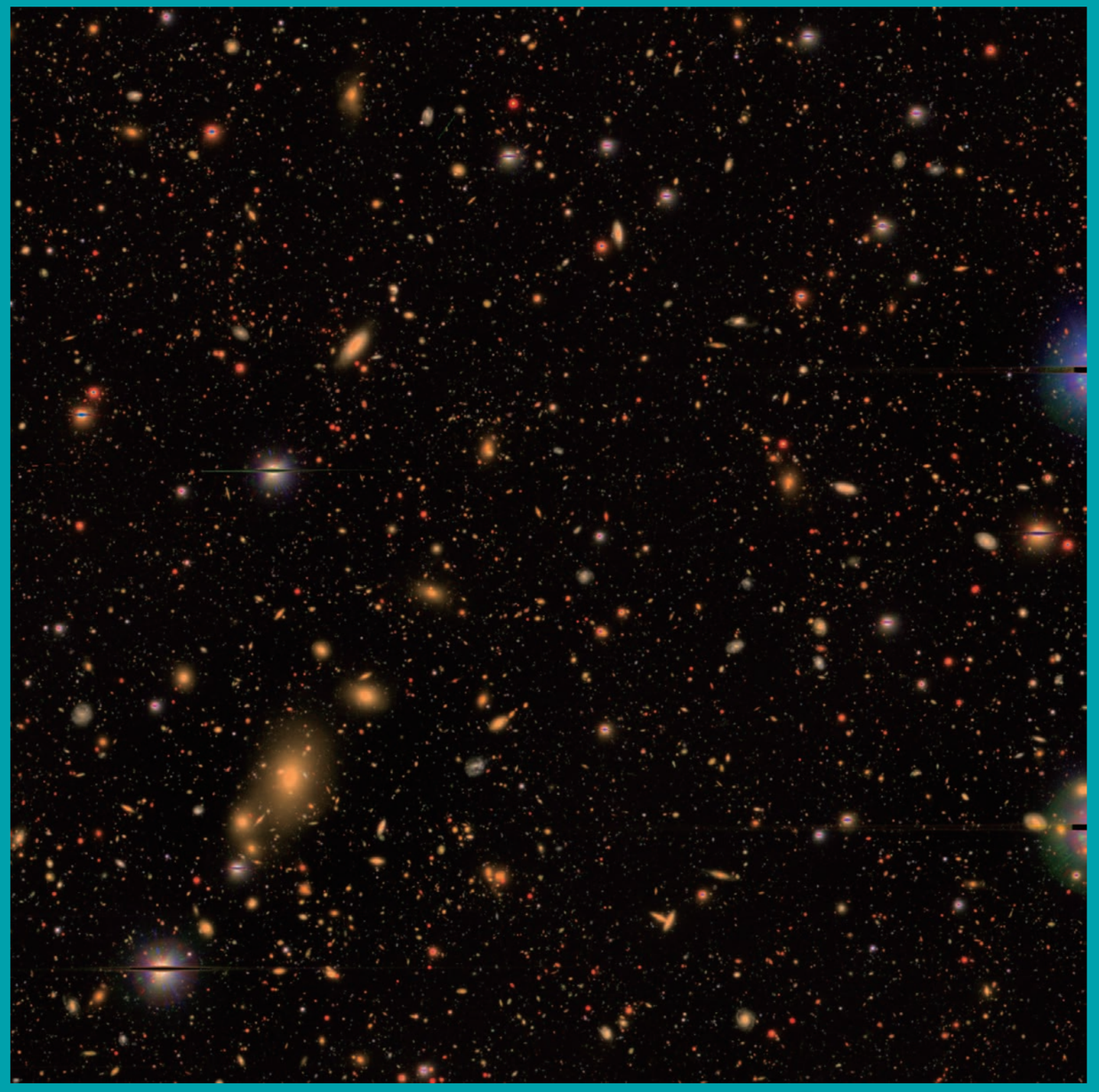
Kavli IPMU Annual Report 2016 April 2016–March 2017



April 2016–March 2017

Kavli IPMU

ANNUAL REPORT 2016

Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU)
The University of Tokyo Institutes for Advanced Study
The University of Tokyo

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KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

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

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KAVLI

IPMU

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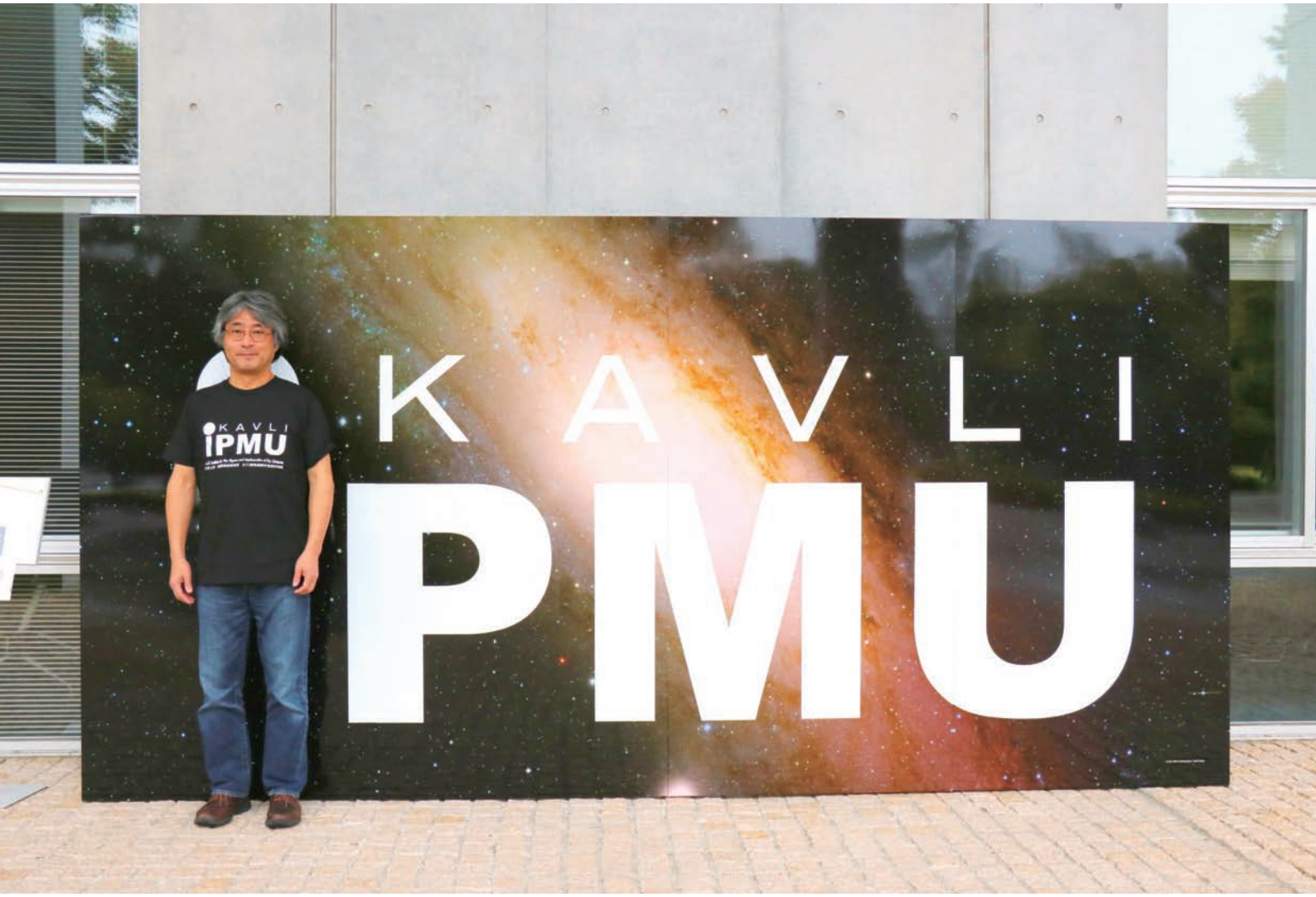
On the cover: A color composite image in the g, r and i bands of a small piece of the COSMOS field, as imaged by the Hyper Suprime-Cam. This image contains thousands of galaxies as faint as 27 th magnitude. The galaxies are seen at such large distances that the light from them has taken billions of years to reach us. The light from the faintest galaxies was emitted when the universe was less than 10% of its present age. (Credit: Princeton University/HSC Project)

FOREWORD



Hitoshi Murayama
Director

I'm amazed. This annual report covers our activity through the Japanese Fiscal Year 2016, and the WPI funding was supposed to be finished on March 31, 2017. Then why haven't we disappeared from the map by now? Institute for the Physics and Mathematics of the Universe was launched on October 1, 2007. The WPI funding was promised for nine and a half years. We started to recruit very best scientists with the fear that they may all leave well before the end of this period. It is a culmination of many forces and sheer luck that got us through these years and beyond.

Kenzo Nakamura was just about to retire from KEK, and agreed to come as the Administrative Director on October 16. He was IPMU Employee #1. Since then, he started to assemble a team of competent staff, to get ready for the anticipated arrival of many scientists, with a large fraction from other countries. All the PIs worked hard to advertise the new institute and announced a large number of available positions. At the same time, many of our research projects, most notably Hyper Suprime-Cam on Subaru telescope, were started but constrained by funding. I began my appointment only on January 1, 2008 because of my duties in Berkeley which I had complete. Kenzo worked out my appointment which was approved only a few days before my arrival.

Many young faculty started to arrive soon, mostly Japanese at the beginning. Kenzo and I worked on our staff to change their mindset from the traditional system to a new open and forward-looking system. Surprisingly, they were very eager to tackle new challenges. Soon enough, the web site our staff put together received President's award, the first recognition by the University that IPMU is off to something good. Yet when the first batch of young international postdocs started to arrive in fall 2008, it was quite a bit of chaos and trial and errors. Thanks to dedication of our staff, we managed to create a system that supports international scientists very well so that they could kickstart their research soon after they arrived. Vast majority of the initial postdocs are already on faculty positions elsewhere in the world because of their great research accomplishments at IPMU. Given their success, IPMU started to become known to the world, and more people came for workshops and appointments. We started to attract international faculty members. The building momentum caught the attention of the University administration, and they created Todai Institutes for Advanced Study (TODIAS) to house IPMU, later renamed as UTokyo Institutes for Advanced Study (UTIAS). It was originally meant to be purely organizational issue, but it turned out to have critical importance later.

Thanks to the wise decision by Executive Vice President Nishio, we could build our wonderful building by borrowing money from ten-years of overhead up front. Thanks to strong support by Executive Vice President Okamura, we could launch daily tea time, and create flexible appointment system. Thanks to then-Presidents Komiyama and Hamada, we started to obtain permanent positions, despite the fixed-term nature of funding. Kavli Foundation observed this development, and decided to make IPMU the first Kavli Institute in Japan; actually the first institute in Japan named after any donor, not to even speak of an international donor. It broke a new ground, and gave us a greater visibility. IPMU became Kavli IPMU in 2012. The Foundation intended to make this happen earlier, but was delayed by Lehman shock in 2008.

Yet Lehman shock helped. It prompted the Japanese government to create economic stimulus package, which included large funding called FIRST to 30 individuals. For a sheer luck, I managed to get one approved, without which the current major project Hyper Suprime-Cam would not have been completed, nor the next major project Prime Focus Spectrograph launched.

We were very keen on public outreach from the onset, because of our sense of our obligation to bring back the research products to who paid for them, namely the general public. Unexpectedly, it created a strong public support to Kavli IPMU, by being volunteers, providing donations, and just being fans.

All of them combined, we received the top mark from the interim review on Dec 2012. Mr. Towatari, then a high-ranking official at MEXT, suggested that we should go after permanent funding that goes beyond WPI. TODIAS framework gave us right to put forward a budget request. It took several years to materialize, but without his suggestion, we would not have put in such a request. It started to produce permanent funding so that Kavli IPMU could go on beyond the WPI funding.

In the mean time, our scientists kept producing world class research as we have shown in the annual reports the last nine times. Then in October 2015, we overjoyed when one of our PIs, Takaaki Kajita, was announced to received Nobel Prize in Physics!

If we had missed any one of them above, we would not be here today.

1 INTRODUCTION

The Kavli IPMU marks the 10th year since it was established on October 2007 as the Institute for the Physics and Mathematics of the Universe by the World Premier International Research Center Initiative of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. The Kavli IPMU aims at establishing a multi-disciplinary research institute with the unifying goal of understanding five fundamental questions about the Universe: how it starts, what it is made of, what its fate is, what its fundamental laws are, and why we exist in it. We proposed to address these questions from the synergistic perspectives of physics, mathematics, experimental physics, and astronomy. Since the quality of our work is well recognized in the community, the Kavli IPMU became a member of the Kavli Institutes in 2012 and it has now grown to a competitive worldclass institute consisting of 252 researchers, and 39 administrative and research support staffs.

In the calendar year (CY) 2016, 345 (450 when including WPI-related) papers were published. We have consistently produced a large number of scientific papers in the past 3 years (452 in CY2014, 466 in CY2015 including WPI-related papers) after a steady increase (75, 199, 240, 292, 347, 380 papers from CY2008 to CY2013). Among the WPI papers published in CY2016, the rate of highly cited papers "top 1% of papers" was 16 (3.6%) based on the Web of Science by Thomson Reuters. The impact factor for all of our refereed papers published from the institute's inception to Dec 2016 are as follows: the average number of citations per paper is 23.1; 85 papers have over 100 citations and 287 over 50 citations in which review papers are excluded. The fraction of CY2016 papers with international collaboration reaches 78 %. The Kavli IPMU members also received 10 valuable prizes/awards during FY2016. For example, N. Yoshida was awarded the Japan Academy Medal and the Japan Society for the Promotion of Science Award. T. Kajita and H. Ooguri received Chunichi Cultural Award. Highlights of our scientific results are summarized below.

- Theoretical physicists in the Kavli IPMU work on a variety of topics. The particle phenomenology group led by T. Yanagida and S. Matsumoto searched for new physics with the 750GeV diphoton anomaly reported by the LHC experiment in 2015. H. Murayama's proposal that dark matter is Strongly Interacting Massive Particle as "dark pions" has attracted a lot of attention, selected as one of Highly Cited Papers based on Thomson Reuters. Our new young professor Y. Tachikawa conducted research in various aspects of quantum field theories including time-reversal anomaly of 2+1 dimensional systems. String theorists performed various studies including that of new aspects of duality map between Heterotic and Type IIA string theories by T. Watari.
- Mathematicians actively work on a variety of subjects in arithmetic, algebraic complex and symplectic geometry and representation theory that have deep connections with theoretical physics in particular with string theory. M. Kapranov is a leader in higher category theory and significantly boosts our international reputation. T. Abe was awarded the 2017 Mathematical Society of Japan Spring Prize.
- The XMASS team led by Y. Suzuki looked for annual modulation of the dark matter signal using the data spanning more than a year. They found that almost all the DAMA/LIBRA allowed region in 6 to 16 GeV/c^2 are excluded when assuming WIMP dark matter.
- The T2K collaboration presented its first neutrino oscillation results using a simultaneous analysis of data collected with neutrino and antineutrino beam configurations. M. Hartz and C. Bronner led the analysis of T2K data to give the world's best constraint on the parameter related to CP violation in neutrino mixing. They found that their result is most consistent with a value of the parameter for which CP violation is large. The result has been accepted for publication in Physical Review Letters (PRL) with the "Editors' Suggestion" designation.
- The KamLAND-Zen led by K. Inoue and A. Kozlov demonstrated the best sensitivity in the search for neutrinoless double-beta decay in Xenon 136. The team set the best limit on the effective Majorana neutrino mass of 61 meV to 165 meV, which excludes most of the degenerate mass region. The work was published in PRL as an "Editor's Suggestion".
- Both the Super-Kamiokande and T2K Collaborations have now officially endorsed and approved the IPMU-originated and IPMU-developed idea of loading Super-K with gadolinium, a concept known as GADZOOKS! (Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!). This new phase of operations, formally known as SK-Gd, is expected to get underway in 2018, with the first gadolinium load going into the tank in 2019.
- The CMB satellite mission, LiteBIRD, is now progressed to the JAXA/ISAS PhaseA1 and has also 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: the Ohsaki group at the

Graduate School of Frontier of Sciences develops the superconducting magnetic bearing technology, while the Gonokami-Yumoto-Ideguchi group at the Institute for Photon Science and Technology develops laser machining technology.

- The Hyper Suprime-Cam (HSC) project, which is currently taking 300 nights worth of images on the Subaru telescope over a 5 year period using a new 900M-pixel digital camera, finally made a public release of the first-year HSC data from its first 1.7 years (61.5 nights of observations) — the HSC DR1. The dataset already contains almost 100 million galaxies and stars including some of the most distant galaxies in the Universe. The total amount of data is already comparable to the size of the US-based Sloan Digital Sky Survey that took over 10 years to establish. The HSC team is now working very hard to prepare a series of the first-year science papers.
- MaNGA (Mapping Nearby Galaxies at Apache Point Observatory) has been collecting integral-field spectroscopy for a vast sample of galaxies since 2014 and a wealth of exciting early science results from the survey have been published. E. Cheung and K. Bundy led a May 2016 Nature publication describing the discovery a new class of galaxy termed "red geysers". Additional 19 scientific and technical articles on MaNGA have been published.

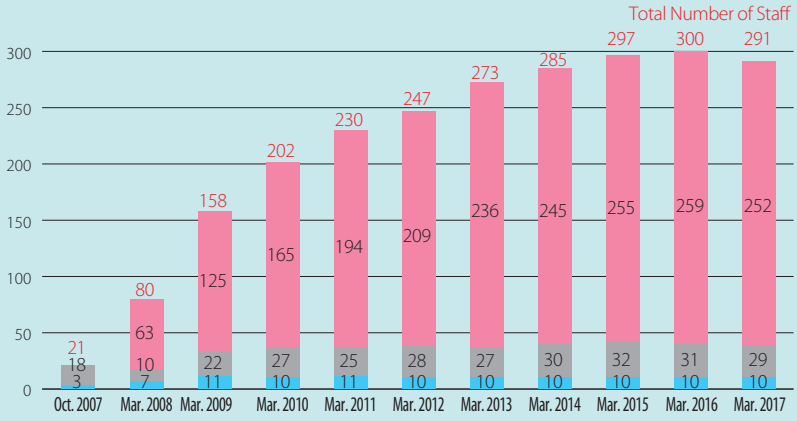
We have held interdisciplinary seminars, including 68 math-string (MS) seminars and 87 Astronomy-Particle physics-Experimental physics-Cosmology (APEC) seminars, among 184 seminars in FY2016. N. Yoshida leads the Statistical Computational Cosmology CREST project funded by JST, which aim to fuse studies between astronomy, statistics and mathematics. In collaboration with the Institute of Statistical Mathematics, the project team is developing fast imaging data analysis applications for Subaru HSC including the machine-learned classifier of supernovae and an "emulator" for weak lensing studies. H. Ooguri, in collaboration with a mathematician, discovered the positivity and monotonicity of the relative entropy in information theory implies a new type of positive energy theorems in General Relativity. This opened a new approach to study General Relativity using information theory. H. Ooguri organized a workshop entitled "Statistics, Quantum Information, and Gravity" to explore the emerging interface between high energy theory and gravity with statistics and information theory. We reappointed Y. Tachikawa from UTokyo as our new professor who works at the interface between physics and mathematics.

The ratio of non-Japanese members among all of researchers is 41% at the end of FY2016. During FY2016, we held 14 conferences and workshops inside the Kavli IPMU. We had 728 (982) visitors (the numbers in the parentheses take into account multiple visits). Among them, 464 (569) were international. We obtained 595 applicants for our postdoctoral positions and 90% of them were from outside Japan. So far the Kavli IPMU has signed 17 cooperative research agreements or memorandum of understanding (MOU). We concluded a new agreement with the Department of Physics, and the University of Oxford, for the purpose of the Kavli IPMU Oxford D.Phil. fellowships, which enforces the globalization of U Tokyo.

The Kavli IPMU administrative staff members were awarded the U Tokyo's 2016 Special Prize for business innovation. Following on from 2008, 2013, 2015, this is the fourth time the staff received this award. Our successful system reforms are expected to spread to the rest of the University and other research institutions to help boost the overall competitiveness of Japan on a global scale. A ripple effect of the host institute's achievement has been cross-appointment. It was initiated at the Kavli IPMU and has now spread across the university and also between other research laboratories.

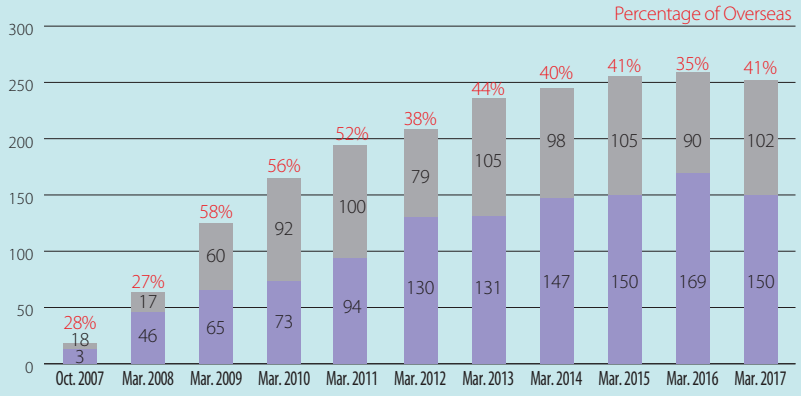
Japanese science documentary special "Hitoshi Murayama's Great Adventures in the Universe – Where did we come from?" was presented by H. Murayama and aired on NHK on Jan 6, and again as a two-part extended version on NHK BS on Feb 9 and 16. A science movie "The Man from the 9 Dimensions", supervised by H. Ooguri, won Best Educational Production Award at the International Planetarium Society Fulldome Festival Brno 2016. We invited Lisa Randall, a well-known theoretical physicist at Harvard University to give a public lecture "Dark Matter and the Dinosaurs". We held a program to encourage female students to study science, "Look into the Universe", in which a total of 70 people including junior high-school and high-school girls listened to lectures given by Y.-K. Kim with interpretation by H. Murayama. We also held an event called "Actually I Really Love Physics! – Career Paths of Female Physics Graduates" to support female students in physics to plan their careers. As part of the Artist in Residence program, media artist Norimichi Hirakawa stayed to carry out research and make new works. The prototype was exhibited at our open campus and at some art galleries.

STAFF



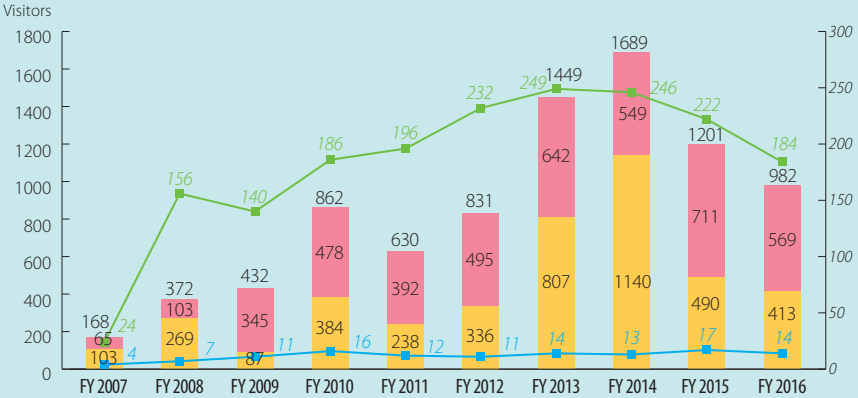
	Oct. 2007	Mar. 2008	Mar. 2009	Mar. 2010	Mar. 2011	Mar. 2012	Mar. 2013	Mar. 2014	Mar. 2015	Mar. 2016	Mar. 2017
Researchers	18	63	125	165	194	209	236	245	255	259	252
Research Support Staffs	0	10	22	27	25	28	27	30	32	31	29
Administrative staff	3	7	11	10	11	10	10	10	10	10	10
Total	21	80	158	202	230	247	273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

RESEARCHERS



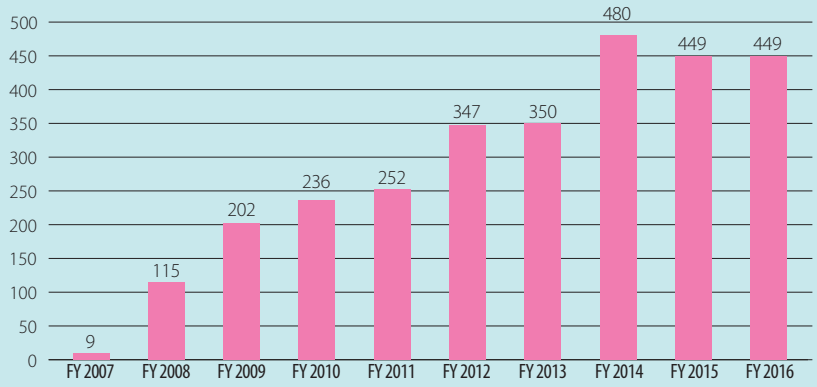
	Oct. 2007	Mar. 2008	Mar. 2009	Mar. 2010	Mar. 2011	Mar. 2012	Mar. 2013	Mar. 2014	Mar. 2015	Mar. 2016	Mar. 2017
Overseas	5	17	60	92	100	79	105	98	105	90	102
Domestic	13	46	65	73	94	130	131	147	150	169	150
% of Overseas	28%	28%	48%	56%	52%	38%	44%	40%	41%	35%	41%
% of Female	0%	2%	5%	6%	5%	2%	5%	5%	6%	4%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

RESEARCH ACTIVITIES

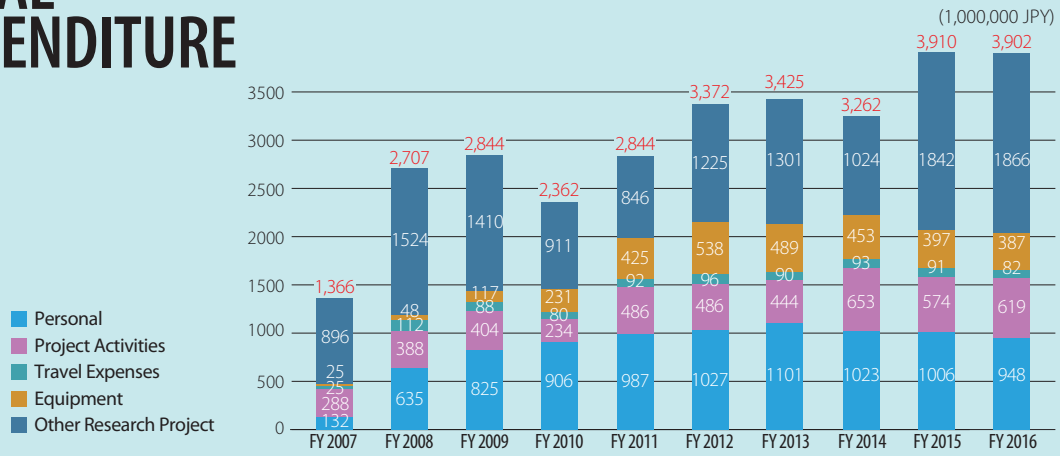


	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Visitors (Overseas)	65	103	345	478	392	495	642	549	711	569
Visitors (Domestic)	103	269	87	384	238	336	807	1140	490	413
Visitors (Total)	168	372	432	862	630	831	1449	1689	1201	982
Seminars	24	156	140	186	196	232	249	246	222	184
Conferences	4	7	11	16	12	11	14	13	17	14

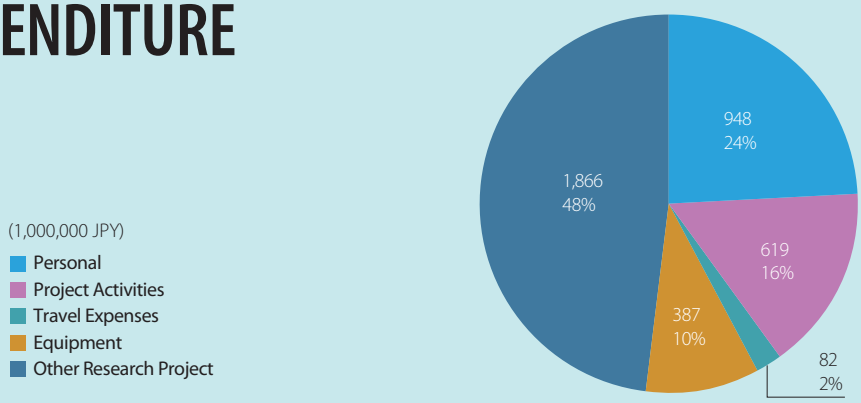
PUBLICATIONS



TOTAL EXPENDITURE



BREAKDOWN OF FY 2016 TOTAL EXPENDITURE



2 NEWS & EVENTS

April 2016-March 2017

APRIL

>> Kavli IPMU and ICRR co-host public lecture "Decoding the Universe"

>> Hirosi Ooguri elected to American Academy of Arts and Sciences

MAY

>> Takaaki Kajita and Hirosi Ooguri receive Chunichi Cultural Award

>> New test by deepest galaxy map finds Einstein's theory stands true

>> Hitoshi Murayama speaks at Symposium on Science and Technology Diplomacy

>> Supermassive black hole wind can stop new stars from forming

>> PhyStat-ν Workshop on Statistical Issues in Experimental Neutrino Physics

JUNE

>> 2016 Kavli Prize Announcement

>> 9 Scientific pioneers receive the 2016 Kavli Prizes

>> Higher Residue Week, 2016

>> Scientists detect most distant signs of oxygen in the universe

>> Kavli IPMU Public Lecture held with Lisa Randall

>> Science movie supervised by Hirosi Ooguri wins Best Educational Production Award

JULY

>> Science Cafe Universe 2016

>> Blue is an indicator of first star's supernova explosions

>> Hirosi Ooguri elected President of the Aspen Center for Physics

>> Hyper Suprime-Cam found an "Ancient Eye" in the sky

AUGUST

>> Investigating the Neutrino Mass Scale with the ultra-low background KamLAND-Zen detector

>> Booth at the 2016 super science high school student fair

>> A Program to encourage female students to study science: "Look into the Universe"

>> Ninth External Advisory Committee Meeting

>> Hyper-Supreme Cam Collaboration Meeting

>> Lectures on Cosmology with Planck at IPMU

>> IGM Tomography Workshop 2016

SEPTEMBER

>> Matrix factorization and related topics, 2016

>> IPMU Annual Report 2014 released

>> Booth at the new scientist live in London

>> Statistics, Quantum Information and Gravity

>> FY2016 WPI Site Visit

OCTOBER

>> Open Campus Kashiwa 2016

NOVEMBER

>> Toshiyuki Kobayashi elected Fellow of the American Mathematical Society

>> Kavli IPMU visiting senior scientist Tadashi Takayanagi receives Nishina Memorial Prize

>> The Minister of State for Special Missions Yosuke Tsuruho visits Kavli IPMU

>> Workshop on Categorical and Analytic invariants IV

>> Event: "Actually I Really Love Physics! - Career Paths of Female Physics Graduates"

>> Record-breaking faint satellite galaxy of the Milky Way discovered

>> Violent collision of massive supernova with surrounding gas powers superluminous supernovae

>> 15th Kavli IPMU/ICRR joint public lecture "The Observable Universe and Beyond"

>> Kavli IPMU Oxford DPhil graduate fellowships

>> 5th String Theory in the Greater Tokyo Area

DECEMBER

>> Resurgence at Kavli IPMU

>> Kyoji Saito awarded 1st Kiyoshi Oka Prize 2016

>> Kavli IPMU Staff Recognized at the University of Tokyo's 2016 Special Business Innovation Prize

>> Naoki Yoshida awarded 13th Japan Society for the Promotion of Science Award

JANUARY

>> Naoki Yoshida awarded 13th Japan Academy Medal

>> Kali IPMU/ELSI joint public lecture "A Question of Origins"

>> Conference: D-modules and Hodge theory

>> Faster-Than-Expected Expansion of the Universe supported by results from cosmic lensing research

FEBRUARY

>> 4th Hyper-Kamiokande Proto-Collaboration Meeting

>> AAAS 2017 Annual Meeting in Boston

>> First public data released by the Hyper Suprime-Cam Subaru strategic program

MARCH

>> Conference: Why does the Universe accelerate? – Exhaustive study and challenge for the future –

>> Meeting of WPI center administrative directors held at Kavli IPMU

>> Japanese class completion ceremony

>> Workshop on Mathematics and Superstring Theory -Unlocking the Mysteries of the Accelerating Universe through Superstring Theory and Astrophysical Observations -

