and weak gravitational lensing

Supernova Neutrino Observations workshop
(2017.10.9-13, Mainz Institute for Theoretical Physics, Germany)
Mark Vagins
DSNB: Experimental Challenges

International Workshop on Superconformal Theories 2017
(2017.10.19, Sichuan University, China)
Gabi Zafrir
The Eight Field Way

The 2017 International Workshop on Future Linear Colliders (LCWS2017)
(2017.10.23-27, Strasbourg Convention Center, France)
Hitoshi Murayama
Dark Spectroscopy

Geometry and combinatorics of associativity
(2017.10.23-27, Dublin)
Mikhail Kapranov
Associativity and higher Segal structures

The 20th Anniversary of AdS/CFT
(2017.10.31-11.3, Princeton, USA)
Hirosi Ooguri
On Distinguishablity of Black Holes

BSM in direct, indirect and tabletop experiments
(2017.11.5-16, Weizmann Institute of Science, Israel)
Tom Melia
Magnetic bubble chambers

Theories of Astrophysical Big Bangs
(2017.11.6-11,RIKEN, Japan)
Alexey Tolstov
Scenarios of superluminous supernovae in radiation hydrodynamics simulations

A Celebration of CEMP and Gala of GALAH
(2017.11.14, Monash University, Melbourne, Australia)
Ken'ichi Nomoto
Yields of Faint Pop III Supernovae and the Abundance Pattern of Most Iron-Poor Stars

Categorical and Analytic Invariants in Alegebraic Geometry V
(2017.11.27-12.1, Osaka University, Osaka, Japan)
Kentaro Hori
Grade restriction rule for QCD with symmetric matters

Categorical and Analytic Invariants in Alegebraic Geometry V
(2017.11.27-12.1, Osaka University, Osaka, Japan)
Will Donovan
Perverse sheaves, wall crossing, and mirror symmetry

Mirror Symmetry and Related Topics 2017
(2017.12.11-15, Kyoto University, Japan)
Tatsuki Kuwagaki
Fukaya category of the projective line and microlocal sheaf theory

International Symposium on Cosmology and Particle Astrophysics (CosPA 2017)
(2017.12.11-15, Yukawa Institute for Theoretical Physics, Kyoto Univ., Japan)
Hitoshi Murayama
Hierarchy Problem, Dark Matter, Dark Energy

International Symposium on Cosmology and Particle Astrophysics (CosPA 2017)
(2017.12.11-15, Yukawa Institute for Theoretical Physics, Kyoto Univ., Japan)
Kentaro Hori
Mirror Symmetry - from 3d to 2d

WFIRST-Subaru Synergistic Observation Workshop
(2017.12.18-20, NAOJ,Tokyo,Japan)
Hitoshi Murayama
Subaru PFS updates

IRCN 1st International Symposium
(2017.12.17, The Ito International Research Center, The Univ. of Tokyo)
Hitoshi Murayama
WPI Overviews: Kavli IPMU

International workshop on "Axion physics and dark matter cosmology"
(2017.12.20-21, Osaka, Japan)
Masahiro Kawasaki
Cosmological problems of QCD axion

Topology of Arrangements and Representation Stability
(2018.1.14-20, Mathematisches Forschungsinstitut Oberwolfach, Germany)
Toshitake Kohno
Local systems on configuration spaces, KZ connections and conformal blocks

Simons Collaboration on Homological Mirror Symmetry
(2018.1.29-2.3, University of Miami, USA)
Mikhail Kapranov
N-spherical functors", Mirror Symmetry and Related Topics

Workshop "Riemann-Hilbert correspondence"
(2017.2.5-9, University of Padova, Italy)
Mikhail Kapranov
Fourier transform on hyperplane arrangements

Workshop "Riemann-Hilbert correspondence"
(2017.2.5-9, University of Padova, Italy)
Tomoyuki Abe
Trace formalism and l-p independence in arithmetic D-modules

PACIFIC
(2018.2.13-19, Kiroro Resort, Hokkaido, Japan)
Tom Melia
Magnetic bubble chambers and dark matter

Robert Brout Memorial Symposium
(2018.1.18, Nanyan Technological Institute, Singapore)
Hirosi Ooguri
Symmetry in Quantum Gravity and Other Swampland Constraints