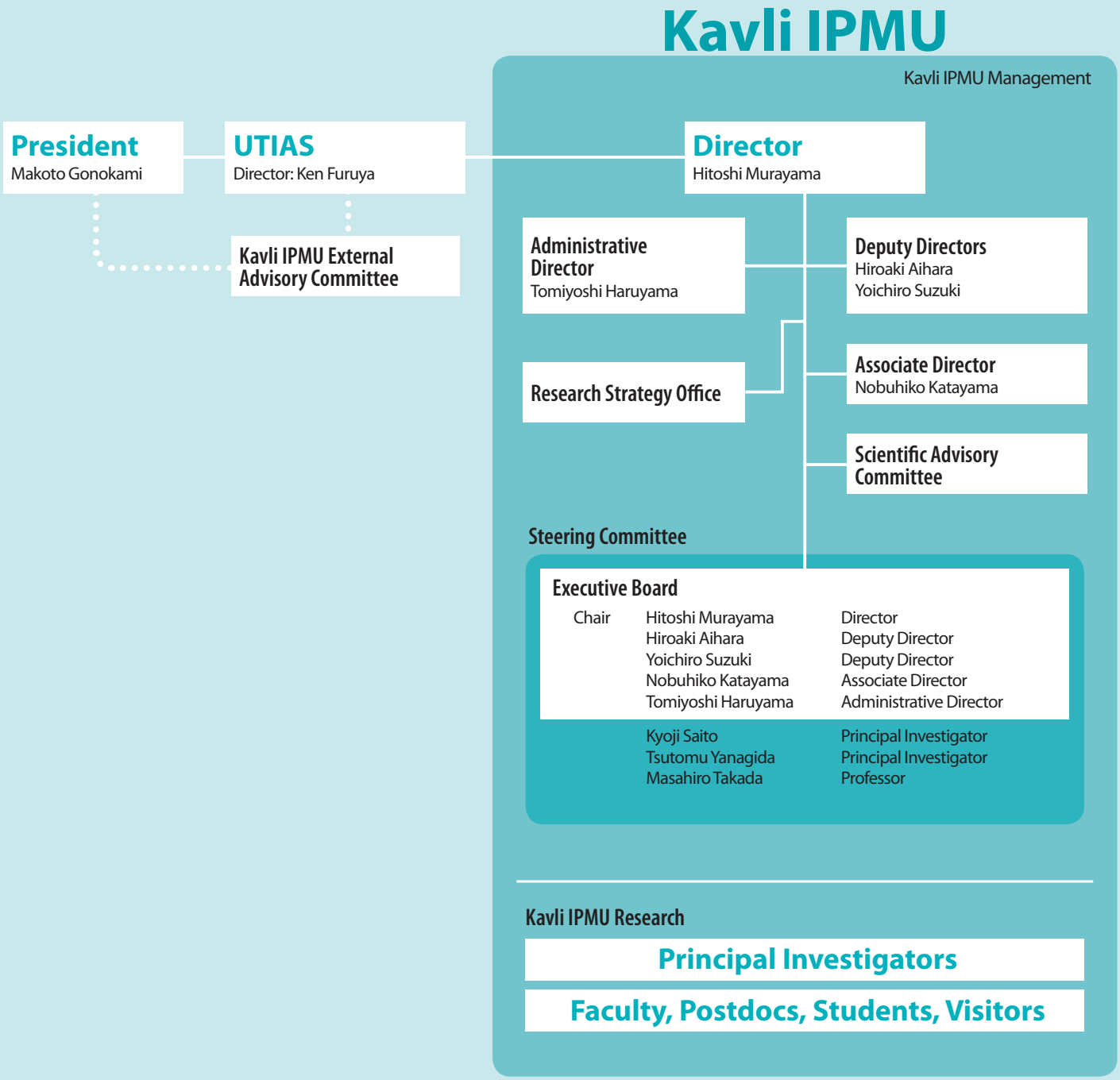
>> Workshop - Searching for the Lost Study - Art x Science x Philosophy

>> Practical Statistics for Particle Physics Analyses

>> Tomoyuki Abe awarded the 2017 Mathematical Society of Japan Spring Prize

>> Mysterious cosmic explosion puzzles astronomers

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 2017)

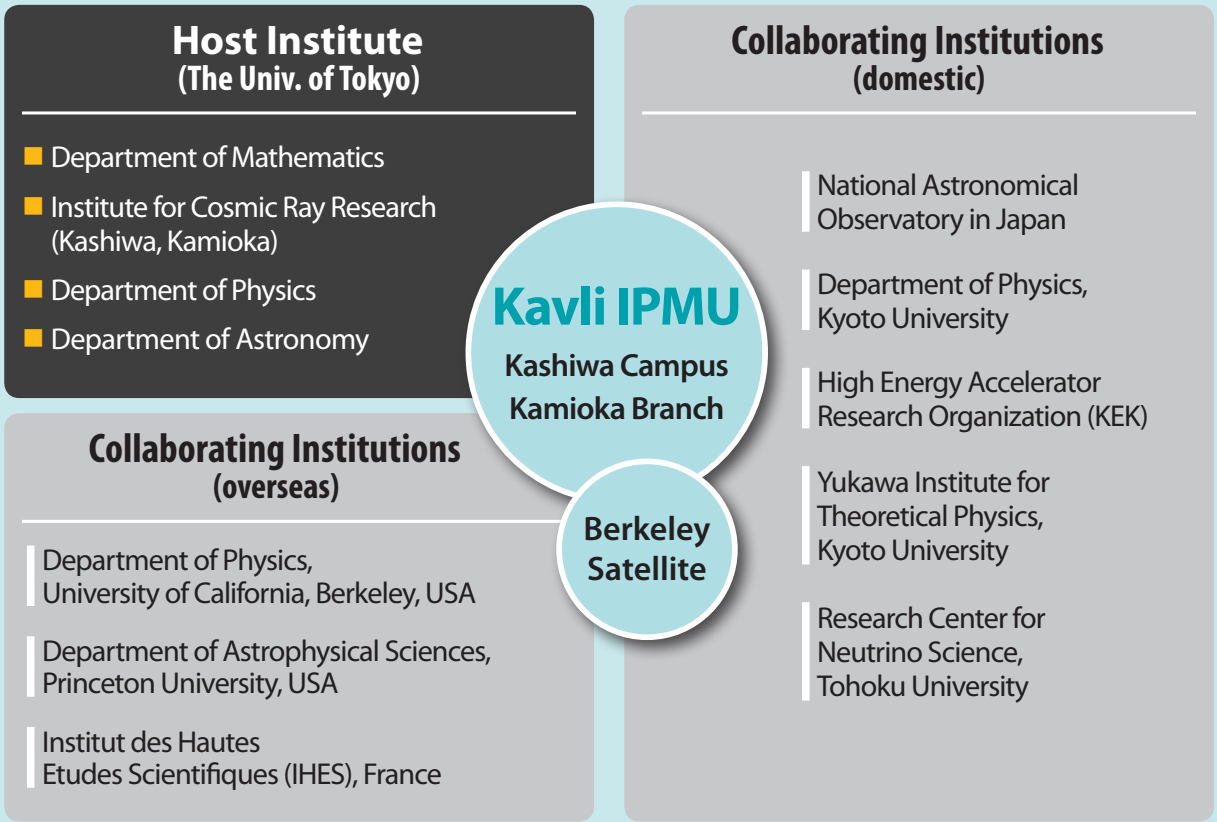
Hiroaki Aihara	U Tokyo, Physics Dept	High Energy Physics
Yoichiro Suzuki	U Tokyo, ICRR	Astroparticle Physics
Nobuhiko Katayama	Kavli IPMU	High Energy Physics
Toshitake Kohno	U Tokyo, Mathematics Dept	Mathematics
Hirosi Ooguri	Caltech	Particle Theory
Kyoji Saito	Kavli IPMU	Mathematics
David Spergel	Princeton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

The External Advisory Committee Members (March 2017)

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 a close collaborative relation 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

4 STAFF

Director

Hitoshi Murayama, Particle Theory

Deputy Directors

Hiroaki Aihara, High Energy Physics
Yoichiro Suzuki, Astroparticle Physics

Associate Director

Nobuhiko Katayama, High Energy Physics

Principal Investigators

Hiroaki Aihara (U Tokyo), High Energy Physics
Alexey Bondal (Steklov Math. Inst.), Mathematics
Kunio Inoue (Tohoku U), Neutrino Physics
Takaaki Kajita (U Tokyo, ICRR), Neutrino Physics
Stavros Katsanevas (U Paris 7), Astroparticle Physics
Masahiro Kawaski (U Tokyo-ICRR), Cosmology
Toshiyuki Kobayashi (U Tokyo-Math), Mathematics
Toshitake Kohno (U Tokyo-Mat), Mathematics
Hitoshi Murayama (Kavli IPMU & UC Berkeley), Particle Theory
Masayuki Nakahata (U Tokyo-ICRR), Astroparticle Physics
Mihoko Nojiri (KEK), Particle Theory
Ken'ichi Nomoto (Kavli IPMU), Astronomy
Hirosi Ooguri (Caltech), Mathematical Physics
Kyoji Saito (Kavli IPMU), Mathematics
Henry W Sobel (UC Irvine), Astroparticle Physics
David Spergel (Princeton U), Cosmology
Naoshi Sugiyama (Nagoya U), Cosmology
Yoichiro Suzuki (Kavli IPMU), Astroparticle Physics
Tsutomu Yanagida (Kavli IPMU), Particle Theory

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5 RESEARCH HIGHLIGHT

5.1 Newly Discovered Strong Lenses in HSC Data

Alessandro Sonnenfeld

Strong gravitational lensing is a very powerful tool for cosmology and galaxy evolution studies. It has allowed us to study in detail the internal structure of massive elliptical galaxies, providing clues about their density profile, their average dark matter content and their stellar initial mass function. However, there are still many open questions that need to be answered in order to understand the formation and evolution of these objects:

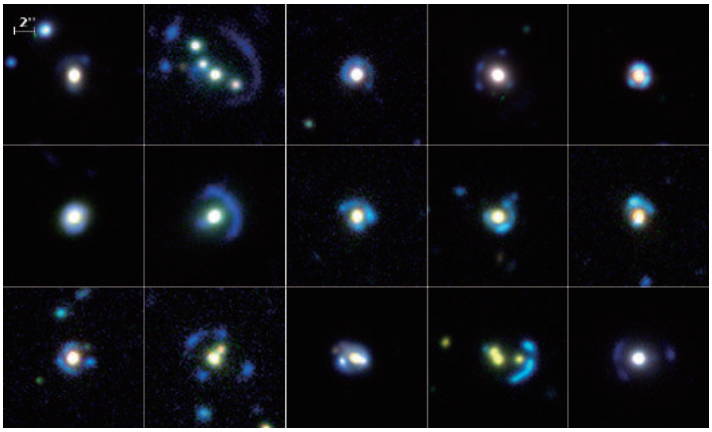
- How do massive elliptical galaxies grow in time?
- How does their stellar content change as a result of mergers with smaller galaxies?
- How does the distribution of dark matter respond to the infall of gas or the presence of a central black hole?

In order to answer these questions it is crucial to carry out observations covering a large range in lookback time, so that the physical mechanisms at the basis of the evolution of these galaxies can be inferred. Although the current number of known strong lenses is on the order of a few hundred systems, most of these lenses are at a relatively low redshift. In order to robustly study the evolution of massive galaxies, more lenses are needed, particularly at redshift $z > 0.5$.

The recent installation of the Hyper Suprime-Cam (HSC) on the Subaru telescope gives us an excellent opportunity to search for new lenses. The currently ongoing HSC survey combines great depth (down to magnitude 26 in the i-band) with great image quality for a ground-based survey (typical seeing 0.6"). This makes HSC the best suited survey for lens finding purposes among ongoing surveys worldwide.

With the goal of discovering the largest possible number of lenses in the HSC survey, I developed a new automatic strong lens finder, called YattaLens. YattaLens scans images of massive galaxies looking for tangentially elongated blue arcs, then models these candidate arcs to determine if they are the gravitationally lensed images of star forming galaxies.

I led a search for strong lenses in the first internal data release of the HSC survey [1]. With my collaborators, we applied three different search algorithms, including YattaLens, to HSC data of 37,000 massive galaxies with BOSS spectroscopy.

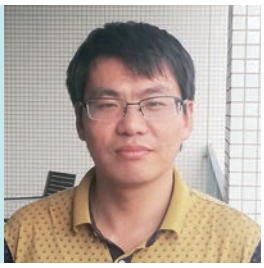


We found 15 new lenses, as well as 36 highly probable lens candidates. These newly found lenses form the first sample of the Survey of Gravitationally-lensed Objects in HSC Imaging (SuGOHI). By the end of the HSC survey, the number of SuGOHI lenses will be several hundreds, making it the largest sample of lenses from a single survey. I will use these new lenses to study the evolution of the stellar initial mass function and the inner dark matter content of massive galaxies from $z = 1$ to the present.

Reference

[1] Sonnenfeld, A. *et al*. 2017, arXiv:1704.01585, accepted for publication in PASJ

5.2 Rare B Decay Anomaly and $U(1)_{(B-L)_3}$



ChengCheng Han

There has recently been significant interest in hints of Lepton flavour universality(LFU) violation in semi-leptonic B decays, as observed by LHCb [1, 2]. Measurements of the ratios

$$R_K^{(*)} = \frac{\Gamma(B \to K^{(*)} \mu^+ \mu^-)}{\Gamma(B \to K^{(*)} e^+ e^-)}, \tag{1}$$

show a consistent departure from the SM prediction, which is under excellent theoretical control. In fact, global fits to the data suggest significant tension with the SM at around the 4 σ level.

In the work with Prof. Tsutomu T. Yanagida, Rodrigo Alonso and Peter Cox, we proposed a $U(1)_{(B-L)_3}$ model [3] which could accommodate the observed low energy phenomenology. In the model, three generation right hand neutrinos are added to explain the neutrino data. The new gauge boson only couples to the third generation quarks and leptons with a charge equaling to *B-L*. To explain the B anomaly, flavor changing coupling need be generated through mixing. The related feynman diagram is shown in Fig. 1.

The model might get other constrains like LHC collider search, flavor physics as well as the Landau pole for the gauge coupling. After considering all the limits, we find plenty of parameter space which can explain the B anomaly, which is shown in Fig. 2. The best-fit region to the LFU anomalies at 1/2 σ is drawn in solid lines (dashed lines). The shaded regions are excluded by existing measurements at 95% CL. We have fixed $\theta_l = \pi/2$, $\theta_q = 0.1$.

In addition, this model has other interesting features:

(i) The model admits two heavy RH neutrinos which can explain the existence of the neutrino mass through see-saw mechanics.
(ii) the observed baryon asymmetry can be generated via leptogenesis by two heavy RH neutrinos.
(iii) the third right hand neutrino could provide a candidate of dark matter [4].

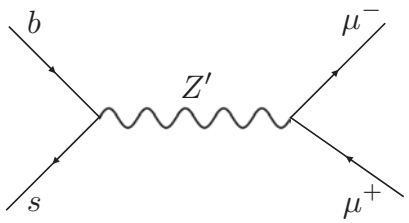


FIG. 1: Feynman diagram for the new gauge boson contributing the B decay.

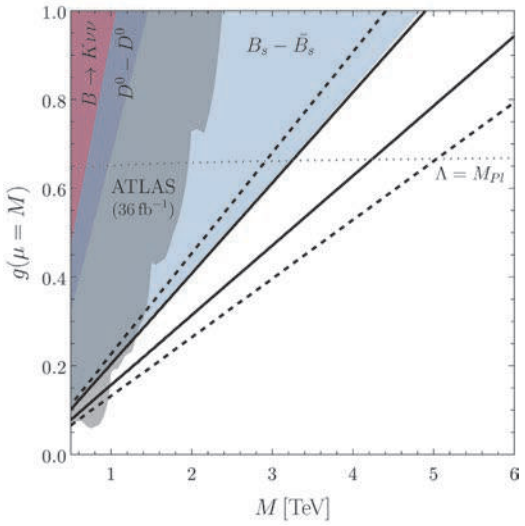
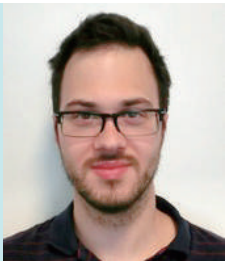


FIG. 2: Favored parameter space to explain the B anomaly.

References

[1] 2017. Talk by Simone Bifani for the LHCb collaboration /. CERN-18-4
[2] R. Aaij *et al.* [LHCb Collaboration], Phys. Rev. Lett. **113** (2014) 151601 doi:10.1103/PhysRevLett.113.151601 [arXiv:1406.6482 [hep-ex]].
[3] R. Alonso, P. Cox, C. Han and T. T. Yanagida, arXiv:1705.03858 [hep-ph].
[4] P. Cox, C. Han and T. T. Yanagida, arXiv:1710.01585 [hep-ph].

5.3 Wonderful Compactifications of Moduli Spaces



Evangelos Routis

An infamous and deep result of Hironaka asserts that any (non-compact) variety Z over an algebraically closed field of characteristic 0 can be embedded in a smooth compact variety Z', such that the complement $Z' \setminus Z$ is a normal crossings divisor. Such Z', sometimes with more assumptions depending on the context, are often referred to in the literature as 'wonderful compactifications'. In the study of moduli spaces in algebraic geometry, the existence of wonderful compactifications suggests that one can control their behavior at infinity; for example, one can often carry out intersection theory and compute enumerative invariants of the compactified moduli space. Therefore, the construction of explicit wonderful compactifications of moduli spaces is often crucial to our understanding of them.

In joint work with P. Gallardo (European Journal of Mathematics, Vol. 3, Issue 3), we showed that, under certain hypotheses, wonderful compactifications that admit an action by a reductive group descend to wonderful compactifications in their GIT quotients by that group. As a consequence, by studying GIT quotients of the Fulton-MacPherson compactification, we were able to construct higher dimensional analogs of the Deligne-Mumford-Knudsen *moduli space of genus 0 stable curves*, which share some of its remarkable properties, such as smoothness, normal crossings boundary and explicit blowup construction. More generally, we introduced and studied wonderful compactifications of the moduli space of n labeled points with weights in projective space, which extend previous work of Hassett in the one dimensional case and are birational to the *moduli space of weighted hyperplane arrangements* introduced by Alexeev and Hacking-Keel-Tevelev. Moreover, we described a novel and natural iterated blow-up construction of the Chen-Gibney-Krashen compactification of the configuration space of n labeled points in affine space up to translation and homothety and we studied a weighted version of it.

In joint work with M. Kapranov (https://arxiv.org/abs/1702.00120), most of which was carried out in 2016, we constructed a natural generalization of the classical space of complete collineations by Chasles-Schubert-Semple-Tyrell dating back to the 19th century. Since then, the space of complete collineations has been studied intensively and has been used to derive groundbreaking results in various areas of mathematics, a striking example being Lafforgue's compactification of the stack of Drinfeld's shtukas, which he subsequently used to prove the Langlands correspondence for the general linear group. A complete collineation can be viewed as a spectral sequence of a two term complex (up to scalar multiplication). Starting from this observation, we considered spectral sequences of a complex with arbitrarily many terms (up to scalar multiplication) and constructed a variety the geometric points of which we proved to be equal to the set of all such spectral sequences. Our construction, the *variety of complete complexes*, is realized as a sequence of blowups of the projectivized Buchsbaum-Eisenbud *variety of complexes* $\mathbb{P}C_X(E^\bullet)$, where $E^\bullet$ is a graded vector bundle concentrated in degrees $[0, m]$, for some $m < \infty$, on an arbitrary smooth variety X over an algebraically closed field. We also showed that the variety of complete complexes is a desingularization of the Buchsbaum-Eisenbud variety of complexes and actually a wonderful compactification of the union of its maximal strata.

5.4 The Search for CP Violation in Neutrino Oscillations at T2K and Beyond

Mark Hartz

The phenomenon of neutrino oscillation was established by measurements in 1998 by the Super-Kamiokande experiment and 2001 by the SNO experiment, leading to the awarding of the 2015 Nobel Prize in Physics. Neutrino oscillations are a quantum mechanical process where neutrinos are produced in one flavor state and may oscillate to a different flavor state after traveling a distance through vacuum or matter. The parameters that govern neutrino oscillations depend on the mechanism for the generation of neutrino masses, which is governed by physics beyond the Standard Model. Neutrino oscillations are also of interest since they allow for a new source of charge conjugation-parity symmetry (CP) violation, i.e. different oscillation rates for neutrinos and antineutrinos.

Fig. 1: The T2K experiment produces a beam of muon (anti) neutrinos at the J-PARC accelerator and detects neutrinos after oscillations at Super-Kamiokande, 295 km away.

The Tokai-to-Kamioka (T2K) experiment has been a world leading experiment studying neutrino oscillations and mixing since 2010. The T2K experiment generates a beam of muon neutrinos (ν_μ) at the J-PARC accelerator on the east coast of Japan and measures the content of the neutrino beam 295 km away at the Super-Kamiokande (SK) detector. In 2014, T2K published the discovery of the $\nu_\mu \rightarrow \nu_e$ oscillations (Phys. Rev. Lett. 112, 061802 (2014)), the first direct measurement of neutrinos oscillating from one flavor to another. Since 2014, T2K has added data collected in antineutrino operating mode, allowing for the study of the muon antineutrino to electron antineutrino oscillation rate. By combining data taken in neutrino and antineutrino operating modes with external oscillation measurements of reactor experiments, T2K can constrain the phase δ_{CP}, that governs CP violation. If δ_{CP}, has a value the that is not an integer multiple of π, then CP violation is present.

In July 2016, T2K presented new results at the Neutrino 2016 conference that included equal amounts of beam operation in neutrino mode and antineutrino mode. T2K observed 32 electron neutrino candidates events and 4 electron antineutrino candidates events. For CP conserving values of δ_{CP}, T2K would expect to observe 24 electron neutrino candidates and 7 electron antineutrino candidates. These data prefer a value of δ_{CP} near $-\pi/2$ and the confidence intervals are shown in Fig. 2. The values that conserve CP symmetry, $\delta_{CP} = 0$ and $\delta_{CP} = \pi$, are disfavored at 90% confidence. This result represents the words best constraint on δ_{CP}. These results were published in Phys. Rev. Lett. 118, 151801 (2017), and received and Editor's Suggestion designation.

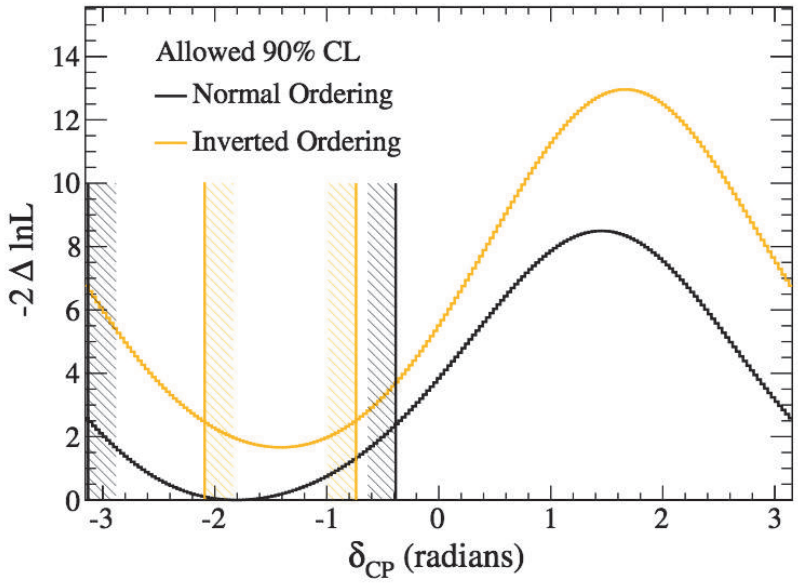


Fig. 2: The $\Delta\chi^2$ from the fit to T2K data as a function of δ_{CP}. The black and yellow curves correspond to the normal and inverted neutrino mass orderings. The regions outside the black (normal ordering) and yellow (inverted ordering) vertical lines are disfavored at 90% confidence.

The T2K results presented in summer 2016 are produced with 20% of the approved beam exposure for the T2K experiment. T2K has proposed an extended operation of the experiment until 2026 that will allow for a beam exposure 13 times larger than that collected through summer 2016. This will give T2K sensitivity to exclude CP symmetry conserving values of δ_{CP} at 3 sigma significance for favorable true values of δ_{CP}.

Beyond the extended operation of T2K, Kavli IPMU researchers are collaborating on the proposed Hyper-Kamiokande (HK) experiment. HK will probe the same physics as T2K, but with an 8 times larger detector to allow for increased sensitivity to CP violation and other neutrino oscillation effects. Kavli IPMU is participating in two proposals aimed at maximizing the experimental sensitivity of HK. The first is the proposed E61 experiment, which consists of a water Cherenkov detector located near the neutrino beam source at J-PARC. This detector can be moved relative to the neutrino beam direction, allowing the energy dependence of neutrino-nucleus interactions to be studied in detail The physics program of E61 is aimed at reducing systematic uncertainties for HK. The second proposal is for the construction of a second HK detector in South Korea, for which a white paper has been produced (arXiv:1611.06118). The location of a second detector at a baseline of ~1100 km will allow for the neutrino oscillation effects to be probed at the second oscillation maximum where the CP violation effect is larger and the measurement is less sensitive to systematic errors. Fig. 3 shows that the best precision for the measurement of δ_{CP} can be achieved with one detector in Japan and a second detector in Korea at an off-axis angle of 1.5 degrees.

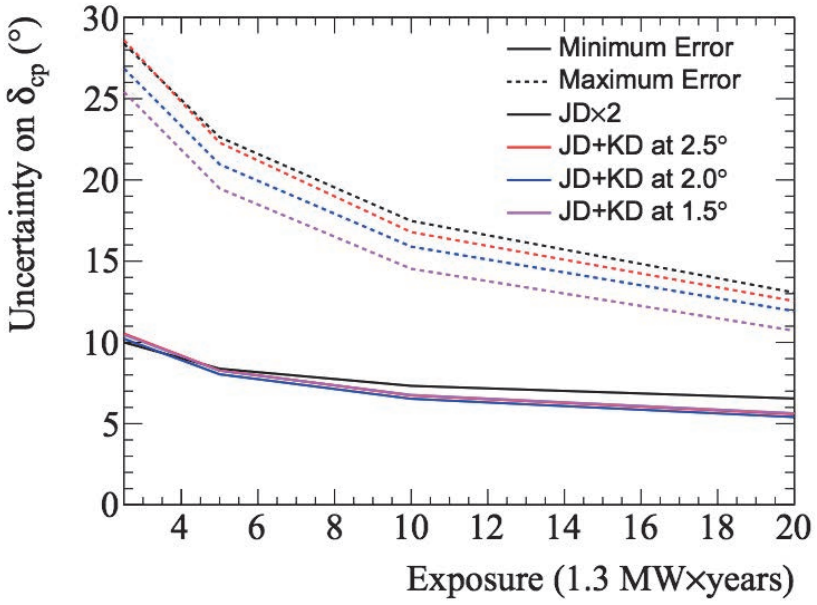


Fig. 3: The best-case and worst-case (depending on the true value) precision of the δ_{CP} measurement with two detectors in Hyper-K. For black, both detectors are in Japan at a 295 km baseline. For red, blue and magenta, one detector is in Japan and a second detector is in Korea at an off-axis angle of 2.5, 2.0 or 1.5 degrees.

The T2K experiment continues to make world leading neutrino oscillation measurements including the best constraints on phase δ_{CP} that governs CP violation. The result presented at Neutrino 2016 has been published in Physical Review Letters with an Editor's Suggestion designation. T2K is approved to collect 5 times the data set presented in 2016, and has proposed to collect a data set that is 13 times larger. Beyond T2K, the Hyper-Kamiokande experiment will further increase the sensitivity to neutrino oscillation effects with an 8 times larger neutrino detector. Kavli IPMU is participating in two proposals to maximize the sensitivity of Hyper-Kamiokande: the E61 experiment which will probe critical neutrino-nucleus scattering physics, and the proposal for a second detector in Korea, which will improve the experimental sensitivity to neutrino oscillation parameters.

5.5 First Public Data Released by the Hyper Suprime-Cam Subaru Strategic Program

Masahiro Takada on behalf of the HSC collaboration

The first massive data set of a "cosmic census" has been released using the largest digital camera on the 8.2 m Subaru Telescope, Hyper Suprime-Cam (HSC). With its beautiful images now available for the public at large, figuring out the fate of the Universe has come one step closer.

Data from the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) was released to the public on February 27th, 2017. HSC-SSP is a large survey being done using HSC, an optical imaging camera mounted at the prime focus of the Subaru Telescope. Since it is difficult to analyze such a huge dataset with standard tools, the HSC team has developed a dedicated database and interface for ease of access and use of the data.

The HSC-SSP project is being done based on collaboration between institutes in Japan, the Academia Sinica Institute of Astronomy and Astrophysics (ASIAA) in Taiwan, and Princeton University in the United States. The project will survey 300 nights over 5 to 6 years. This survey consists of three layers: Wide, Deep, and UltraDeep, using optical and near infrared wavelengths in five broad bands (g, r, i, z, y) and four narrow-band filters (see Figure 1 for an example image of the deep HSC data).

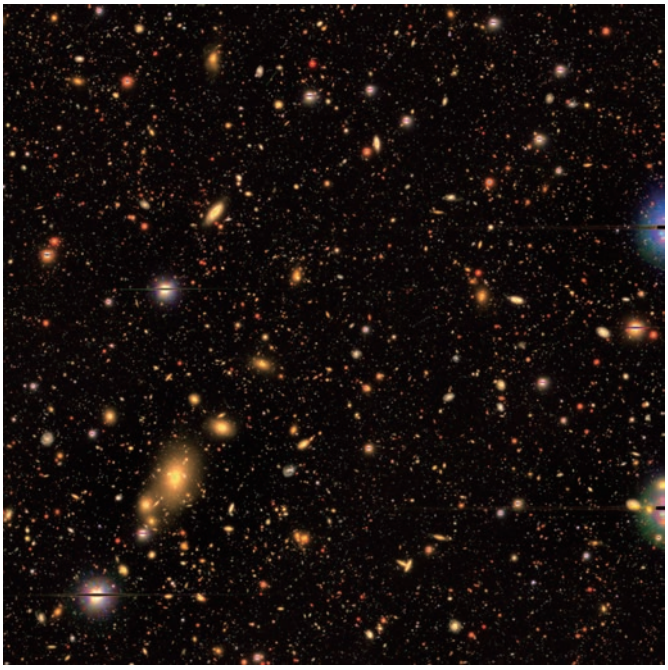


Figure 1. A color composite image in the g, r and i bands of a small piece of the COSMOS field, as imaged by the Hyper Suprime-Cam. This image contains thousands of galaxies as faint as 27th magnitude. The galaxies are seen at such large distances that the light from them has taken billions of years to reach us. The light from the faintest galaxies was emitted when the universe was less than 10% of its present age. (Credit: Princeton University/HSC Project)

This first public dataset already contains almost 100 million galaxies and stars. It demonstrates that HSC-SSP is making the most from the performance of the Subaru Telescope and HSC. In contrast, the US-based Sloan Digital Sky Survey (SDSS)—which is known for its wide area observation and equivalent data sets—took over 10 years to establish. The total amount of data taken so far by the HSC-SSP, meanwhile, comprises 80 terabytes, which is comparable to the size of about 10 million images by the SDSS.

This release includes data from the first 1.7 years (61.5 nights of observations beginning in 2014). The observed areas covered by the Wide, Deep, and UltraDeep layers are 108, 26, and 4 square degrees, respectively. The limiting magnitudes, which refer to the depth of the observations, are 26.4, 26.6 and 27.3 mag in r-band (about 620 nm wavelength), respectively, allowing observations of some of the most distant galaxies in the Universe.

In multi-band images, the images are extremely sharp, with only 0.6 to 0.8 arcseconds across for point-like objects like stars. One arcsecond equals 3600 th part of a degree. The high-quality data will allow an unprecedented view into the nature and evolution of galaxies and dark matter.

HSC team is now working very hard to carry out science with the early-year HSC data. The team, which consists of more than 200 scientists, is preparing a series of scientific papers to submit to the HSC special issue of the peer-review journal, the Publication of the Astronomical Society of Japan (PASJ). About 20 papers among the 42 submitted papers are accepted as of Sep 1st, 2017 and the others are under the reviewing process. The key papers include the paper describing the overview and survey design of the HSC SSP survey (Aihara et al. arXiv:1704.05858, accepted), and the details of the First Public Data Release of HSC data and products (Aihara et al., arXiv:1702.08449). The authors in these papers are in alphabetical order, but Masahiro Takada and Masayuki Tanaka (the former IPMU member, and now an assistant professor at NAOJ) led these papers.

The wide, deep and high-angular-resolution datasets of HSC enable accurate measurements of weak lensing effects caused by hierarchical structures in the universe. Weak lensing provides us with a way of observing the total matter distribution (including dark matter) in the universe, via the deflection of light due to intervening matter along the line-of-sight, which distorts galaxy shapes. By measuring a coherent distortion pattern in galaxy shapes as a function of scales and redshifts, we can trace structure growth as a function of time, which is a very powerful probe of cosmological parameters including the nature of dark energy. Compared to competing other wide-area lensing surveys such as the Kilo-Degree Survey (KiDS) in Europe and the Dark Energy Survey (DES) in the US, the depth and angular resolution of HSC gives it the best constraining power for higher-redshift cosmological constraints covering a transition between the cosmic decelerating and accelerating

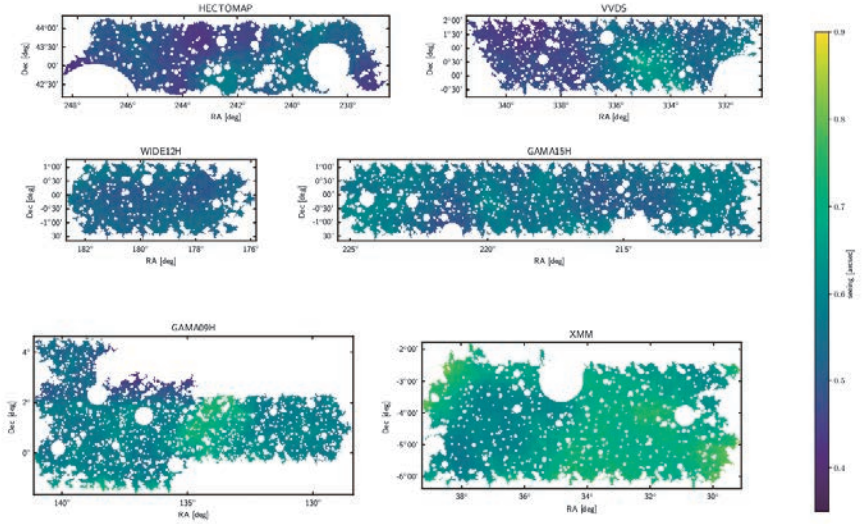


Figure 2. Maps of the i-band point spread function (PSF) size (its full width at half maximum) across each HSC-Wide field, which characterizes the "sharpness" of the image. The HSC-Wide data consists of 6 fields on the sky, which cover an area of 137 sq. degrees in total. The mean PSF size is about 0.58" and the 5σ point-source depth reaches to i~26. The PSF size is compared to about 1" for a typical PSF size of 4 m Dark Energy Survey that is being operated in the US. The holes in area coverage are due to masking bright stars.

expansion phases. The HSC Weak Lensing Working Group (HSC WLWG), being run by Masahiro Takada & Rachel Mandelbaum (CMU) as co-chairs, managed to build the catalog of galaxy shape measurements from the HSC-SSP data (Mandelbaum, Miyatake et al. 2017, submitted to PASJ). Figure 2 shows that the HSC data has an excellent image quality. The team defined the requirements for cosmological weak lensing science with this catalog, characterized potential systematics in the catalog using a series of internal null tests for problems with point spread function (PSF) modeling, shear estimation, and other aspects of the image processing, and described systematics tests also using image simulations. The team carefully showed that the current shear catalog meet the requirements (i.e. passed all the systematics tests compared to the statistical errors of the early-year datasets).

As the first application, the team, being led by Masamune Oguri, used the galaxy shape catalog to reconstruct the matter distribution (including dark matter) that is then compared with maps of the distribution of the stellar mass associated with luminous red galaxies (Oguri et al., 2017, accepted for publication in PASJ). The team found a strong correlation between these two maps, supporting the structure formation scenario where galaxies are preferentially formed in a place of matter concentration in an expanding universe. Moreover, by combining the galaxy shape catalog with the photometric redshift information for each source galaxy, the team successfully reconstructed the three-dimensional maps of matter up to a high redshift of z~1, as shown in Figure 3. The three-dimensional mass map is also found to correlate with the three-dimensional galaxy map. Thus these results clearly show the power of HSC data for unveiling the dark matter distribution up to high redshifts. The team is now working on the cosmological weak lensing analysis, and will deliver the results within a few months (Hikage et al. in preparation).

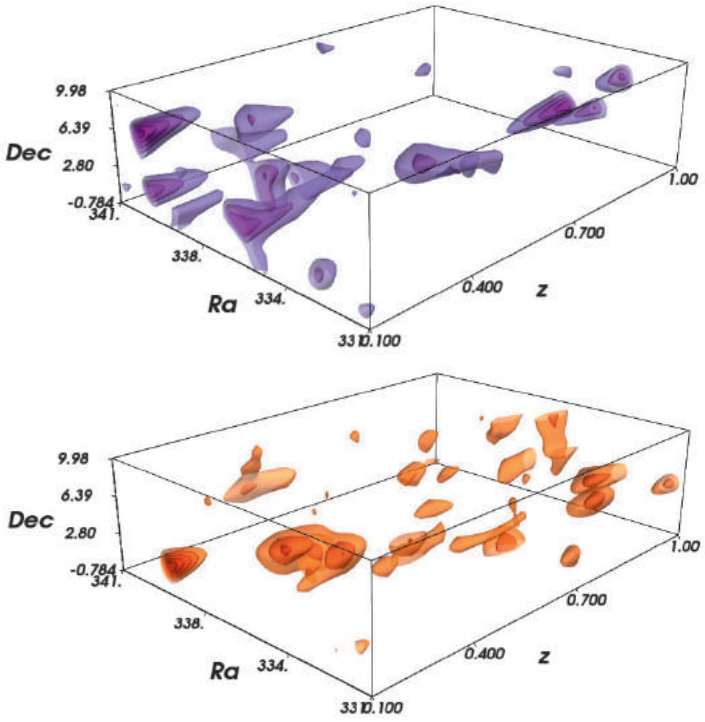


Figure 3. Top panel: Three-dimensional map of matter reconstructed by combining the galaxy shape catalog and the photometric redshift information for each source galaxy for the VVDS field (about 25 sq. degrees for the area). The bottom panel shows three-dimensional map of galaxies. The two maps show a nice correlation, supporting the structure formation scenario where galaxies tend to be formed in a place of dark matter concentration.

5.6 Discovery of the Two Faint Satellites in the Milky Way by the Hyper Suprime-Cam Subaru Strategic Program

Miho Ishigaki

The number of faint satellite galaxies around our own Milky Way Galaxy provides one of the important observational tests for the standard Λ cold-dark-matter (CDM) model for the structure formation of the universe. It has been known that the number of satellite galaxies around Milky-Way-mass galaxies predicted by cosmological simulations of dark matter is in serious disagreement with the actual number of observed satellite galaxies. The discrepancy could suggest that there are still a number of satellites yet undiscovered because of their low-surface brightness and/or large distances. Indeed, thanks to the recent massive photometric surveys such as the Sloan Digital Sky Survey (SDSS), many faint satellite galaxies have newly been discovered in the past ~20 years. If the number of satellites including fainter ones are actually smaller than that predicted by the CDM model, it suggests that the current understanding of either the nature of dark matter or the baryonic physics should be updated.

The team lead by Daisuke Homma, a former PhD student of Tohoku University, made a great effort to analyze the initial data-set for ~300 deg^2 of the sky from the Hyper Suprime-Cam (HSC) Subaru Strategic Program (SSP) and discovered new faint satellites in the constellations of Virgo and Cetus [1, 2]. These objects, named as Virgo I and Cetus III, were identified as an extended stellar overdensity, whose likely member stars have colors and magnitudes consistent with an old and metal-poor stellar population at distances of 91 and 215 kpc, respectively. It turned out that these systems are the faintest satellites known so far at respective distances and thus are beyond the detection limit of SDSS (Figure 1). The discoveries of these objects demonstrate that the HSC is powerful in detecting these faint and ancient stellar systems at the outer region of the Milky Way, where no other surveys can reach.

The discoveries have important implication for the current understanding of the structure formation of the universe under the ΛCDM model. The detection of two faint satellites ($M_V < 0.0$) for the current HSC-SSP survey depth and area is consistent with the number of satellites predicted by the cosmological simulations. When the survey completes, the area will be extended to 1400 deg^2 allowing further tests for the cosmological model with a larger statistical sample.

In the future, follow-up spectroscopic observations can measure line-of-sight velocities and chemical composition of individual stars in these systems. The stellar velocities give an estimate of dark matter masses in these systems, providing a clean test for the cold dark matter model. The stellar chemical compositions tell us about the metal-enrichment history in these systems through supernova explosions and thus provide insights into how these small galaxies formed in the early universe.

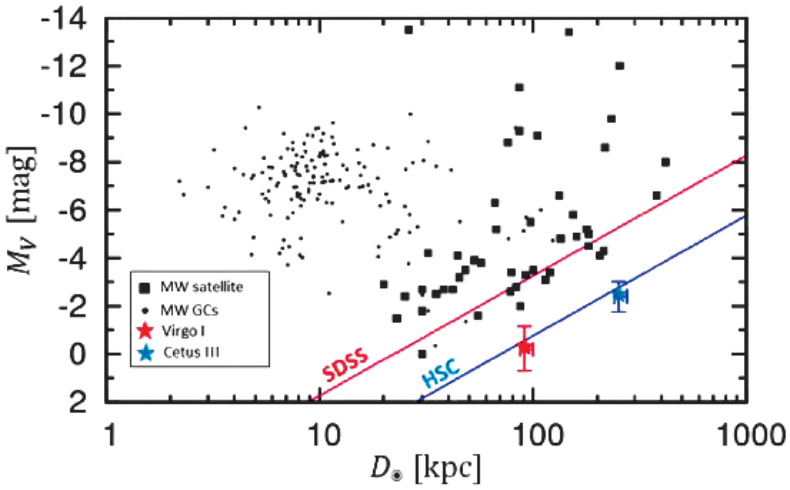


Figure 1: Total absolute magnitudes plotted against helio-centric distances for globular clusters and dwarf satellite galaxies in the Milky Way. The red and blue symbols with error bars show the locations of Virgo I and Cetus III, respectively. The solid red and blue lines show the detection limits of SDSS and HSC, respectively.

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5.7 Splashback Radius: A Physical Boundary for Dark Matter Halos

Surhud More

Dark matter halos form out of the gravitational collapse of initial density fluctuations in the Universe. They form the fundamental building blocks of the large scale structure in the Universe and are prime sites for galaxy formation. Our research addresses the following questions: do dark matter halos have physical boundaries, can they be accessed with observations, and what can we potentially learn from them?

Dark matter halos grow continuously by accretion of mass from the outskirts of the halo. This mass falls into the halo and eventually reaches the apocenter of its orbit (where the radial infall velocity is zero by definition). The coherent reduction in the radial velocities for particles reaching the apocenter causes a pileup of material and results in a sharp feature in the density distribution [1–4]. We have advocated that this physical feature, which we call the "splashback radius", should be used to define the boundary of the dark matter halo [5]. This feature is sensitive to the physical accretion rate on to the halo [3–5]. At fixed mass, halos which accrete faster have smaller splashback radii. We have provided fitting formulae to describe this dependence on the mass accretion history and redshift for use by the wider community. We have also worked out the implications of using such a boundary for the mass accretion rates of halos and its impact on galaxy formation.

Given that the splashback radius corresponds to a physical feature in the density distribution, we have used the Sloan digital sky survey (SDSS) data to look for the boundaries of dark matter halos in observations. In [6], we found that the density distribution of galaxies around massive galaxy clusters in SDSS shows a sharp density drop associated with the splashback radius (see Fig. 1). Compared to the expected location of the splashback radius based on similar mass clusters found in cosmological simulations, we find that the observed location is smaller by about 20 percent. This could either be a systematic effect in the optical cluster selection or could be an indication of the nature of self-interactions of dark matter. We are currently pursuing these interesting avenues for further research.

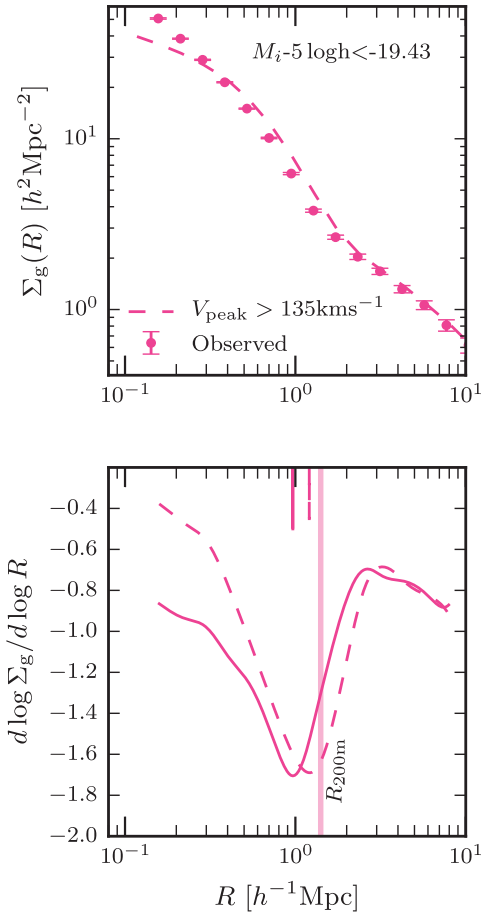

Figure 1: Figure adapted from [6] Upper panel: The observed surface density profile of galaxies around massive clusters in SDSS is shown as solid points with errorbars. The surface density distribution of subhalos around similar mass clusters selected from cosmological simulations is shown with a dashed line. Lower panel: The logarithmic derivative of the observed density profile is shown using a solid line, while that of the subhalos from numerical simulations is shown using a dashed line. The splashback radius corresponds to the location where the logarithmic slope of the density profile reaches its minimum.

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5.8 A Lefschetz Theorem for Overconvergent Isocrystals with Frobenius Structure

Tomoyuki Abe

Langlands' philosophy suggests that, in certain situations, there exists a correspondence between "number theoretic objects" and "analytic objects". In the case of the original conjecture, or program, of Langlands, the number theoretic objects were Galois representations and the analytic objects were automorphic representations. After Langlands formulated these striking program, various analogous phenomena had been observed, some of which may be related to theoretical physics under the name of S-duality.

Rather straightforward analogue of the program is the one for function fields of varieties of finite fields. Interpreting this program, P. Deligne conjectured a correspondence between Galois representations for the fundamental group of algebraic variety over a finite field. More precisely, let X be a smooth variety over $\mathbb{F}_p$. Fixing a prime number ℓ different from p, we have a cohomology theory called ℓ-adic cohomology. A priori, there are no relation between different ℓs. However, the Deligne's conjectured that there exists a natural correspondence between ℓ-adic and ℓ'-adic local systems. A remarkable fact is that, contrary to many mathematical correspondences, this correspondence is not functorial. Many of this conjecture of Delinge was proven by Lafforgue almost 20 years ago.

In this Lafforgue's theorem, he did not treat the p-adic part. This is because the behavior is extremely different from ℓ-adic cohomology theories. However, Deligne was also conjecturing a similar correspondence. In the curve case, I succeeded in proving this conjecture a few years ago. In the ℓ-adic case, the conjecture had been proven also for smooth varieties not necessarily curves. This year, I showed, in a collaboration with H. Esnault, that we can construct ℓ-adic local systems when we are given p-adic objects. The essential point of the proof is to establish the Lefschetz type theorem for p-adic objects. This roughly says that if we have an irreducible p-adic object on a smooth scheme, we may find a curve such that the restriction of the p-adic object to the curve remains to be irreducible. Even though this type of theorems is expected to hold more generally, our proof works only for varieties over finite field. This is because we use class field theory and Langlands correspondence for curves in a crucial manner. In the future, I plan to prove the existence of corresponding p-adic objects of ℓ-adic local systems in the sense of Langlands.

5.9 Time-Reversal Anomalies of Quantum Field Theories

Yuji Tachikawa

Quantum field theory is a general framework to describe any extended medium quantum mechanically, and symmetry is the first principle we use to constrain a given quantum field theory. Symmetry in quantum field theory is often anomalous, or equivalently has an anomaly, meaning that there is a precisely controllable phase ambiguity in the response of a system to the action of the symmetry. The concept of the anomaly can be thought of as a generalization of the concept of a projective representation of a group. As the structure of the anomaly is strongly constrained by the symmetry, it is often a robust and computable quantity, and is a useful handle for us to explore the properties of systems otherwise hard to analyze.

The anomaly of continuous symmetries has been studied for almost half a century in high energy physics, but the anomaly of discrete symmetries has received less attention until about a decade ago, when condensed matter physicists realized its importance. In the last several years, high energy theorists joined condensed matter theorists in uncovering the properties of the anomaly of discrete symmetries. This also opened up a new interaction between theoretical physics and a subfield of mathematics, this time the algebraic topology.

For example, there is a prediction that the anomaly of the time-reversal symmetry of fermionic systems in 2+1 d (i.e. with two spatial dimensions and one temporal dimension) is a quantity measured by an integer modulo 16. In particular, this implies that N gapless fermions in 2+1 d can be completely gapped without leaving any trace whatsoever in a time-reversal invariant manner if N is a multiple of 16. Mathematically, this number 16 comes from the so-called Pin+ cobordism group in 3+1 dimensions, which can be seen e.g. in an old review article:

gives the isomorphism in the following table.

$$\begin{array}{llll} \Omega_1^{Spin} = \mathbf{Z}/2\mathbf{Z} & \Omega_2^{Spin} = \mathbf{Z}/2\mathbf{Z} & \Omega_3^{Spin} = 0 & \Omega_4^{Spin} = \mathbf{Z} \\ \Omega_1^{Pin^-} = \mathbf{Z}/2\mathbf{Z} & \Omega_2^{Pin^-} = \mathbf{Z}/8\mathbf{Z} & \Omega_3^{Pin^-} = 0 & \Omega_4^{Pin^-} = 0 \\ \Omega_1^{Pin^+} = 0 & \Omega_2^{Pin^+} = \mathbf{Z}/2\mathbf{Z} & \Omega_3^{Pin^+} = \mathbf{Z}/2\mathbf{Z} & \Omega_4^{Pin^+} = \mathbf{Z}/16\mathbf{Z} \end{array}$$

In §2 we calculate the 1 and 2 dimensional groups and show that the non–zero one dimensional groups are generated by the circle with its Lie group framing. S^1

(Taken from Kirby&Taylor, p.177-242 in London Math. Soc. Lect. Notes 151, 1990)

In a collaboration with an IPMU postdoc Kazuya Yonekura, we approached this property using the technique of duality of supersymmetric field theories in PTEP 2016 093B07 [arXiv:1604.06184]: 16 gapless fermions can be realized on a domain wall of a softly-broken N=2 supersymmetric SU(2) gauge theory with four flavors. This system is a classic example where the so-called S-duality is applicable, and indeed this duality allows us to continuously eliminate the fermions.

In 2+1d, it also happens that N gapless fermions can be completely gapped but they leave topological degrees of freedom behind. In this case, the question is to determine what is the value of N modulo 16, if we are given a time-reversal invariant system of topological degrees of freedom. Again in a collaboration with Kazuya Yonekura, we addressed this issue in a set of two papers (PTEP 2917 033B04 [arXiv:1610.07010] and arXiv:1611.01601 currently under review), where we showed that N modulo 16 can be computed by putting the system on a Möbius strip and by measuring the fractional momentum flowing around it. This analysis leads to an explicit formula giving N modulo 16 in terms of the properties of the anyons in the system.

5.10 Microlensing Constraints on Primordial Black Holes with the HSC Observation of M31

Hiroko Niikura

The nature of dark matter (DM) is one of the biggest mysteries in cosmology and physics. Previous studies have suggested that DM is non-baryonic, non-relativistic and interact with ordinary matter only via gravity. Primordial black holes (PBH), which can be formed during the early universe. It is also speculated that such PBHs, if the mass scale is around ~10 Msun, are potential candidates of black hole binary systems whose gravitational wave events are recently detected by the LIGO experiment.

The abundance of PBHs at different mass scales are constrained by various observations except for a mass window of $M_{PBH} \simeq [10^{19}, 10^{24}]$ g or equivalently $[10^{-14}, 10^{-9}]$ Msun. Gravitational microlensing, the prediction of Einstein's gravity theory, provides us with a powerful way of probing PBHs in the unconstrained mass window, where microlensing causes a time-varying magnification of a background star while a lensing PBH crosses the line-of-sight to the star at close proximity. For this purpose, we carried out a dense cadence observation of the Andromeda galaxy (M31), with the Subaru Hyper Suprime-Cam (HSC). M31 is the largest neighboring spiral galaxy, at a distance of 770 kpc. Even a single night of HSC yields an ideal dataset to search for a microlensing event due to PBHs. First, the 1.5 degree diameter field-of-view of HSC allows us to cover the entire region of M31 (the bulge, disk and halo regions) with a single pointing. Secondly, the 8.2 m large aperture and its superb image quality (typically 0.6" seeing size) allow us to detect fluxes from M31 stars for each exposure, even with a short exposure of 90 sec. Hence we can monitor much more than millions stars in M31 simultaneously for each exposure. Thirdly, the 90 sec exposure and a short camera readout of ~35 sec enable us to take data at an unprecedented cadence of 2 min, giving us an access to a microlensing search of smaller mass-scale PBHs than previously done. Fourthly, there is a huge volume between M31 and the Earth, leading to a large optical depth of PBH microlensing to each star in M31.

We used 188 exposures of the HSC M31 data, which were taken with every 2 min cadence, in order to make a careful search of PBH microlensing event(s). In doing so, we extensively used an image subtraction method to efficiently identify candidates of various stars, and then monitor the light curve of each candidate with the high cadence data. Although we successfully identified a number of real variable stars such as eclipsing binaries and stellar flares, we find only one possible candidate of PBH microlensing whose genuine nature is yet to be confirmed. We then used this result to derive the most stringent upper bounds on the abundance of PBHs in the mass range, as shown in Figure 1. When combined with other observational constraints, our constraint rules out almost all the mass scales for the PBH dark matter scenario where all PBHs share a single mass scale.

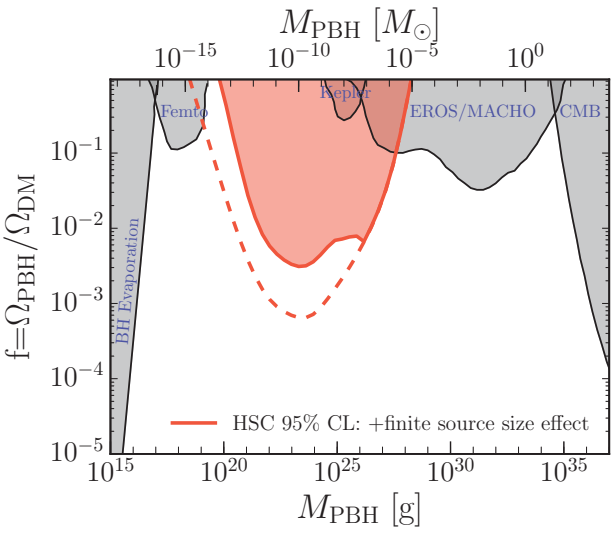

Fig. 1. The red-color shaded region show the 95% C.L. upper bound on the PBH mass fraction to DM in the halo regions of MW and M31, derived from our microlensing search of M31 stars. Our constraint can be compared with other observational constraints as shown by the gray shaded regions: extragalactic γ-rays from PBH evaporation, femtolensing of γ-ray burst (`Femto"), microlensing search of stars from the satellite 2-years Kepler data (`Kepler"), MACHO/EROS/OGLE microlensing of stars (`EROS/MACHO"), and the accretion effects on the CMB observables (`CMB").

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5.11 Assembly of Massive Galaxy Traced by Extended Stellar Halo

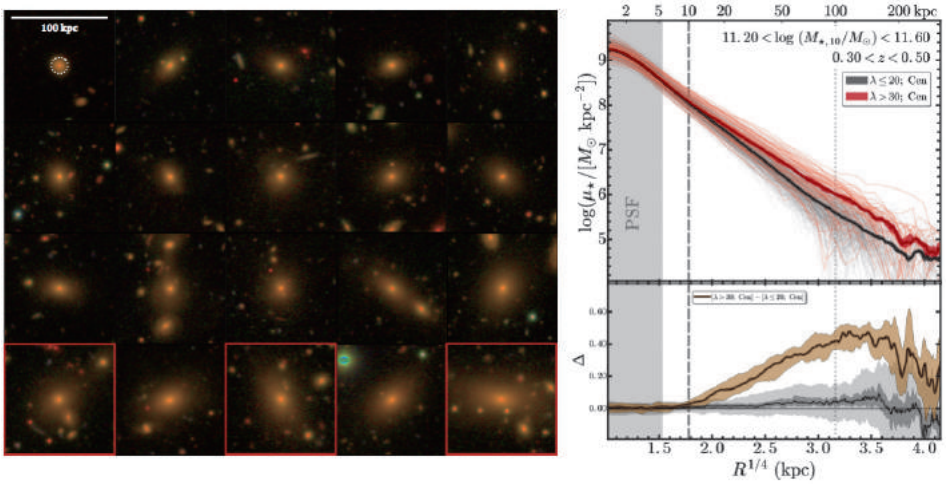
Song Huang

Massive galaxies are important laboratories to study galaxy formation and cosmology. As galaxies that live in very massive dark matter halo, they also provide unique constraint of the galaxy-halo connection. Yet, there are still many open questions regarding their star-formation history and mass assembly process. Massive galaxies often display extremely extended surface brightness profiles that can reach several hundreds of kilo parsecs. Although these stellar halos provide crucial fossil record to their assembly history, they have been proved to be difficult to study mainly due to their low surface brightness.

Using deep imaging data from Hyper Suprime-Cam Subaru Strategic Program (HSC SSP)- an ambitious multi-band wide-field survey, Song Huang and his collaborators systematically study the stellar halos of a sample of more than 7000 galaxies at $0.3 < z < 0.5$ with stellar mass more massive than $10^{11.4}$ solar masses. These deep (reach to > 28.5 mag arcsec^{-2} in i-band), high quality (average 0.6 arcsec seeing) imaging data enable us to trace the surface mass density profiles of massive galaxies out to 100 kpc individually, without using stacking method. We find the extended stellar halos of massive galaxies show a diversity of significance and larger intrinsic scatter than their inner structures.

In Huang et al. (2017), we find that more massive galaxies exhibit more extended outer halos. When this extended stellar halo is not properly accounted for as a result of shallow imaging or inadequate profile modeling, the derived stellar mass function can be significantly underestimated at the highest masses. Across our sample, the ellipticity of outer halo increases substantially with radii. We show for the first time that these ellipticity gradients steepen as a function of total stellar mass. These results support the two-phase formation scenario for massive galaxies in which outer envelopes are built up at late times from a series of merging events.

We also investigate the dark matter halo mass dependence of the surface mass density profiles and outer stellar envelopes of these galaxies. In Huang et al. (submitted), we conclusively show that at fixed total stellar mass, the stellar mass density profiles of massive galaxies depend on the masses of their dark matter halos. On average, massive central galaxies in more massive halos at $0.3 < z < 0.5$ have shallower inner stellar mass density profiles (within ~10 kpc) and more prominent outer envelopes. These differences translate into a halo mass dependence of the mass-size relation: central galaxies in halos more massive than 10^{14} solar masses are ~20% larger in effective radius at fixed total stellar mass. Our results demonstrate that, with deep images from HSC, we can quantify the connection between halo mass and the outer stellar halo, which may provide new constraints on the formation and assembly of massive central galaxies.



Left: Three-color images of massive galaxies using HSC data. All these galaxies have similar amount of stellar mass within inner 10 kpc. It perfectly demonstrates the diversity of extended stellar halos among massive galaxies. We use red boxes to highlight the ones living in very massive dark matter halos. Right: Average surface mass density profiles of massive galaxies from more massive [Red] and less massive [Black] dark matter halos. The two samples share the same stellar mass within inner 10 kpc, while the ones in more massive dark matter halos show more prominent outer stellar envelope.

6 AWARDS

Takaaki Kajita and Hirosi Ooguri Chunichi Cultural Award

The University of Tokyo's Institute for Cosmic Ray Research Director and Kavli IPMU Principal Investigator Takaaki Kajita, and California Institute of Technology's Walter Burke Institute for Theoretical Physics Director and Kavli IPMU Principal Investigator Hirosi Ooguri were honored at the 69th Chunichi Cultural Awards at a ceremony in Nagoya on June 3, 2016.

The Chunichi Cultural Awards were established by the Chunichi Shimbun in 1947 to commemorate the enactment of the Constitution of Japan, and they recognize individual and group contributions to the arts, humanities, and natural and social sciences.

Kajita was recognized for his Nobel prize-winning work "discovering that neutrinos have mass, and for discovering neutrino oscillations" using the Kamiokande and Super-Kamiokande detectors located 1000m underground in the Kamioka Mine in central Japan.

Ooguri was recognized for his work "developing cutting edge theories by implementing modern mathematics into elementary particle theory," which includes using modern mathematics to create new superstring theories to help solve fundamental problems in physics.

Hirosi Ooguri Member of American Academy of Arts and Sciences

Hirosi Ooguri was named a new member of the American Academy of Arts and Sciences, it was announced on April 20, 2016. The academy was established in 1780, making it one of the oldest in the United States, and is considered to be one of the most prestigious honorary societies. Its members have made significant accomplishments in academia, arts, business, and politics.

The 213 new members announced this year will be inducted at a ceremony at the academy's headquarters in Cambridge, Massachusetts on October 8.

IPS Best Educational Production Award

The International Planetarium Society (IPS) awarded this year's Best Educational Production Award to the 3D dome theater movie "The Man from the 9 Dimensions." It was announced at the IPS Fulldome Festival 2016, held in Brno, Czech Republic from June 15 to 17.

The movie was supervised by Hirosi Ooguri, and was produced by Japan's National Museum of Emerging Science and Innovation (Miraikan). It had just opened to the public in April this year. Directed by noted horror film director Takashi Shimizu, the movie explores the Theory of Everything and follows a group of physicists in pursuit of T.o.E – a man of mystery. T.o.E. takes his pursuers to a world of superstring theory, a leading candidate for the Theory of Everything.

The IPS Fulldome Festival showcased 66 dome theater movies from 15 countries. The Best Education Production Award is the only prize chosen by an international jury. The judges commented that the Man from the 9 Dimensions "is a piece that sparks curiosity, and provides fresh insight into the complex and deep subject that is the Theory of Everything." A prize ceremony was held in Warsaw, Poland on June 23 — the last day of the IPS Warsaw Conference.

Movie poster for Miraikan's" The Man from the 9 Dimensions" (Credit: Miraikan)

President of the Aspen Center for Physics

Hirosi Ooguri, Principal Investigator of the Kavli IPMU and Professor of California Institute of Technology, has been elected the President of the Aspen Center for Physics for a three-year term by its board of trustees on July 12, 2016.

The Aspen Center for Physics was established in 1962 in Aspen, Colorado, one of America's picturesque resort areas, to provide physicists with a creative environment for their individual research and to encourage interactions between different fields to open new directions of research. It is a short-stay type physicists' paradise for thinking and talking, and, every year, more than 1000 physicists from around the world come to the Center, mostly in summer and winter. Since 1968 the Center has been an independent non-profit corporation operated for scientists by scientists.

Toshiyuki Kobayashi Fellow of the American Mathematical Society

On November 1, 2016, the American Mathematical Society (AMS) announced the list of the 2017 Class of Fellows; University of Tokyo Graduate School of Mathematical Sciences Professor and Kavli IPMU Principal Investigator Toshiyuki Kobayashi was among those selected. The AMS has recognized his contributions to the structure and representation theory of reductive Lie groups. Professor Kobayashi has paved the way for a new mathematics via his research on the theory of discontinuous groups, branching laws of infinite-dimensional representations, and global analysis of minimal representations, and pioneered revolutionary breakthroughs in mathematics.