YKIS2018a Symposium: General Relativity - The Next Generation -
(2018.2.19-23, Yukawa Institute for Theoretical Physics, Kyoto University, Japan)
Shigeki Matsumoto
Weak-charged WIMP

Transient Universe conference
(2018.2.26-3.1, Nanyang Technological University, Singapore)
Ken'ichi Nomoto
Fisrst Stars and First Supernovae

Higher dimensional algebraic geometry
(2018.3.12-16, University of Tokyo, Japan)
Chen Jiang
On Noether type inequality, II - 3-folds with (1,2) surface fibration

Higher dimensional algebraic geometry
(2018.3.12-16, University of Tokyo, Japan)
Yukinobu Toda
Birational geometry for d-critical loci and wall-crossing in Calabi-Yau 3-folds

Higher dimensional algebraic geometry
(2018.3.12-16, University of Tokyo, Japan)
Yukari Ito
Higher dimensional McKay correspondence

14th Interational Conference of Computational Method in Science and Engineering (ICCMSE 2018)
(2018.3.14-18, Thessaloniki, Greece)
Masahiro Kawasaki
Formation of primordial black holes in multi-field inflation models

Communicating Astronomy with the Public 2018
(2018.3.24-28, Fukuoka, Japan)
Hitoshi Murayama
Dark Side of the Universe for Everybody

Communicating Astronomy with the Public 2018
(2018.3.24-28, Fukuoka, Japan)
Hiromi Yokoyama
Does crowd funding change the shape of science?

Communicating Astronomy with the Public 2018
(2018.3.24-28, Fukuoka, Japan)
Hitoshi Murayama
What is the universe made of?

Shedding Light on the Dark Universe with Extremely Large Telescopes
(2017.8.30-9.2, Lanzhou, China)
Anupreeta More
Probing Dark Energy with strong gravitational lensing

Texas 2017: the 29th International Texas Symposium on Relativistic Astrophysics
(2017.12.3-8, Cape Town, South Africa)
Hitoshi Murayama
Dark Matter and Fundamental Physics

9 OUTREACH AND PUBLIC RELATIONS

TITLE	DAY	VENUE	number of participants
Kavli IPMU and ICRR Host 16th Joint Public Lecture	Apr. 15, 2017	Amuser Kashiwa	327
Science Café Universe 2017	Jun. 24, 2017	Tamarokuto Science Center	32
Institute tour for Japan - Asia Youth Exchange Program in Science	Jul. 4, 2017	Kashiwa Campus	25
Science Café Universe 2017	Jul. 8, 2017	Tamarokuto Science Center	42
Kavli IPMU Science Café "What Can a Particle Accelerator Discover?"	Jul. 15, 2017	Kavli IPMU	39
Booth at the 2017 Super Science High School Student Fair	Aug. 8-9, 2017	Kobe International Exhibition Hall	250
Learning and Creating Physics - From High School to the Forefront Research of the Universe	Aug. 19, 2017	Seihoku Gallery of the Yayoi Auditorium Annex	28
KEK×Kavli IPMU Joint Media Background Briefing	Oct. 13, 2017	Genius Seminar Room B (Akihabara)	29
Open Campus Kashiwa 2017	Oct. 27-28, 2017	Kashiwa Campus	3139
17th Kavli IPMU/ICRR Joint Public Lecture	Nov. 3, 2017	Ito Hall	369
"Actually I Really Love Physics! - Career Paths of Female Physics Graduates"	Nov. 18, 2017	Kavli IPMU	19
Learning and Creating Physics - From High School to the Forefront Research of the Universe	Jan. 6, 2018	Fukutake Learning Studio	51
3rd Kavli IPMU / ELSI Joint Public Lecture "A Question of Origins"	Jan. 21, 2018	Kuramae Hall	300
6th Annual WPI Science Symposium "Unfolding Future"	Feb. 11, 2018	Miraikan	800
AAAS 2018 Annual Meeting	Feb. 16-18, 2018	Austin Convention Center	400
"re^n-Encounter between Science and Art 2018"	Mar. 9-25, 2018	KAMATA_ SOKO	344
"Uncovering the basis of science and art through Truth, Good, and Beauty"	Mar. 11, 2018	Tamarokuto Science Center	38

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