The Fellows of the American Mathematical Society program was inaugurated in 2012. It recognizes members who have made outstanding contributions to the creation, exposition, advancement, communication, and utilization of mathematics. *The responsibilities of Fellows are to take part in the election of new Fellows, to present a "public face" of excellence in mathematics, and to advise the President and/or the Council on public matters when requested.**

* Cited from the AMS Fellows Program Document.

Kyoji Saito Kiyoshi Oka Prize

On December 3, 2016, Kavli IPMU Principal Investigator Kyoji Saito was awarded the inaugural Kiyoshi Oka Prize. The award ceremony was held at the beginning of the 15th Oka Symposium at Nara Women's University in Nara City. The award bears the name of world-renowned mathematician Kiyoshi Oka, who was a professor emeritus at Nara Women's University. Established in 2016, the prize is given to *mathematicians who have found interesting problems and solutions, have broken new ground in mathematics, and have made promising discovery and innovation for future mathematics.***

Professor Saito is a world-class mathematician in the field of complex geometry. He has been working on various subjects in complex geometry and representation theory.In particular, his theory of primitive forms and their period maps, and theory of elliptic Lie algebras and their representation theory have had a wide influence not only in mathematics but also in physics, including superstring theory and topological field theory. These achievements, which have led to new developments, as well as his longtime contributions to the mathematics community, have been recognized.

** Cited from http://www.nara-wu.ac.jp/omi/oka_prize_en.html

Naoki Yoshida JSPS Prize and Japan Academy Medal

Naoki Yoshida, Professor of the University of Tokyo School of Science and Kavli IPMU, was awarded the 13th JSPS (Japan Society for the Promotion of Science) Award and the 13th Japan Academy Medal in recognition of his "Large-Scale Numerical Simulations of Structure Formation in the Early Universe." The award ceremony was held at The Japan Academy on February 8, 2017.

The JSPS Prize and Japan Academy Medal were both established in 2004. The JSPS Prize is meant to recognize young researchers with fresh ideas who have the potential to become world leaders in their fields. The purpose of the Japan Academy Medal is to honor outstanding young researchers, and up to six awardees (6 researchers this time) are selected every year from among the annual winners of the JSPS Prize (25 researchers this time).

Professor Yoshida has developed a computer simulation code called GADGET (GAlaxies with Dark matter and Gas intEracT) with collaborators. Using this code he has been studying structure formation and the evolution of the early universe, the formation of the first stars, and the origin of massive black holes.

Now, GADGET is a standard code in the field of large-scale computer simulation studies of the Universe. It also has a great influence on astronomical observations. Thus, Professor Yoshida's contribution to astronomy and future prospects of his research have been recognized.

Tomoyuki Abe MSJ Spring Prize

Kavli IPMU Associate Professor Tomoyuki Abe won the Mathematical Society of Japan (MSJ) Spring Prize for his contributions to the "Study of Arithmetic D-module Theory and Langlands Correspondence." An award ceremony was held on March 25 during the MSJ's Annual Meeting at Tokyo Metropolitan University.

The MSJ Spring Prize was inaugurated in 1988 as the successor to the Iyanaga Prize which had been established in 1973. It is awarded to MSJ members under the age of 40 to recognize outstanding mathematical achievement.

There are mainly two cohomology theories for varieties over fields of positive characteristic: one with a topological nature and the other with a more analytic nature. Deligne conjectured that these two cohomology theories have similar information. Professor Abe used a variant of "analytic cohomology theory," called theory of arithmetic D-modules, to establish Langlands type correspondence, and verified a part of Deligne's hope. His research is difficult to understand, but you may get some idea from his article in the Kavli IPMU News, No. 35, pp. 4-9.

Tadashi Takayanagi Nishina Memorial Prize

Kavli IPMU Visiting Senior Scientist and Kyoto University Yukawa Institute for Theoretical Physics Professor Tadashi Takayanagi has been awarded the 2016 Nishina Memorial Prize. Commemorating the achievements of the late Dr. Yoshio Nishina, the Nishina Memorial Prize honors young researchers who have outstanding attainments in nuclear physics research and application.

Six notable Japanese who have won the Nobel Prize in Physics, namely Reona Esaki, Masatoshi Koshiba, Makoto Kobayashi, Toshihide Masukawa, Shuji Nakamura, and Takaaki Kajita, have also received the award.

Moreover, Kavli IPMU Principal Investigator, California Institute of Technology Professor, Caltech Walter Burke Institute for Theoretical Physics Director, and Aspen Center for Physics Director Hirosi Ooguri, won the award in 2009, as did Kavli IPMU Principal Investigator and Tohoku University Research Center for Neutrino Science Professor Kunio Inoue.

This time, Takayanagi received the Nishina Memorial Prize for his "discoveries in—and development of—holographic entanglement entropy formula." Based on theories of black hole entropy, the holographic principle—which was established within the framework of string theory in 1997—has had significance in superstring theories. The concept of entanglement (or quantum entanglement) plays an important role in quantum mechanics, quantum information theory, and condensed matter physics, while entanglement entropy is a measure of how much a given quantum state is entangled.

Announced in 2006 by Takayanagi (and co-author Shinsei Ryu), holographic entanglement entropy formulas calculate entanglement entropy using theories of gravity. Based on the holographic principle, it describes entanglement entropy by linking it to the geometric character of gravitational theories.

Known as the Ryu-Takayanagi Formula, and developed over some 10 years, the calculations and its development have elucidated our understanding of holographic entanglement entropy, and made significant contributions to theoretical physics.

Upon receiving the Nishina Memorial Prize, Takayanagi said: "I am very honored to receive this prestigious prize which appreciates that we opened up an interdisciplinary field between string theory and quantum information theory. I am very grateful to my collaborators, especially Shinsei Ryu.

"Taking this great opportunity, I would like to make greater efforts in developing related subjects. It is also my pleasure if, in receiving this award, I can encourage young researchers who are challenging new interdisciplinary fields in theoretical physics."

7 CONFERENCES

7.1 PhyStat-ν Workshop on Statistical Issues in Experimental Neutrino Physics

Mark Hartz
Kavli IPMU Assistant Professor

The PhyStat-ν workshop on statistical issues in experimental neutrino physics attracted over 90 particle physicists and statisticians from around the world to Kavli IPMU on May 30-June 1, 2016. The workshop focused on the statistical methods used to interpret data from current and future neutrino experiments.

The discovery of neutrino masses through the phenomenon of neutrino oscillations opened a new window to physics beyond the standard model and led to the 2015 Nobel Prize awarded to Takaaki Kajita and Arthur B. McDonald. Neutrino experiments now aim to further understand the phenomenon of neutrino oscillations and the mechanism by which neutrinos obtain their very small masses. Outstanding questions include: do neutrinos and antineutrinos oscillate differently (so-called CP violation), is the neutrino its own anti-particle, what is the ordering of masses for the three neutrinos, will precision measurements of the parameters governing oscillations indicate an underlying symmetry involved in the generation of neutrino masses?

To study these outstanding questions, neutrino physicists are building ever more complex experiments that require significant human and monetary resources. Therefore, it is critical to maximize the information extracted from these experiments while also ensuring that inferred information on neutrino model parameters and choices between models are statistically sound. The PhyStat-ν workshop addressed three major statistical issues: event classification, parameter estimation and model selection.

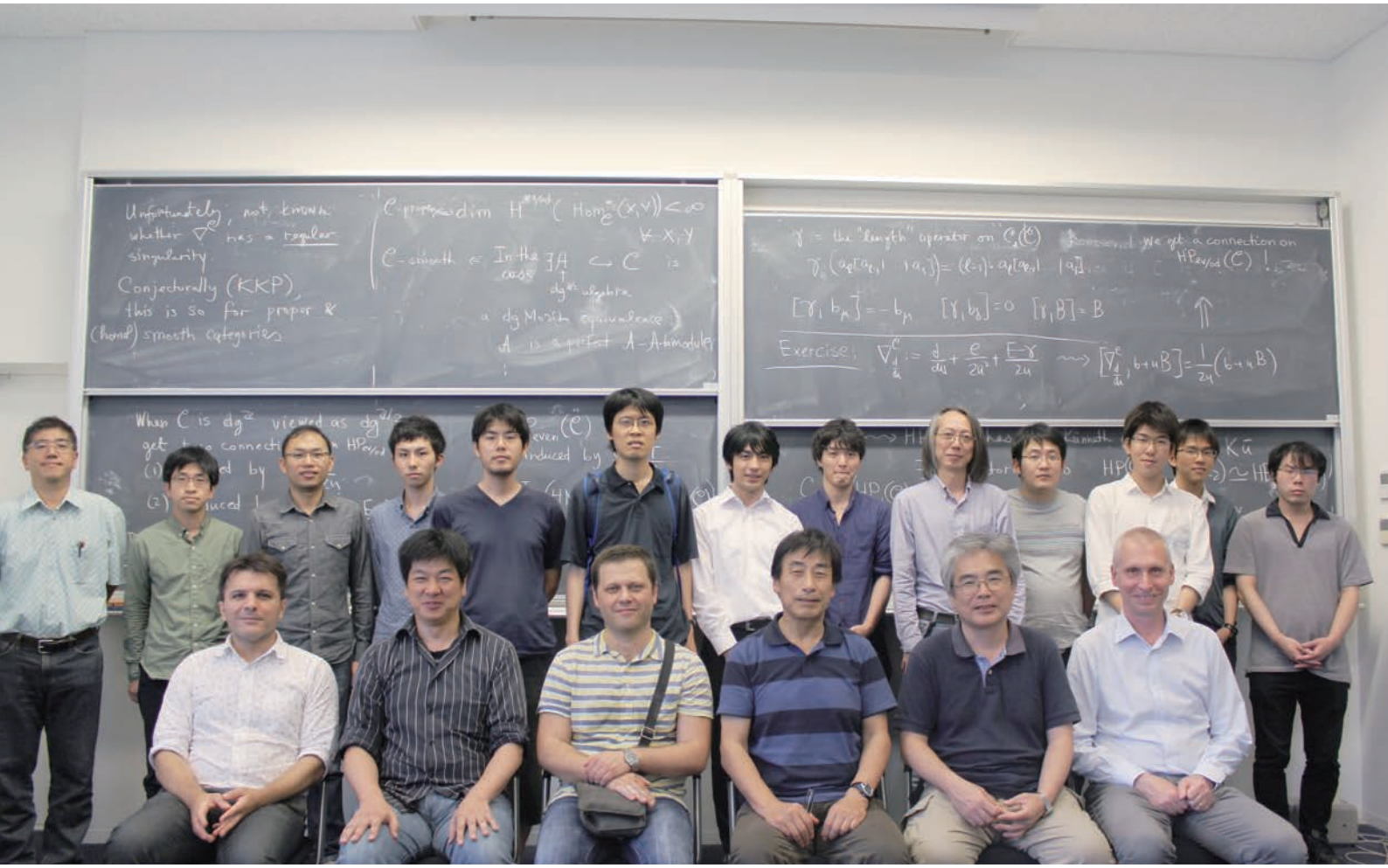
Event classification refers to the process by which physicists interpret raw data observed in detectors as physical processes. For example, a pattern of light observed in a neutrino detector may be interpreted as one or more charged particles propagating through the detector medium and producing Cherenkov light. New techniques that can maximize the information extracted from the raw data were presented, including boosted decision trees and a non-parametric Bayesian event reconstruction.

Parameter estimation involves the inference of allowed values for model parameters given the data that is observed. Both classical and Bayesian methods were presented at PhyStat-ν with a focus on challenging cases such as parameters with physical bounds and deciding between a two-sided or one-sided interval for a parameter.

The topic of model selection received significant attention since the next generation of experiments will measure the hierarchy of neutrino masses, which has two options, normal or inverted hierarchy. Since this measurement involves a discrete choice rather than a continuous parameter, naive expectations for what constitutes a significant result can be wrong. The methods of model selection in both the classical and Bayesian approaches were discussed and comparisons were made to a similar discrete choice made with LHC data, the determination of the Higgs boson candidate spin-parity.

The PhyStat-ν workshop at IPMU was the first PhyStat workshop in the field of neutrino physics and laid the groundwork for future workshops on statistical methods in experimental neutrino physics. A second PhyStat-ν workshop will be held at Fermilab on September 19-21.

7.2 Higher Residue Week, 2016



Todor Milanov
Kavli IPMU Associate Professor

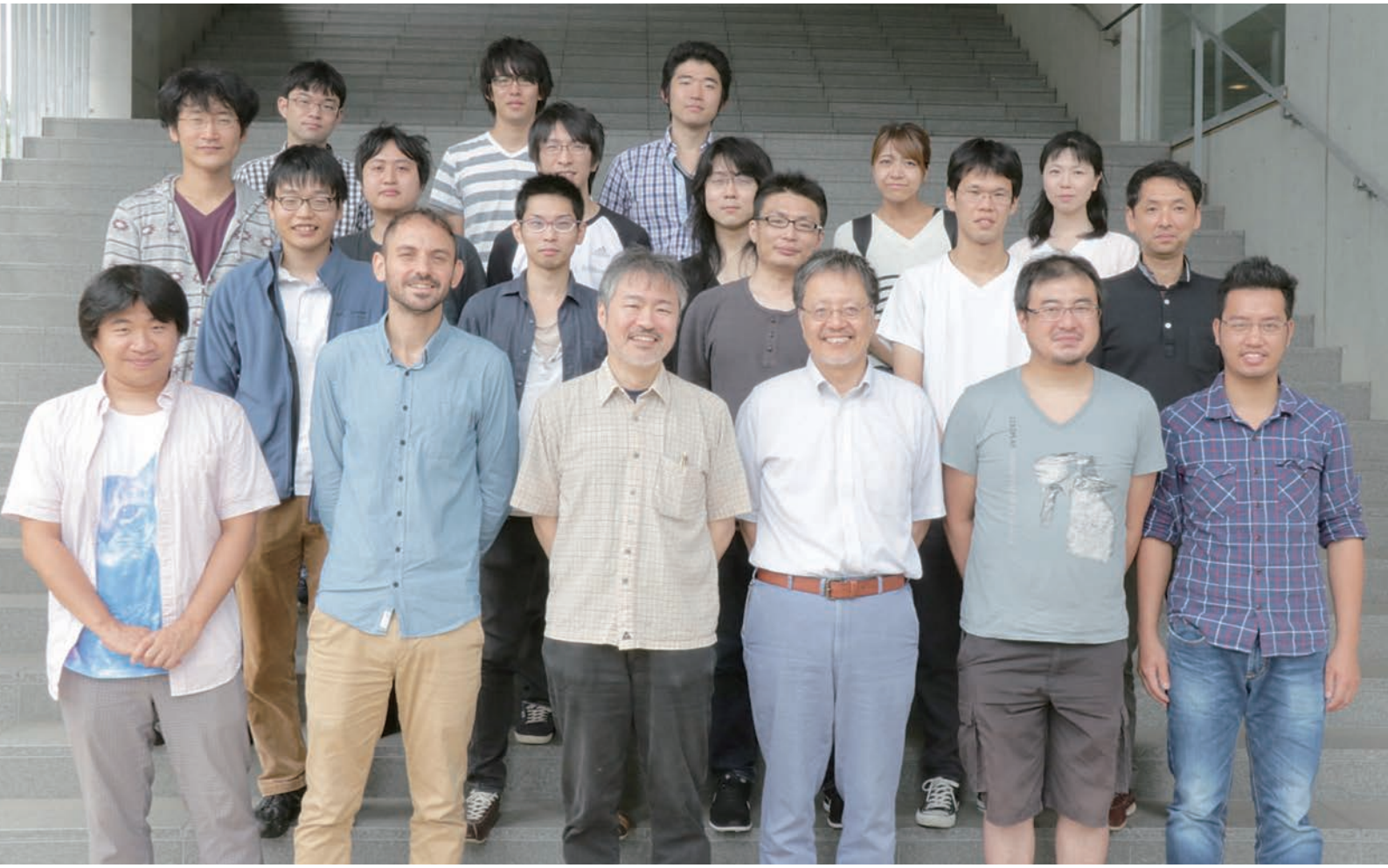
The "Higher Residue Week, 2016" at Kavli IPMU took place from June 6 to 10, 2016. The event started with a two-day mini-workshop and it continued as a series of lectures by Dmytro Shklyarov (TU Chemnitz). The main goal of the workshop was to present the recent work of Shklyarov who has introduced Hodge-like structures of dg-categories motivated by Kyoji Saito's theory of primitive forms. The notion of a primitive form was invented by K. Saito during his visit to Harvard in 1980. The main motivation is to provide a generalization of the classical period map for Riemann surfaces in the settings of Singularity Theory, i.e., the study of isolated critical points of holomorphic functions.

The importance of K. Saito's work increased significantly in the early 90s when Alexander Givental and Maxim Kontsevich noticed that the theory of primitive forms provides the key concepts to state mirror symmetry and it can be used in symplectic geometry to compute Gromov-Witten invariants of compact Kahler manifolds. Mirror symmetry consists of finding a triple of an affine manifold Y, a holomorphic function f on Y, and a primitive form ω. The key ingredient in Saito's theory is the so-called *Higher Residue Pairing*. This is a certain non-degenerate bi-linear pairing defined on the twisted de Rham cohomology of Y via a sequence of residues. The primitive form is a special cohomology class satisfying an infinite system of bi-linear relations. The key observation of Givental is that the oscillatory integral built from f and ω coincides with what he called the J-function, i.e., a certain generating series of genus-0 Gromov-Witten invariants.

The main contribution of Shklyarov is that by studying the category of matrix factorizations he found a categorical interpretation of the twisted de Rham cohomology and the Higher Residue Pairing. In particular, the ideas and the concepts of K. Saito's theory could be extended in much more general settings. As an application, Shklyarov also gave a talk during the mini-workshop based on his solution of a conjecture of Anton Kapustin and Yi Li, which implies the existence of an interesting A-infinity structure.

During the workshop, Hiroshi Ohta explained his joint work with Kenji Fukaya, Kaoru Ono and Yong-Geun Oh in open Gromov-Witten theory, which provides yet another tool to construct A-infinity structures and primitive forms. The workshop made an interesting contribution to understanding the big puzzle of mirror symmetry and primitive forms. Many ideas were exchanged and most importantly several possible directions for further investigations were clearly outlined.

7.3 Lectures on Cosmology with Planck at IPMU



Daisuke Kaneko
Kavli IPMU Postdoctoral Fellow

"Lectures on Cosmology with Planck at IPMU"* was quite a stormy seminar due to Typhoon No. 10. The seminar was held from August 29 to 31 at the Kavli IPMU, but the schedule for August 30 and 31 was postponed in order to avoid the typhoon and any other accidents. Therefore, supplementary lectures were held on September 13 on the University of Tokyo's Asano campus. The lecturer was Dr. Guillaume Patanchon (University Paris Diderot) who is working on the Planck experiment: a cosmic microwave background (CMB) observation with a satellite which was launched in 2009 by the European Space Agency.

The main target in the audience was young post-docs and students who are not yet particularly familiar with cosmology, and many attendees came from KEK (Sokendai), JAXA, NAOJ, Yokohama National University, and Okayama University, in addition to the University of Tokyo. It shows a high level of interest in the recent results of the Planck experiment.

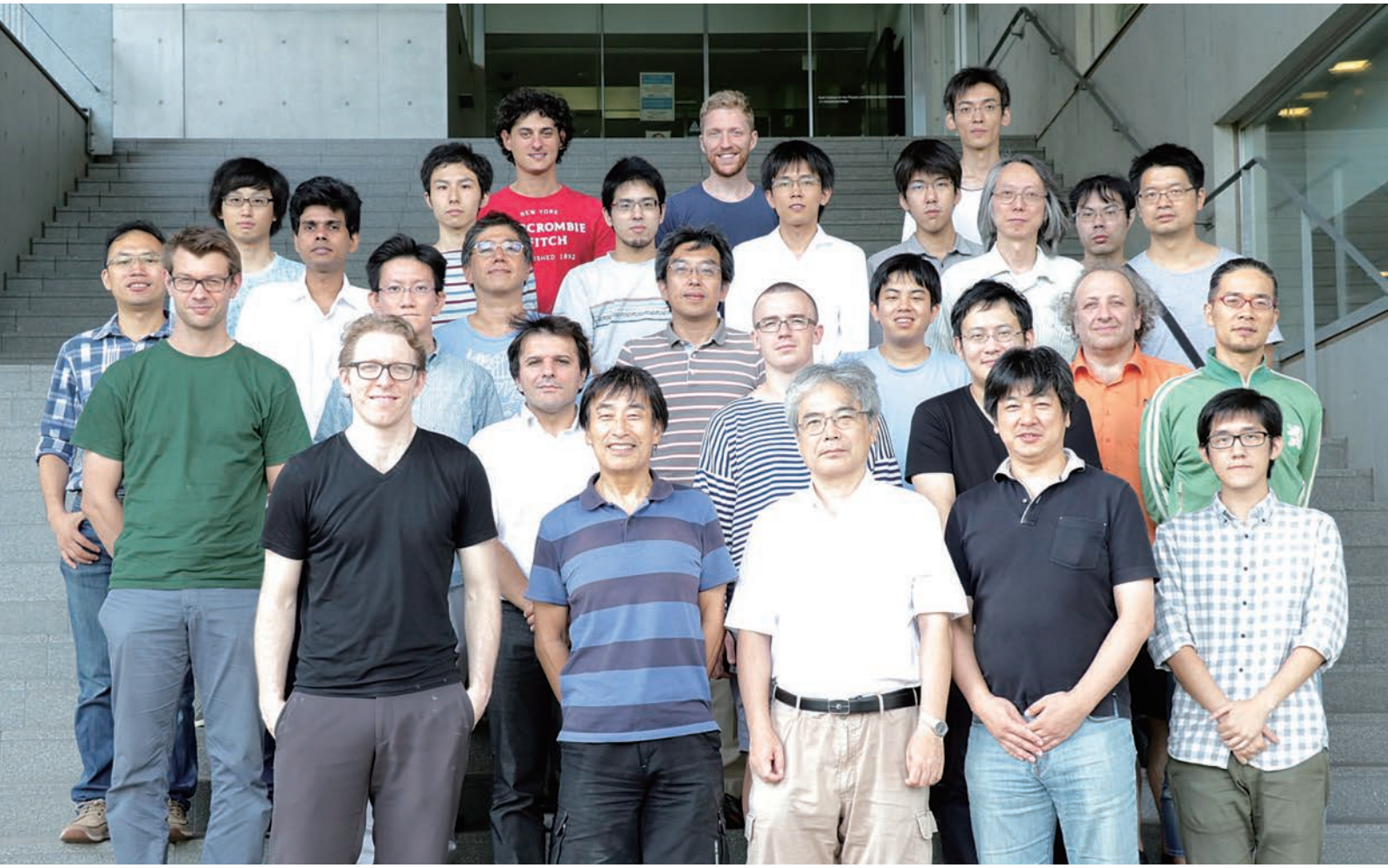
The lecture started with general relativity and an introduction to cosmology. Basic parameters in the standard model of cosmology were also introduced. The expansion of a homogeneous and isotropic universe was explained by calculating the FLRW (Friedmann-Lemaître-Robertson-Walker) metric. On the second day, perturbation in the universe was discussed. Calculation of the anisotropy was carefully performed, as anisotropy of the CMB photon temperature is one of the most important topics. The relation between the CMB power spectrum and cosmological parameters was explained for beginners. Lectures then moved into observation of the CMB. The design of the Planck satellite, high-frequency and low-frequency instruments, cooling system, and bolometer sensor of the detectors were shown. At the end, results from the recent Planck experiment (published in 2015) were presented. The observed CMB maps and spectra, as well as the fitted cosmological parameters, were shown in comparison with other experiments. The results with respect to B-mode polarization were presented with a comparison to a recent BICEP2 experiment. A measurement of non-Gaussianity was also mentioned.

On the additional day, the analysis method and systematic uncertainties were discussed. Issues such as long time-constant signal by cosmic rays, noise from 4K coolers, and non-linearity of ADC were realistically discussed, thanks to the lecturer's experience in analyzing the Planck data.

Finally, a Q&A session of the lessons of the Planck experiment was held, and meaningful information was exchanged by CMB experimentalists. The seminar finished on a high note.

* These lectures were supported by JSPS Core-to-Core Program, A. Advanced Research Networks.

7.4 Matrix Factorization and Related Topics, 2016



Dulip Piyaratne
Kavli IPMU Postdoctoral Fellow

The workshop "Matrix factorization and related topics, 2016", organised by Hiroshi Ohta (Nagoya), Kyoji Saito (Kavli IPMU) and Atsushi Takahashi (Osaka), was successfully held at the Kavli IPMU for four days from September 5, 2016. The programme consisted of two series of lectures by Tobias Dyckerhoff (Bonn) and Daniel Murfet (Melbourne) together with related research talks by Atsushi Takahashi (Osaka), Andrei Losev (Moscow), and Michael Brown (Bonn). This workshop has brought together 35 participants from algebra, geometry, and mathematical physics.

Matrix factorizations were introduced by David Eisenbud, as a tool for studying the homological behaviour of modules over a hypersurface ring. More recently, matrix factorizations have begun appearing in a wide variety of contexts. For instance they arise in string theory as categories of D-branes for Landau-Ginzburg B-models. The expectation in homological mirror symmetry is that for any given symplectic manifold, there is a mirror Landau-Ginzburg model such that, the Fukaya category of the symplectic manifold should be equivalent to the matrix factorization category of the Landau-Ginzburg model. In addition, Kajiura-Saito-Takahashi's explicit description of the equivalence of triangulated categories involving matrix factorizations of simple singularities nicely fits into this categorical expectation.

Tobias Dyckerhoff, following his joint works with Mikhail Kapranov, Chris Brav, Vadim Schechtman, and Yan Soibelman, discussed various topics on topological Fukaya categories. Firstly he constructed topological Fukaya categories for the two dimensional case. Then he introduced the concept of a relative Calabi-Yau structure and constructed them on topological Fukaya categories. Finally, he discussed more details using the categorical machinery of perverse sheaves.

Daniel Murfet gave his lectures under the title of generalized orbifolding of simple singularities. He started his lecture series by explaining an important result due to Carqueville-Ros Camacho-Runkel, which directly leads to new descriptions and relations between the associated categories of matrix factorizations and Dynkin quiver representations of simple singularities. Then he discussed these concepts in the abstract bicategorical framework for generalised orbifolding. He concluded his lectures with some concrete examples of Ladau-Ginzburg models and its graded version. In the final lecture, he explained how to obtain finite dimensional models of matrix factorization categories.

Atsushi Takahashi gave a gentle introduction to Kyoji Saito's theory of primitive forms. He highlighted the historical development of the subject and directions for further advancements mainly in the categorical setup. Under the section of research talks, Michael Brown explained about the topological K-theory of matrix factorization categories in order to extract topological information from the matrix factorization category associated to an isolated singularity. In his research talks, Andrei Losev first discussed about the theory of primitive forms and generalised Hodge theory; and then he went to talk on tropical mirror symmetry where he considered tropical limit of Gromov-Witten theory.

Numerous discussions among the participants, most importantly from different mathematical communities, have contributed to the workshop in an essential way. Furthermore, participants also appreciated ample time for interaction with other researchers. So the workshop provided an ideal atmosphere for fruitful interaction and exchange of ideas.

7.5 Statistics, Quantum Information, and Gravity

Hirosi Ooguri
Kavli IPMU Principal Investigator

Unification of general relativity and quantum mechanics has been one of the holy grails of modern physics. After the discovery of the Ryu-Takayanagi formula for the entanglement entropy 10 years ago, it has become increasingly clear that information theory provides powerful tools to study quantum gravity and quantum field theory. In turn, the study of quantum gravity has provided a new set of problems that information theorists can study and stimulated its progress.

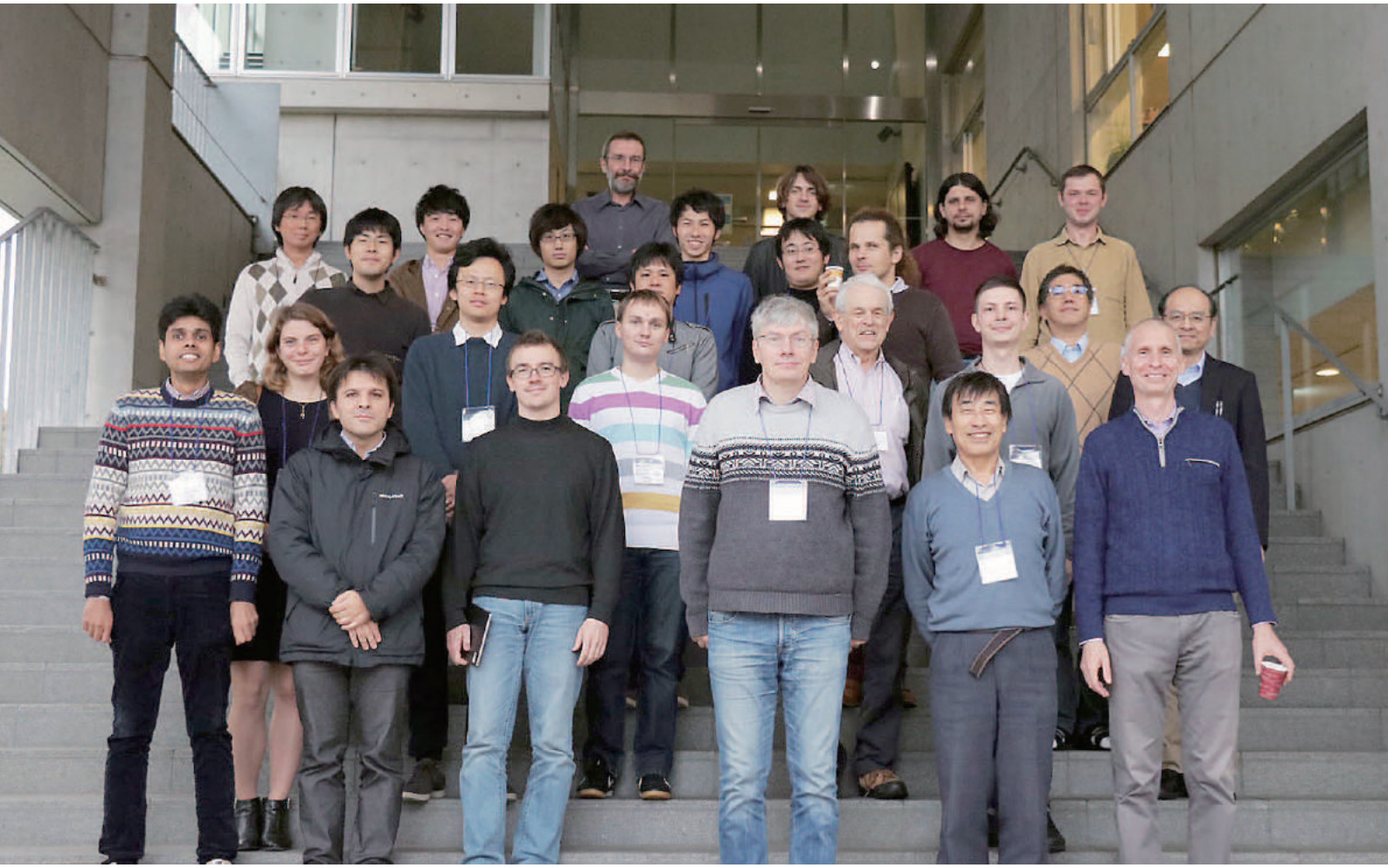
In the past, the Kavli IPMU has successfully hosted Focus Weeks at the interface of high energy physics and condensed matter physics, and they have led to new collaborations between theorists at the Kavli IPMU and condensed matter theorists at other institutes. The purpose of this one-day conference is to explore another interface area, between high energy physics and information theory.

We invited a broad range of scientists as speakers: Masanao Ozawa (who studies quantum information theory and foundations of quantum mechanics), Hal Tasaki (who studies fundamental questions in statistical mechanics), Takahiro Sagawa (who studies non-equilibrium statistical mechanics, quantum measurement, control and information theory), Yasuyuki Kawahigashi (who studies operator algebras, which are important for quantum field theory), and Simmeon Hellerman (who is at the Kavli IPMU and studies string theory, which is the leading candidate for the unification of general relativity and quantum mechanics).

Ozawa is well-known for his discovery of "Ozawa inequality" in quantum measurement theory. The conference opened with Ozawa's talk, in which he discussed measurement theory in quantum field theory. He was followed by Kawahigashi, who discussed operator algebraic approach to conformal field theory, which is an important class of quantum field theories, relevant to many aspects of string theory and AdS/CFT correspondence. In the afternoon, Tasaki discussed thermalization of statistical systems and Sagawa used information theoretic methods to discuss fundamental questions in statistical mechanics. The conference ended with a talk by Hellerman, who pointed out an issue with defining quantum entanglement in quantum field theories with non-vanishing gravitational anomalies.

The conference offered an excellent opportunity for scientists with such a broad range of backgrounds to interact with each other. We hope to foster such interactions further and encourage collaborations between high energy physics and information theory.

7.6 Workshop on Categorical and Analytic Invariants in Algebraic Geometry IV



Alexey Bondal
Kavli IPMU Principal Investigator

The year 2016 was final for the bilateral Japanese-Russian project "Categorical and analytic invariants in algebraic geometry." It was financially supported jointly by JSPS and Russian Foundation for Basic Research (RFBR). The project is governed by Kyoji Saito and Alexey Bondal.

In 2016, the series of events started in 2015 was continued. A conference "Categorical and Analytic Invariants in Algebraic geometry III" under the auspice of this project was organized by the Kavli IPMU, Steklov Institute, Higher School of Economics in Moscow (where this conference was held) and the Institute of Fundamental Science on September 12–16. Members of the Kavli IPMU participated, as well as mathematicians from the Graduate School of Mathematical Sciences of Tokyo University, Osaka University, Tokyo Metropolitan University, Steklov Institute in Moscow, Higher School of Economics in Moscow and from other institutions in Britain and Poland.

Another workshop "Categorical and Analytic Invariants in Algebraic geometry IV" took place at the Kavli IPMU in the week of 14-18 November 2016. Further exchange of ideas and cooperation between Japanese and Russian participants of the project as well as with other Russian and Japanese scientists took place.

A particular attention was given to birational transformations and their mirror symmetric partners. Constructions of derived equivalences of algebraic varieties given by both birational and nonbirational varieties were discussed. Noncommutative mirror partners of ordinary algebraic varieties were scrutinized. The foundational base of the theory via properties of DG-enhanced categories, introduced by A. Bondal and M. Kapranov almost 30 years ago, was carefully studied.

The work of analytical invariants constructed by means of mirror symmetry was presented in several talks from the Japanese side. As in the events of the previous year, many talks of the workshop were devoted to the study of one of the sides of the mirror and/or to comparison of the two.

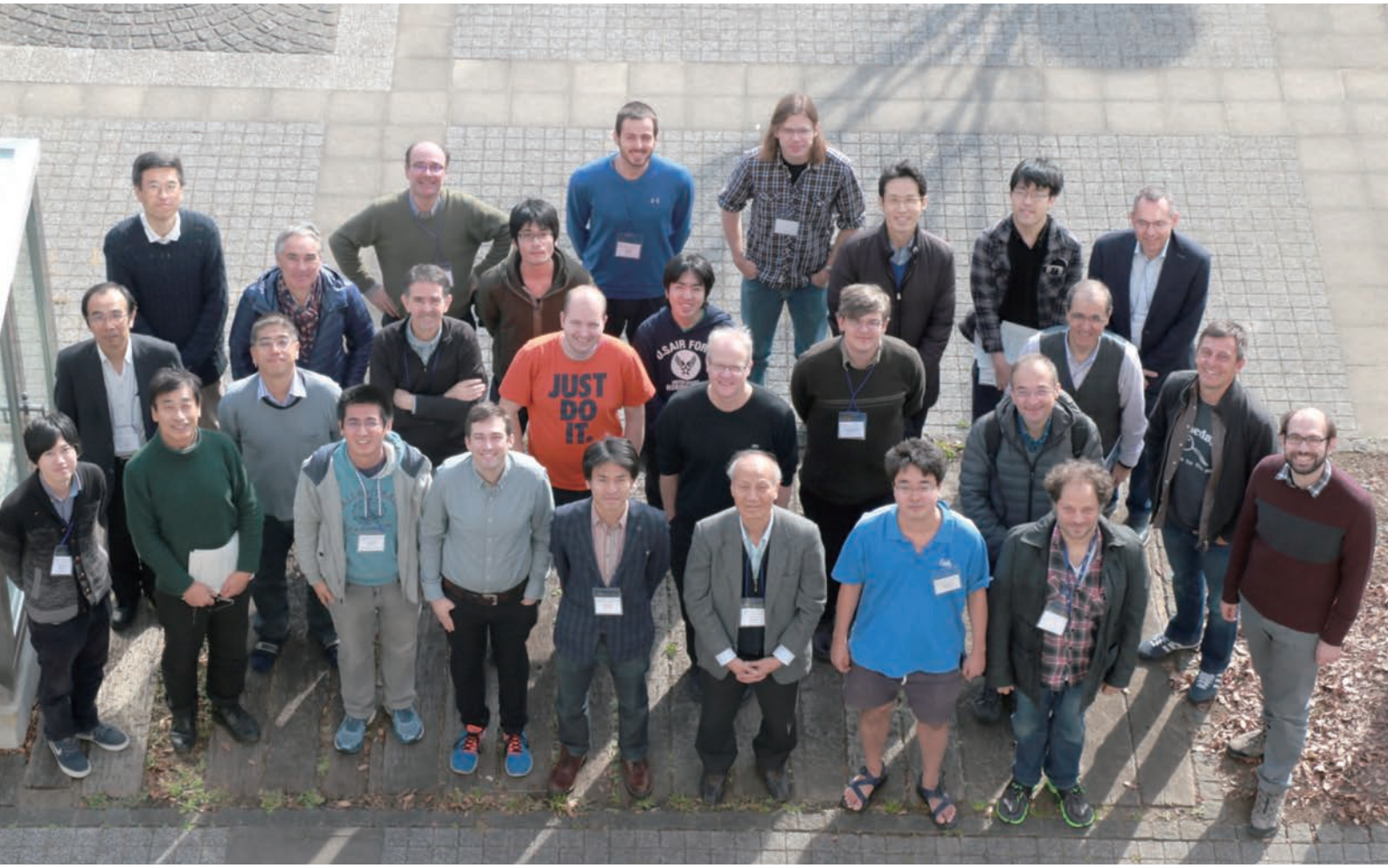
Mikhail Kapranov outlined a new perspective in his talk on higher Kac-Moody algebras and derived moduli spaces of G-bundles. He developed a generalization for higher dimensional varieties of one of the fundamental features of the Conformal Field Theory on Riemann surfaces, that is the action of the current (Kac-Moody) algebras on the moduli space of rigidified G-bundles.

A young Japanese mathematician T. Kuwagaki presented his powerful result on coherent-constructible correspondence. The first observation and results of A. Bondal on equivalence of derived categories of coherent sheaves on toric varieties with the derived categories of constructible sheaves on the real torus subordinated to a suitable stratification was developed by a range of authors into a general conjecture of such equivalence for toric stacks. The conjecture can be interpreted in terms of mirror symmetry by identifying the constructible side with the relevant Fukaya category. T. Kuwagaki reported on his proof of the conjecture in full generality.

The cooperation with physicists was particularly fruitful. Kentaro Hori presented mathematical conjectures about derived equivalences of some Calabi-Yau varieties based on consideration of a two parameter gauged linear sigma model that has six phases. It can be regarded as a two parameter extension of Hosono-Takagi model. Sh. Hosono in his turn described a series of examples of mirror symmetric partners for Calabi-Yau varieties that have infinite birational automorphisms and identify these automorphisms with monodromy transformations in their mirror families.

A young Russian mathematician Andrei Yonov developed the physics proposal of A. Belavin that the Witten's descent deformation of the chiral ring should correspond to the certain K. Saito's primitive forms for the Gepner singularity. Yonov constructed by purely mathematical tools primitive forms for Gepner singularities.

7.7 Resurgence at Kavli IPMU



Aleksey Cherman
University of Washington Postdoctoral Research Associate

The "Resurgence at Kavli IPMU" was held from December 12 to 16, and focused on surveying recent developments in resurgence theory and related topics. Resurgence theory is a framework to systematically construct solutions to non-linear problems arising in physics and mathematics. For example, one may want to construct solutions to non-linear differential equations, or to write expressions for observables in a quantum field theory (QFT) as a function of its coupling constants. The starting point for the analysis of such problems is of course perturbation theory around a linearized limit. But perturbation theory alone is usually not enough, because it produces divergent asymptotic series, and the result is not valid non-perturbatively. Resurgence theory allows one to develop exact solutions by systematically putting together perturbative expansions around different linearized limits. For example, in QFT, this involves understanding how perturbative fluctuations around various instanton-like sectors fit together to produce an unambiguous result valid for any value of the coupling constants.

The workshop was highly international, with participants from Europe, North America, South America, and Asia. The talks highlighted exciting developments along several directions. Many talks, for example by Y. Tanizaki, T. Schafer, E. Poppitz, P. Putrov, G. Basar, and T. Misumi, discussed the relation between resurgence theory, which gives an algebraic perspective on semiclassical expansions, and Lefshetz thimbles, which give a geometric perspective on the same topic. A. Cherman and T. Sulejmanpasic gave overviews of techniques necessary to produce smooth weakly-coupled limits for asymptotically-free QFTs, which is a necessary step to apply resurgence theory techniques. O. Costin and G. Dunne announced intriguing results on practical new methods for summation of semiclassical expansions and relations between perturbative and non-perturbative effects. R. Schiappa and M. Yamazaki explained recent developments in applications of resurgence theory to string theory and supersymmetric gauge theory, while T. Aoki, Y. Takei, and A. Getmanenko presented advances in the study of the WKB expansion and related topics in resurgence and Stokes phenomena.

The format of the workshop was focused on leaving as much time for informal discussion as possible, with most days having two talks in the morning and two in the evening, and plenty of tea and cookies placed near blackboards to trigger interactions. Kavli IPMU's wonderful staff and facilities provided an excellent and stimulating environment, and the workshop was very successful, with many participants remarking that they developed new research ideas from the talks and interactions with other researchers.

7.8 Conference "D-modules and Hodge Theory"

Tomoyuki Abe
Kavli IPMU Associate Professor

From 23rd to 27th of January 2017, a conference entitled "D-modules and Hodge Theory" was held at the Kavli IPMU. There were 15 invited speakers, including three who gave two lectures.

Hodge theory, a main theme of the conference, sits at the intersection of various fields: algebraic, analytic, and arithmetic geometry. The story starts when W.B.D. Hodge discovered a marvelous decomposition of singular cohomologies of Kähler varieties by means of harmonic forms. Even though the proof is completely analytic, this decomposition can be interpreted in terms of algebraic geometry, and the existence of such decomposition is regarded as a unique feature of algebraic (or Kähler) geometry. Some decades after Hodge's discovery, A. Weil conjectured a surprising conjecture for varieties over finite fields. J.P. Serre pointed out that complex analogue of his conjecture could be solved by using Hodge theory. Since then, Hodge theory has been a source of inspiration for those studying cohomology theory over finite fields. On the other hand, inspired by works on the Weil conjecture, P. Deligne found a new way to understand Hodge decomposition from a more philosophical point of view: invention of Hodge structure. Following this philosophy as well as Grothendieck's "yoga of 6 functors," M. Saito established the theory of Hodge modules by using ideas from D-module theory. The next step was seeking for analogous structure for "irregular connection" generalizing Saito's theory. The program was initiated C. Sabbah after C. Simpson's work on twister Hodge structure, and recently completed by T. Mochizuki. One of the main aims of the conference was to understand this theory and relevant topics.

Mochizuki gave two lectures on his works. In the first lecture, he explained some basic facts on this theory, and in the second lecture, he gave some applications. His theory enabled him to explain some facts appearing in mirror symmetry in a more natural way, which is expected to lead to more applications. K.S. Kedlaya gave two lectures on the resolution of turning points, which was shown independently by Mochizuki. Kedlaya's method uses ideas from p-adic analysis. The most interesting aspect of his proof is that, by combining differential equation theory for Berkovich spaces and valuation theoretic point of view, he can explain the blow-up locus in a coherent manner. A. D'Agnolo gave lectures on irregular Riemann-Hilbert correspondence that he established in the work with M. Kashiwara. This result enables us to understand Stokes phenomenon in a higher dimensional situation. In the heart of the proof, they used resolution of turning points.

The conference was very successful with a lot of attendance from many universities and with various backgrounds.

7.9 Conference: MEXT Scientific Research on Innovative Area "Why Does the Universe Accelerate? – Exhaustive Study and Challenges for the Future –"

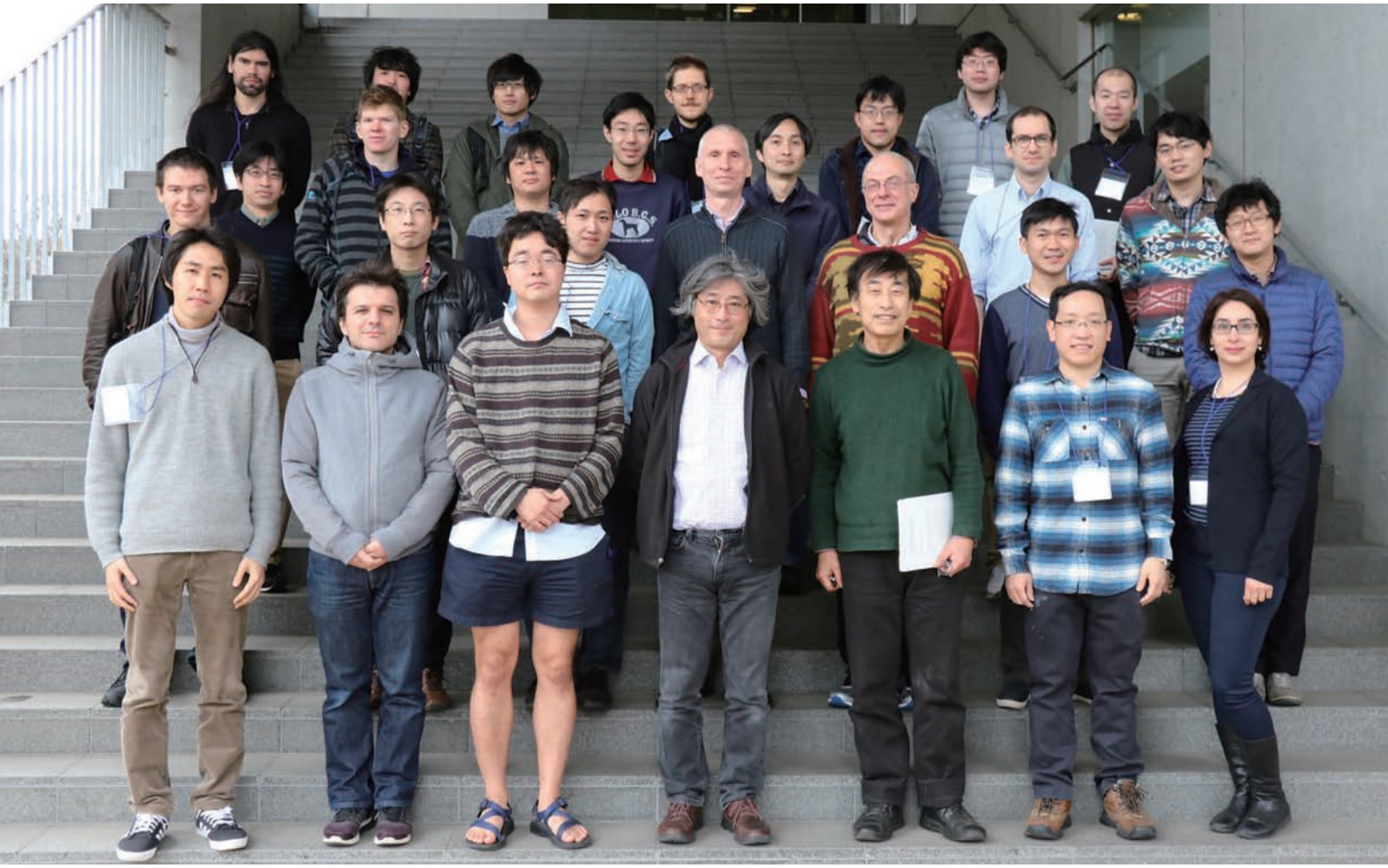
Masahiro Takada
Kavli IPMU Professor

There are observational evidences for two periods of accelerated cosmic expansion: at the very beginning, known as inflation, and the present. Since gravity, according to Newton as well as Einstein, is known as an attractive force, gravity can only "pull" the expansion to slow it down. Hence cosmic acceleration is the biggest mystery in cosmology. What is "pushing" the Universe to speed it up? We often invoke "inflation" and "Einstein's cosmological constant" as its theory, but they have many unnatural features and are far from satisfying explanations. The purpose of this research area is to understand the origin of the accelerated cosmic expansion, as well as its interplay with dark matter which competes with the acceleration to build galaxies and clusters of galaxies. To address this problem, we launched the research program "Why Does the Universe Accelerate? – Exhaustive Study and Challenges for the Future –" (PI: Hitoshi Murayama), based on the MEXT Scientific Research on Innovative Area (FY2015 – 2019). We propose to conduct the research program based on a comprehensive approach; Theory units ranging from cosmic acceleration due to inflation (A01: Misao Sasaki, Kyoto Univ.), to decelerated expansion phase due to dark matter (A02: Fuminobu Takahashi, Tohoku Univ.), and late-time cosmic acceleration due to dark energy (A03: Naoshi Sugiyama, Nagoya Univ./Kavli IPMU): Observational units based on the CMB experiments (B01: Masashi Hazumi, KEK/Kavli IPMU), galaxy imaging survey (B02: Satoshi Miyazaki, NAOJ), galaxy redshift survey (B03: Masahiro Takada, Kavli IPMU), and the Thirty-Meter Telescope (B04: Tomonori Usuda, NAOJ): and then Ultimate units developing tools of combining different cosmological datasets to fully extract cosmological information (D01: Eiichiro Komatsu, MPA/Kavli IPMU) and seeking ultimate theory of cosmic acceleration from super-string theory with top-down perspective (C01: Hirosi Ooguri, Caltech/Kavli IPMU). This is a 5-year research program (FY2015 – 2019).

We held the conference at the High Energy Accelerator Research Organization (KEK) at around the end of the second year from the launch of this program, March 8 – 10 in 2017, where almost all members from each research group gathered together. At the conference we had updates from each research group/program and there were a lot of productive, stimulating discussions. We also had contributed talks mainly by young researchers. In addition, we had a special session "Primordial Black Hole" (PBH) on the third day, where we discussed the current observational constraint, a scenario to generate PBHs from an inflationary universe, a scenario to explain dark matter with PBHs, and a connection of PBHs to the gravitational events in the Advanced LIGO experiment that detected gravitational waves from a binary black hole system. We had more than 120 participants, and the conference was greatly successful.

Finally we would like to thank the organizers, Masaya Hasegawa, Haruiki Nishino, Shuichiro Yokoyama, and Teruaki Suyama. We also thank the secretaries of KEK for their dedicated support.
Photo: Courtesy of KEK IPNS.

7.10 Workshop "Mathematics and Superstring Theory"



Yukinobu Toda
Kavli IPMU Associate Professor

From March 21 to 23, 2017, the workshop entitled "Mathematics and Superstring theory" was held at the Kavli IPMU. This workshop was organized as a summary of the JSPS program "Advancing Strategic International Networks to Accelate the Circulation of Talented Researchers"adopted as "Unlocking the Mysteries of the Accelerating Universe through Superstring Theory and Astrophysical Observations." The aim of this program is to support young researchers in Japan to go abroad and do joint works with foreign researchers. Several researchers in Japan, including workshop organizers Masahito Yamazaki and Yukinobu Toda, went abroad and had discussions in foreign countries.

In the workshop, both mathematicians and string theorists came together and had significant discussions. From the mathematics side, there were 7 speakers: Ivan Ip, Zheng Hua, Akishi Ikeda, Atsushi Kanazawa, Georg Oberdieck, Yinbang Lin, and Kyoung-Seog Lee. The contents included various topics: derived algebraic geometry, mirror symmetry, stable pair invariants, derived categories of coherent sheaves, etc. Atsushi Kanazawa talked about Doran-Harder-Thompson conjecture on the construction of mirror Calabi-Yau manifolds by their degenerations, and showed that their conjecture is true for elliptic curves and some abelian surfaces. Georg Oberdieck talked about his very strong result on the proof of Katz-Klemm-Vafa conjecture on Pandharipande-Thomas stable pair invariants, which count algebraic curves on Calabi-Yau 3-folds, for the products of K3 surfaces and elliptic curves.

From the superstring theory side, there were also 7 speakers: Mauricio Romo, Nezhla Aghaee, Shamil Shakirov, Pietro Longhi, Bruno Le Floch, Dongming Gang, and Taizan Watari. Mauricio Romo talked about sphere correlators for a hybrid model given by some non-affine algebraic variety equipped with a super-potential. Shamil Shakirov talked about deformations of Chern-Simons topological field theory. It was known that such a deformation exists in the case that boundaries are Riemann surfaces with genus less than or equal to one, but Shakirov explained that it extends to the case that boundaries have genus two. There were also talks on quantization of super Teichmueller spaces, wall-crossing of BPS states, etc., which were also interesting for mathematicians.

During the workshop, both mathematicians and physicists enjoyed many discussions.

8 SEMINARS

FY2016

Nicholas Battaglia (Princeton U)
Cross correlations with CMB secondaries: constraining cosmological parameters and cluster astrophysics
Apr 05, 2016

Yongbin Ruan (U Michigan)
Moduli spaces in gauged linear sigma model (GLSM)
Apr 05, 2016

Ryosuke Sato (Weizmann Inst)
Self-consistent Calculation of the Sommerfeld Enhancement
Apr 06, 2016

Benedikt Diemer (Harvard U)
The edge of darkness, and other halo surprises
Apr 07, 2016

Michael Wemyss (U Edinburgh)
Affine actions from 3-fold flops, and tilings of the plane
Apr 08, 2016

Krzysztof Gorski (JPL / Kavli IPMU)
The Future of Cosmology with the CMB
Apr 08, 2016

Alan Weinstein (UC Berkeley)
Special subspaces in symplectic vector spaces
Apr 11, 2016

Robert Lupton (Princeton U)
Difference Imaging: Algorithms, Problems, and some Possible Solutions
Apr 12, 2016

Min-Seok Seo (IBS)
On dark mesonic realization of the SIMP scheme
Apr 12, 2016

Edgar Shaghoulian (UCSB)
Modular forms, new Cardy formulas, and black hole entropy
Apr 13, 2016

Po-Yan Tseng (Natl. Tsing Hua U, Taiwan)
A Higgcision study on the 750 GeV Di-photon Resonance and 125 GeV SM Higgs boson with the Higgs-Singlet Mixing
Apr 13, 2016

Mathew Madhavacheril (Stoney Brook U)
Dark energy science from CMB lensing and cross-correlations
Apr 14, 2016

Alan Weinstein (UC Berkeley)
Geometric and algebraic Poisson modules
Apr 14, 2016

Gabriel Lopes Cardoso (Instituto Superior Técnico)
Deformed special geometry and topological string theory
Apr 19, 2016

Anatol Kirillov (RIMS, Kyoto)
Affine braid groups of classical types, baxterization and integrable systems
Apr 20, 2016

Akito Kusaka (LBNL)
Path toward next-generation CMB missions
Apr 20, 2016

Henry McCracken (IAP)
Galaxies, dark matter haloes and how efficient galaxy formation really is: new results from the UltraVISTA survey
Apr 21, 2016

Kota Ogasawara (Rikkyo U)
High energy particle collision and collisional Penrose process near a Kerr black hole
Apr 22, 2016

Jie-qiang Wu (Peking U)
Entanglement entropy and higher genus partition function in AdS_3/CFT_2
Apr 26, 2016

Razieh Emami (HongKong U)
Different aspects of Anisotropic Inflation: From Theoretical side to Observation
Apr 26, 2016

Osamu Yasuda (TMU)
Future prospects of neutrino oscillation study
Apr 27, 2016

Luca Merlo (Instituto de Física Teórica, Madrid)
The problem of the Mass in SM and Beyond
Apr 27, 2016

Jean Coupon (U Geneva)
The gas-galaxy-halo connection
Apr 28, 2016

Wilfried Buchmüller (DESY)
Grand Unification and Supersymmetry at High Scales
May 09, 2016

Eric Sharpe (Virginia Tech)
Recent developments in 2d (0,2) theories
May 10, 2016

Robert Williams (Space Telescope Science Inst)
The Distant Universe Revealed by Hubble Space Telescope
May 11, 2016

Yoshiki Oshima (Kavli IPMU)
Orbit method and characters of representations
May 12, 2016

John Carlstrom (U Chicago)
Cosmic Microwave Background: Neutrino & GUT-Scale Physics from the Cosmos
May 13, 2016

Satoshi Shirai (DESY)
Quest for Dark Matter
May 16, 2016

Valentin Tonita (Humboldt U)
K-theoretic mirror formulae
May 17, 2016

Nassim Bozorgnia (U Amsterdam)
The dark matter halo from hydrodynamic simulations
May 18, 2016

Akikazu Hashimoto (U Wisconsin, Madison)
Supergravity duals of N=4 theories in 2+1 dimensions on a Coulomb branch
May 18, 2016

Tom Melia (LBNL / UCB)
Colliding frontiers: the search for new physics at the LHC
May 23, 2016

Fredrik Bjorkeroth (Southampton U)
Towards a complete Delta(27) × SO(10) SUSY GUT
May 25, 2016

Bogdan Stoica (Caltech)
Gravitational Positive Energy Theorems from Information Inequalities
May 26, 2016

Neil Barrie (Sydney U)
Explaining the LHC 750 GeV Diphoton Excess via Photon Fusion
May 26, 2016

Chen Jiang (Kavli IPMU)
Boundedness results on Fano varieties
May 26, 2016

Junichi Yokoyama (RESCEU, U Tokyo)
Creation of an inflationary universe out of a black hole
Jun 01, 2016

Lei Hao (Shanghai Optical Observatory)
The Co-evolution of AGNs and Galaxies, Viewed from 2D Spectroscopy and Mid-infrared Spectroscopy
Jun 01, 2016

Roland Diehl (MPE)
Cosmic Gamma-Ray Lines: About supernova interiors, diffuse radioactivity, and black hole accretion
Jun 02, 2016

Johannes Walcher (U Heidelberg)
Exponential networks and representations of quivers
Jun 02, 2016

Mark K. Mezei (Princeton U)
Spread of entanglement and chaos
Jun 06, 2016

Enrico Brehm (Ludwig Maximilian U)
Entanglement, conformal field theory, and interfaces
Jun 07, 2016

Viraf M. Mehta (Heidelberg U)
Monodromy Dark Matter
Jun 08, 2016

Takuro Abe (Kyushu U)
Divisionally free arrangements of hyperplanes
Jun 16, 2016

Massimo Porrati (NYU)
On a Canonical Quantization of Pure AdS3 Gravity
Jun 21, 2016

Todor Milanov (Kavli IPMU)
The Painleve property for the Schlesinger equations
Jun 23, 2016

Hisayoshi Matsumoto (U Tokyo)
Parabolic Verma modules
Jun 25, 2016

William Raphael Hix (U Tennessee)
Multidimensional Simulations of Core-Collapse Supernovae & their Impact on Supernova Nucleosynthesis
Jun 27, 2016

Chiaki Kobayashi (U Hertfordshire)
Simulating metallicity distribution in the Universe
Jun 28, 2016

Rene Meyer (Stony Brook U)
Nonequilibrium Chiral Magnetic Effect in Asymmetric Weyl Semimetals
Jun 28, 2016

Colin Ingalls (U New Brunswick)
Noncommutative resolutions of discriminants of reflection groups
Jun 29, 2016

Kipp Cannon (RESCEU, U Tokyo)
Latest Results from Advanced LIGO's First Science Run
Jun 29, 2016

Takashi Nakamura (Kyoto U)
Physics, Astronomy and Cosmology from the first direct detection of gravitational wave
Jun 29, 2016

Shingo Kamimoto (Hiroshima U)
Iterated convolution of resurgent functions
Jun 30, 2016

Roberto Franceschini (CERN)
Precision Top mass from energy peaks
Jul 01, 2016

Bernhard Mueller (Queen's U, Belfast)
Understanding the Explosions of Massive Stars
Jul 06, 2016

Shuai Zha (Chinese U Hong Kong)
Accretion Induced Collapse of White Dwarf and its Possible Signals
Jul 07, 2016

Kyoji Saito (Kavli IPMU)
De Rham cohomology of vanishing cycles for non-isolated critical points
Jul 07, 2016

Andrew Kels (Australian National U)
Introduction to the star-triangle relation form of the Yang-Baxter equation and modern applications
Jul 12, 2016

Francesco Belfiore (U Cambridge)
The spatially resolved transition between star formation and quiescence with SDSS IV MaNGA
Jul 14, 2016

Andreas Karch (U Washington)
Particle-Vortex Duality from 3d Bosonization
Jul 26, 2016

Sho Tanimoto (U Copenhagen)
On the geometry of thin exceptional sets in Manin's conjecture
Jul 26, 2016

Hassan Firouzjahi (IPM, Tehran)
Primordial anisotropies and asymmetries during inflation
Jul 27, 2016

Sunil Mukhi (IISER Pune)
Recent Developments in the Study of Rational Conformal Field Theories
Jul 28, 2016

Wen Yin (Tohoku U)
Novel Approach to Fine-tuned Supersymmetric Standard Models, and the Explanation of the Muon Anomalous Magnetic Dipole Moment Anomaly
Jul 29, 2016

Kazuki Sakurai (Durham U)
Search for Sphalerons: LHC vs. IceCube
Aug 03, 2016

Tomoyuki Abe (Kavli IPMU)
A localization formula for epsilon factor of algebraic D-modules
Aug 04, 2016

Djordje Radicevic (Stanford U)
3D bosonization and Chern-Simons-matter theory
Aug 10, 2016

Encieh Erfani (IASBS)
Dark Matter Primordial Black Holes and their Formation
Aug 10, 2016

Lakshya Bhardwaj (Perimeter Inst for Theoretical Physics)
State-sum constructions of spin-TFTs and fermionic SPT phases
Aug 23, 2016

Yasuhito Sakaki (Kavli IPMU)
QCD jet substructure and its simulation
Aug 24, 2016

Yoshifumi Hyakutake (Ibaraki U)
Quantum Nature of D-branes
Aug 25, 2016

David Morrison (UC Santa Barbara)
Spaces with holonomy G2 and their use in M-theory
Aug 25, 2016

Jason Xavier Prochaska (UC Santa Cruz)
Rise of the Proto-Galaxy System in the Universe
Aug 31, 2016

Jason Evans (KIAS)
Natural Low-Scale Inflation and the Relaxion
Sep 07, 2016

Kallol Sen (Kavli IPMU)
Conformal bootstrap in Mellin space
Sep 21, 2016

Po-Yen Tseng (Kavli IPMU)
Z' and Lepton-Flavor Violation
Sep 21, 2016

Daisuke Kaneko (Kavli IPMU)
The result of the MEG experiment with the full dataset
Oct 05, 2016

Scott Carnahan (Tsukuba U)
Generalized Monstrous Moonshine
Oct 11, 2016

Ke-Jung Chen (NAOJ)
Multidimensional Simulations of Magnetar Powered Supernovae
Oct 13, 2016

Yalong Cao (Kavli IPMU)
Gauge Theory and Calibrated Geometry for Calabi-Yau 4-folds
Oct 13, 2016

Francisco Morales (INFN Sezione di Roma)
Exact results in N=2 gauge theories
Oct 18, 2016

Olcyr Sumensari (LPT Orsay)
B-Physics Puzzles and Lepton Flavor Violation
Oct 19, 2016

Tommaso Treu (UCLA)
The other 95%: Insights from Strong Gravitational Lensing
Oct 19, 2016

Toshiya Namikawa (Stanford U)
Cosmology beyond the B-mode spectrum from BICEP2/Keck Array
Oct 20, 2016

Harold Williams (UT Austin)
The Coherent Satake Category and Line Operators in N=2 Gauge Theory
Oct 20, 2016

Akihiro Suzuki (Kyoto U)
Radiation-hydrodynamic modeling of supernova shock breakout in multi-dimension
Oct 20, 2016

Tim Tait (UCI)
Hints for New Physics from a Rare Decay of Beryllium-8?
Oct 21, 2016

Boris Pioline (CERN)
D-instantons and indefinite theta series
Oct 21, 2016

Houjun Mo (U Massachusetts)
Lecture 1: Dark matter halos
Oct 25, 2016

Houjun Mo (U Massachusetts)
Lecture 2: Gas processes and galaxy formation
Oct 25, 2016

Takuo Matsuoka
Introduction to topological field theories
Oct 26, 2016

Houjun Mo (U Massachusetts)
Reconstructing the initial conditions to simulate the formation of the local universe
Oct 26, 2016

Petr Baklanov (ITEP Moscow)
A Massive Progenitor of Strongly Lensed Supernova Refsdal
Oct 27, 2016

Takuo Matsuoka
Introduction to topological field theories
Oct 27, 2016

David A. Nichols (Radboud U Nijmegen)
Gravitational-wave memory observables and charges of the extended BMS algebra
Oct 28, 2016

Yalong Cao (Kavli IPMU)
Gauge Theory and Calibrated Geometry for Calabi-Yau 4-folds: Part II
Oct 28, 2016

Simona Murgia (UCI)
Searching for Dark Matter with Gamma Rays
Oct 31, 2016

Ran Yacoby (Princeton U)
A 1d Theory for Higgs Branch Operators
Nov 01, 2016

Paolo Rossi (Inst Mathematics at Burgundy)
Double ramification hierarchies
Nov 01, 2016

Felix Kahlhoefer (DESY)
Dark matter self-interactions - from observations to particle physics
Nov 02, 2016

Richard Stancliffe (Argelander-Institut fur Astronomie, Bonn)
Carbon-Enhanced Metal-Poor Stars and Asymptotic Giant Branch Nucleosynthesis
Nov 08, 2016

Alexei Rosly (ITEP)
Self-Dual Yang-Mills Theory and Twistors
Nov 08, 2016

Zvonimir Vlah (KIPAC)
Towards understanding the Large-Scale Structure in the Universe using perturbation theory
Nov 09, 2016

Samuel Jones (HITS, Heidelberg)
Supernovae and their progenitor systems
Nov 10, 2016

Yalong Cao (Kavli IPMU)
Gauge Theory and Calibrated Geometry for Calabi-Yau 4-folds: Part III
Nov 11, 2016

Andrei Ionov (HSE)
Primitive forms for Gepner singularities
Nov 14, 2016

Charles Kirkham Rhodes (U of Illinois, Chicago)
Decoding the perfect Universe
Nov 15, 2016

Gabi Zafrir (Kavli IPMU)
4d N=1 from 6d (1,0)
Nov 15, 2016

Patrick Francois (Observatoire de Paris-Meudon)
The search for the oldest stars in our Galaxy
Nov 16, 2016

Philipp Edelmann (HITS, Heidelberg)
Hydrodynamics of Rotating Stars
Nov 17, 2016

Tatsuki Kuwagaki (U Tokyo)
Homological mirror symmetry via constructible sheaves
Nov 18, 2016

Mikhail Kapranov (Kavli IPMU)
Geometric Satake correspondence
Nov 21, 2016

Satoshi Yamaguchi (Osaka U)
The $\in$-expansion of the codimension two twist defect from conformal field theory
Nov 22, 2016

Atsushi Kanazawa (Kyoto U)
Tyurin conjecture and SYZ mirror symmetry
Nov 28, 2016

Miguel A. Vazquez-Mozo (Universidad de Salamanca)
Planar zeros in gauge theories and gravity
Nov 29, 2016

Elisabeth Krause (U Stanford)
Combining Cosmological Probes in the Dark Energy Survey, and Beyond
Dec 06, 2016

Yuya Tanizaki (RIKEN BNL Research Center)
Cheshire Cat Resurgence and Quasi-Exact Solvability
Dec 06, 2016

Danilo Marchesini (Tufts U)
The Assembly of Today's Most Massive Galaxies Over the Last 12.8 Gyr
Dec 07, 2016

Gary Hill (U Texas)
HETDEX: the Hobby-Eberly Telescope, VIRUS, and the evolution of dark energy
Dec 08, 2016

Alexey Bondal (Kavli IPMU)
Canonical relative tilting generator
Dec 08, 2016

Daniel Jafferis (Harvard U)
Bulk reconstruction in the Hartle-Hawking formalism
Dec 09, 2016

Aleksey Cherman (U Washington)
Constructing expansion parameters for QCD-type theories
Dec 13, 2016

Manos Chatzopoulos (Louisiana State U)
Pre-supernova Convection in Massive Stars
Dec 13, 2016

Gerald Dunne (U Connecticut)
On Perturbative/Non-perturbative Relations
Dec 14, 2016

Peter Behroozi (UC Berkeley)
The Connection between Galaxy Growth and Dark Matter Halo Assembly from z=0-10
Dec 15, 2016

Martin Bureau (U Oxford)
3D Observations of Molecular Gas in Galaxies: From Global Dynamics to Supermassive Black Holes
Dec 22, 2016

Igor Klebanov (Princeton U)
Random Tensor Models and Melonic Large N Limits
Jan 05, 2017

Dmitry Budker (Johannes Gutenberg University)
Searching for ultralight dark matter with atomic spectroscopy and magnetic resonance
Jan 06, 2017

David Simmons-Duffin (IAS)
The Lightcone Bootstrap and the Spectrum of the 3d Ising CFT
Jan 10, 2017

Masahiro Nozaki (U Chicago)
Entanglement Entropy in Smooth Quenches
Jan 10, 2017

Erwin Lau (Yale U)
Modeling baryonic physics in galaxy clusters
Jan 11, 2017

Frederico Garcia (Institute of Radioastronomy, Argentina)
Observable properties of accretion disks in Kerr spacetimes
Jan 12, 2017

Francesco Sala (Kavli IPMU)
K-HA/CoHA of the stack of Higgs sheaves on a curve
Jan 12, 2017

Devendra Sahu (IIAP)
Peculiar Type Ia Supernovae - An Observational Perspective
Jan 13, 2017

Gary Lowe (Montana State U)
Collapsar Model of Gamma Ray Bursts with MHD
Jan 16, 2017

Susanne Reffert (U Bern)
Global properties of gauge theories via M-Theory
Jan 17, 2017

Domenico Orlando (U Bern)
Compensating strong coupling with large charge
Jan 17, 2017

Ryosuke Sato (Weizmann Institute)
Spherical symmetry of the bounce solution
Jan 18, 2017

Alexander Heger (Monash U)
Life and Death of the First Stars
Jan 18, 2017

Kenneth Wong (NAOJ)
A Tale of Three Lenses: From Galaxy Structure to Cosmology
Jan 19, 2017

Milen Yakimov (Louisiana State U)
Double Bruhat cells, clusters and maximal green sequences
Jan 25, 2017

Antonio Sciarappa (KIAS)
Painlevé equations and AGT correspondence
Jan 27, 2017

Kin-Wang Ng (Academia Sinica)
1. Production of high stellar-mass primordial black holes in trapped inflation / 2. Axion Dark Matter Induced Cosmic Microwave Background B-modes
Jan 27, 2017

Marco Bertolini (Kavli IPMU)
(0,2) hybrid models
Jan 31, 2017

Elena Sorokina (Moscow State U)
Theoretical Models for Hydrogen-poor Superluminous Supernovae
Feb 01, 2017

Xue-Bing Wu (KIAA, Peking U)
Ultraluminous quasars with the most massive black holes at cosmic dawn
Feb 02, 2017

Qizheng Yin (ETH Zurich)
Curves and cycles on K3 surfaces
Feb 07, 2017

Marco Chianese (U Naples)
Dark Matter interpretation of the IceCube diffuse neutrino flux
Feb 08, 2017

Kimyeong Lee (KIAS)
Higher Dimensional Quantum Theories
Feb 14, 2017

Yue-Lin Sming Tsai (NCTS, Taiwan)
Ultra-Light Axion Dark Matter and its impacts on dark halo structure in N-body simulation
Feb 15, 2017

Arka Banerjee (UIUC)
Simulating nonlinear cosmological structure formation with massive neutrinos
Feb 15, 2017

Masahiko Yoshinaga (Hokkaido U)
Characteristic polynomials of Linial arrangements
Feb 16, 2017

Susmita Adhikari (UIUC)
Splashback and outskirts of Dark Matter halos
Feb 16, 2017

Patricio Gallardo (U Georgia)
On geometric invariant theory for hypersurfaces and their hyperplane sections
Feb 21, 2017

Yoshihisa Saito (U Tokyo)
On quantized elliptic algebras
Feb 21, 2017

Jack Kearney (FNAL)
A (The?) Higgs Vacuum Instability During Inflation
Feb 22, 2017

Igor Panov (ITEP)
Nucleosynthesis of heavy elements in the r-process
Feb 22, 2017

Ming-Chung Chu (Chinese U of Hong Kong)
The Degeneracy of Cosmic Neutrinos
Feb 23, 2017

Anupama Chakrapani (Inidian Institute of Astrophysics)
The Thirty Meter Telescope - India Perspective
Feb 23, 2017

Marc-Hubert Nicole (Institut mathematique de Marseille)
Algebraic Cycles and Modular Forms
Feb 24, 2017

Peiwen Wu (KIAS)
Top and Top+Charm Flavored Scalar Dark Matter with a Vector-like Fermion Partner
Feb 24, 2017

Michele Frigerio (CNRS)
Non-perturbative analysis of the spectrum of meson resonances in an ultraviolet-complete composite-Higgs model
Mar 01, 2017

Takahiro Nishinaka (Kyoto U)
Superconformal index of Argyres-Douglas theories of class S
Mar 07, 2017

Kohei Kamada (Arizona State U)
The interplay between the primordial magnetic fields and particle physics
Mar 08, 2017

Dennis Gaitsgory (Harvard U)
Langlands conjecture for function fields via shtukas
Mar 13, 2017

Nick Battaglia (Princeton U)
Cosmology with Shadows in the Microwave Sky
Mar 13, 2017

Giulio Rosani (ARI Heidelberg)
The Influence of Galaxy Environment on the Stellar Initial Mass Function of Early-Type Galaxies
Mar 14, 2017

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2016/09/05 - 09/08

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2016/09/05 - 09/08 , 2017/01/23 - 01/27

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2016/04/18 - 04/29 , 05/29 - 08/13 , 10/03 - 10/28 , 11/06 - 12/30 , 2017/03/15 - 05/31

Kooktae Kim
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Kota Ogasawara
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U Hyogo
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Kunimoto Komatsu
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2016/10/24 - 11/11 , 11/29 - 12/09 , 2017/02/06 - 03/03

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2016/06/19 - 06/28

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Sokendai
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Robert Cousins
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2016/03/30 - 04/22 , 08/22 - 08/27 , 11/15 - 11/23

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2016/06/25 - 07/21

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2017/02/13 - 02/15

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Sadayoshi Kojima
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Sakurako Okamoto
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Sampei Usui
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Samuel Jones
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2016/11/06 - 11/19

Sandy Sihan Yuan
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Sanghoon Jeon
Sungkyunkwan U
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Sangmin Lee
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Vadim Schechtman
U Paul Sabatier
2016/10/16 - 10/30

Valentin Tonita
Humboldt U
2016/05/10 - 05/22 , 12/07 - 12/10

Valentin V Khoze
Duhram University
2017/03/20 - 03/30

Vanessa McBride
University of Cape Town
2016/08/15 - 08/19

Victor Przhiyalkovskiy
Steklov Math. Inst.
2016/11/13 - 11/19

Vincenzo Berardi
INFN Bari
2017/02/13 - 02/15

Viraf M Mehta
Heidelberg University
2016/06/03 - 06/09

Vladimir Kazalov
Baksan Neutrino observatory
2017/02/06 - 02/18

Wanmin Liu
IBS, POSTECH
2017/01/22 - 01/29

Wanqiu He
Tohoku U
2016/08/22 - 08/27

Wen Yin
Tohoku U
2016/07/29

Werner Tornow
Duke U
2017/01/17 - 01/24

Wilfried Buchmller
DESY
2016/05/09 - 05/10

William Raphael Hix
U Tennessee
2016/06/27 - 06/28

Wing Yan Ma
Imperial Coll. London
2016/05/30 - 06/01

Wonqook Choi
KISTI
2016/05/30 - 06/01

Xiaohui Fan
U Arizona
2016/08/22 - 08/27

Xiaoyi Cui
Goettingen U
2016/07/29 - 10/04 , 2017/02/06 - 04/28

Xue-Bing Wu
KIAA, Peking U.
2017/02/02 - 02/03

Yasuhiro Nishimura
U Tokyo, ICRR
2016/05/30 - 06/01 , 2017/02/13 - 02/15 , 03/27 - 03/29

Yasuyuki Kawahigashi
U Tokyo, Math Sci
2016/09/27

Yen-Ting Lin
ASIAA
2016/04/06 - 04/28 , 08/21 - 08/26

Yeongmin Jang
Chonnam National U
2017/03/27 - 03/29

Yi-Kuan Chiang
U Tokyo, ICRR
2016/08/22 - 08/26 , 08/29 - 08/31

Yifan Jin
U Tokyo
2017/03/27 - 03/29

Yinbang Lin
Tsinghua U, Beijing
2017/03/18 - 03/26

Ying-Tung Chen
ASIAA
2016/08/22 - 08/26

YIPENG JING
Shanghai Jiao Tong U
2016/08/23 - 08/31

Yohei Itoh
U Tokyo, Math Sci
2017/01/23 - 01/27

Yohei Kashima
U Tokyo
2016/09/27

Yongbin Ruan
U Michigan
2016/04/02 - 04/09

Yoshi Uchida
Imperial Coll. London
2016/05/30 - 06/01 , 2017/02/13 - 02/15

Yoshiaki Goto
Otaru University of Commerce
2017/01/23 - 01/27

Yoshiaki Ono
U Tokyo, ICRR
2016/08/22 - 08/26

Yoshiaki Seino
Niigata U.
2016/06/23

Yoshifumi Hyakutake
Ibaraki U
2016/08/25

Yoshihiko Yamada
NAOJ
2016/08/23 - 08/25

Yoshihisa Saito
U Tokyo, Math Sci
2017/02/21

Yoshiki Matsuoka
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2016/08/22 - 08/27

Yoshiki Toba
ASIAA
2016/08/22 - 08/27

Yoshinari Hayato
U Tokyo, ICRR
2016/05/31 - 06/01 , 2017/02/13 - 02/15

Yoshitaka Itow
Nagoya U
2017/02/13 - 02/16

Yoshitsugu Takei
Kyoto U
2016/12/12 - 12/16

Yoshiyuki Onuki
U Tokyo, ICEPP
2016/06/13 - 06/17 , 06/23 - 06/24 , 06/30 - 07/01 , 07/04 - 07/07 , 07/15 , 07/18 - 07/20 , 07/22 , 07/26 - 07/27 , 08/03

Yota Shamoto
Kyoto U
2016/09/05 - 09/08 , 2017/01/23 - 01/27

Young-Kee Kim
U Chicago
2016/08/19 - 08/23

Youngju Ko
CAU
2016/05/30 - 06/01

Yousuke Utsumi
Hiroshima U
2016/08/22 - 08/26

Yu-Chi Cheng
NCU
2016/08/22 - 08/26

Yu-Jing Qin
KIAA, Peking U.
2016/07/11 - 07/15

Yu-Wei Fan
Harvard U
2017/01/04 - 01/13

Yudai Suwa
Kyoto U
2017/02/13 - 02/15

Yue Wang
SUNY, Stony Brook
2016/05/30 - 06/01

Yue-Lin Sming Tsai
NCTS
2017/02/13 - 02/24

Yufeng Li
IHEP, CAS
2016/05/30 - 06/01

Yuichi Harikane
U Tokyo, ICRR
2016/08/23 - 08/31

Yuichi Higuchi
ASIAA
2016/08/22 - 08/28

Yuichi Ike
U Tokyo, Math Sci
2017/01/23 - 01/27

Yuichiro Hoshino
Waseda U
2016/09/27

Yuichiro Tanaka
U Tokyo, Math Sci
2017/01/23 - 01/27

Yuji Chinone
UC Berkeley
2016/09/20 - 09/21

Yuji Okajima
Tokyo Tech
2017/02/13 - 02/15

Yuji Shirasaki
NAOJ
2016/08/23 - 08/25

Yuji Urata
NCU
2016/08/23 - 08/25

Yuki Kimura
Tohoku U
2016/08/23 - 08/25

Yuki Okura
RIKEN
2016/08/22 - 08/26

Yukie Oishi
NAOJ
2016/08/23 - 08/25

Yukiko Konishi
Kyoto U
2017/01/23 - 01/27

Yuri Efremenko
U Tennessee
2016/11/27 - 12/07

Yuri Kudenko
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2017/02/13 - 02/15

Yuri Yatagawa
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2017/01/23 - 01/27

Yusuke Hayashi
NAOJ
2016/08/23 - 08/25

Yusuke Koshio
Okayama U
2017/02/13 - 02/15

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2017/01/16 - 01/20

Yutaka Komiyama
NAOJ
2016/08/23 - 08/25

Yutaka Ushiroda
KEK
2016/04/01 , 04/25 , 06/29 , 09/06 , 11/18

Yutaro Sonoda
U Tokyo, ICRR
2017/02/13 - 02/15

Yuto Ichinohe
Tokyo Metropolitan U
2016/08/23 - 08/25

Yuuki Shiraishi
Kyoto U
2016/09/05 - 9/08 , 11/14 - 11/18 , 2017/03/13 - 03/17

Yuval Flicker
Ohio State U
2017/03/15 - 07/11

Yuya Dan
Matsuyama U
2016/09/27

Yuya Tanizaki
RIKEN BNL
2016/12/12 - 12/16

Zha Shuai
CUHK
2016/06/28 - 07/19 , 11/07 - 11/22 , 2017/02/23 - 02/24

Zheng Hua
HKU
2017/03/20 - 03/23

Zheng Zheng
U Utah
2016/08/29 - 09/01

Zoya Vallari
SUNY, Stony Brook
2016/05/30 - 06/01

Zvonimir Vlah
Stanford U
2016/11/04 - 11/15

10 PUBLICATIONS

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8. Polypolar spherical harmonic decomposition of galaxy correlators in redshift space: Toward testing cosmic rotational symmetry
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M; Kawabata, M; Morihana, K; Morikawa, Y; Murakami, K; Nagayama, T; Ono, T; Onozato, H; Sarugaku, Y; Sato, M; Suzuki, D; Takahashi, J; Takayama, M; Yaguchi, H; Akitaya, H; Asakura, Y; Kawabata, KS; Kuroda, D; Nogami, D; Oasa, Y; Omodaka, T; Saito, Y; Sekiguchi, K; Tominaga, N; Uemura, M; Watanabe, M
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22. Development of an Optical Coupling with Ground-Side Absorption for Antenna-Coupled Kinetic Inductance Detectors
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29. Zooming on the internal structure of $z \simeq 6$ galaxies
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Y. Tachikawa, K. Yonekura
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IPMU16-0162
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Toshiyuki Kobayashi

IPMU16-0163
Shortening Anomalies in Supersymmetric Theories
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IPMU16-0164
A map of the non-thermal WIMP
Hyungjin Kim, Jeong-Pyong Hong, Chang Sub Shin
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Alexander Kusenko, Lauren Pearce, Louis Yang
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Masahito Yamazaki
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Conformal geometry and branching problems in reporesentation theory
Toshiyuki Kobayashi

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Yalong Cao, Chen Jiang
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Primordial black holes from supersymmetry in the early universe
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On Longevity of I-ball/Oscillon
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On homotopy Lie bialgebroids
Denis Bashkirov, Alexander A. Voronov
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IPMU16-0199
An effective selection method for low-mass active black holes and first spectroscopic identification
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Alexey Tolstov, Ken'ichi Nomoto, Nozomu Tominaga, Miho Ishigaki, Sergey Blinnikov, Tomoharu Suzuki
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Antonio De Felice, Shinji Mukohyama, Michele Oliosi
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Takashi J. Moriya, Brian D. Metzger, Sergei I. Blinnikov
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IPMU16-0211
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Takashi J. Moriya, Paolo A. Mazzali, Nozomu Tominaga, Stephan Hachinger, Sergei I. Blinnikov, Thomas M. Tauris, Koh Takahashi, Masaomi Tanaka, Norbert Langer, Philipp Podsiadlowski
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Thomas Rink, Kai Schmitz, Tsutomu T. Yanagida
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IPMU16-0215
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Toshiyuki Kobayashi
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IPMU17-0001
Conformal symmetry breaking operators for anti-de Sitter spaces
Toshiyuki Kobayashi, Toshihisa Kubo, Michael Pevzner
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IPMU17-0002
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Hiroko Niikura, Masahiro Takada, Naoki Yasuda, Robert H. Lupton, Takahiro Sumi, Surhud More, Anupreeta More, Masamune Oguri, Masashi Chiba
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Pawel Caputa, Yuya Kusuki, Tadashi Takayanagi, Kento Watanabe
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A. A. Volnova et al.
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IPMU17-0005
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Andrea Addazi, Sergei V. Ketov
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IPMU17-0006
Inflation from (R+gamma R^n -2 Lambda) gravity in higher dimensions
Sergei V. Ketov, Hiroshi Nakada

IPMU17-0007
Higgs mechanism and cosmological constant in N=1 supergravity with a vector multiplet
Yermek Aldabergenov, Sergei V. Ketov
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IPMU17-0008
Gravitino Problem in Minimal Supergravity Inflation
Fuminori Hasegawa, Kyohei Mukaida, Kazunori Nakayama, Takahiro Terada, Yusuke Yamada
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IPMU17-0009
Inflationary Primordial Black Holes as All Dark Matter
Keisuke Inomata, Masahiro Kawasaki, Kyohei Mukaida, Yuichiro Tada, Tsutomu T. Yanagida
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IPMU17-0010
Clustering of infrared-bright dust-obscured galaxies revealed by the Hyper Suprime-Cam and WISE
Yoshiki Toba, Tohru Nagao, Masaru Kajisawa, Taira Oogi, Masayuki Akiyama, Hiroyuki Ikeda, Jean Coupon, Michael A. Strauss, Wei-Hao Wang, Masayuki Tanaka, Mana Niida, Masatoshi Imanishi, Chien-Hsiu Lee, Hideo Matsuhara, Yoshiki Matsuoka, Masafusa Onoue, Yuichi Terashima, Yoshihiro Ueda, Yuichi Harikane, Yutaka Komiyama, Satoshi Miyazaki, Akatoki Noboriguchi, Tomonori Usuda
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Guillem Domenech, Takashi Hiramatsu, Chunshan Lin, Misao Sasaki, Maresuke Shiraishi, Yi Wang
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IPMU17-0012
On Vertex Operators in Effective String Theory
Simeon Hellerman, Shunsuke Maeda
arXiv:1701.06406

IPMU17-0013
4d N=1 from 6d N=(1,0) on a torus with fluxes
Ibrahima Bah, Amihay Hanany, Kazunobu Maruyoshi, Shlomo S. Razamat, Yuji Tachikawa, Gabi Zafrir
JHEP 1706 (2017) 022, arXiv:1702.04740

IPMU17-0014
An Alternative Method of Determining the Neutrino Mass Ordering in Reactor Neutrino Experiments
S. M. Bilenky, F. Capozzi, S.T. Petcov
Phys. Lett. B772 (2017) 179-183, arXiv:1701.06328

IPMU17-0015
Operator Dimensions from Moduli
Simeon Hellerman, Shunsuke Maeda, Masataka Watanabe
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IPMU17-0016
Cornering Compressed Gluino at the LHC
Natsumi Nagata, Hidetoshi Otono, Satoshi Shirai
JHEP 1703 (2017) 025, arXiv:1701.07664

IPMU17-0017
Schur indices with class S line operators from networks and further skein relations
Noriaki Watanabe
arXiv:1701.04090

IPMU17-0018
Higher Kac-Moody algebras and moduli spaces of G-bundles
Giovanni Faonte, Benjamin Hennion, Mikhail Kapranov
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IPMU17-0019
Dirac CP phase in the neutrino mixing matrix and the Froggatt-Nielsen mechanism with det[M_ν]=0
Yuya Kaneta, Morimitsu Tanimoto, Tsutomu T. Yanagida
Phys. Lett. B770 (2017) 546-550, arXiv:1701.08938

IPMU17-0020
K-semistable Fano manifolds with the smallest alpha invariant
Chen Jiang
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IPMU17-0021
Dark Matter Candidates in a Visible Heavy QCD Axion Model
Hajime Fukuda, Masahiro Ibe, Tsutomu T. Yanagida
Phys. Rev. D95 (2017) no.9, 095017, arXiv:1702.00227

IPMU17-0022
Stable pairs on nodal K3 fibrations
Amin Gholampour, Artan Sheshmani, Yukinobu Toda
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IPMU17-0023
Localized Donaldson-Thomas theory of surfaces
Amin Gholampour, Artan Sheshmani, Shing-Tung Yau
arXiv:1701.08902

IPMU17-0024
Nested Hilbert schemes on surfaces: Virtual fundamental class
Amin Gholampour, Artan Sheshmani, Shing-Tung Yau
arXiv:1701.08899

IPMU17-0025
Relaxation leptogenesis, isocurvature perturbations, and the cosmic infrared background
Masahiro Kawasaki, Alexander Kusenko, Lauren Pearce, Louis Yang
Phys. Rev. D95 (2017) no.10, 103006, arXiv:1701.02175

IPMU17-0026
New-Type Charged Q-ball Dark Matter in Gauge Mediated SUSY Breaking Models
Jeong-Pyong Hong, Masahiro Kawasaki
Phys. Rev. D95 (2017) no.12, 123532, arXiv:1702.00889

IPMU17-0027
Universality in volume law entanglement of pure quantum states
Hiroyuki Fujita, Yuya O. Nakagawa, Sho Sugiura, Masataka Watanabe
arXiv:1703.02993

IPMU17-0028
Probing a dark photon using rare leptonic kaon and pion decays
Cheng-Wei Chiang and Po-Yan Tseng

IPMU17-0029
No inflation in type IIA strings on rigid CY spaces
Yuki Wakimoto, Sergei V. Ketov
PTEP 2017 (2017), no. 8, 083E02, arXiv:1703.08993

IPMU17-0030
Complete complexes and spectral sequences
Mikhail Kapranov, Evangelos Routis
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IPMU17-0031
The ALP miracle: unified inflaton and dark matter
Ryuji Daido, Fuminobu Takahashi, Wen Yin
JCAP 1705 (2017) no.05, 044, arXiv:1702.03284

IPMU17-0032
Anomaly Matching on the Higgs branch
Hiroyuki Shimizu, Yuji Tachikawa, Gabi Zafrir
arXiv:1703.01013

IPMU17-0033
Anisotropic deformations of spatially open cosmology in massive gravity theory
Charles Mazuet, Shinji Mukohyama, Mikhail S. Volkov
JCAP 1704 (2017) no.04, 039, arXiv:1702.04205

IPMU17-0034
Extending bimetric models of massive gravity to avoid to rely on the Vainshtein mechanism on local scales and the Higuchi bound on cosmological scales
Antonio De Felice, Shinji Mukohyama, Jean-Philippe Uzan
arXiv:1702.04490

IPMU17-0035
The RESOLVE Survey Atomic Gas Census and Environmental Influences on Galaxy Gas Reservoirs
David V. Stark, Sheila J. Kannappan, Kathleen D. Eckert, Jonathan Florez, Kirsten R. Hall, Linda C. Watson, Erik A. Hoversten, Joseph N. Burchett, David T. Guynn, Ashley D. Baker, Amanda J. Moffett, Andreas A. Berlind, Mark A. Norris, Martha P. Haynes, Riccardo Giovanelli, Adam K. Leroy, D. J. Pisano, Lisa H. Wei, Roberto E. Gonzalez, Victor F. Calderon
Astrophys. J, 832 (2016),126, arXiv:1610.06932

IPMU17-0036
SDSS-IV MaNGA: Constraints on the Conditions for Star Formation in Galaxy Disks
David V. Stark, Kevin A. Bundy, Matthew E. Orr, Philip F. Hopkins, Kyle Westfall, Matthew Bershady, Cheng Li, Dmitry Bizyaev, Karen L. Masters, Anne-Marie Weijmans, Daniel Thomas, Renbin Yan, Kai Zhang, Niv Drory

IPMU17-0037
Higher derivatives in Type II and M-theory on Calabi-Yau threefolds
Thomas W. Grimm, Kilian Mayer, Matthias Weissenbacher
arXiv:1702.08404

IPMU17-0038
Holographic Entanglement Entropy on Generic Time Slices
Yuya Kusuki, Tadashi Takayanagi, Koji Umemoto
JHEP 1706 (2017) 021, arXiv:1703.00915

IPMU17-0039
Anti-de Sitter Space from Optimization of Path Integrals in Conformal Field Theories
Pawel Caputa, Nilay Kundu, Masamichi Miyaji, Tadashi Takayanagi, Kento Watanabe
Phys. Rev. Lett. 119 (2017) 071602, arXiv:1703.00456

IPMU17-0040
A Gauged $U(1)$ Peccei-Quinn Symmetry
Hajime Fukuda, Masahiro Ibe, Motoo Suzuki, Tsutomu T. Yanagida
Phys. Lett. B771 (2017) 327-331, arXiv:1703.01112

IPMU17-0041
New Kaluza-Klein Instantons and Decay of AdS Vacua
Hirosi Ooguri, Lev Spodyneiko
arXiv:1703.03105

IPMU17-0042
The sign of the dipole-dipole potential by axion exchange
Ryuji Daido, Fuminobu Takahashi
Phys. Lett. B772 (2017) 127-129, arXiv:1704.00155

IPMU17-0043
Two-loop Anomalous Dimensions for Four-Fermi Operators in Supersymmetric Theories
Junji Hisano, Takumi Kuwahara, Yuji Omura, Takeki Sato
Nucl. Phys. B922 (2017) 77-93, arXiv:1703.08329

IPMU17-0044
Contractions and deformations
Will Donovan
arXiv:1511.00406

IPMU17-0045
Perverse schobers and wall crossing
Will Donovan
arXiv:1703.00592

IPMU17-0046
Out-of-Time Ordered correlators in $(T^2)^n/Z_n$
Pawel Caputa, Yuya Kusuki, Tadashi Takayanagi, Kento Watanabea
arXiv:1703.09939

IPMU17-0047
CFT descriptions of bulk local states in the AdS black holes
Kanato Goto, Tadashi Takayanagi
arXiv:1704.00053

IPMU17-0048
Primordial black holes and *r*-process nucleosynthesis
G.M. Fuller, A. Kusenko, V. Takhistov
Phys. Rev. Lett. 119 (2017) 061101, arXiv:1704.01129

IPMU17-0049
On finite symmetries and their gauging in two dimensions
Lakshya Bhardwaj
arXiv:1704.02330

IPMU17-0050
Higgsino Dark Matter or Not: Role of Disappearing Track Searches at the LHC and Future Colliders
Hajime Fukuda, Natsumi Nagata, Hidetoshi Otono, Satoshi Shirai
arXiv:1703.09675

IPMU17-0051
All-order volume conjecture for closed 3-manifolds
Dongmin Gang, Mauricio Romo, Masahito Yamazaki
arXiv:1704.00918

12 Conference Presentations and Seminar Talks

Seminar talks given at the Kavli IPMU are not included. For seminar talks given at the Kavli IPMU, see Section 8.

FY2016

The Interplay Between Local and Global Processes in Galaxies
(2016.04.11 - 2016.04.15, Cozumel, Mexico)
David Stark
Multi-Scale Environmental Influences on Galaxy Gas Content

Subaru's synergy with space missions in 2020s
(2016.04.21 - 2016.04.22, NAOJ Mitaka)
Naoyuki Tamura
Subaru's synergy with space missions: From the viewpoint of PFS

Southeastern Regional Mathematical String Theory Meeting
(2016.04.23, Virginia Tech, Blacksburg VA, USA)
Taizan Watari
Heterotic--Type IIA duality and degeneration of K3 surface

KIAS Algebraic Seminar
(2016.04.26 - 2016.04.29, KIAS)
Chen Jiang
On boundedness problem of Fano varieties I, II

Beauty 2016
(2016.05.02, Marseille, France)
Hitoshi Murayama
Theory in the LHC era overview and vision

Wolfgang Paul Lecture
(2016.05.03, Bonn University)
Hitoshi Murayama
The Quantum Universe

Theory Special Seminar
(2016.05.04, Bonn University, Germany)
Hitoshi Murayama
Two themes on Goldstone: generalization and dark matte

Caltech Colloquium
(2016.05.05, Caltech)
Hitoshi Murayama
When a Symmetry Breaks

Tokyo-Princeton algebraic geometry conference
(2016.05.08, Princeton University)
Chen Jiang
Binational boundedness of singular log Fano 3-folds

Pheno 2016
(2016.05.09 - 2016.05.11, Pittsburgh University, USA)
Hitoshi Murayama
Future Perspectives

Revealing the history of the universe with underground particle and nuclear research 2016
(2016.05.11 - 2016.05.13, U. Tokyo)
Shigeki Matsumoto
Current Status and Future Prospects of WIMP Paradigm

Cross-correlation Spectacular with LSST: Exploring Synergies Between LSST and External Datasets to Discover Fundamental Physics
(2016.05.22 - 2016.05.25, Brookhaven National Lab & Stony Brook University)
Masahiro Takada
SuMIRe: Subaru imaging and spectroscopic galaxy surveys (invited talk)

GTM Seminar
(2016.05.26, Kavli IPMU)
Chen Jiang
Boundedness results on Fano varieties

The 1st KEK-KIAS-NCTS Joint Workshop on Particle Physics Phenomenology
(2016.05.26 - 2016.05.28, NCTS, Taiwan)
Shigeki Matsumoto
Current Status and Future Prospects of WIMP Paradigm

PhyStat
(2016.05.30 - 2016.06.01, Kavli IPMU)
Hitoshi Murayama
the future of experimental neutrino physics

The Third International Meeting for Large Neutrino Infrastructures
(2016.05.30 - 2016.05.31, KEK)
Hitoshi Murayama
Neutrinos and cosmology

Euclid Consortium Meeting 2016
(2016.05.30 - 2016.06.03, Lisbon, Portugal)
Masahiro Takada
A proposal/discussion on Subaru HSC Ultra-Wide Survey (for Euclid) (invited)

Journees SL2R
(2016.06.09 - 2016.06.10, Metz, France)
Toshiyuki Kobayashi
Branching Problems and Symmetry Breaking Operators

Kyoto Algebraic Geometry seminar
(2016.06.10, University of Kyoto)
Will Donovan
Contractions and deformations

ULTIMATE-Subaru science workshop
(2016.06.16 - 2016.06.17, NAOJ Mitaka)
Naoyuki Tamura & Kiyoto Yabe
ULTIMATE & PFS

New perspective on theory and observation of large-scale structure
(2016.06.16, YITP, Kyoto University)
Masahiro Takada
Cosmic Covariance 2.5:1

Math-Physics seminar
(2016.06.17 - 2016.07.17, IHES)
Artan Sheshmani
Nested Hilbert schemes and local DT theories

Darboux seminar
(2016.06.17 - 2016.07.17, IHP)
Artan Sheshmani
Donaldson Thomas theory, Modular forms, and S-duality conjecture.

Kyoto Mirror Symmetry seminar
(2016.06.17, University of Kyoto)
Will Donovan
General 3-fold flops and perverse sheaves of categories

Neutrinos and Light Particles in Cosmology
(2016.06.22 - 2016.06.24, UCBerkeley, California, USA)
Hitoshi Murayama
Introduction Neutrino s and Cosmology

Neutrinos and Light Particles in Cosmology
(2016.06.22 - 2016.06.24, UC Berkeley, USA)
Masahiro Takada
Neutrinos from lensing surveys I (invited)

SPIE2016
(2016.06.26 - 2016.07.01, University of Glasgow, UK)
Hitoshi Murayama
Studying the birth and the fate of the Universe

SPIE Astronomical Telescopes and Instrumentation
(2016.06.26 - 2016.07.01, Edinburgh International Conference Centre)
Naoyuki Tamura
Prime Focus Spectrograph for the Subaru Telescope: overview, recent progress, and future perspectives

Understanding the First Results form LHC Run II
(2016.06.27 - 2016.07.22, Mainz University)
Michihisa Takeuchi
di-photon from QCD bound states

Analysis on Manifolds with Symmetries and Related Structures.
(2016.06.28 - 2016.06.29, Bath, UK)
Toshiyuki Kobayashi
Global Geometry and Analysis on Locally Symmetric Spaces with Indefinite-metric

particle theory seminar
(2016.06.30, TU Dortmund University)
Feng Luo
Gluino Coannihilation

SUSY 2016
(2016.07.03 - 2016.07.08, The University of Melbourne, Australia)
Hitoshi Murayama
Outlook

Algebraic Geometry Seminar
(2016.07.05, Graduation School of Mathematical Science, Komaba Campus, The University of Tokyo)
Dulip Piyaratne
Generalized Bogomolov-Gieseker type inequality for Fano 3-folds

PASCOS 2016
(2016.07.10 - 2016.07.16, ICISE, Vietnam)
Shigeki Matsumoto
Estimating J-factors of dSphs for indirect dark matter detections

MPP
(2016.07.11, MPP Munich, Germany)
Matthias Weissenbacher
Higher derivative IIB supergravity in Calabi-Yau orientifolds

From theory to applications: celebrating a century of gravitational lensing
(2016.07.11 - 2016.07.15, Leiden, The Netherlands)
Alessandro Sonnenfeld
Luminous and dark matter in earlytype galaxies: a tale of many lenses

Physics seminar
(2016.07.14, Tohoku University)
Hitoshi Murayama
Goldstone bosons, effective operators, and dark pions

METU Algebraic Geometry seminar
(2016.07.15, Middle East Technical University, Ankara, Turkey)
Will Donovan
Twists and braids for general 3-fold flops

7th European Congress of Mathematics
(2016.07.18 - 2016.07.22, Berlin)
Will Donovan
Twists and braids for general 3-fold flops

Geometry, Representation Theory and the Baum-Connes Conjecture (in honor of Professor Baum for his 80th birthday))
(2016.07.18 - 2016.07.22, Fields Institute, Tronto, Canada)
Toshiyuki Kobayashi
Conformally Covariant Symmetry Breaking Operators on Differential Forms and Some Applications

ILC Summer school
(2016.07.23 - 2016.07.26, Itsukushien, Ichinoseki, Iwate)
Hitoshi Murayama
Aim of ILC

Mini workshop on Seiberg-Witten Floer stable homotopy type
(2016.07.23 - 2016.07.24, University of Tokyo)
Tirasan Khandhawit
Unfolded Seiberg-Witten Floer spectra

Geometric and algebraic aspects of integrability
(2016.07.28 - 2016.08.04, Durham, UK)
Todor Milanov
Eynard--Orantin recursion for simple singularities of type A

Tambara Summer School 2016
(2016.07.30 - 2016.08.03, Tambara Institute of Mathematical Sciences, The University of Tokyo)
Chen Jiang
Birkar's Anti-pluricanonical systems on Fano varieties explanation

Tambara Summer School 2016
(2016.07.30, Tambara Institute of Mathematical Sciences, The University of Tokyo)
Chen Jiang
On Fujita spectrum and Fujita invariants

Mapping the Pathways of Galaxy Transformation Across Time and Space
(2016.07.31 - 2016.08.05, Catalina Island, USA)
Wiphu Rujopakarn
JVLA and ALMA Spatially-Resolved Observations of Intensely Star-Forming Regions in Galaxies at z ~ 1-3 in the Hubble Ultra-Deep Field

Twists and braids for general 3-fold flops
(2016.08.17, Hong Kong University)
Will Donovan
Twists and braids for general 3-fold flops

Mini Workshop on Knot theory
(2016.08.19, PMI, Pohang, South Korea)
Dongmin Gang
3-manifolds and 3 dimensional superconformal field theories

Quantum theory of finite temperature
(2016.08.22 - 2016.08.24, Riken, Japan 2016)
Shigeki Matsumoto
Current status and Future prospects of WIMP dark matter

Workshop on Lie groups and representation theory
(2016.08.24, Aarhus University)
Yoshiki Oshima
Characters of unitary representations and semisimple coadjoint orbits

On explicit description of holomorphic symplectic varieties
(2016.08.29 - 2016.09.01, Onuma International Seminar House)
Dulip Piyaratne
Generalized Bogomolov-Gieseker type inequality for Fano 3-folds

Crossing the Rubicon: The fate of gas flows in galaxies
(2016.09.05 - 2016.09.09, Santarcangelo di Romagna)
Andreas Schulze
Insight into the fueling and feedback of AGN through their mass functions and accretion rate distribution functions

Invisible 16 school
(2016.09.05 - 2016.09.09, SISSA, Italy)
Shigeki Matsumoto
Theoretical aspects of dark matter

Workshop on Volume Conjecture and Quantum Topology
(2016.09.06 - 2016.09.09, Nishi-Waseda Campus, Waseda University Tokyo, JAPAN)
Dongmin Gang
A State integral model for SL(2) Chern-Simons theory on closed hyperbolic 3-manifolds

MSJ Autumn Meeting 2016
(2016.09.15 - 2016.09.18, Kansai University)
Yoshiki Oshima
Unitary representations of real reductive Lie groups and orbit method

70th anniversary lecture (featured invited talk), Mathematical Society of Japan
(2016.09.15 - 2016.09.18, Kansai University, Japan,)
Toshiyuki Kobayashi
Birth of New Branching Problems

Derived categories and Chow groups of hyperkaehler and Calabi-Yau varieties
(2016.09.19 - 2016.09.23, Simons Center at Stony Brook University, USA)
Dulip Piyaratne
Stability conditions and Fourier-Mukai theory

Symposium by group of optical and infrared astronomy in Japan
(2016.09.26 - 2016.09.28, NAOJ, Mitaka)
Naoyuki Tamura
Prime Focus Spectrograph: Development updates, collaboration policy, future plans

Distinguished BSA Lecture
(2016.10.04 - 2016.10.07, Brookhaven National Laboratory, NY, USA)
Hitoshi Murayama
The Quantum Universe

Colloquium at KMI
(2016.10.05, Nagoya U.)
Shigeki Matsumoto
Current Status and Future Prospects of WIMP

Algebraic Geometry Seminar
(2016.10.06 - 2016.10.07, KIAS, Korea)
Dulip Piyaratne
Stability conditions on derived categories of varieties I, II, III

2016 International Conference on Ultra-High Energy Cosmic Rays
(2016.10.11 - 2016.10.14, Kyoto)
Alexander Kusenko
Summary Talk of UHECR-2016 conference

Duham KEK KIPMU KIAS Workshop
(2016.10.24 - 2016.10.28, KIAS, Seoul, Korea)
Hitoshi Murayama
SIMP dark matter and EFT

The 6th KIAS Workshop on particle physics and cosmology
(2016.10.24, Seoul, Korea)
Han, Chengcheng
Recent stop searches in the Natural SUSY

First stars and first galaxies
(2016.10.25 - 2016.10.27, Kanazawa)
Masahiro Takada
Upper bound on the abundance of PBH with HSC observation of M31

Seminar @ Tokyo Metropolitan University
(2016.10.25, Tokyo Metropolitan University)
Shigeki Matsumoto
Current status & Future prospect on WIMP searches

7th KIAS workshop on cosmology and structure formation
(2016.10.30 - 2016.11.04, Korea Institute of Advanced Study)
Naoyuki Tamura
Subaru Prime Focus Spectrograph: Overview, current status, and future perspectives (invited talk)

Yale Physics Colloquium
(2016.11.01, Yale University, Connecticut, USA)
Hitoshi Murayama
When a Symmetry Breaks

Fall school for Dark matter
(2016.11.09, NAOJ)
Hitoshi Murayama
Strongly Interacting Massive Particle

Dark Matter Autumn School
(2016.11.09, NJO)
Shigeki Matsumoto
Current status and future prospects of WIMP searches

Fermilab Joint Experimental-Theoretical Physics seminar (Wine and cheese seminars)
(2016.11.11, Fermilab)
Christophe Bronner
Neutrino oscillation results from T2K

Categorical and Analytic invariants IV
(2016.11.14 - 2016.11.18, Kavli IPMU)
Dulip Piyaratne
Modification of Bogomolov-Gieseker type inequality conjecture and Fano 3-folds

SDSS MaNGA Team Meeting
(2016.11.14 - 2016.11.19, Shanghai, China)
David Stark
What Sets the Conditions for Star Formation in Outer Galaxy Disks

Categorical and Analytic invariants in Algebraic geometry IV
(2016.11.14 - 2016.11.18, Kavli IPMU)
Todor Milanov
K-theoretic Gromov--Witten invariants in genus 0 and integrable hierarchies

JAXA lecture
(2016.11.16, JAXA)
Hitoshi Murayama
Modern cosmology and space borne instruments

NCTS Algebraic Geometry Day, II
(2016.11.18, National Cheng Kung University)
Chen Jiang
Birationality problem on varieties with numerically trivial canonical divisors

The 5th workshpo of observational cosmology
(2016.11.23 - 2016.11.26)
Tomomi Sunayama
Shift of Baryon Acoustic Oscillation as a function of galaxy bias

The 5th workshpo of observational cosmology
(2016.11.24 - 2016.11.26, Hiroshima University)
Masahiro Takada
Cosmology with cosmic large-scale structures

Representation Theory Seminar
(2016.11.25, RIMS)
Yoshiki Oshima
Determinant formula for parabolic Verma modules of Lie superalgebras

Geometry and Topology Seminar
(2016.11.25, University of Waterloo, Canada)
Francesco Sala
Moduli spaces and stacks of sheaves on resolutions of toric singularities

SFB-Seminar
(2016.11.25)
Will Donovan
Deformations: classical and modern

CosPA 2016
(2016.11.28 - 2016.12.02, The University of Sydney)
T. Yanagida
Neutrino Masses in the Landscape of Vacuua

Symposium on Parity Violation and Neutrino Physics
(2016.11.28 - 2016.11.29, Shanghai Jiao Tong University)
Hitoshi Murayama
CP Violation

The 13th International Symposium on Cosmology and Particle Astrophysics
(2016.11.28 - 2016.12.02, the University of Sydney)
Tsutomu Yanagida
Neutrino Masses in the Landscape of Vacuua (Invited)

Panoramas of the evolving cosmos - the 6th Subaru international conference
(2016.11.28 - 2016.12.02, International conference center Hiroshima)
Naoyuki Tamura
Prime Focus Spectrograph (PFS) for the Subaru Telescope: A very wide-field, massively multiplexed, optical and near-infrared spectrograph

The 6th Subaru international conference "Panoramas of the Evolving Cosmos"
(2016.11.28 - 2016.12.02, Hiroshima)
Masahiro Takada
Tightest upper bound on the abundance of PBH with dense-cadence HSC observation of M31

Symposium of Representation Theory
(2016.11.29 - 2016.12.02, Okinawa)
Toshiyuki Kobayashi
Conformal geometry and branching problems in reporesentation theory (2 lectures)

Algebraic geometry seminar
(2016.12.02, Nagoya University)
Will Donovan
Applications of noncommutative deformations

The Universal Problem of the Non-Universal IMF
(2016.12.05 - 2016.12.09, Lorentz Center, Leiden, The Netherlands)
Alessandro Sonnenfeld
Dry merger evolution and stellar IMF

Harmonic analysis on Lie groups and group algebras of locally compact groups
(2016.12.05 - 2016.12.09, TSIMF, China)
Yoshiki Oshima
The orbit method and characters of representations for real reductive groups

HINT 2016
(2016.12.05 - 2016.12.08, J-PARC)
Christophe Bronner
Physics potential of the current neutrino oscillation program in Japan

Focus Workshop on Particle Physics and Cosmology
(2016.12.05, IBS, Daejeon)
Shigeki Matsumoto
TeV scale WIMP and Astrophysics

PFS collaboraton in JHU
(2016.12.12 - 2016.12.16, Johns Hopkins University, Maryland,USA)
Hitoshi Murayama
PFS collaboration updates

PFS collaboraton in JHU
(2016.12.12 - 2016.12.16, Johns Hopkins University, Maryland,USA)
Hitoshi Murayama
PFS collaboration updates

PFS meeting
(2016.12.12 - 2016.12.17, Johns Hopkins University)
Tomomi Sunayama
How n(z) for ELGs affects Baryon Acoustic Oscillation

Current Topics in String Theory : Conformal field theories
(2016.12.15 - 2016.12.17, KIAS in Korea)
Dongmin Gang
Simple 3d SCFTs and simple 3-manifolds

Arithmetic and algebraic geometry in Tokyo
(2016.12.15, University of Tokyo)
Will Donovan
Applications of noncommutative deformations

Current Topics in String Theory
(2016.12.15 - 2016.12.17, KIAS, Seoul, South Korea)
Gabi Zafrir
4d N=1 from 6d (1,0)

Algebraic Geometry
(2016.12.18 - 2016.12.22, Hanga Roa, Chile)
Will Donovan
Applications of noncommutative deformations

Interactions between topological recursion, modularity, quantum invariants, and low-dimensional topology
(2016.12.18 - 2016.12.23, Melbourne University, Creswick Campus)
Todor Milanov
Hurwitz Frobenius manifolds and K. Saito's primitive forms

JST Workshop topological quantum strategy
(2016.12.19, JST, Chiyoda, Tokyo)
Hitoshi Murayama
Spontaneous symmetry breaking, soliton, topology

Winter School on Higher Categories and TQFTs
(2016.12.19 - 2016.12.23, Gangwon, South Korea)
Alexander A. Voronov
Higher Categories and TQFTs

Christmas Workshop on Quivers, Moduli Spaces and Integrable Systems
(2016.12.19 - 2016.12.21, Department of Mathematics, Università degli Studi di Genova, Italy)
Francesco Sala
K-HA/CoHA of the stack of Higgs sheaves on a curve

Rironkon Symposium
(2016.12.20 - 2016.12.22, Tohoku University)
Masahiro Takada
Recent progresses in studies of cosmic large-scale structure (invited)

AMS Special Session on Harmonic Analysis (In Honor of Gestur Olafsson's 65th Birthday)
(2017.01.04, Atlanta)
Toshiyuki Kobayashi
Conformally Covariant Symmetry Breaking Operators on Differential Forms and Some Applications (invited)

The 2017 Workshop on Algebraic Geometry
(2017.01.04 - 2017.01.06, Xiamen University)
Chen Jiang
Remarks on Kawamata's effective non-vanishing conjecture"

KMI2017
(2017.01.05 - 2017.01.07, Nagoya U.)
Shigeki Matsumoto
Unexplored region of WIMP

Higher Dimensional Algebraic Geometry, Holomorphic Dynamics and Their Interactions
(2017.01.09 - 2017.01.20, National University of Singapore)
Chen Jiang
Explicit birational geometry of Fano and Calabi-Yau 3-folds

Higher Dimensional Algebraic Geometry, Holomorphic Dynamics and Their Interactions
(2017.01.09 - 2017.01.20, National University of Singapore)
Chen Jiang
Explicit birational geometry of Fano and Calabi-Yau 3-folds

Subaru Users Meeting FY2016
(2017.01.10 - 2017.01.12, NAOJ, Mitaka campus)
Naoyuki Tamura
Subaru Prime Focus Spectrograph (PFS) project (invited)

IPMU week @ Berkeley
(2017.01.11 - 2017.01.13, Berkeley University)
Matthias Weissenbacher
String Length Induced Operators in EFT

IPMU Week
(2017.01.11 - 2017.01.13, UC Berkeley)
Peter Cox
The Unnatural Composite Higgs at the LHC

Particle Phenomenology Mini Workshop
(2017.01.18, R312, New Physics Building, Nationa Taiwan University)
Po-Yan Tseng

Invited Colloquium, NRAO
(2017.01.19, National Radio Astronomy Observatory; Charlottesville, USA)
Wiphu Rujopakarn
Probing the peak epoch of galaxy assembly with VLA and ALMA

JSPS-RFBR Collaboration Workshop
(2017.01.20 - 2017.01.21, Nagoya University)
Itamar Yaakov
Supersymmetric Renyi Entropy - information, localization and defects

Seminar
(2017.01.23, JAXA)
Masahiro Takada
Tightest bounds on PBH abundance with HSC observation of M31

D modules and Hodge theory
(2017.01.23 - 2017.01.27, Kavli IPMU)
Yoshiki Oshima
Tropical geometric compactifications and Satake compactifications

Galaxy Group, Steward Observatory/National Optical Astronomy Observatory
(2017.01.30, University of Arizona, Tucson)
Wiphu Rujopakarn
Probing the peak epoch of galaxy assembly with ultra-deep VLA and ALMA surveys

Seminaire de analyse, geometrie et algebre
(2017.02.02, Institut Elie Cartan de Lorraine, Metz, France.)
Francesco Sala
Faisceaux de Higgs sur une courbe et algebres de Hall

Holography, Quantum Entanglement and Higher Spin Gravity
(2017.02.06 - 2017.02.07, YITP, Kyoto)
Itamar Yaakov
Supersymmetric Renyi Entropy and Defect Operators

Seminaire de geometrie et quantisations
(2017.02.06, Institut Henri Poincare, Paris, France)
Francesco Sala
Faisceaux de Higgs sur une courbe et algebres de Hall

Seminarie de geometrie et systemes dynamiques
(2017.02.07, Institut de Mathematiques de Bourgogne, Dijon, France)
Francesco Sala
Faisceaux de Higgs sur une courbe et algebres de Hall

Seminaire de geometrie algebrique
(2017.02.09, IMJ-PRG and ENS, Paris, France)
Francesco Sala
Faisceaux de Higgs sur une courbe et algebres de Hall

Geometry, Analysis, and Mathematical Physics
(2017.02.13 - 2017.02.17, Kyoto University)
Todor Milanov
Primitive forms and Frobenius structures on the Hurwitz spaces

Hitchin systems in mathematics and physics
(2017.02.13 - 2017.02.17, Perimeter Institute, Waterloo, Canada)
Francesco Sala
Higgs sheaves on a curve and Hall algebras

Echigo Yuzawa Symposium
(2017.02.13 - 2017.02.17, Echigo Yuzawa)
Chen Jiang
Remarks on Kawamata's effective non-vanishing conjecture

New Ideas in Stringphenomenology 2017
(2017.02.14 - 2017.02.17, DESY, Hamburg, Germany)
Taizan Watari
Revisiting Kronecker's Jugendtraum

78th meeting of ICFA
(2017.02.16 - 2017.02.17, ICFA, Valencia, Spain)
Hitoshi Murayama
ILC Progress in Japan

Derived category and birational geometry
(2017.02.20 - 2017.02.23, Graduate School of Science Building, Osaka University, Japan)
Dulip Piyaratne
Stability conditions, Bogomolov-Gieseker type inequalities and Fano 3-folds

Derived category and birational geometry
(2017.02.20 - 2017.02.23, Osaka University)
Will Donovan
Perverse sheaves of categories and birational geometry

2017 Fudan Young Mathematicians Forum
(2017.02.27 - 2017.03.02, Fudan University)
Chen Jiang
Remarks on Kawamata's effective non-vanishing conjecture

Superconformal Field Theories in Four or More Dimensions
(2017.03.05 - 2017.03.11, Aspen Center for Physics, Aspen, USA)
Gabi Zafrir
Anomaly polynomials, 6d (1,0) SCFTs and 4d N=1 SCFTs

Algebraic geometry seminar
(2017.03.06, Scuola Internazionale Superiore di Studi Avanzati, Trieste)
Will Donovan
Perverse sheaves of categories and birational geometry

String Theory Seminar
(2017.03.06, Duke University)
Marco Bertolini
B-model correlators in hybrid models

Current Topics in Algebraic and Symplectic Geometry
(2017.03.06 - 2017.03.10, Kyoto University)
Yoshiki Oshima
Tropical geometric compactification of moduli spaces of abelian varieties and K3 surfaces

Physics seminar
(2017.03.06, KIAS, Seoul)
Itamar Yaakov
Supersymmetric Renyi Entropy and Defects

Cosmic acceleration conference
(2017.03.08 - 2017.03.10, KEK)
Naoyuki Tamura
Updates on the PFS project

Why does the Universe accelerate?-Exhaustive study and challenge for the future-
(2017.03.08 - 2017.03.10, KEK)
Masahiro Takada
Updates in B03 group and PBH constraints with HSC observation of M31

Algebraic Geometry Seminar
(2017.03.10, Facultad de Matematicas, Pontificia Universidad Catolica de Chile, Chile)
Dulip Piyaratne
Stability conditions on derived categories of varieties I, II

AG seminar
(2017.03.10, Fudan University)
Chen Jiang
On alpha-invariants of Fano varieties

SCJ Symposium Seek the horizon of astrophysics
(2017.03.11 - 2017.03.12, UTokyo)
Hitoshi Murayama
Is the Current Process to Select Big Projects Appropriate?

JPS conference (symposium)
(2017.03.17 - 2017.03.20, Osaka U.)
Shigeki Matsumoto
Physics of Dark Sector

Mathematics and Superstring Theory
(2017.03.21 - 2017.03.23, IPMU)
Dongmin Gang
All-order Volume conjecture for closed 3-manifolds

Subaru International Partnership Science and Instrumentation Workshop
(2017.03.22 - 2017.03.24, NAOJ, Tokyo)
Masahiro Takada
Subaru large surveys (HSC and PFS)

Matsue Phenomenology workshop
(2017.03.24 - 2017.03.25, Shimane U.)
Shigeki Matsumoto
Electroweakly interacting massive particle

Seminar
(2017.03.27, University of Arizona)
Masahiro Takada
Constraining PBH with Subaru HSC Observation of M31

The AGB-Supernovae Mass Transition
(2017.03.27 - 2017.03.31, Rome, Italy)
Alexey Tolstov
Supernova explosions of 8-12 solar mass stars: light curve simulations

13 OUTREACH AND PUBLIC RELATIONS

The Kavli IPMU continues to convey the importance and pleasure of our research on physics and mathematics of the universe to the general public through a variety of outreach programs.

April :
- Kavli IPMU and ICRR Co-Host Public Lecture "Decoding the Universe"
- General Theory of Relativity Holds True 13 Billion Light Years from Earth

May :
- Director Murayama Speaks at Symposium on Science and Technology Diplomacy
- Supermassive Black Hole Wind Can Stop New Stars from Forming

June :
- Kavli IPMU Public Lecture Held with Lisa Randall

July :
- Science Café Universe 2016
- Hyper Suprime-Cam Found an "Ancient Eye" in the Sky

August :
- Booth at the 2016 Super Science High School Student Fair
- A Program to Encourage Female Students to Study Science: "Look into the Universe"
- Ninth External Advisory Committee Meeting
- KamLAND-Zen Searched for Neutrinoless Double β Decay with World Record Sensitivity

September :
- Booth at the New Scientist Live in London
- FY2016 WPI Site Visit

October :
- Open Campus Kashiwa 2016

November :
- Minister of State Yosuke Tsuruho Visits Kavli IPMU
- Event: "Actually I Really Love Physics! —Career Paths of Female Physics Graduates"
- 15th Kavli IPMU/ICRR Joint Public Lecture, "The Observable Universe and Beyond"

December :
- VLA and ALMA Team up to Give First Look at Birthplaces of Most Current Stars
- Kavli IPMU Staff Received the University of Tokyo's Special Award for Operational Improvement in 2016

January :
- Kavli IPMU / ELSI Joint Public Lecture "A Question of Origins"

February :
- AAAS 2017 Annual Meeting in Boston
- Director Murayama Talked at the WPI 10th Anniversary Symposium
- First Public Data Released by Hyper Suprime-Cam Subaru Strategic Program

March :
- Meeting of WPI Center Administrative Directors Held at Kavli IPMU
- Japanese Class Completion Ceremony
- Workshop –Searching for the Lost Study– Art × Science × Philosophy

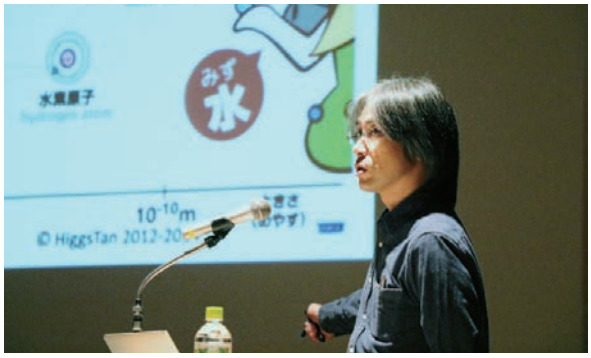
Kavli IPMU and ICRR Co-Host Public Lecture "Decoding the Universe"

More than 280 young teenagers and adults took part in the 14th Kavli IPMU and Institute for Cosmic Ray Research (ICRR) public lecture "Decoding the Universe" at Amuser Kashiwa in Kashiwa city on April 16, 2016.

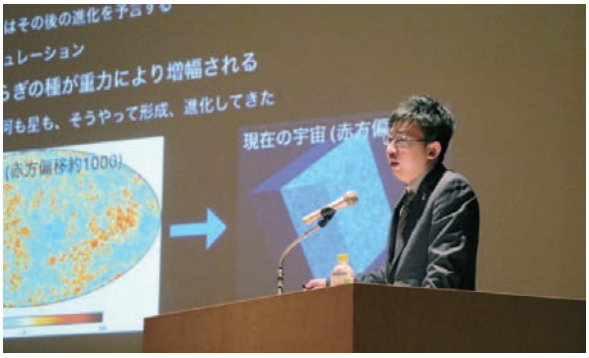
Following a welcoming from ICRR Director Takaaki Kajita, ICRR Associate Professor and Kavli IPMU Scientist Yoshinari Hayato gave a talk titled "Neutrinos: What we've learned, and what remains a mystery." He explained what neutrino oscillations were, their interesting properties, and about the research being carried out at the Super-Kamiokande.

Then, Kavli IPMU Assistant Professor Takahiro Nishimichi gave a talk titled "Subaru Telescope: Using big data to uncover the dark properties of the Universe." He talked about topics in precise cosmological theory needed to correctly interpret huge amounts of data from the Hyper-Suprime Cam attached to the Subaru Telescope in Hawaii. He also said "Big-Data Astronomy" using statistical methods and super computers to deal with astronomical big data from observations, is

becoming important in astronomy.
Afterwards, the audience was invited to the hall's foyer to chat and discuss ideas with the speakers.



Yoshinari Hayato giving a talk.



Takahiro Nishimichi giving a talk.

General Theory of Relativity Holds True 13 Billion Light Years from Earth

A team led by Kavli IPMU Postdoctoral Researcher Teppei Okumura and Kavli IPMU Assistant Professor Chiaki Hikage, together with University of Tokyo Department of Astronomy Professor Tomonori Totani, have found that 13 billion light years from Earth, Einstein's general theory of relativity still holds true.
The scientists first used data from the FastSound galaxy survey, collected using the Subaru Telescope, to analyze the velocity and clustering of more than 3000 galaxies about 13 billion light years away, and created a 3D map of the distant universe. By studying the galaxy map in more detail, the researchers managed to calculate the rate at which the distant universe was expanding due to gravity, and found that it was in agreement with the general theory of relativity within experimental uncertainty. This result confirmed the general theory of relativity is correct, and supports the idea that the expansion of the universe could be explained by a cosmological constant which Einstein had proposed.
The results were published online in *Publications of the Astronomical Society of Japan* on April 26, and scientists in the future will need to consider this outcome when developing new models.

Director Murayama Speaks at Symposium on Science and Technology Diplomacy

Kavli IPMU Director Hitoshi Murayama spoke about science and technology diplomacy at an event attended by senior government officials and academics at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo on May 24, 2016.
Hosted by the Cabinet Office, Ministry of Foreign Affairs, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Economy, Trade and Industry, and GRIPS, the symposium was an opportunity to discuss the current state and future of science and technology in diplomacy, taking into account the G7 Ise-Shima Summit that took place from May 26-27.
Murayama pointed out that international organizations such as CERN and a synchrotron light source SESAME under construction in Jordan have led world peace efforts by allowing scientists from different countries to work together. He called on government officials to allow Japan to share its knowledge with other countries, and support future fundamental science projects to further contribute to world peace.
Other notable talks included a welcoming from Minister of Foreign Affairs Fumio Kishida, a speech from Science and Technology Advisor to the Minister of Foreign Affiars Teruo Kishi, and a panel discussion on "A New Direction for Japan's Diplomacy through Science and Technology" between distinguished guests, including Murayama, to debate how Japan's science and technology can better contribute to the global society.

Hitoshi Murayama (far right) with other panelists (Courtesy of the Ministry of Foreign Affairs of Japan)

Supermassive Black Hole Wind Can Stop New Stars from Forming

Kavli IPMU Postdoctoral Researcher Edmond Cheung and Kavli IPMU Assistant Professor Kevin Bundy have led an international collaboration that discovered a new class of galaxies called red geysers, where supermassive black hole winds are energetic enough to heat the surrounding gas and suppress star formation. As part of the MaNGA (Mapping Nearby Galaxies at Apache Point Observatory) project using the Sloan Digital Sky Survey telescope and its spectrograph attachment, the team caught red geyser galaxies heating gas within its host galaxy. Despite the fact these galaxies had enough gas for star formation, the wind from the black hole would create an environment too hot for star formation.

The study was published online in *Nature* on May 26, 2016. Also, in this issue of the *Kavli IPMU News No. 34*, Kevin Bundy explains this study, see pp. 4-9.

Kavli IPMU Public Lecture Held with Lisa Randall

On June 19, 2016, Harvard University Professor of Physics Lisa Randall delivered her lecture in the 21 Komcee Lecture Hall at the Komaba campus of the University of Tokyo, where 200 people attended the full house event. To begin, Shinji Mukohyama, Professor at the Kyoto University Research Institute for Fundamental Physics and Kavli IPMU Visiting Senior Scientist, delivered a lecture titled "Beyond the Imagined 4th Dimension." He explained that from superstring theory — which is thought to be the ultimate theory because it can describe all of the forces of nature, including gravity — extra dimensions beyond the 4-dimensional spacetime are derived. However, as the justification for such extra dimensions cannot be observed, theories have emerged such as that extra dimensions are compactified in such a way that at every point in the 4-dimensional spacetime, there exists a small circle, and that the visible 4-dimensional spacetime clings to a brane inside a higher-dimensional space.

Next, Lisa Randall delivered a lecture titled "Dark Matter and the Dinosaur Extinction." Kavli IPMU Director Hitoshi Murayama, who also provided extended commentary on the points raised, interpreted Randall's presentation into Japanese. Randall raised a new theory — which was introduced in her recently published book for the general public — where a comet collides with the dark matter found in our Milky Way Galaxy, causing the object to impact with the Earth, and possibly resulting in the extinction of dinosaurs.

A question and answer session followed the lectures. Murayama asked questions sourced from the audience — which had been written on post-it notes stuck to a whiteboard — to which the presenters gave answers. Even after the event, the speakers made themselves available, and were surrounded by many inquirers.

Lisa Randall giving a talk, interpreted by Hitoshi Murayama


Shinji Mukohyama giving a talk


(From left) Shinji Mukohyama, Lisa Randall, and Hitoshi Murayama answer questions submitted by the audience

Science Café Universe 2016

The annual "Science Café Universe 2016" was held at the Tamarokuto Science Center (TSC) in NishiTokyo City, jointly sponsored by the Kavli IPMU and the TSC. Two lectures were given, first in July and then in September.

On July 3, Kavli IPMU Postdoctoral Fellow Ryo Namba talked about "Primordial Gravitational Waves and Magnetic Fields from the Very Early Universe: Forefront of Cosmology." About 40 people listened, 70% being high-school and junior high-school students.

On September 4, Kavli IPMU Postdoctoral Fellow Akishi Ikeda talked about the"Deep Relation between Mathematics and Physics: Equation of Everything Derived from Principle of Least Action." About 50 people listened, 80% being high-school and junior high-school students.

During his lecture, Ryo Namba took time out to talk to each group of the audience sitting around the same table.

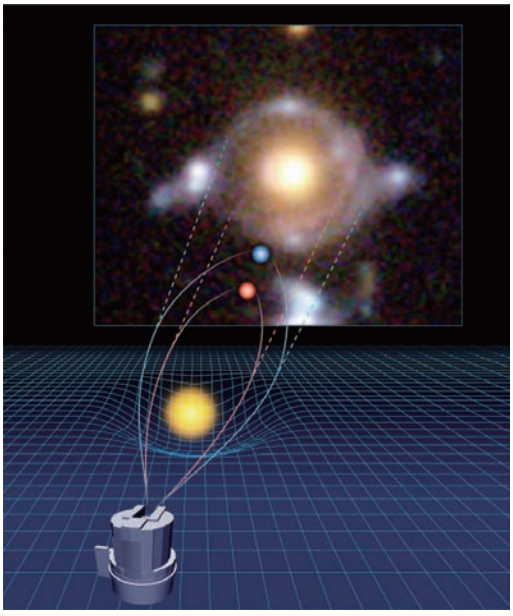
Akishi Ikeda giving a lecture.

Hyper Suprime-Cam Found an "Ancient Eye" in the Sky

An international team of researchers from the National Astronomical Observatory of Japan (NAOJ), Kavli IPMU, and other institutes have discovered a rare gravitational lensing effect in the images obtained from the Subaru Telescope's Hyper Suprime-Cam (HSC). It suggests lensing by a foreground galaxy of two background galaxies at different distances. The rare finding has been dubbed the "Eye of Horus" because of its eye-like appearance, resembling the eye of Horus, the ancient Egyptian sky god.

This discovery was reported in *Astrophysical Journal Letters* on July 25, 2016. Researchers involved in the discovery include Kavli IPMU Postdoctoral Fellows Anupreeta More and Alessandro Sonnenfeld as well as the University of Tokyo Graduate School of Science Assistant Professor Masamune Oguri, who is also Kavli IPMU Associate Scientist. It should also be noted that the first author of this paper, NAOJ Assistant Professor Masayuki Tanaka was at the Kavli IPMU as a Postdoctoral Fellow until March 2013.

In the HSC survey, it is expected to find 10 more systems of the same kind.



Schematic diagram showing the location of galaxies creating the gravitational lens effect of Eye of Horus. A galaxy at 7 billion light years from the Earth bends the light from the two galaxies behind it, one at 9 billion light years, and the other at 10.5 billion light years. (Credit: NAOJ)

Booth at the 2016 Super Science High School Student Fair

On August 10 and 11, the 2016 Super Science High School Student Fair was held at the Kobe International Exhibition Hall in Kobe, Hyogo Prefecture. The Kavli IPMU and other 8 WPI centers jointly ran a booth exhibiting their research activities.

A Program to Encourage Female Students to Study Science: "Look into the Universe"

On August 20, 2016, a Program to Encourage Female Students to Study Science, "Look into the Universe," was held at the Kavli IPMU. A total of 70 people, including junior high-school and high-school girls, their parents, and teachers listened to two lectures given by Chicago University Professor Young-Kee Kim, who was a former Deputy Director of Fermilab. The lectures were given in English and interpreted consecutively by Kavli IPMU Director Hitoshi Murayama in Japanese. After the lectures, there was a Q&A session, and finally, the attendants enjoyed friendly conversation with Professor Kim and Director Murayama.

Ninth External Advisory Committee Meeting

On August 22, 2016, the 9th Meeting of the Kavli IPMU External Advisory Committee was held. Chairman Steve Kahn (Stanford/SLAC), and all the committee members, John Ellis (King's College London), Young-Kee Kim (University of Chicago), Sadayoshi Kojima (Tokyo Institute of Technology), David Morrison (UC Santa Barbara), Sadanori Okamura (Hosei University), and Nigel Smith (SNOLAB), were present.

This time, the purpose of the Meeting was to prepare for the FY2016 WPI site visit, and the Committee discussed topics such as "Whether the research and implementation plan of the IPMU as a WPI center, proposed in 2007 when it was launched, has been fully achieved?" and "Whether the preparation for the five years of extension period is appropriate?" and provided many useful comments and suggestions.

Kavli IPMU External Advisory Committee members discussing with researchers during tea time.

KamLAND-Zen Searched for Neutrinoless Double β Decay with World Record Sensitivity

If neutrinos are Majorana particles (the anti-neutrino is the same as the neutrino), neutrinoless double-beta decay ($0\nu\beta\beta$) offers decisive evidence for it, and neutrinos may be responsible for the dominance of matter over antimatter in the Universe. As a result, a number of experiments world-wide are in intense competition to discover $0\nu\beta\beta$.

The KamLAND-Zen international collaboration, led by Kunio Inoue (Director of the Research Center for Neutrino Science, Tohoku University and Kavli IPMU Principal Investigator), has been searching for $0\nu\beta\beta$ in an unprecedented amount of Xenon-136, the isotope where the double-beta decay occurs, using its ultra-low background liquid-scintillator detector located 1000 m underground in the Kamioka mine in Gifu Prefecture. Kavli IPMU Assistant Professor Alexandre Kozlov is one of the main players in this experiment. Recently, KamLAND-Zen succeeded in dramatically improving the upper limit of $0\nu\beta\beta$ rate by a factor of 6. This result has been published in Physical Review Letters on August 16, 2016 and selected as an Editors' Suggestion paper.

Booth at the New Scientist Live in London

From September 22 through 25, 2016, a science event "New Scientist Live" was held in London. Eight Japanese universities and research institutes, including the Kavli IPMU, OIST (The Okinawa Institute of Science and Technology), Osaka University, RIKEN, and NAOJ (National Astronomical Observatory of Japan) jointly ran an exhibition booth, titled "The Best of Japan Science."

FY2016 WPI Site Visit

An FY2016 WPI site visit was conducted on September 29 and 30 to evaluate the scientific results recorded by the Kavli IPMU researchers since the launch of the Institute from scratch in October 2007, the level of achievement of the initial implementation plan of the Institute as a WPI center, and its progress plan during the extension period starting from FY2017. The site visit team consisted of WPI Program Director (PD) Toshio Kuroki, Deputy PD Akira Ukawa, Program Officer (PO) in charge of the Kavli IPMU Ichiro Sanda, PO in charge of Tokyo Institute of Technology's Earth-Life Science Institute (ELSI) Shoken Miyama, members of the Working Group in charge of the Kavli IPMU (Hiraku Nakajima, Yutaka Hosotani, Tetsuji Miwa, Matthias Staudacher, Ian Shipsey, and Anthony Tyson), some of the WPI Program Committee members (Maki Kawai and Michiharu Nakamura), MEXT and JSPS officers, Takuya Saito (Director, Office for the Promotion of Basic Research, the Basic Research Promotion Division, Research Promotion Bureau) and others.

The first day was devoted to the overview report by Kavli IPMU Director Murayama and presentations by Kavli IPMU researchers on representative research accomplishments as well as 19 poster presentations by young researchers.

In the morning of the second day, Director Murayama presented the progress plan of the Kavli IPMU. The University of Tokyo's President Makoto Gonokami and Executive Vice President for Research Kazuo Hotate joined the discussion and, together with the Kavli IPMU management, answered various questions from the site visit team. In the final session, PD, POs, and members of the Working Group expressed their comments, and the site visit was adjourned.

Director Hitoshi Murayama explaining the Kavli IPMU's future activity program to the site visit team.

Open Campus Kashiwa 2016

On October 21 and 22, 2016, the University of Tokyo's Kashiwa Campus held an open campus under the banner "Kashiwa Knowledge: Discover and Experience."

At the Kavli IPMU lecture hall, two public lectures were given. On the first day, Kavli IPMU Associate Professor Naoyuki Tamura spoke about "A Survey of the Universe with the PFS (Prime Focus Spectrograph), A New Spectrometer for the Subaru Telescope, Will Observe an Unprecedented Number of Galaxies and Stars at the Same Time." The next day, Kavli IPMU Director Hotoshi Murayama spoke about "Ripples in Spacetime—Gravitational Waves Open Up a New Way to Probe the Universe—."

In addition, Kavli IPMU Professor Naoki Yoshida and Kavli IPMU Artist-in-Residence Norimichi Hirakawa, a media artist who stayed at the Kavli IPMU twice in July and September 2016, had a conversation about "Common Features between Science and Art."

The Kavli IPMU also presented a two-day program including an exhibition of artist Hirakawa's new media art pieces inspired by his residence at the Kavli IPMU, "Research at Kavli IPMU" poster presentations, mathematical puzzles, guided tours of the Kavli IPMU building, a display of books written or recommended by IPMU researchers, and a screening of Particle Fever. This is a documentary film that follows the lives of six researchers as they search for answers about how our universe was made, and witnesses moments of scientific breakthrough at the Large Hadron Collider. It has Japanese subtitles, in cooperation with UC Berkeley Professor and Kavli IPMU Visiting Senior Scientist Yasunori Nomura, and by Kavli IPMU staff.

In two days, a total of 9,600 people visited the campus. The Kavli IPMU attracted more than 2,900 people

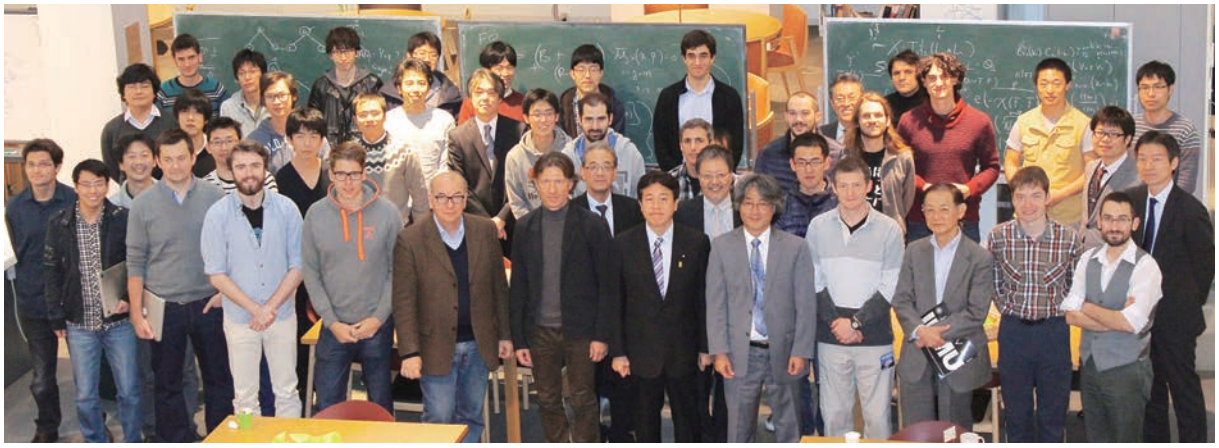
Note: Readers who are interested in Mr. Hirakawa's Artist-in-Residence story at the Kavli IPMU can find his report as well as an Artist Interview in this issue of the *Kavli IPMU News No. 36* (pp. 20–23).

Naoyuki Tamura, giving a lecture.

Minister of State Yosuke Tsuruho Visits Kavli IPMU

On November 11, Minister of State for Science and Technology Policy Yosuke Tsuruho visited the Kavli IPMU, accompanied by Yoshio Yamawaki (Director General for Science, Technology and Innovation of Cabinet Office), Yasuyoshi Kakita (Director, Promotion Policy Division, Research Promotion Bureau of Ministry of Education, Culture, Sports, Science and Technology), and other government officers.

Director Hitoshi Murayama began by presenting an overview of the Kavli IPMU and its research activities. He also explained the World Premier International Research Center Initiative (WPI) as well as the present status of the SuMIRe project conducted under the Cabinet Office's Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST) and the applications and technologies derived from basic research. Then, after having looked over the Kavli IPMU building, the guests joined researchers and talked with them at tea time.



Minister of State for Special Missions Yosuke Tsuruho (Minister of State for Science and Technology Policy / Minister of State for Space Policy) visited Kavli IPMU

Event: "Actually I Really Love Physics! —Career Paths of Female Physics Graduates"

On November 19, 2016, the University of Tokyo's Kavli IPMU, Institute for Solid State Physics, and 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, and there were 33 participants. This event was held to support female students in physics to plan their careers. For that purpose, various speakers of physics graduates talked their career paths and the attractiveness of the field of physics. It was also aimed to create a network of participants on this occasion.

In the morning, four speakers talked about topics including their career paths and research for 10 to 20 minutes each.

In the afternoon, there were two thirty-minute lectures. Kavli IPMU Director Hitoshi Murayama spoke on the topic "What I started to see as I majored in physics—the forefront of astrophysics research and achievements of female researchers." The University of Electro-Communications Associate Professor Haruka Tanji then gave a lecture entitled "What I saw when I broke out of my shell—Study at a graduate school in the U.S. and afterwards." In her lecture, she also spoke about reconciling research with raising a child.

After the lectures, the participants toured the three host institutes. The final program of the event was a meeting of the lecturers and participants. A friendly atmosphere, with tea and cookies being served, produced active interactions among the participants, and the event ended successfully.

Talking with undergraduate and graduate women students at the event to support their thinking of physics careers", I Actually Really Love Physics: Careers for Girls in Physics"

15th Kavli IPMU/ICRR Joint Public Lecture, "The Observable Universe and Beyond"

On November 27, 2016, the Kavli IPMU and the Institute for Cosmic Ray Research (ICRR) held the 15th joint public lecture at the Ito Hall of the University of Tokyo's Hongo campus. "Observable Universe and Beyond" was the main topic and it attracted an audience of about 300 people including junior high school and high school students.

The first lecture entitled "Observing Formation and Evolution of Galaxies with Large Telescopes" was given by ICRR Assistant Professor Yoshiaki Ono. He talked about studies of the evolution of the neutrality of the universe, which elucidate the reionization epoch when cosmological structure formation started. In particular, he focused on surveys of distant galaxies that are important in understanding the number density of galaxies in the early universe.

Then Kavli IPMU Associate Professor Taizan Watari spoke on "Beyond Our Universe, Far to Observe, People Say, Different Worlds Exist." Having started with quoting Karl Busse's poem Über den Bergen,*** he developed the topic by comparing "happiness imagined to dwell over the mountains" to the laws of physics in the worlds which we cannot yet observe. He said, "While our laws of physics seem to hold within the universe we can observe, it is possible that the laws of physics and constants beyond the observable universe are different from ours." He then explained a possible world resulting from slight changes in physics laws and constants.

After the lectures, Professor Ono and Professor Watari answered questions from each other and the audience. There was then a further opportunity of communication between the lecturers and the attendees in the foyer of Ito Hall, and many of them eagerly asked questions at that time.

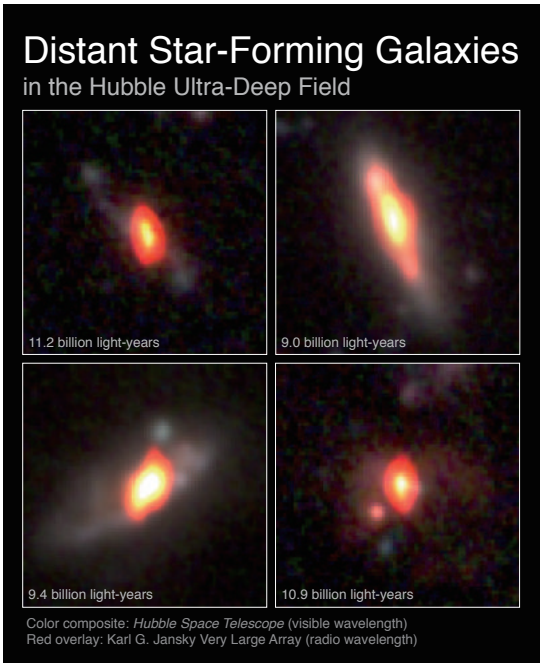
*** English translation (copyrighted):
The LiederNet Archive: http://www.lieder.net/lieder/get_text.

Taizan Watari (left) and Yoshiaki Ono (right).

VLA and ALMA Team up to Give First Look at Birthplaces of Most Current Stars

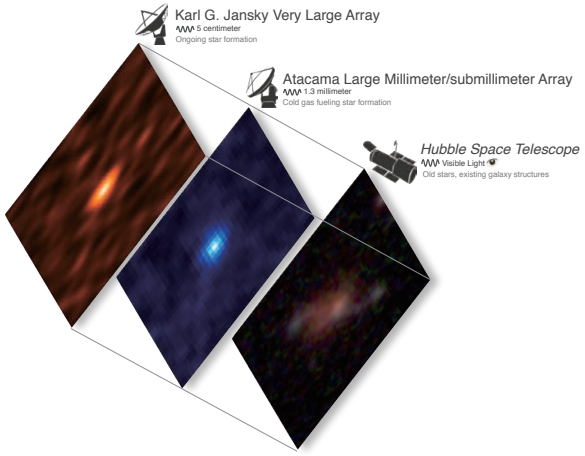
An international team of astronomers, including Kavli IPMU postdoctral fellow Wiphu Rujopakarn (who is also affiliated with Chulalongkorn University in Bangkok) as the first author of the paper reporting this research, got their first look at the exact place where stars were born at a peak rate of star formation. To do so, they used the National Radio Astronomy Observatory's Karl G. Jansky Very Large Array (VLA) in New Mexico and the Atacama Large Millimeter/Submillimeter Array (ALMA) in Chile to look at eleven distant galaxies selected from the Hubble Ultra-Deep Field. They are seen as they were 8.9 – 11.5 billion years ago.

Most stars in the present Universe are thought to have been born then. However, galaxies forming stars prolifically are shrouded in a great deal of dust due to star formation activity. This makes it difficult to look at the birthplace of stars because intervening dust hides it from visible-light observations. However, radio waves, having longer wave lengths than visible light, can get through the dust. Therefore, the astronomers made the most sensitive image of such distant galaxies where star formation was occurring with the VLA, and observed the distribution of cold gas (which is the fuel



Radio/Optical combination images of distant galaxies as seen with VLA and Hubble Space Telescope. Their distances from Earth are indicated in the images. Credit: K. Trisupatsilp, NRAO/AUI/NSF, NASA.

for star formation) with the ALMA using radio waves in the millimeter wavelength region (called millimeter waves), as seen in the two figures shown on the right.
The new observations, using the VLA and ALMA, have shown that intense star formation in the galaxies they studied most frequently occurred throughout the galaxies, as opposed to much smaller regions in present-day galaxies with similar high star-formation rates. The star formation rate (the total mass of stars formed per year) in the galaxies they studied turned out to be 20 times as large as that in the present-day average galaxies.
By precisely observing and analyzing the images of more distant galaxies where star formation was occurring using both radio waves and millimeter waves in future research like the present one, it is expected that we can investigate what mechanisms were responsible for the bulk of star formation in those galaxies at that time, and how they are different from the star-formation mechanisms in present-day galaxies, and eventually, we can shed light on the history of galaxy evolution.
These results were published in the December 1 issue of the Astrophysical Journal.



The combination of VLA, ALMA, and Hubble Space Telescope provides simultaneous insights into star formation, cold dust, and the existing stellar populations in distant galaxies in the Hubble Ultra Deep Field. Credit: Wiphu Rujopakarn/Kavli IPMU.

Kavli IPMU Staff Received the University of Tokyo's Special Award for Operational Improvement in 2016

The Kavli IPMU Administrative Division team, represented by Rieko Tamura of the International Relations and Researchers Support Section, received the University of Tokyo's 2016 Special Award for Operational Improvement. The team consists of 20 members that took part in the "Win-Win Project towards University Globalization."The Awards for Operational Improvement is divided into three ranks: the President's Award, the Executive Vice President's Award, and the Special Award given by the University's Division for Operational Improvements. Every year, teams of university staff members are invited to implement ideas for operational improvement, and the awards are given to teams that have shown excellent achievements.
The Kavli IPMU team planned and implemented two programs: "Lunchtime English Training" and "Language Exchange with IPMU Researchers." These programs raised the English proficiency of administrative staff, and reduced inefficiencies around English language-related tasks. In addition, "Language Exchange with IPMU Researchers" is a program carried out between Kavli IPMU staff and researchers from abroad. It is a win-win program as recognized by the award: the exchange is an opportunity for the researchers to improve their knowledge of Japanese language and culture.

Kavli IPMU / ELSI Joint Public Lecture "A Question of Origins"

On January 22, 2017, the 2nd public lecture—"A Question of Origins"—co-sponsored by Kavli IPMU and Tokyo Institute of Technology's Earth-Life Science Institute (ELSI) was held at the University of Tokyo's Ito Hall at Hongo campus.
The purpose of the Kavli IPMU is to pursue the "Origin of the Universe" and the purpose of the ELSI is to pursue the "Origin of the Earth and Life." These two WPI institutes planned this public lecture as an event to convey the latest findings of their research in an easy-to-understand way as well as to offer a diversity of perspectives, including the philosophical perspective to the audience, under the common theme of "A Question of Origins," which is fundamental to mankind. The venue was filled to capacity with 350 people.
After an opening address by WPI Program Director Toshio Kuroki, Kavli IPMU Principal Investigator Hirosi Ooguri talked about "The Origin of the Universe from

the Physics Point of View," ELSI Director Kei Hirose talked about "Learning the Past from the Present—Travelling through Time over 4.5 Billion Years—," and the University of Tokyo's Graduate School of the Humanities and Sociology Professor Noburu Notomi spoke about "Question of the Origin (arkhē)
Posed by Ancient Greek Philosophy." After the lectures, the three speakers took part in a round table discussion entitled "What Does It Mean to Question Origins?" Finally, there was a discussion between the lecturers and the audience, and the event ended on a high note.

Round-table discussion. From right to left: Hirosi Ooguri, Kei Hirose, and Noburu Notomi.

AAAS 2017 Annual Meeting in Boston

The American Association for the Advancement of Science (AAAS) annual meeting was held in Boston from February 16 through 20, 2017. At this AAAS annual meeting, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Japan Society for the Promotion of Science (JSPS), and the nine WPI centers including the Kavli IPMU hosted the WPI booth for three days from February 17. Open to all attendees, the booth showcased some of the latest research from WPI centers, as well as highlighted their efforts to create an open research environment that attracts scientists from around the world, with WPI Program Director Toshio Kuroki in attendance. During the three days, the WPI booth was visited by more than 300 people, including researchers, journalists, students, and families.

WPI booth at the AAAS annual meeting in Boston. Photo: Courtesy of the International Institute for Carbon-Neutral Energy Research (I^2CNER), Kyushu University.

At this AAAS annual meeting, Nobel laureate Takaaki Kajita (Director of the University of Tokyo's Institute for Cosmic Ray Research and Kavli IPMU Principal Investigator) participated as a panelist at the panel discussion entitled, "Opening a New Era to the Universe with Gravitational Waves."

Director Murayama Talked at the WPI 10th Anniversary Symposium

On December 17, 2016, the WPI 10th Anniversary Symposium "Towards the Future of Science in Japan" was held at Assembly Hall, East Annex, Ministry of Education, Culture, Sports, Science and Technology (MEXT), under the sponsorship of MEXT and the Japan Society for the Promotion of Science (JSPS) and with the cooperation of all the nine WPI centers. In this symposium, Kavli IPMU Director Hitoshi Murayama spoke on "The Beginning and the End of the Universe." His lecture and other lectures (all in Japanese) can be seen at https://www.jsps.go.jp/j-toplevel/13_lecture.html.

Surrounded by young students, Director Murayama answers their questions, at the WPI 10th Anniversary Symposium" Towards the future of science in Japan". Photo: Courtesy of IFReC.

First Public Data Released by Hyper Suprime-Cam Subaru Strategic Program

The first public data set from the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) was released on February 27, 2017 (local time in Hawaii). The HSC-SSP is a large survey being done using HSC, an optical imaging camera mounted at the prime focus of the Subaru Telescope. Since it is difficult to analyze such a huge dataset with standard tools, a dedicated database and interface for ease of access and use of the data has been developed.

The HSC-SSP is a "cosmic census" project expected to spend 300 nights over 5 to 6 years to conduct an imaging survey of various galaxies over a wide solid angle of the sky, corresponding to 6,000 times the area of the full moon, in sufficient depth to probe the distant Universe. The HSC-SSP is an international collaboration of astronomers from NAOJ, Kavli IPMU, and other institutes in Japan, the Academia Sinica Institute of Astronomy and Astrophysics (ASIAA) in Taiwan, and Princeton University in the United States. Kavli IPMU Professor Masahiro Takada serves as a leader of the HSC-SSP Science Working Group using the HSC-SSP data.

This release includes data from the first 1.7 years (61.5 nights of observations beginning in 2014) and the total amount of data comprises of 80 terabytes. Though this first public dataset represents only a sixth of that expected from the entire HSC-SSP survey, it already contains almost 100 million galaxies. In contrast, the US-based Sloan Digital Sky Survey (SDSS)—which is known for its wide area observation—took over 10 years to create equivalent data sets.

Why was it possible for the HSC-SSP survey to collect such a large amount of data within this short period? It is because the HSC-SSP is a large survey project which fully takes advantage of the performance of the Subaru telescope and the HSC. First, the Subaru telescope has a large 8.2 m diameter primary mirror, and, therefore, a high light-collecting power. Further, the HSC, a wide-field camera mounted at the prime focus of the Subaru telescope, has 104 CCDs (870 million pixels in total) for science exposures and a 1.77 square-degree field of view—about 1000 times as large as that of the Hubble Space Telescope.

In contrast to other surveys, the HSC-SSP can collect high-quality data including information on dim galaxies and distant galaxies. In future, it is expected to shed light on such topics as the origin of galaxies, and the nature of dark matter and dark energy, using these data.

Meeting of WPI Center Administrative Directors Held at Kavli IPMU

On March 8, 2017, a meeting of the WPI (World Premier International Research Center Initiative) center Administrative Directors was held at the Kavli IPMU. In addition to the Administrative Director and some administrative staff from each WPI center, WPI Program Director (PD) Toshio Kuroki, Deputy PD Akira Ukawa, Director Takuya Saito of the Office for the Promotion of Basic Research, the Basic Research Promotion Division, Research Promotion Bureau, Ministry of Education, Culture, Sports, Science and Technology (MEXT), and some officers from MEXT and JSPS (Japan Society for the Promotion of Science) WPI Secretariat also attended the meeting.

To begin, meeting host and Kavli IPMU Administrative Director Haruyama reported on the necessity for the WPI program, 10 years after its launch, to deepen cooperation among the centers. Then, PD Kuroki, MEXT Director Saito, and others explained the present status toward establishing the "WPI Academy." According to these explanations, the WPI centers, which started in 2007 as first-generation centers, can maintain and develop their status of "World Premier International Research Center," attained through their ten years of activities, in the new framework of the WPI Academy. As the Kavli IPMU is a WPI center with a five-year extension, it is expected to play its role in the WPI Academy as well as in the current WPI program. Further, there was a presentation of information by a fundraising specialist. He pointed out the necessity of an approach toward various kinds of fundraising, sufficient appeal power the WPI activities have, etc.

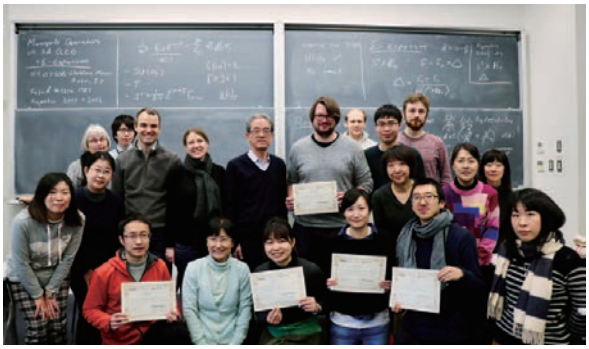
The participants toured the Kavli IPMU building which is known for its unique design, and attended daily tea

A scene from the WPI Administrative Directors meeting.

time which is aimed at cross-disciplinary communication of researchers.
Finally, there was a discussion regarding problems that are common to each center. The participants recognized the importance of the Administrative Directors meeting like the one held this time, and agreed upon a policy of gathering periodically as often as possible for the purpose of building up WPI's bank of information that can be shared among the centers.

Japanese Class Completion Ceremony

At the Kavli IPMU, its own Japanese classes are open to researchers and their families. To date, many people have completed their 40 hours of Introductory Japanese Course taught by Kavli IPMU's Japanese Language teacher Masami Nishikawa.
On March 13, 2017, six students celebrated finishing their Japanese classes. They presented speeches in Japanese and received their certificates. They are Kavli IPMU Postdoctoral Fellows Jiaxin Han, Ting-Wen Lan, Juliana Kwan, Fabian Koehlinger, Po-yen Tseng, and his wife Chia-I Chen.



It looks that there are only five people holding their certificates, but there is another one who is not showing his certificate clearly.

Workshop –Searching for the Lost Study– Art × Science × Philosophy

On March 25, 2017, a workshop Called "Searching for the Lost Study– Art × Science × Philosophy" was held at Tamarokuto Science Center in Nishi-Tokyo City.
This workshop was aimed at considering similarities and differences between science, art, and philosophy. The following specialists were invited to present their view on this theme: Masahito Yamazaki (Kavli IPMU Assistant Professor; Physics), Yoshihiro Maruyama (Kyoto University's Hakubi Project/Graduate School of Letters Assistant Professor; Mathematical Philosophy), Masafumi Oizumi (ARAYA's Manager; Cognitive Science), Shunsuke Kuwahara (The University of Tokyo's Department of Aesthetics Assistant Professor; Aesthetics), and Nozomu Ogawa (Art Center Ongoing Director; Contemporary Art). There were about 40 participants. More than half of them were women.
The workshop lasted the whole day, with a Science session, Art session, and General session, and it was organized in such a way that there were frequent discussion times among the participants. In each group sitting around a table, a very active discussion was made to deepen the understanding of the presentation given by lecturers.

Presentation of Kavli IPMU's physicist Masahito Yamazaki.

A scene of the workshop.

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